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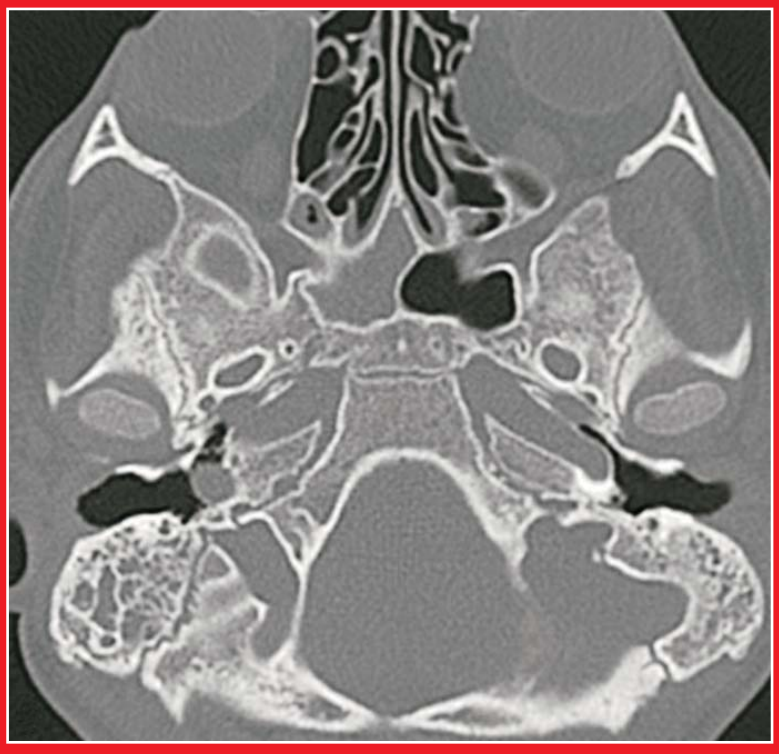

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Non-inflammatory and non-neoplastic soft tissue lesions of the tympanic cavity

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Abstract

Objectives: Tympanic cavity (TC) is an anatomically challenging region for the diagnosis of lesions located inside it. Radiological diagnosis and demonstration of the anatomic localization of sporadic lesions such as vascular malformations and meningocele are essential for the prevention of complications that may occur during operation and recurrent unnecessary interventions. The aim of the present study was to demonstrate the radiological appearance of the vascular variations and the post-traumatic soft tissue lesions which are rarely encountered in TC.

Methods: A total of 3525 temporal multi-slice computed tomography (MSCT) images were evaluated between 2010–2018. Twelve cases with non-inflamatory and non-neoplastic soft tissue lesions in TC were detected and 2 with meningocele were included in the study.

Results: Of the 12 cases, 6 were males and 6 were females. The mean age of the patients was 26.16 years. Four cases had an aberrant internal carotid artery (ICA), being bilateral in 2 cases and right sided in the remaining 2 cases. Six cases had dehiscent mega jugular bulb (DMJB); and 2 cases had post-traumatic meningocele.

Conclusion: Vascular malformations and meningoceles are rarely observed in TC. They may present nonspecific clinical signs and symptoms; however, they should be evaluated with MSCT and MRI before the surgical interventions regarding the middle ear to prevent possible complications.

Keywords: meningocele; radiologic finding; tympanic cavity; vascular malformation

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Introduction

Temporal bone has a complicated structure since it contains two of the cranial nerves (facial and vestibulocochlear nerves), blood vessels such as meningeal arteries and internal carotid artery (ICA) and elements of vestibule-auditory system. The tympanic cavity (TC) is a rectangular cavity with 6 walls located within the petrosal part of the temporal bone. The lateral wall consists of the tympanic membrane and epitympanic recess, the medial wall is formed by the lateral wall of the inner ear featuring the oval and round windows. The roof (tegmental wall) separates the TC from the dura mater of the middle cranial fossa. The floor (jugular wall) forms the base of the hypotympanum and provides separation from the jugular bulb. The anterior wall is a thin bone plaque with an opening for eustachian tube and tensor tympani muscle. This wall separates ICA from TC. The posterior wall separates mastoid cells from TC. TC is divided into three parts by taking the tympanic membrane as the key point. The upper part of the tympanic membrane is described as epitympanum, the lower part as hypotympanum and the tympanic membrane level as mesotympanum. A bone chain consisting of manubrium, incus, and stapes in mesotympanum allows connection between the external ear and inner ear.[1,2] The complicated structure, vital neurovascular relationships and relative small area of TC makes the clinical and radiological evaluation of lesions in this region challenging. The soft tissue masses, located in TC could be evaluated by otoscopic examination and all the details in this area could be shown more clearly by radiological examinations such as multislice computed tomography (MSCT) and magnetic resonance imaging (MRI).[3]

In this study, we aimed to present the vascular variations and the radiological appearance of the post-traumatic soft tissue lesions that are rarely encountered in TC.

Materials and Methods

Patients who referred to Radiology Department after being evaluated in Mustafa Kemal University hospital due to hearing problems, tinnitus, dizziness, trauma and post-traumatic control between 2010–2018 were retrospectively reviewed. Totally, radiological images of 3525 patients were evaluated for presence of any vascular variations and post-traumatic soft tissue lesions in the TC. Any infectious or neoplastic pathologies causing soft tissue appearance were excluded. Non-inflammatory and non-neoplastic soft tissue lesions were detected in TC of 12 patients who underwent temporal MSCT (Toshiba Aquillon 64 MDCT, Tustin, CA, USA). The evaluation of the cases with MSCT was done by the Basic Vitrea 2 (version 4.0) workstation. In addition to this, four of the patients underwent temporal MRI (1.5 Tesla Philips MRI, Achieva, Best, the Netherlands) for further differential diagnosis of soft tissue lesions. The diagnosis was made with the pathological contrast enhancement in contrast-enhanced MSCT and contrast-enhanced MRI. In addition, CT angiography and MR angiography examinations were made to show vascular structures.

Results

The mean age of the patients with non-neoplastic and non-inflammatory soft tissue lesions was 26.16 (range: 17–45) years. Six of them were male, and six were female. In 5 of the patients, hearing related findings (total hearing loss in three cases, conductive type hearing loss in two) were the main symptoms. Tinnitus and ear pain was present in 3, non-suppurative otitis media in 3, suppurative otitis media and ear pain in 1. Two cases had a history of trauma, and total hearing loss and one patient had peripheral facial paralysis. The age, gender, clinical and radiological findings of these 12 patients were summarized in **Table 1**.

Four patients had aberrant internal carotid artery (ICA) in TC (**Figure 1**). Bilateral ICA was detected in 2 of these cases, and right aberrant ICA was found in the remaining 2 cases (**Figure 2**). One of the cases with aberrant bilateral ICA had total hearing loss, two cases had otitis media, and one case had tinnitus and ear pain.

A "mega" jugular bulb with dehiscence extending to the TC was present in 6 of the cases. In one case, the jugular

Table 1

Age, gender, clinical and radiological findings of 12 cases.

No	Age	Gender	Clinical findings	Radiological diagnosis
1	22	F	Bilateral total hearing loss	Bilateral aberrant ICA
2	17	M	Suppurative otitis media, ear pain	R- aberrant ICA
3	34	F	Ear pain and tinnitus	R- aberrant ICA
4	35	F	Non-suppurative otitis media	Bilateral aberrant ICA, Close relationship with bone chain on the right
5	21	M	Right conductive hearing loss, suppurative otitis media	R- DMJB
6	18	F	Non-suppurative otitis media	R- DMJB
7	22	K	Non-suppurative otitis media	L- DMJB
8	42	M	Right conduction-type hearing loss	R- DMJB
9	45	M	Tinnitus, ear pain and fullness	R- DMJB
10	18	F	Tinnitus	R-DMJB
11	22	M	Traffic accident 2 years ago, hearing loss in the right ear, and facial paralysis	The transfer fracture line in petrous bone that starting from apical level of ICA and passing in front of the cochlea, the meningocele sac extending along this line to the tympanic cavity.
12	18	F	Falling from height10 years ago, total hearing loss in the left ear	Transverse fracture in the left petrous bone, jugular foramen walls. Cochlear labyrinthitis ossificans, dislocation in the bone chain, pseudopenningocele extending to the tympanic cavity at the oval window level.

DMJB: dehiscent mega jugular bulb; **F:** female; **ICA:** internal carotid artery; **L:** left; **M:** male; **R:** right.

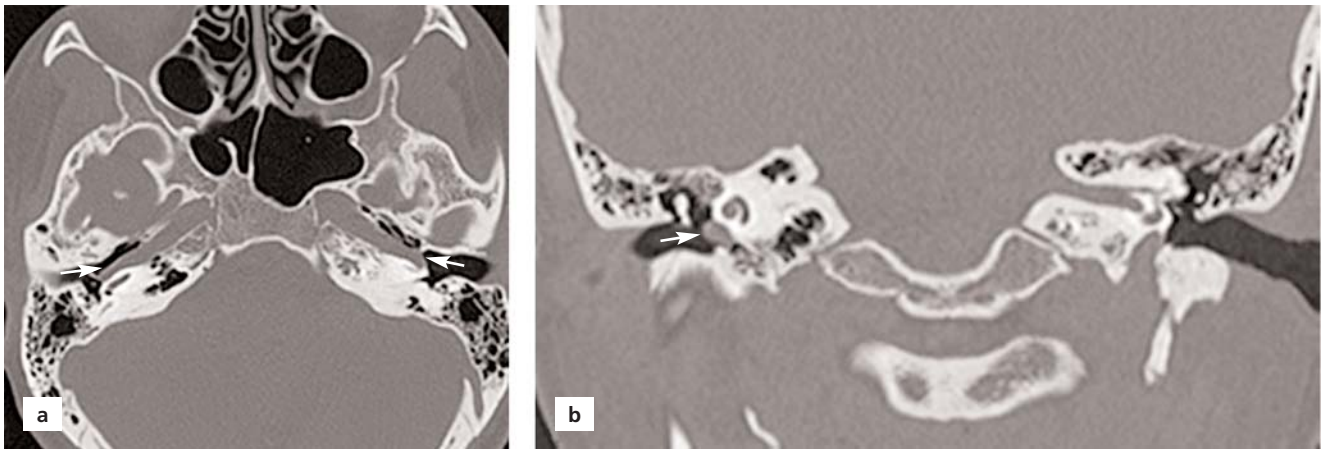
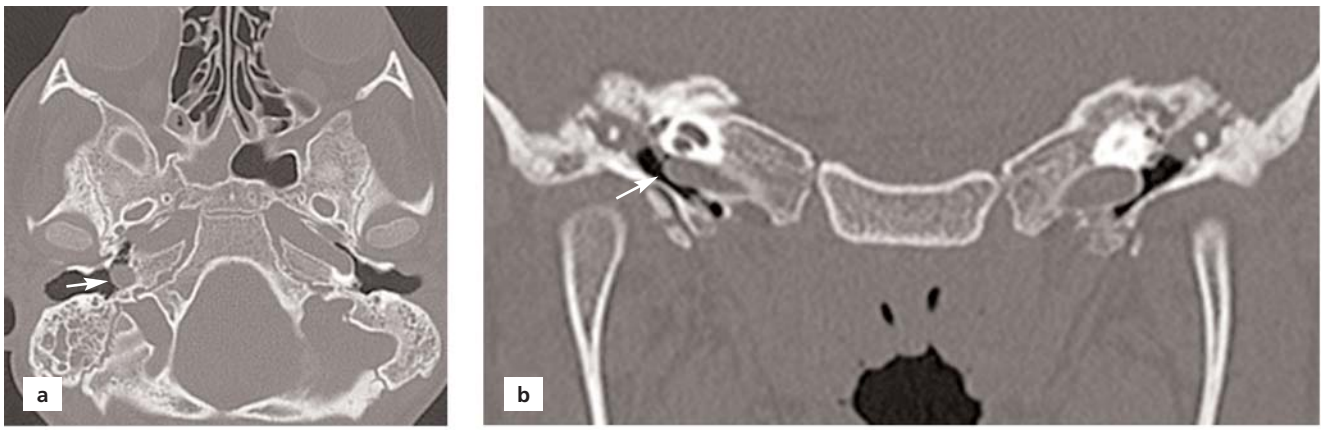


Figure 1. (**a**) Axial and (**b**) coronal MSCT sections of a 17-year-old male patient, aberrant ICA in contact with tympanic membrane in the right tympanic cavity (**white arrows**).

bulb contacted the lower edge of the tympanic membrane (**Figure 3**). Two patients with dehiscent mega jugular bulb (DMJB) had right conductive hearing loss, one patient had tinnitus and aural fullness, while the other three patients were asymptomatic. The patients with otitis and ear pain had a DMJB that was detected in temporal MSCT. In six cases, temporal MSCT examination showed that jugular bulb caused dehiscence in the bone (**Figure 4**).

The temporal MSCT obtained from 2 patients with post-traumatic total hearing loss revealed old transverse



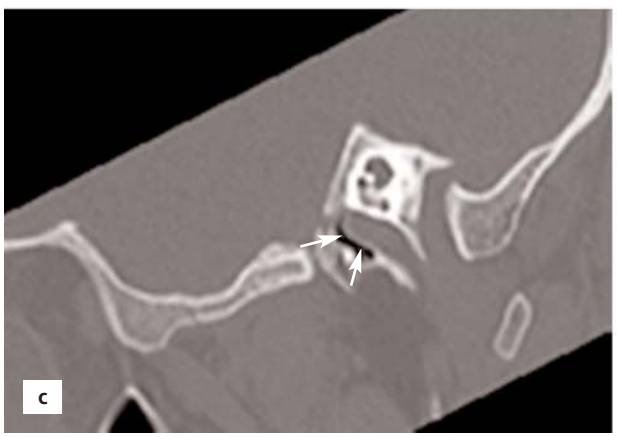


Figure 2. (**a**) Axial (**b**) coronal and (**c**) sagittal MSCT sections of a 35-year-old female patient, bilateral aberrant ICA on the right is more prominent and in contact with the tympanic ossicles (**white arrows**).

Figure 3. (**a**) Axial and (**b**) coronal MSCT sections of a 42-year-old male patient, mega-jugular bulbus which caused dehiscence on the base of tympanic cavity, extending to the tympanic cavity and touching the tympanic membrane (white arrows).

fracture lines in the right petrous bone including the otic capsule. The first case was a 22-year-old male with a previous motor vehicle accident happened 2 years ago. The patient had total hearing loss and peripheral facial paralysis in the right ear after the trauma. The temporal MSCT revealed a fracture line starting from the apical level of IAC, passing close to the cochlea and reaching to TC by passing through the labyrinthine part of the facial nerve. In addition to this, a meningocele was detected by MSCT and MRI in the same patient (**Figure 5**). The second case with meningocele was an 18-year-old woman. She had a total hearing loss in her left ear after falling from a height 8 years ago. A transverse fracture in the petrous bone was detected by MSCT and MRI just in front of the cochlea, which passed from the proximal part of the tympanic portion of the facial nerve. The fracture caused dislocation of the stapes separating it from the oval window. A meningocele sac extending from the left oval window to TC was also detected. In this case, labyrinthitis ossificans developed in cochlea (**Figure 6**).

Discussion

Any inflammatory, neoplastic and/or vascular soft tissue or bony lesions may be encountered in TC. The soft tissue lesions of TC include cholesteatoma, paraganglioma, aberrant carotid artery, schwannoma, meningocele, and high mega jugular bulb.[1,4] Hearing loss, ear pain and tinnitus are among common symptoms of these patients. Soft tissue lesions in TC are diagnosed by otoscopic or radiologic examinations. The change in the color of the tympanic membrane can easily be detected by otoscopic examination which provides essential information for the several lesions. A red tympanic membrane is a sign for aberrant ICA and glomus tumor in TC; a blue tympanic

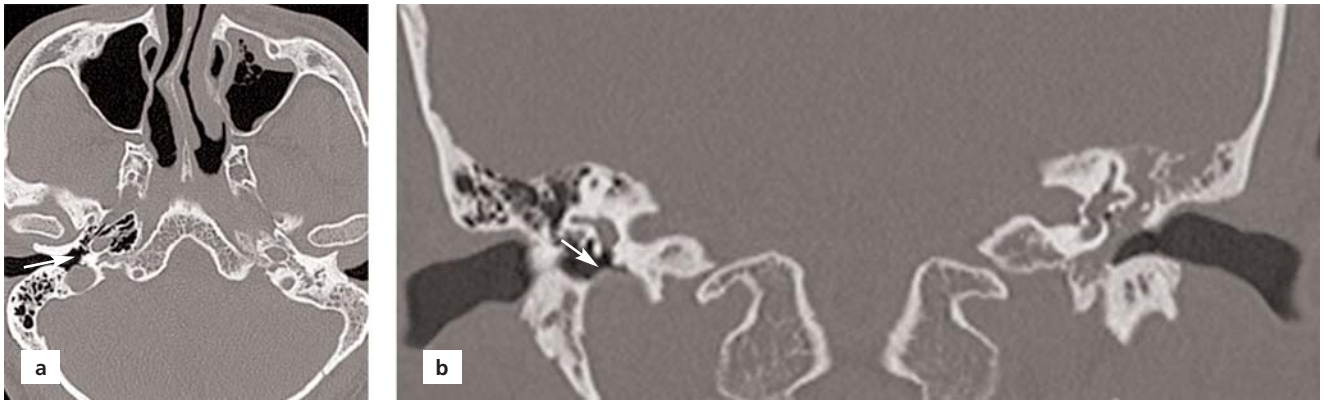


Figure 4. (**a**) Axial and (**b**) coronal MSCT sections of a 45-year-old male patient, right mega-jugular bulbus which caused dehiscence on the base of tympanic cavity and extending to the tympanic cavity (white arrows).

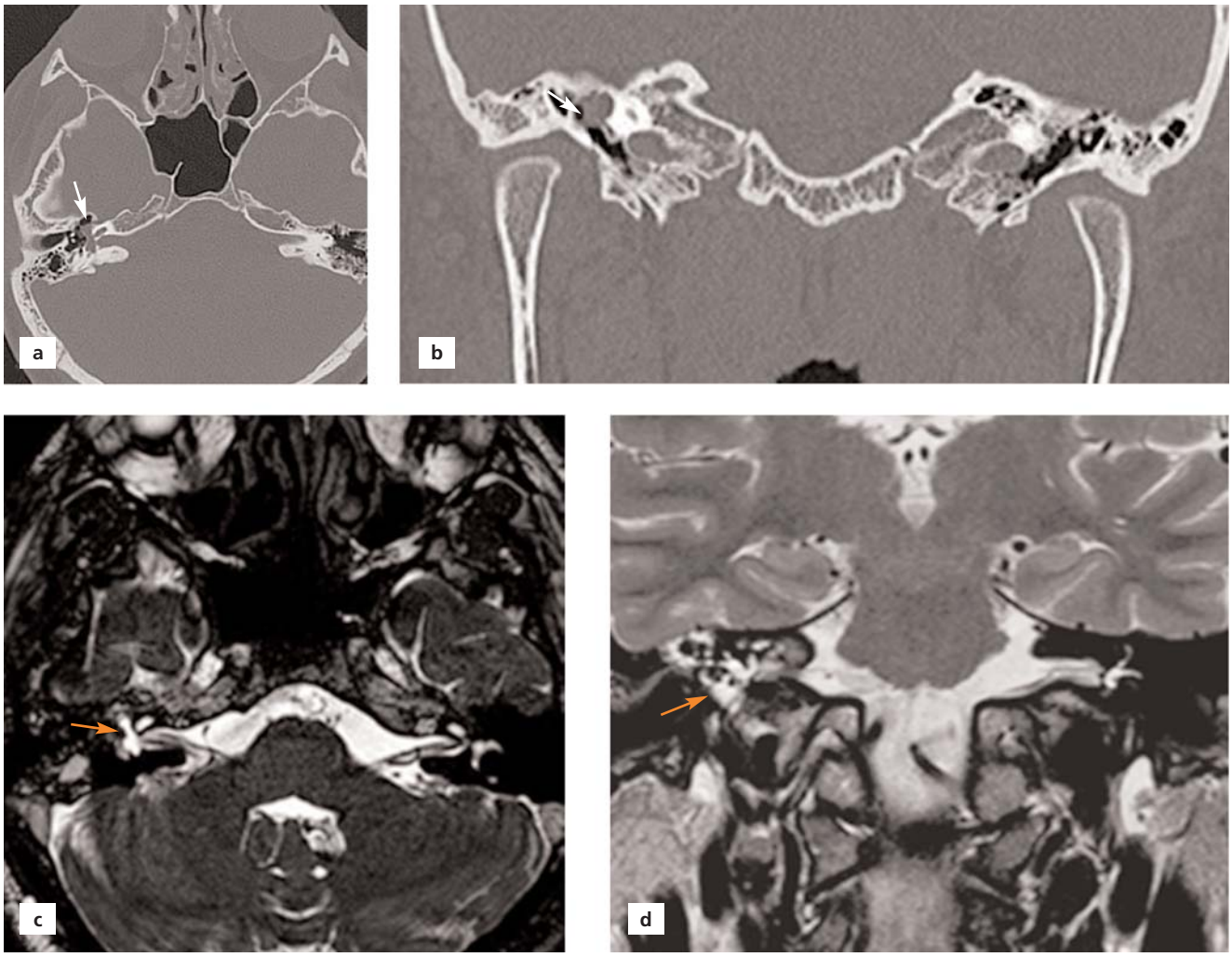


Figure 5. (**a**) Axial and (**b**) coronal MSCT sections of a 22-year-old male patient, meningocele pouch is located at the fissure line which crossed internal acoustic canal, labyrinthine part of the facial nerve and reached tympanic cavity (**white arrows**); (**c**) axial and (**d**) coronal T2-weighted MR images showing meningocele pouch in tympanic cavity (**orange arrows**).

membrane for DMJB, meningocele, meningoencephalocele and cholesterol granuloma; and a white tympanic membrane for the primary tympanic cavity tumors such as congenital cholesteatoma and schwannoma. However, making a differential diagnosis among these lesions is difficult by otoscopic examination thus multiplanar imaging techniques such as MSCT and MRI are gold standard for evaluating TC. It is possible to obtain thin sections with MSCT making it easy to interpret the structures located within the TC in details. MRI is used to evaluate soft tissue lesions and their relationships, while MRI angiography provides useful information for vascular structures.[1,5–7]

An aberrant ICA and a DHJB are not so common. Typically, ICA is located in the carotid canal of the petrous part of the temporal bone and is adjacent to the anterior wall of TC. The aberrant ICA in TC is known to occur by the combination of inferior tympanic artery with the carotico-tympanic artery. In such a case, the ICA extends more laterally into the TC. The diagnosis is difficult with the clinical examination because the symptoms are nonspecific. Diagnosis is made with MSCT, which could take thin sections. Vascular pathologies such as glomus tumor, cholesterol granuloma, DMJB, hemangioma, aneurysm of the petrosal segment of the ICA should be considered in the differential diagnosis.[6,8,9] Bilateral aberrant ICA was observed in 2 out of 4 aberrant ICA cases, and 2 cases had an unilateral aberrant ICA on the right TC.

The jugular bulb is the junctional region of the sigmoid sinus and the internal jugular vein and is separated

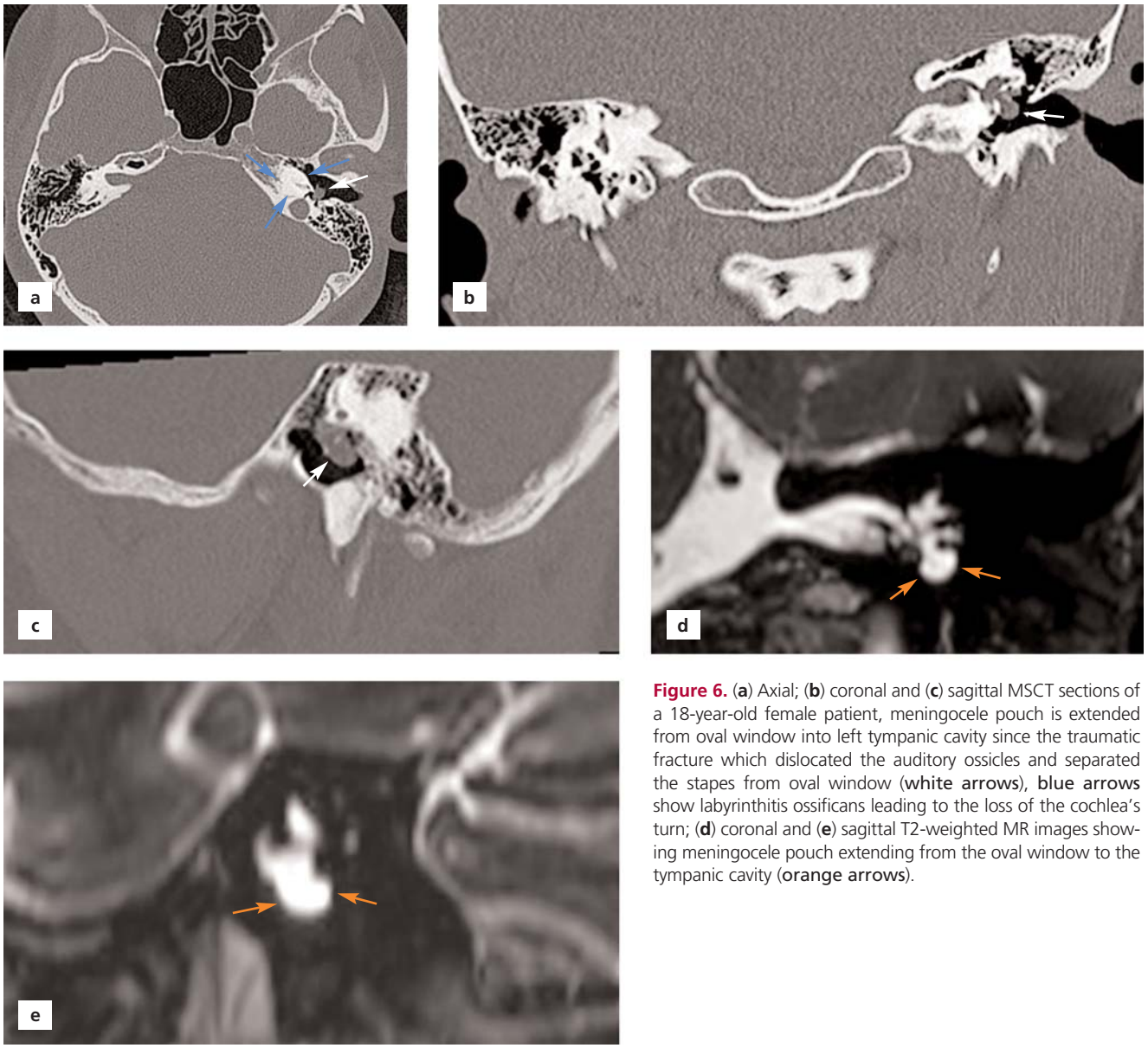


Figure 6. (**a**) Axial; (**b**) coronal and (**c**) sagittal MSCT sections of a 18-year-old female patient, meningocele pouch is extended from oval window into left tympanic cavity since the traumatic fracture which dislocated the auditory ossicles and separated the stapes from oval window (**white arrows**), **blue arrows** show labyrinthitis ossificans leading to the loss of the cochlea's turn; (**d**) coronal and (**e**) sagittal T2-weighted MR images showing meningocele pouch extending from the oval window to the tympanic cavity (**orange arrows**).

from the compact bone (hypotympanum) that forms the base of the middle ear. If the upper edge of the jugular bulb extends over the superior part of the fibrocartilaginous ring of the tympanic membrane or above the basal fold of the cochlea, it is considered as high jugular bulb; whereas if the transverse diameter of the bulb is increased it is considered as mega jugular bulb. Localization and diameter of the jugular vein is subject to a wide range of variations. The high and mega jugular bulb could extend into the middle ear cavity and could be with or without a thin bony septum. The incidence of DMJB is reported to be 0.5–1.7%. It is more frequently observed on the right side. It may be asymptomatic or may cause tinnitus and conductive hearing loss.[10,11] Conductive hearing loss was present in 2 of our cases with DMJB. The other 4 cases had otitis, ear pain, and tinnitus in their physical examinations.

Temporal bone fractures occur after severe high-energy-blunt head trauma and develop most frequently after the motor vehicle accidents. Falling from a height, industrial injuries are among the other reasons. They constitute 30–70% of the calvarial fractures. Temporal bone fractures are classified according to their position on the petrous bone axis as longitudinal, transverse and

mixed type. In a new classification system, it is classified as including the otic capsule (10%) or not (90%), which could better determine the occurrence and prognosis of posttraumatic complications such as hearing loss. Hearing loss is the most common clinical finding, and clinical findings vary according to the type of fracture in the acute and chronic period. Although longitudinal fractures are more common, transverse fractures are more dangerous, and their complications are more frequent. Complications are seen more frequently in the fractures related with the otic capsule. Dislocation in the middle ear ossicles and conduction-type hearing loss, tympanic membrane rupture, hemotympanum and facial nerve paralysis are more frequently observed in longitudinal fractures, whereas sensorineural hearing loss, facial nerve paralysis, and labyrinth fistula are observed in transverse type fractures. In the mixed type fracture, a mixture of these findings may be observed. Labyrinthitis ossificans, which have been reported far less frequently after trauma, could also be seen secondary to the post-traumatic repair process. Post-traumatic vascular injuries, other cranial nerve injuries and meningitis may develop as well. Meningocele/meningoencephalocele are observed rarely. Meningocele formation after trauma is reported in 11% of the cases and after surgical interventions in 59%.[7,12–15] One of the meningocele cases in our study had total hearing loss and peripheral nerve paralysis in the right ear. The other case with meningocele was characterized with post-traumatic labyrinthitis ossificans. To our knowledge, no similar meningocele cases were previously reported possessing such a fracture line. Labyrinthitis ossificans observed in the second case is also very rare after trauma.

The limitation of our study was inclusion of only retrospective cases. However, the number of the images evaluated are considerably high to draw a conclusion.

Conclusion

If the vascular variations in TC such as aberrant ICA and DMJB are not recognized before the operations such as tympanoplasty or cochlear implant placement, there may be severe neurovascular complications. In meningocele, inappropriate and unnecessary interventions would cause perilymphatic fistula and leakage of cerebrospinal fluid, and therefore may lead to severe complications. Consequently, a detailed radiological evaluation with multiplanar MSCT and MRI will be useful before applying any interventions in the middle ear.

Conflict of Interest

No conflict of interest was declared by the authors.

Author Contributions

The authors equally contributed to concept, design, data processing, literature reviewing, data analysis and interpretation, and writing manuscript.

Ethics Approval

The study was approved by Mustafa Kemal University Clinical Research Ethics Committee (Ethics No: 2019/81). The study was also carried out in accordance with the Helsinki Declaration of Principles.

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Radioanatomical examination of the dorsal tubercle and surrounding regions for intraosseous infusions

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Abstract

Objectives: The aim of the study was to determine the soft tissue thickness overlying the dorsal tubercle and the relationship with adjacent anatomical structures in the distal radius for using this area as an alternative intraosseous route.

Methods: Contrast-enhanced MR images of 56 adult patients (28 females, 28 males) without any wrist pathology were evaluated. The shape of dorsal tubercle and its relations with neighboring tendons and vessels with a diameter larger than 2 mm was identified on the axial T1-weighted sections. The soft tissue thickness above the most protruding point of the dorsal tubercle, the distance of the dorsal tubercle to closest tendon on the radial and ulnar sides, as well as its distance to the bone edges on the ulnar and radial sides, and the cortical bone thickness of the radius was evaluated.

Results: The dorsal tubercle had sharp edges in 40 cases (71.4%), blunt in 12 cases (21.4%), and hump in 4 (%7.1) cases. Branches of dorsal venous plexus were found on its surface in 11 cases, extensor pollicis longus tendon only was found superficial to the dorsal tubercle in 7 cases while both extensor pollicis longus and dorsal venous branches were found in 2 cases.

Conclusion: Dorsal tubercle of the distal radius can be considered as an important alternative route for IO infusions since it can be easily accessed without having a risk of injury to important structures, and can provide effective flow.

Keywords: dorsal tubercle; intraosseous infusion; Lister's tubercle; radius

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Introduction

Intraosseous infusions (IO) are widely used when the intravenous route is not available.[1] Although the anterior proximal tibia is conventionally used for IO route,[2] the proximal humerus has recently been preferred to reduce the medullary pressure and pain. However, detecting reliable anatomical landmarks in this area is difficult due to the high soft tissue thickness in the proximal humerus region. This method is particularly difficult in people with a prominent deltoid muscle. IO performed on the proximal humerus are reported to have a success rate of 76% in various studies while this rate is given as 92% for the proximal tibia.[3] From this point of view, the distal radius where the overlying soft tissue thickness is much lower, can be preferred for IO in the upper extremity. The dorsal tubercle (DT) or Lister's tubercle, which is the most prominent protrusion in the dorsal part of the distal radius, can especially be used as an anatomical mark for many invasive procedures.[4–7]

Since IO are performed in primary health centers, they are mostly conducted without a guide or USG.[8] Therefore, important formations near the intervention area are at risk of injury during invasive procedures. For example, the biceps tendon and branches of the axillary artery are located right next to the greater tubercle serving a potential risk of injury during the interventions targeted to the proximal humerus.

The tibia, humerus, and sternum are of the most common used bones for IO.[8–10] However, the number of studies to determine the safe areas on the distal radius for

the intraosseous route is inadequate. Although the cortical bone thickness of the distal radius is well known,[11–13] the safety of the region for intraosseous procedures has not been confirmed.

The aim of the study was to determine the soft tissue thickness overlying the DT in the distal radius region and to evaluate the adjacent anatomical structures using magnetic resonance (MR) images, and to determine whether this area can be used as an alternative IO route safely or not.

Materials and Methods

The contrast-enhanced MR images of 56 adult patients (28 females, 28 males) without any wrist pathology from archives of Ankara Medical Park Hospital were used (**Tables 1** and **2**). The cases were randomly selected from Radiology archives in terms of their ages, genders and sides, and only one side of each case was included to the study. The age distribution of the gender groups analyzed by two-tailed t test was statistically similar (p=0.81).

DICOM images of distal forearm with hand obtained from the MR sections (Siemens Aera® 1.5 T, slice thickness: 3 mm, both T1 and T2 weighted images) were evaluated with the Adobe Photoshop CC® (Adobe Inc. version 21.2.4 for Windows®, San Jose, CA, USA) software. The number of pixels per 10 mm was calibrated using the scales present in the MR sections. Every 28 pixels corresponded to 10 mm during this calibration and subsequent measurements were conducted accordingly. Measurements were made with a precision of one tenth of a millimeter.

The long axes of the radius and ulna were arranged parallel to the imaging surface in the axial sections before the measurements if positional anomalies due to rotation were present. Two measurements were performed at different times by the same observer for each case, and the mean values of these measurements were used. Intraobserver reliability was calculated with SPSS® (Version 20.1, Chicago, IL, USA) for all the parameters (intra-class correlation coefficients >0.910).

The DT was morphologically classified under three groups: sharp, where it peaks with a difference of 2 mm or more from the other protrusions in the dorsal region; hump, if there is a height difference of less than 2 mm between the protrusions; and blunt, if two significant protrusions are not present (**Figure 1**). In each group, the most protruding point of DT was taken as reference for measurements.

The sections where DT was the most prominent were used for measurements. The shape of the DT, the neighboring tendons and the neurovascular structures with a diameter larger than 2 mm were identified in the axial T1-weighted sections and recorded. The superficial branch of the radial nerve was not taken into consideration since its branches were less than 2 mm in this area.

The soft tissue thickness above the most protruding point of the DT, the distance between the closest tendon on the radial and ulnar sides, the distance between the DT and the bony edges on the ulnar and radial sides, and the cortical bone thickness of the radius in these sections was measured (**Figures 2–4**).

Table 1
Demographic information of patients.

	Mean±SD	Range (min–max)
Age (year)	38±9.64	22–62
Weight (kg)	68±9.24	54–100
Height (cm)	167±7.44	155–189
BMI (kg/m²)	24.4±3.01	18.6–34.1

BMI: body mass index; **SD:** standard deviation.

Table 2
Gender, age and side distribution of patients.

Gender	Side	Mean age±SD (year)	n (%)
Males	Right	38.25±9.80	16 (28.6%)
	Left	38.70±9.78	12 (21.4%)
Females	Right	38.15±9.33	16 (28.6%)
	Left	38.81±10.32	12 (21.4%)
Total			56 (100.0%)

SD: standard deviation; **n:** number.

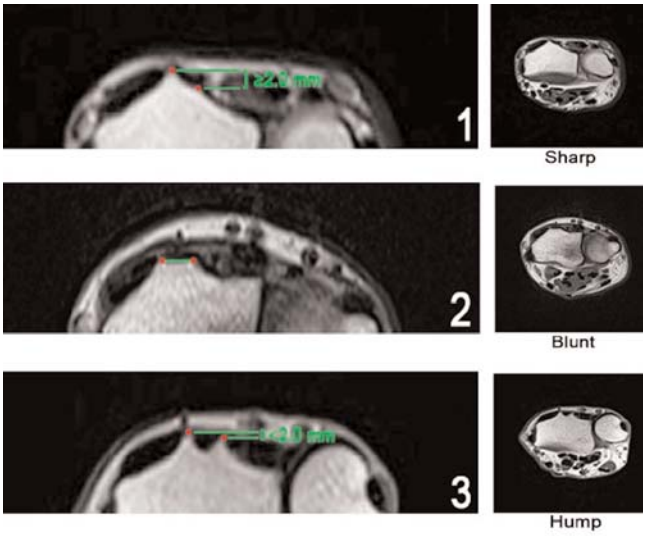

Figure 1. Classification of dorsal tubercle according to its shape as sharp (1), blunt (2), and hump (3).

Contrast ratios where the medullary and cortical bone could be distinguished most clearly were used in the measurement of the cortical bone thickness of the radius in the T2-weighted sections in which DT was the most prominent (**Figure 4**).

Results

DT shapes were classified under three groups and were identified as sharp, blunt and hump (**Figure 1**). The DT was sharp in 40 (71.4%) (22 females, 18 males) cases, blunt in 12 cases (21.4%) (6 females, 6 males), and hump in 4 (%7.1) cases (all male). No significant difference was found between the genders and the morphological type.

The tip of the DT separated the extensor pollicis longus (EPL) and extensor carpi radialis brevis (ECRB) tendons in 41 (73.2%) cases and the EPL and extensor digitorum (ED) tendons in 6 cases (10.7%).

The vessels and tendons located superficial to the tip of the DT were identified by examining other sections as well. Vessels with a thickness of 2 mm or more were only the branches of dorsal venous plexus (DVB) and were found on the surface of the DT in 11 cases (3 females, 8 males). EPL tendon was superficial to the DT in 7 cases (5 females, 2 males). Both EPL tendon and DVB was superficial to the DT in 2 cases (all males). No tendon or vein larger than 2 mm in diameter was found on the DT surface in 36 cases (20 females, 16 males) (**Figure 5** and **Table 3**).

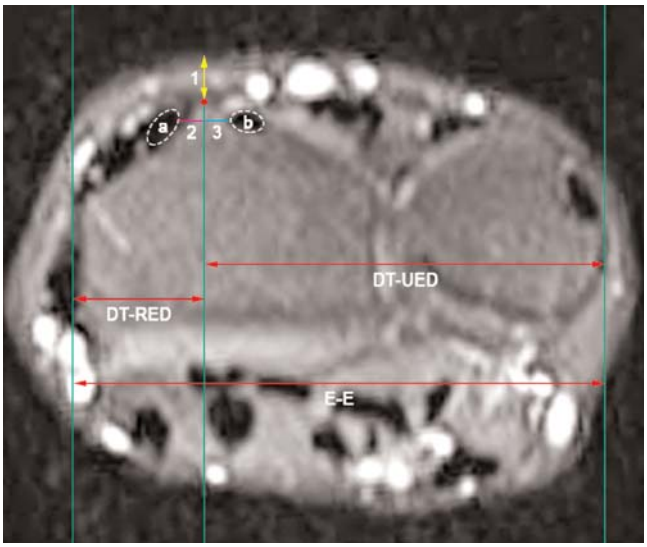

Figure 2. Landmarks used for measurements on an axial wrist MRI. **1:** measurement of soft tissue thickness over the tip of the dorsal tubercle; **2:** measurement of the horizontal distance between the tip of the dorsal tubercle and the closest tendon on the radial side; **3:** measurement of the horizontal distance between the tip of the dorsal tubercle and the closest tendon on the and ulnar side, **a:** extensor carpi radialis brevis tendon; **b:** extensor pollicis longus tendon; **red dot:** tip of the dorsal tubercle, **DT-RED:** the horizontal distance between the tip of dorsal tubercle and the radial bony edge; **DT-UED:** the horizontal distance between the tip of the dorsal tubercle and the ulnar bony edge; **E-E:** edge to edge distance. The green vertical lines were drawn for guidance.

In all cases, the branches originating from the superficial branch of the radial nerve fell below 2 mm in diameter before the DT level, thus were not considered in measurements.

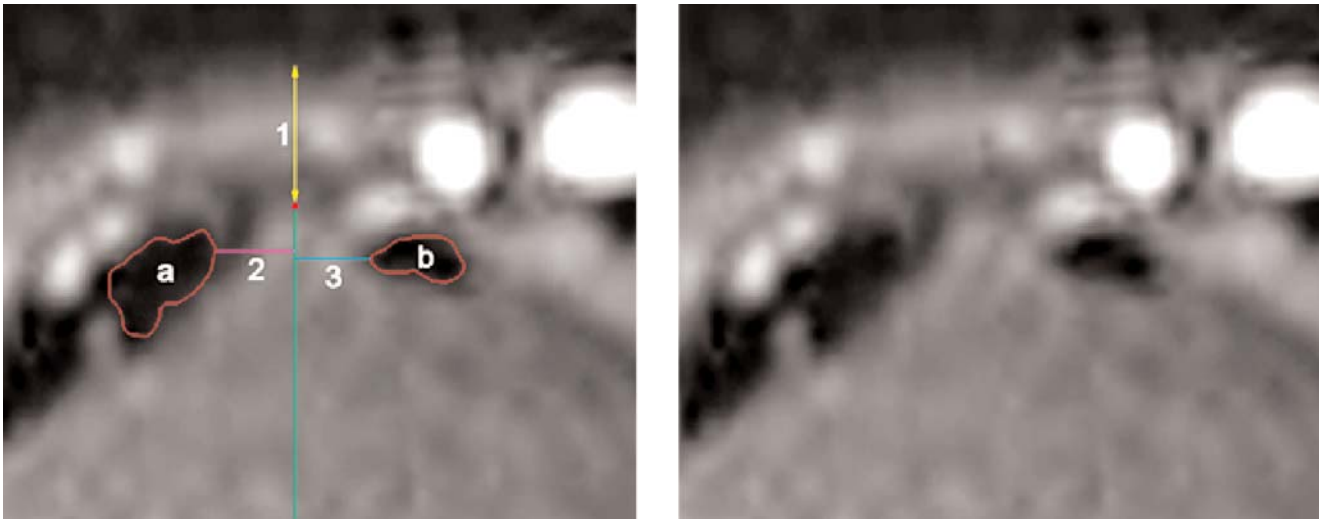

Figure 3. ×3 magnification of Figure 1 focusing on dorsal tubercle to demonstrate the measurements. **1:** measurement of soft tissue thickness over the tip of the dorsal tubercle; **2:** measurement of the horizontal distance between the tip of the dorsal tubercle and the closest tendon on the radial side; **3:** measurement of the horizontal distance between the tip of the dorsal tubercle and the closest tendon on the and ulnar side, **a:** extensor carpi radialis brevis tendon; **b:** extensor pollicis longus tendon; **red dot:** tip of the dorsal tubercle. The green vertical line was a grid line for guidance.

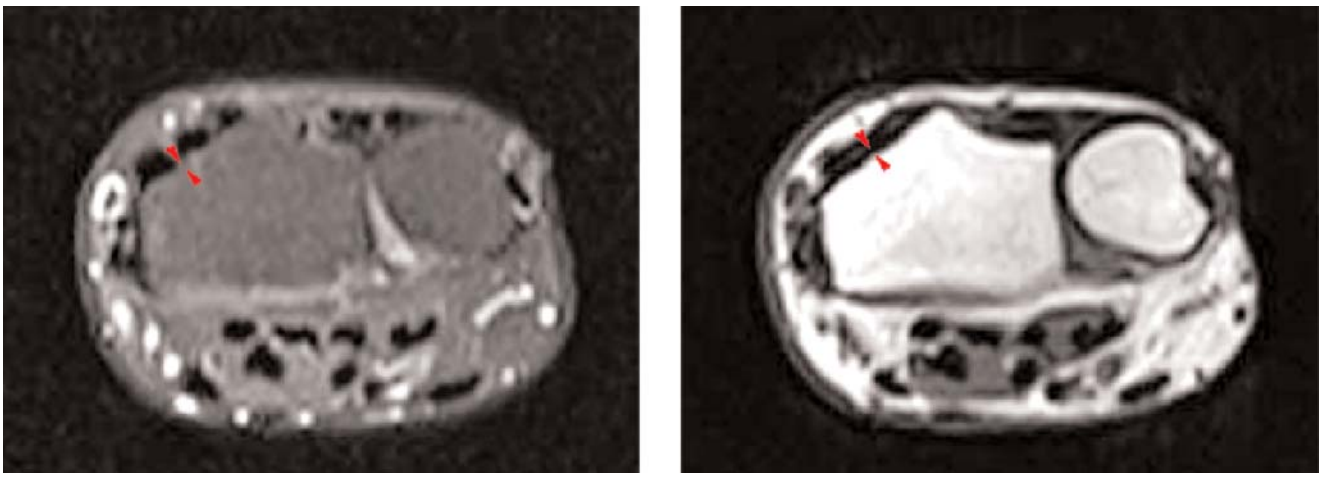

Figure 4. Cortical bone measurements on the distal radius. Cortical bone is demonstrated by red arrows in both T1- and T2-weighted images of the same section.

Table 3
Structures located superficial to the tip of the dorsal tubercle.

	Females	Males	Total
Only DVB	3	8	11 (19.6%)
Only EPL	5	2	7 (12.5%)
EPL and DVB	0	2	2 (3.6%)
Total	8	12	20 (35.7%)

EPL: extensor pollicis longus; **DVB:** branches of dorsal venous plexus.

Table 4
Results of the measurements.

	n	Minimum	Maximum	Mean±SD
STT (mm)	56	1.9	10.4	4.6±1.7
DT-RCT (mm)	56	0.0	5.8	1.7±1.2
DT-UCT (mm)	56	0.0	9.8	2.3±1.8
DT-RED (mm)	56	9.4	20.3	14.5±2.3
DT-UED (mm)	56	28.1	40.2	34.5±3.3
E-E (mm)	56	40.0	56.9	49.0±4.1
CBT (mm)	56	0.7	1.8	1.1±0.2

CBT: cortical bone thickness; **DT-RCT:** distance of the closest tendon to the dorsal tubercle from the radial side; **DT-RED:** the horizontal distance between the tip of dorsal tubercle and the radial bony edge; **DT-UCT:** distance of the closest tendon to the dorsal tubercle from the ulnar side; **DT-UED:** the horizontal distance between the tip of the dorsal tubercle and the ulnar bony edge; **E-E:** edge to edge distance; **SD:** standard deviation; **STT:** soft tissue thickness over the dorsal tubercle.

The following measurements were done (**Figures 2–4**) and the results were given in **Table 4**.

- soft tissue thickness over the tip of the DT
- the horizontal distance between the tip of the DT and the closest tendons on the radial and ulnar sides
- the horizontal distance between the tip of the DT and the ulnar (DT-UED) and radial (DT-RED) bony edges
- the total horizontal distances between the radial and ulnar bony edges (E-E)
- cortical bone thickness (CBT) of distal radius

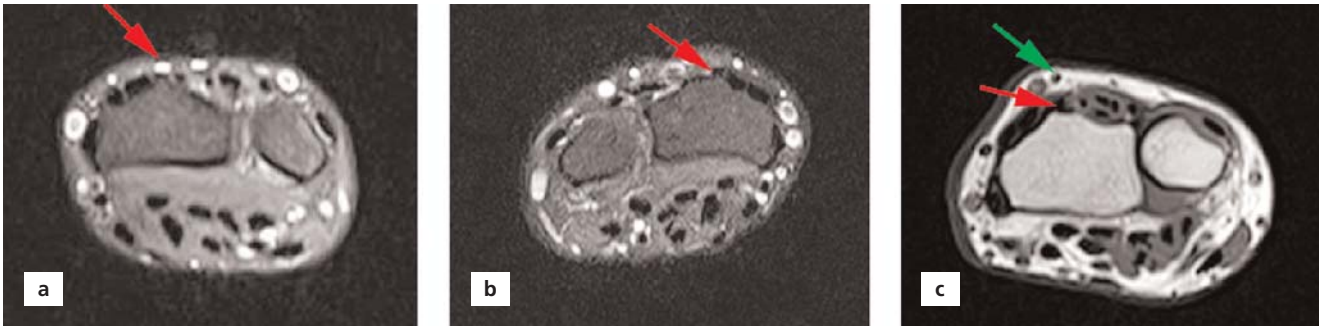

Figure 5. Structures superficial to the dorsal tubercle. (**a**) a branch of dorsal venous plexus was demonstrated with red arrow; (**b**) tendon of extensor pollicis longus was demonstrated with red arrow; (**c**) green and red arrows were used for demonstrating the branch of dorsal venous plexus and extensor pollicis longus tendon respectively.

There was a positive correlation between soft tissue thickness with body mass index (BMI) of the cases (Pearson correlation coefficient=0.497, p=0.000).

Discussion

The diversity of IO is important in terms of early intervention to the patient under emergency conditions. Various areas on the upper and lower extremities may need to be identified for an effective infusion in the cases of limb losses, burns, and war injuries.[14] In addition to this, new IO routes can become vital when more vascular access is needed in emergency. Therefore, safe and effective intraosseous routes other than the standard anterior tibial approach and proximal humerus may also be needed.

The regions can be selected in accordance with three criteria: easy detection without a guide or by radiological examination, having a proximal location, and the ability to provide an effective fluid flow.[8,14,15] Additionally, being close to the central circulation (the heart) can also be considered as an advantage, and the upper extremity and the body may be more suitable in this respect.

The DT and its shape can easily be detected by palpation. Chan et al.[16] divided DT into 3 main types according to its shape and emphasized its relationship with EPL previously. We suggest that DT can be classified according to the characteristics of its tip as sharp, hump and blunt. The DT with a sharp tip could be more suitable for intraosseous infusions and 71% of the cases were found to be of this type in our study. It may be difficult to reach the DT with a blunt or hump tip and it may be possible to injure an overlying tendon in such cases.

We observed that the structures which can be injured on the DT surface were DVB and the EPL tendon. The DT was superficially covered by the DVB in 20%, by the EPL tendon in 13%, and by both in 3% of our cases. Considering that the injuries to the DVB are acceptable for such an intervention, the most important structure in the region becomes the EPL tendon, which was located exactly on the DT in 16% of our cases, in total. Although it was reported that the distance between DT and the closest superficial branch of radial nerve is approximately 16 mm, it is important to note that no neuronal structure thicker than 2 mm was found adjacent to the DT in our study.[6]

The mean soft tissue thickness above the tip of the DT was 4.6±1.7 mm in our cases and we suggest that this distance can easily be passed through with a standard IO needle. Rush et al.[1] have reported that the humerus may need a longer needle than the tibia. Hence, the distal radius may be a more preferable point when compared to the greater tubercle of humerus.

The closest adjacent tendons to the tip of the DT on the radial and ulnar sides were ECRB and EPL. However, the tip of the DT separated the EPL and ED tendons in 6 cases (11%). The mean distance of the DT to the EPL and ED tendons was 1.7±1.2 mm and 2.3±1.8 mm, respectively, on the radial and ulnar sides. Adding these two values indicates that a horizontal line of approximately 4.0 mm will be suitable for IO infusions as intraosseous needles are generally 15 G caliber (the outer diameter of the needle is 1.83 mm and the inner diameter is 1.37 mm).[17]

CB thickness is important to prevent the IO needle from damaging the bone. In this context, the mean CB thickness in the sections where the DT was most distinct was 1.1±0.2 mm in our study. Our measurements were performed on standard T1-weighted sections and the T1 sequence may not be sufficient for cortical bone measurements by itself.[18] However, it can be thought that our measurements give an idea regarding CB thickness in the distal radius region. Computed tomography or microstructural studies for detecting CB thickness at the distal radius region will be more useful.[19,20] CB has been reported to be approximately 4 mm for the humeral head and 6 mm for the tibia diaphysis.[1,21] Since the CB at distal radius is thinner than the aforementioned structures, the force needed to be applied during infusion should be less as well.

An IO route over the humerus was reported to have a better flow compared to the tibia in a study made on animals.[15] This can be explained by the better vascularization of the humerus and its proximity to the heart. Lamas et al.[22] showed that the distal radius was better supplied by various arteries and pointed DT as the entrance of one of these arteries.[22] Therefore, radius, just like the humerus, can be considered as a better alternative to the tibia in terms of a strong vascular supply and proximity to the heart.

In conclusion, we suggest that the DT of the distal radius can be considered as an important alternative route for IO since it can be easily accessed without having a risk of injury to important structures, and can provide effective flow.

Conflict of Interest

The authors certify that they have no conflict of interest and no affiliations or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

Author Contributions

SA: project development, data acquisition, writing text, critical revision of manuscript; MAG: project development, data acquisition, conducting measurements, writing text; IG: data acquisition, conducting measurements; SB: project development, critical revision of manuscript; OT: project development, writing text, critical revision of manuscript.

Ethics Approval

The study was approved by the Health Sciences University Ethics Committee (approval no: 19/340, approval date: 22 October 2019).

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Variations of the circumflex humeral arteries: a cadaveric study

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Abstract

Objectives: Surgery is the main treatment option of both anatomical and surgical neck humeral fractures, which could result in damage to the circumflex humeral vessels. Current research studies have found that vascular supply to the shoulder is variable. However, the incidence of these variations and how they can affect the blood supply to the shoulder region is still under investigation. The aim of this study is to identify possible variation patterns of the circumflex humeral vessels.

Methods: A total of 10 shoulders (3 males, 2 females; average age of 68.8 years) were dissected in Anatomy, University of Edinburgh, under the regulation of the Human Tissue (Scotland) Act 2006. Each shoulder was dissected, and tissues were removed to identify the axillary artery and its branches.

Results: The anterior and posterior circumflex humeral arteries were observed to arise as single branches from the 3rd part of the axillary artery in 70% (n=7) and 80% (n=8), respectively. In one cadaver, the posterior circumflex humeral artery (PCHA) arose from the subscapular artery in one side (10%, n=1) and from the profunda brachii artery on the contralateral side (10%, n=1). In the remaining 10% (n=1), the anterior circumflex humeral artery (ACHA) was found as a branch from the PCHA, with the latter being a direct branch from the 3rd part of the axillary artery.

Conclusion: Knowledge and awareness of these variations is essential to not only suspect, diagnose and treat possible complications of common fractures and dislocations in the region, but also to prevent iatrogenic injury.

Keywords: anatomical variation; axillary artery; circumflex humeral arteries; profunda brachii artery; quadrangular space

Anatomy 2020;14(3):171–176

Introduction

The axillary artery is a large blood vessel that supplies the lateral thorax, axilla and upper limb. It is formed as a continuation of the subclavian artery at the lateral border of the first rib. Anatomically, it is divided into three parts by the pectoralis minor and provides branches from each part that supply the pectoral region, lateral thoracic wall, the shoulder girdle and mammary gland.[1] The third part of the axillary artery starts at the lateral border of pectoralis minor and terminates at the inferior border of teres major to become the brachial artery. Classically, there are three branches of the third part of the axillary artery, which are the anterior and posterior circumflex humeral arteries and the subscapular artery.[1–3] According to Standring,[1] the anterior circumflex humeral artery (ACHA) arises at the distal border of subscapularis and runs horizontally posterior to coracobrachialis and the short head of biceps brachii. It reaches the surgical neck of the humerus anteriorly and continues laterally inferior to the long head of biceps and deltoid to anastomose with the terminal branches of the posterior circumflex humeral artery (PCHA). The PCHA, which is the larger of the two circumflex humeral branches, additionally originates at the distal border of subscapularis. However, it runs posteriorly through the quadrangular space accompanied by the axillary nerve. It circumflexes around the surgical neck of the humerus to form an anastomosis with branches of the ACHA.[1,3]

A series of studies has reported variations in the origin of the anterior and posterior circumflex humeral arteries. The ACHA was observed to arise from the profunda brachii

This study was an oral presentation at the Anatomical Society Winter Meeting, 18th – 20th December 2017, Dundee, Scotland, UK.

artery (PBA).[4–6] Whereas Patnaik et al.[5] reported that the ACHA was found to arise from the brachial artery. A study conducted by Saeed et al.[7] involving 106 formalin-fixed adult human cadavers concluded that an anomalous topographic pattern of the subclavian-axillary arterial system was found in 7.5% of the samples. The same authors found that the ACHA and PCHA originated from the second part of the axillary artery in 1.9%, which was described as a thoracohumeral trunk giving rise to the lateral thoracic, circumflex humeral, subscapular and thoracodorsal arteries.[7]

Classical anatomy of the PCHA is described as arising from the third part of the axillary artery.[4,5,8] However, Huelke et al.[4] reported that this was the case in only 67.5% of the specimens. They found that the PCHA originated directly from the subscapular artery and the PBA in 15.2% and 2.8% respectively.[4] In contrast, Hartley and Marquez,[9] dissected 48 cadaveric upper limbs and reported that the traditional "textbook" branching pattern (Type 1) was only observed in 56% of the sample. Whereas in more than 6% of the cases, the PCHA was found to arise from the subscapular artery.[9] Based on multidetector-row computed tomography angiography of 62 upper extremities, Hattori et al.[10] highlighted that the classic origin and branching patterns of the subscapular artery and the PCHA were only observed in 33.9% of cases. Other very rare patterns of origin of the PCHA arising from the lateral thoracic artery, brachial artery and circumflex scapular artery have also been reported.[8,11]

The incidence of variations of the circumflex humeral arteries is still under investigation, as the branching pattern has shown considerable variation. It is fundamental to report all variations of the ACHA and PCHA as it provides guidance on rare symptomatology of upper limb neurovascular pathology, such as axillary artery occlusion and quadrilateral space syndrome. Additionally, it helps anticipate surgical outcome related to trauma or fixation surrounding the surgical neck of the humerus and expands knowledge for surgical exploration of the region to avoid iatrogenic vascular injury. Therefore, the aim of this study was to identify the variational patterns of the ACHA and PCHA to aid the surgeon, anatomist and radiologist regarding the possible prevalence of this variation.

Materials and Methods

Five Genelyn-fixed cadavers (3 males and 2 females, average age 68.8 years), with 10 shoulders (n=10), were dissected. The cadaveric specimens were obtained from Anatomy, University of Edinburgh, which is under ethical regulation of the Human Tissue (Scotland) Act 2006. Each specimen was clear from any signs of trauma or surgery at the shoulder or axillary region, with the cause of death unrelated to the region being studied. Dissection was performed according to Grant's Dissector, with a full exposure of the shoulder, axilla and upper arm.[12] The skin and subcutaneous tissues and muscles around the shoulder have been dissected, appreciated then removed. The axillary artery and its branches were dissected, identified and recorded.

Results

The axillary artery and its branches were detected and recorded in all 10 shoulders. A full exposure and record of the axillary artery and its branches have been performed. The circumflex humeral arteries branched as follows:

- ACHA as single branch from the third part of the axillary artery in 70% (n=7).
- PCHA as single branch from the third part of the axillary artery in 80% (n=8).
- ACHA from the PCHA in 10% (n=1) (**Figure 1**).
- PCHA from the subscapular artery in 10% (n=1) (**Figure 2**).
- PCHA from the PBA in 10% (n=1) (**Figure 3**).

In all the specimens, the ACHA coursed laterally posterior to both the short head of biceps brachii and coracobrachialis to reach the surgical neck of the humerus (**Figure 1**). In 90% (n=9) of the specimens, the PCHA passed posteriorly through the quadrangular space (**Figure 2**), whereas in 10% (n=1), after arising from the PBA, it ran superolaterally between the long and lateral heads of triceps (**Figure 3**) towards the surgical neck of the humerus to anastomose with the ACHA.

Discussion

The origin of ascending branch of the ACHA is quite variable[13–19] (**Table 1**) and clinically it the is single most important artery in supplying the humeral head.[20–21] Studies have shown that surgical complications related to proximal humeral fracture (PHF) repair can adversely affect the blood supply to the head of the humerus. In a systematic review by Lanting et al.[22] involving 2155 patients, who completed follow up with an average age of 62.8 years, open reduction and internal fixation (ORIF) was found to cause avascular necrosis of the humeral head in 37% of the patients. The ACHA is typically a branch from the third part of the axillary artery and runs laterally in a horizontal direction to reach the surgical neck of the humerus.[1] The current study has shown that in only 90% this classical pattern is observed with the ACHA arising directly from the third part of the axillary artery (**Table 1**). However, in 10% it aroused as a branch from the PCHA

(**Figure 1**). It can be argued that variations in the ACHA origin may contribute to the risk of developing avascular necrosis in patients with PHF. Xu et al.[23] demonstrated in a meta-analysis involving seven studies with a total number of 291 patients that plate fixation was associated with a higher rate of avascular necrosis than conservative treatment (p=0.019). This highlights the importance of recognising that anatomical variations may contribute to clinical outcome related to PHF.

Observations from a study on branches of the axillary artery involving 178 sides by Hulke et al.,[4] demonstrated that 80.3% arise directly from the third part of the axillary artery. The same study reported that in 11.2% the ACHA arises as a common trunk with the PCHA from the third part of the axillary artery and in 1.7% it arises from the PBA. Other studies have shown similar findings with the most common origin of the ACHA being the third part of the axillary artery.[5] Rarely, it may arise from the PBA and the second part of the axillary artery, or it can even be absent.[4–6] Interestingly, Brooks et al.,[21] had demonstrated the effects of simulated PHF on the arterial supply of the humeral head. In their study with barium sulphate perfusion after simulated PHF in 16 cadavers, they report that blood supply was preserved after the fracture.[21] However, anastomotic branches with the posteromedial vessels from the PCHA may have a role in preserving the vascularity of the humeral head in certain types of fractures.

Embryologically, the lateral branch of the seventh intersegmental artery (later will become the subclavian artery) is thought to form the arterial trunk that supplies the upper limb during fetal development.[1] The principal arteries and anastomoses appear according to a sequence and regression of some networks that were initially functionally dominant can lead to anatomical variations and vascular anomalies.[1] The continuation of the subclavian artery, the axial artery, persists as the axillary and brachial arteries, which supply the upper limb.[24] A typical axillary

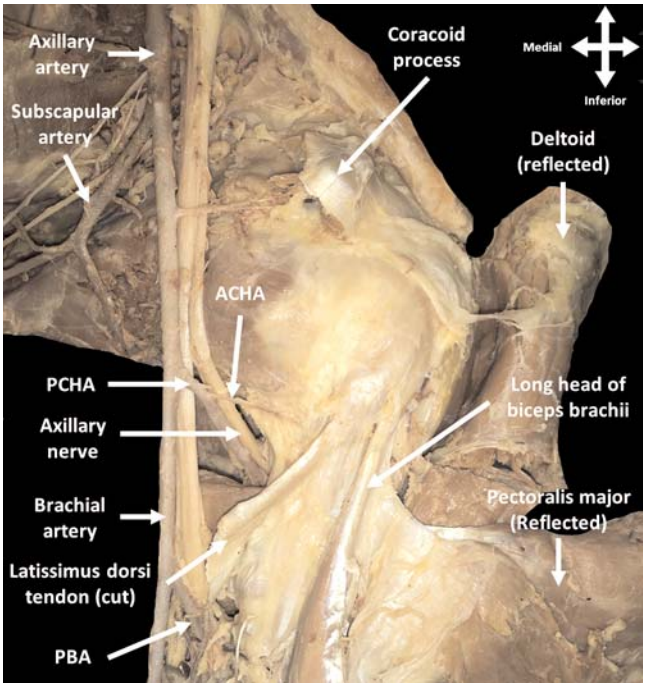

Figure 1. Anterior view of the left shoulder after dissection with exposure of the axillary artery and its branches. The anterior circumflex humeral artery (**ACHA**) is seen arising from the posterior circumflex humeral artery (**PCHA**). **PBA:** Profunda brachii artery.

artery gives origin to six branches: superior thoracic, thoraco-acromial, lateral thoracic, subscapular and anterior and posterior circumflex humeral arteries with other unnamed branches that might additionally be present.[4] However, the classical description of the axillary artery branches only represents 10% of cases and not all variants incidence is reported in the current literature.[25]

Variations in the origin of the PCHA are also common (**Table 2**). The common branching pattern of the PCHA is of the classical type arising from the third part of the axillary artery.[4,5,8–10] As with the ACHA, variations of the

Table 1

Frequency of distribution of the origin of the ACHA.

Studies	Origin of ACHA (%)					
	2nd part of AA	3rd part of AA	PBA	BA	PCHA	Others
Hulke et al.[4]		80.3	1.7			0.65
Saeed et al.[7]	1.9	3.8				
Bhat et al.[13]	CR					
Patnaik et al.[5]			2	2		
Bagoji et al.[6]			CR			
Present study		90			10	

AA: Axillary artery; **ACHA:** anterior circumflex humeral artery; **BA:** brachial artery; **CR:** case report; **PBA:** profunda brachii artery; **PCHA:** posterior circumflex humeral artery.

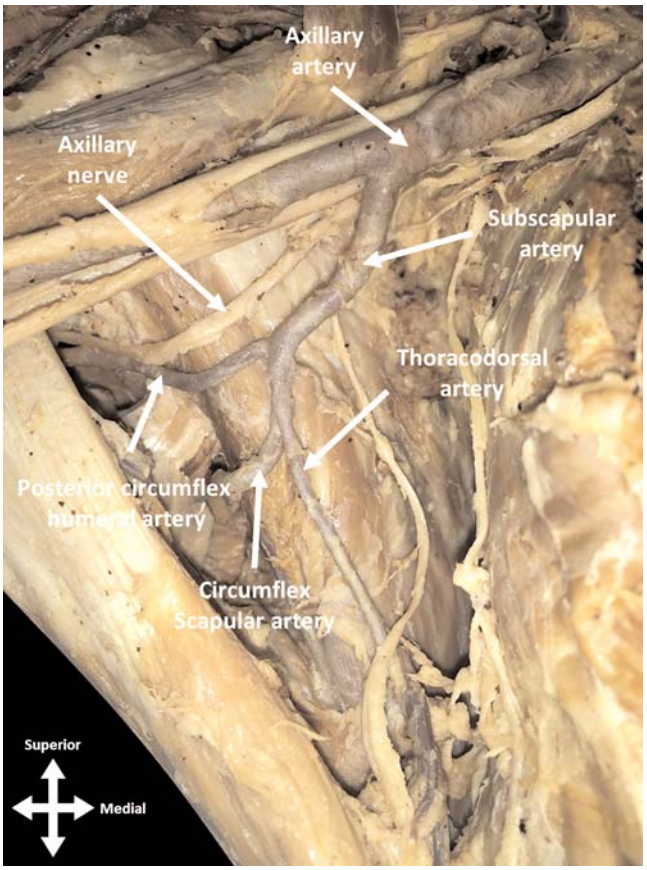

Figure 2. Anterior view of the right shoulder after dissection with exposure of the axillary artery and its branches. The posterior circumflex humeral artery is seen arising from the subscapular artery. It then courses through the quadrilateral space along with the axillary nerve.

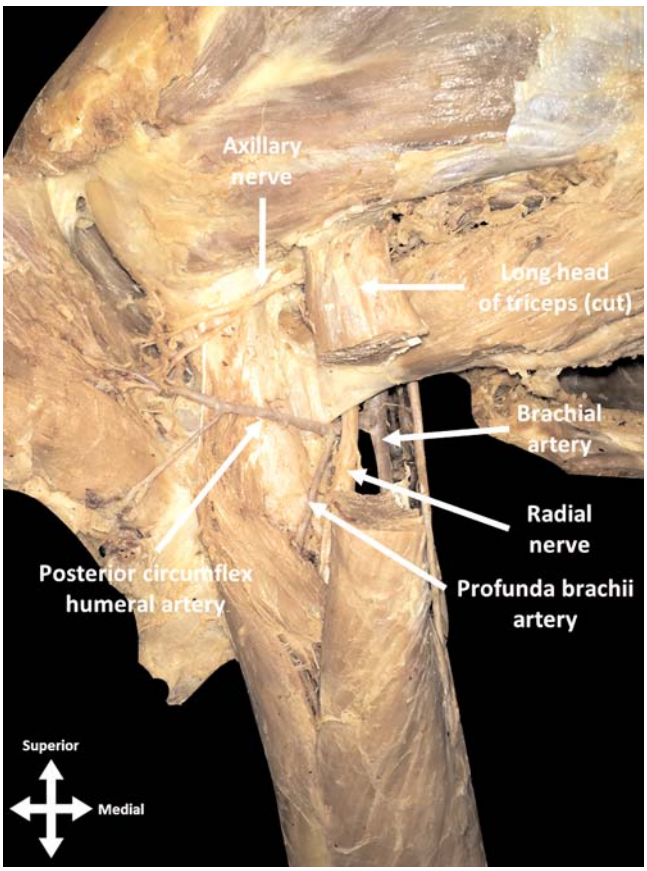

Figure 3. Posterior view of the left shoulder after dissection with exposure of the profunda brachii artery. The long head of triceps was cut to reveal the origin of the posterior circumflex humeral artery as it originates from the profundi brachii artery.

Table 2

Frequency of distribution of the origin of the PCHA.

Studies	Origin of ACHA (%)								
	LT	SS	1st part of AA	2ndpart of AA	3rd part of AA	BA	CS	PBA	Others
Farhan and Selman[11]	2	11				9			
Saralaya et al.[14]			CR						
Goldman[15]		CR							
Lee and Kim[16]			CR						
Durgun et al.[17]		CR							
Swamy et al.[18]				CR					
Olinger and Benninger[8]	1.2				77.1	8.4	12		
Hartley and Marquez[9]		6			56				
Majumdar et al.[19]		CR							
Patnaik et al.[5]						2		2	
Hattori et al.[10]					33.9				
Huelke et al.[4]		15.2			67.5			2.8	2.2
Present study		**10**			**80**			**10**	

AA: Axillary artery; **BA:** brachial artery; **CR:** case report; **CS:** circumflex scapular artery; **LT:** lateral thoracic artery; **PBA:** profunda brachii artery; **PCHA:** posterior circumflex humeral artery; **SS:** subscapular artery.

PCHA may clinically contribute to trauma or surgical intervention for PHF. However, the anatomical course of the PCHA is additionally of clinical importance in relation to sports injuries. Kraan et al.,[26] reported in a systematic review in relation to PCHA aneurysms, which can lead to ischemic emboli in the upper limb, that an anatomical variation may be protective. If the PCHA is running through the quadrangular space, this poses a risk of the artery being damaged by repetitive muscle contraction as it passed through the narrow space. Interestingly, Huelke et al.,[4] have reported a rare variation in which the PCHA is observed to originate from the PBA. By following this course, the artery avoids the narrow quadrangular space for which it can be compressed from repetitive muscle contraction, i.e. in boxers, baseball players and professional swimmers. This is thought to be a protective variation of the PCHA in relation to overuse injuries in the dominant shoulder of sport professionals. This variation does not follow the classical anatomical course as it does not enter the quadrangular space. The current study has reported this variation in 10% of the samples (**Figure 3**) and this may provide essential knowledge regarding risk factors for developing PCHA pathology in relation to its anatomical origin.

This study was limited by the sample size of cadavers, which may require further studies on a larger sample size. Additionally, no clinical data was available regarding clinical symptoms, if present, in relation to the anatomical variations studied.

Conclusion

Knowledge of the anatomical variations of the circumflex humeral arteries is of paramount importance in relation to pathology and surgical intervention. Understanding the possible anatomical branching pattern of the vascular structures around the shoulder is clinically relevant to help manage patients with acute shoulder injuries or pathology.

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Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Author Contributions

ME: data collection, photography for figures, manuscript writing; AA: data collection, manuscript writing.

Ethics Approval

Cadaveric specimens were obtained with ethical approval of Anatomy, University of Edinburgh, regulated by the Human Tissue (Scotland) Act 2006.

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Age related morphometric changes of the glenoid labrum

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Abstract

Objectives: Although the glenoid labrum is linked to glenohumeral joint stability, its anatomy remains controversial. This study aimed to investigate the shape, consistency of the glenoid labrum, and whether these and its thickness and depth are age related.

Methods: A total of 140 shoulders were dissected to expose the glenoid labrum. the shape and consistency of the glenoid labrum were assessed at a gross level. Measurements were taken of the labrum depth and thickness, using callipers, in the superior, anterior, inferior and posterior regions. ANOVA and chi-square tests were conducted to determine statistical significance, which was set at $p<0.05$.

Results: The consistency of the superior half of the labrum was rubbery in 97.9% of specimens and firm in the remaining 2.1%, whereas the entire inferior half was firm. There was a significant difference (p=0.043) in the consistency of the superior half between males and females. The superior half was triangular in 95.7% of specimens, flat in 2.1% and flat to triangular in 2.1%, whereas the shape of the inferior half was rounded in 99.3% of specimens and flat in 0.7%. The labrum was observed to be thicker in younger individuals, with the differences being significant superiorly (p=0.011), anteriorly (p=0.050), inferiorly (p=0.001) and posteriorly (p=0.047). It was also observed to be deeper in younger individuals, but only significantly so superiorly (p=0.044).

Conclusion: Labrum thickness and depth significantly decreased with increasing age, suggesting that these observations could be age-related.

Keywords: glenoid; labrum; morphometry; scapula; shoulder

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Introduction

The glenoid fossa is deepened by the glenoid labrum, which is located at the junction between the fibrous capsule of the glenohumeral joint and glenoid fossa.[1] Several studies describe the labrum as being variable in shape and size, being rounded, triangular, undersized, blunt-tipped, crescentic, flat, cleaved, notched or absent.[2–8]

The precise function of the glenoid labrum is still unknown. Several studies agree that it provides stability to the glenohumeral joint, but the methods used, as well as the observations and interpretation about how the glenoid labrum contributes to stability differ. The glenoid labrum has been reported to increase the width and depth of the glenoid fossa by about 4 mm.[5,9,10] Others with the opinion that the glenoid labrum effectively increases the depth of the glenoid socket by 9 mm superoinferiorly and 5 mm anteroposteriorly contributing to the overall circumferential depth by 50%. Tears of the anterior glenoid labrum, such as in Bankart lesions, decrease glenoid socket depth

This study has been presented at the Winter Meeting of the British Association of Clinical Anatomists (BACA), 13th December 2018, Northumbria University, Newcastle, UK.

between 2.4 – 5mm anteroposteriorly and could lead to glenohumeral joint instability.[11]

The concavity compression stabilization of the glenohumeral joint is enhanced by increasing both the magnitude of the compressive load, as a result of dynamic muscle contraction, and glenoid cavity depth. The existence of an intact glenoid labrum is therefore important for concavity compression, as well as scapulohumeral balance, which also leads to further stabilization of the glenohumeral joint.[12] The effect of the glenoid labrum and movement of the arm on stability of the glenohumeral joint has been quantified using a concavity-compression technique; the average glenoid labrum contribution to stability being 10%.[13] Others believe the glenoid labrum extends the articular surface.[9,14] Therefore, loss of the anteroinferior aspects of the glenoid labrum leads to a decrease in the contact surface area from 7% to 15% compared to normal shoulders, and an increase in contact pressure from 8% to 20%.[15]

All the histological evaluated criteria of the labrum, including grading of tears, structural defects, cell number, and vascularity, showed a highly significant positive relationship with age.[16] Others with the opinion that variation of labrum size is due to aging.[1,17] It was observed that individuals in their fifth decade at the time of death, that the glenoid labrum was thin and virtually absent.[1] One study applied an anterior force at different degrees of external rotation and abduction and observed that the radial thickness and tensile modulus of the glenoid labrum varied, for instance the peak strains of a thinning glenoid labrum at the axillary region increase at 60° external rotation, which goes some way to explain the aetiology of thinning of the glenoid labrum with age.[17] Others reported no significant correlation between the size of the glenoid labrum and the underlying glenoid bone, adding that if one region of the glenoid labrum is large other regions also tend to be larger. It was also noticed that the anterior and inferior aspects of the glenoid labrum are the largest, suggesting that they could contribute to glenohumeral joint stability.[18]

Although the important function of the glenoid labrum in shoulder joint stability is recognised, its gross morphometric changes in relation to age are seldom reported. The purpose of the current study was to investigate the shape, consistency and mode of attachment of the glenoid labrum, and whether these and it's the thickness and depth were related to age.

Materials and Methods

A total of 220 cadaveric shoulders from 58 males and 59 females, with a median age of 82 (range 53–102) years were obtained from the Centre for Anatomy and Human Identification University of Dundee in accordance with the Human Tissue Act 2006. Macroscopically normal shoulder joints were selected for this study – i.e., shoulders with signs of previous surgery, fracture or pathology were excluded.

Consequently, 140 specimens (30 male and 40 female cadavers: an average age 81.5 years) were recruited for this study. All shoulders were carefully dissected to expose the glenoid fossa with the labrum attached. The shape and consistency of the glenoid labrum were examined grossly and divided into superior (9 – 3 o'clock) and inferior (3 – 9 o'clock) halves as suggested by Prodromos et al.[1] (**Figure 1**) Measurements were taken of labrum depth (defined as the distance from the glenoid edge to the anterior edge of the glenoid labrum) and thickness (defined as the distance from the outer to the inner edges of the glenoid labrum) in the superior, anterior, inferior and posterior regions: thickness and depth labrum were taken in millimetres using Vernier digital callipers.[19]

Specimens were stratified according to their age into these groups: Group 1, aged 50–55 years old; Group 2, aged 55–60 years old; Group 3, aged 60–65 years old; Group 4, aged 65–70 years old; Group 5, aged 70–75 years old; Group 6, aged 75–80 years old; Group 7, aged 80–85 years old; Group 8, aged 85–90 years old; and Group 9, aged >90 years old. The age groups, side, consistency, shape, and both the thickness and depth of the glenoid labrum were double-entered into Statistical Package for Social Sciences (SPSS Version 21, Armonk; NY, USA). Kruskal-Wallis one way analysis of variance of ranks, ANOVA and Chi-square tests were conducted to determine statistical significance, which was set at $p<0.05$. The repeatability and the reliability of the taken measurement

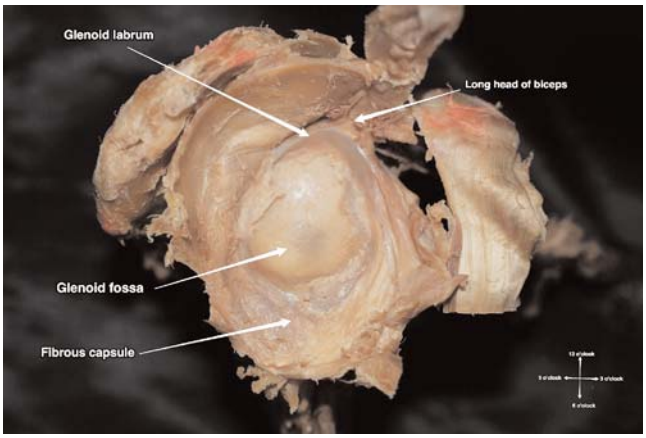

Figure 1. Right shoulder showing the glenoid labrum, glenoid fossa, fibrous capsule and long head of biceps brachii muscle.

were assessed by randomly selecting shoulders from those studied. Three measurements were taken on a three separate occasions by the researcher, while two other individuals took the measurements on two other occasions. Kruskal-Wallis one way analysis of variance of ranks showed that there was no difference for a single observer between the same measurements taken on separate occasions ($p<0.504$); there was also no difference in measurements taken by different observers ($p<0.759$). These results indicate that the measurement methodology that was used is reliable and repeatable.

Results

The total number of shoulder specimens was 140 from 30 male and 40 female cadavers, with a mean age of 81.5± 9.81 years.

The consistency of the superior half of the labrum was rubbery in 97.9% (n=137) of specimens and firm in the remaining 2.1% (n=3), while the entire inferior half was firm. Based on age the consistency of the superior and inferior half of the labrum was variable, but not significant. Based on side and sex a difference in the consistency of the superior half of the labrum between males and females was observed (p=0.043). No difference was observed in consistency between side.

The superior half of the glenoid labrum was triangular in 95.7% (n=134), flat in 2.1% (n=3) and flat to triangular in 2.1% (n=3) of specimens, while the shape of the inferior half was rounded in 99.3% (n=139) and flat in 0.7% (n=1). Based on age, sex and side the shape of the glenoid labrum varied, but not significantly so.

Based on age groups, the thickness of the glenoid labrum varies, and significantly associated with age. There were differences in thickness between age groups, being thicker in younger in all the regions (**Table 1**, **Figure 2**). The differences were significant superiorly (p=0.011), anteriorly (p=0.050), inferiorly (p=0.001), and posteriorly (p=0.047). The depth of the glenoid labrum was also variable. There was a difference in depth between the age groups (**Table 2**, **Figure 3**), being deeper in younger in all the regions. The difference was significant superiorly (p=0.044), but not anteriorly, inferiorly or posteriorly (p=0.232, p=0.760 and p=0.84 respectively).

For thickness and depth of the superior aspect of the glenoid labrum, the post-hoc LSD revealed that (1) the thickness of the glenoid labrum of Group 9 (mean thickness: 5.66 mm) was significantly thinner than Group 5 (mean thickness: 6.59 mm) (p=0.004) and Group 6 (mean thickness: 6.54 mm) (p=0.002); (2) the thickness of the glenoid labrum of Group 8 (mean thickness: 5.71 mm) was significantly thinner than Group 5 (mean thickness: 6.59 mm) (p=0.010) and Group 6 (mean thickness: 6.54 mm) (p=0.007); (3) and the thickness of the glenoid labrum of Group 7 (mean thickness: 5.75 mm) was significantly thinner than Group 5 (mean thickness: 6.59 mm) (p=0.014) and Group 6 (mean thickness: 6.54 mm) (p=0.010); (4) the depth of the glenoid labrum of Group 8 (mean depth: 6.12 mm) was significantly shallower than Group 3 (mean depth: 5.11 mm) (p=0.021); (5) the depth of the glenoid labrum of Group 7 (mean depth: 5.76 mm) was significantly shallower than Group 5 (mean depth: 6.41 mm) (p=0.029); (6) the depth of the glenoid labrum of Group 6 (mean depth: 5.80 mm) was significantly shallower than Group 5 (mean depth: 6.41 mm) (p=0.036); (7) the depth of the glenoid labrum of Group 5 (mean depth: 6.41 mm) was significantly shallower than Group 3 (mean depth: 5.11 mm) (p=0.004); and (8) the depth of the glenoid labrum of Group 3 (mean depth: 5.1 mm) was significantly shallower than Group 2 (mean depth: 7 mm) (p=0.016).

For thickness and depth of the anterior aspect of the glenoid labrum, the post-hoc LSD revealed that (1) the thickness of the glenoid labrum of Group 8 (mean thickness: 3.69 mm) was significantly thinner that Group 4 (mean thickness: 4.76 mm) (p=0.043) and Group 6 (mean thickness: 4.36 mm) (p=0.16); (2) the thickness of the glenoid labrum of Group 7 (mean thickness: 3.79 mm) was significantly thinner that Group 6 (mean thickness: 4.36 mm) (p=0.039); (3) the thickness of the glenoid labrum of Group 6 (mean thickness: 4.36 mm) was significantly thinner that Group 3 (mean thickness: 3.44 mm) (p=0.036); (4) the thickness of the glenoid labrum of Group 4 (mean thickness: 4.76 mm) was significantly thinner that Group 3 (mean thickness: 3.44 mm) (p=0.036); and (5) the depth of the glenoid labrum of Group 7 (mean depth: 3.34 mm) was significantly shallower than Group 4 (mean depth: 4.16 mm) (p=0.038) and Group 6 (mean depth: 3.79 mm) (p=0.030).

For the thickness and depth of the inferior aspect of the glenoid labrum, the post-hoc LSD revealed that (1) the thickness of the glenoid labrum of Group 9 (mean thickness: 5.08 mm) was significantly thinner that Group 4 (mean thickness: 7.67 mm) (p=0.0001); (2) the thickness of the glenoid labrum of Group 8 (mean thickness: 4.78 mm) was significantly thinner that Group 4 (mean thickness: 7.67 mm) (p=0.0001); (3) the thickness of the glenoid labrum of Group 7 (mean thickness: 5.15 mm) was significantly thinner that Group 4 (mean thickness: 7.67 mm) (p=0.0001); (4) the thickness of the glenoid labrum of Group 6 (mean thickness: 5.15 mm) was significantly thinner that Group 4 (mean thickness: 7.67 mm) (p=0.0001); and (5) the thickness of the glenoid labrum of Group 5

Table 1
The thickness of glenoid labrum (mm) with respect to age.

	Group	Mean±SD	Minimum	Maximum	p-value
Superior region	1	5.54±0.523	5.17	5.91	0.011
	2	6.52±2.375	4.84	8.20	
	3	6.01±0.898	4.45	7.06	
	4	6.28±0.886	5.50	7.17	
	5	6.59±1.265	4.42	8.60	
	6	6.54±1.002	5.10	8.78	
	7	5.75±0.982	3.88	7.37	
	8	5.71±1.268	3.12	8.53	
	9	5.66±0.923	2.90	7.67	
	Total	**6.01±1.121**	**2.90**	**8.78**	
Anterior region	1	3.66±1.131	2.86	4.46	0.050
	2	4.97±0.254	4.79	5.15	
	3	3.44±0.562	2.85	4.16	
	4	4.76±1.008	3.70	5.93	
	5	3.79±0.887	2.04	5.41	
	6	4.36±1.472	1.50	7.91	
	7	3.79±0.841	2.12	5.48	
	8	3.69±0.769	2.41	5.35	
	9	3.88±0.724	2.78	5.62	
	Total	**3.93±0.984**	**1.50**	**7.91**	
Inferior region	1	6.14±0.855	5.54	6.75	0.001
	2	5.88±0.650	5.42	6.34	
	3	4.40±0.826	3.27	5.41	
	4	7.67±0.629	6.65	8.12	
	5	5.14±1.032	3.26	7.49	
	6	5.15±1.392	2.13	8.83	
	7	5.15±0.982	2.79	7.18	
	8	4.78±0.867	2.52	6.32	
	9	5.08±0.744	4.13	6.78	
	Total	**5.13±1.091**	**2.13**	**8.83**	
Posterior region	1	3.78±0.084	3.72	3.84	0.047
	2	5.49±0.459	5.17	5.82	
	3	3.66±0.469	3.15	4.54	
	4	5.52±1.132	4.36	6.68	
	5	4.47±0.984	2.66	5.96	
	6	4.44±1.008	2.83	6.77	
	7	4.24±0.982	2.81	6.60	
	8	4.29±1.052	2.89	6.99	
	9	4.04±1.006	2.08	6.40	
	Total	**4.29±1.015**	**2.08**	**6.99**	

Group 1: 50–55 years old; **Group 2:** 55–60 years old; **Group 3:** 60–65 years old; **Group 4:** 65–70 years old; **Group 5:** 70–75 years old; **Group 6:** 75–80 years old; **Group 7:** aged 80–85 years old; **Group 8:** aged 85–90 years old; and **Group 9:** aged >90 years old.

(mean thickness: 5.14 mm) was significantly thinner that Group 4 (mean thickness: 7.67 mm) (p=0.0001). No significant difference was noticed in the glenoid labrum depth between the groups.

For the thickness and depth of posterior aspect of the glenoid labrum, the post-hoc LSD revealed that (1) the thickness of the glenoid labrum of Group 9 (mean thickness: 4.04 mm) was significantly thinner that Group 4 (mean thickness: 5.52 mm) (p=0.006) and Group 2 (mean thickness: 5.49 mm) (p=0.047); (2) the thickness of the glenoid labrum of Group 8 (mean thickness: 4.29 mm) was significantly thinner that Group 4 (mean thickness: 5.52 mm) (p=0.024); (3) the thickness of the glenoid labrum of Group 7 (mean thickness: 4.24 mm) was significantly thinner that Group 4 (mean thickness: 5.52 mm) (p=0.019); (4) the thickness of the glenoid labrum of Group 6 (mean thickness: 4.44 mm) was significantly thinner that Group 4 (mean thickness: 5.52 mm) (p=0.046); (5) the thickness of the glenoid labrum of Group 4 (mean thickness: 5.52 mm) was significantly thinner that Group 3 (mean thickness: 3.66 mm) (p=0.004); (6) the thickness of the glenoid labrum of Group 3 (mean thickness: 3.66 mm) was signif-

Table 2
The depth glenoid labrum (mm) with respect to age.

	Groups	Mean±SD	Minimum	Maximum	p-value
Superior region	1	7.38±0.989	6.68	8.08	0.044
	2	7.00±0.318	6.78	7.23	
	3	5.11±1.024	4.07	6.80	
	4	5.48±1.352	4.05	7.30	
	5	6.41±1.358	4.05	8.73	
	6	5.80±0.699	4.32	7.51	
	7	5.76±0.983	3.36	7.08	
	8	6.12±0.732	4.52	7.22	
	9	5.90±0.912	4.19	7.57	
	Total	**5.95±0.985**	**3.36**	**8.73**	
Anterior region	1	3.83±0.035	3.81	3.86	0.232
	2	4.22±1.817	2.94	5.51	
	3	3.44±0.538	2.57	3.96	
	4	4.16±0.157	3.95	4.30	
	5	3.59±0.488	2.77	4.46	
	6	3.79±1.072	.72	5.44	
	7	3.34±0.657	2.23	4.49	
	8	3.58±0.615	2.35	4.86	
	9	3.69±0.544	2.34	4.75	
	Total	**3.63±0.716**	**.72**	**5.51**	
Inferior region	1	4.00±0.820	3.42	4.58	0.760
	2	3.80±0.275	3.61	4.00	
	3	3.42±0.206	3.18	3.69	
	4	3.99±0.462	3.38	4.40	
	5	3.70±0.534	3.16	5.00	
	6	3.88±0.729	1.72	5.43	
	7	3.62±0.536	2.62	4.53	
	8	3.72±0.738	2.14	5.36	
	9	3.73±0.739	2.07	4.84	
	Total	**3.73±0.650**	**1.72**	**5.43**	
Posterior region	1	3.82±0.487	3.48	4.17	0.840
	2	4.79±1.315	3.86	5.72	
	3	3.35±0.255	3.16	3.75	
	4	4.26±0.441	3.70	4.71	
	5	3.91±0.686	2.70	5.40	
	6	3.92±0.597	3.13	5.22	
	7	3.90±0.639	2.66	5.22	
	8	3.67±0.752	2.46	5.03	
	9	3.80±0.515	2.83	4.88	
	Total	**3.84±0.634**	**2.46**	**5.72**	

Group 1: 50–55 years old; **Group 2:** 55–60 years old; **Group 3:** 60–65 years old; **Group 4:** 65–70 years old; **Group 5:** 70–75 years old; **Group 6:** 75–80 years old; **Group 7:** aged 80–85 years old; **Group 8:** aged 85–90 years old; and **Group 9:** aged >90 years old.

icantly thinner that Group 2 (mean thickness: 5.49 mm) (p=0.026); (7) the depth of the glenoid labrum of Group 9 (mean depth: 3.80 mm) was significantly shallower than Group 2 (mean depth: 4.79 mm) (p=0.032); (8) the depth of the glenoid labrum of Group 8 (mean depth: 3.67 mm) was significantly shallower than Group 2 (mean depth: 4.79 mm) (p=0.017); (9) the depth of the glenoid labrum of Group 6 (mean: 3.92 mm) was significantly shallower than Group 3 (mean depth: 3.35 mm) (p=0.046); (10) the depth of the glenoid labrum of Group 4 (mean depth: 4.26 mm) was significantly shallower than Group 3 (mean depth: 3.35 mm) (p=0.025); and (11) the depth of the glenoid labrum of Group 3 (mean depth: 3.35 mm) was significantly shallower than Group 2 (mean depth: 4.79 mm) (p=0.006).

Discussion

As all the evaluation criteria of the glenoid labrum, including grading of tears, structural defects, cell number, and vascularity, showed a highly significant positive relationship with age.[16] Changes in the gross morphometry of the

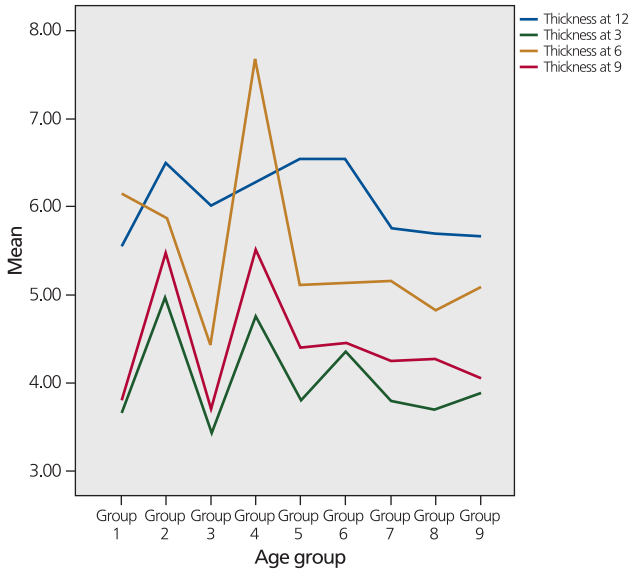

Figure 2. Glenoid labrum thickness according to age.

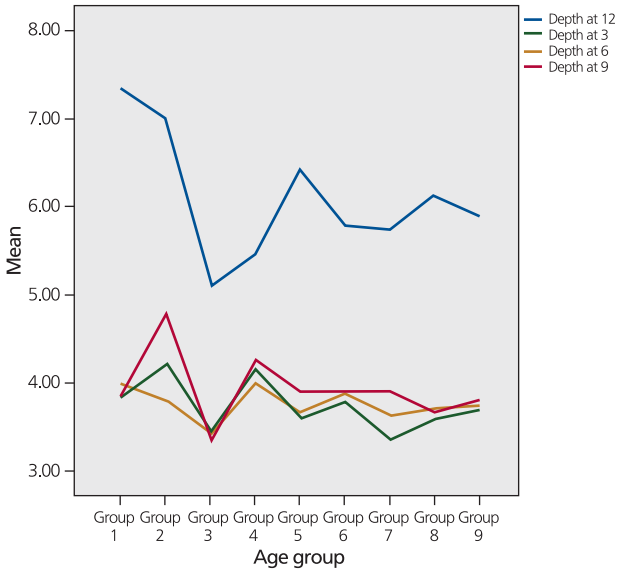

Figure 3. Glenoid labrum depth according to age.

labrum in relation to age is seldom reported. Therefore, the current study was undertaken to investigate the correlation between glenoid labral thickness and depth with age. Labral thickness in the superior, anterior, inferior and posterior aspects of the glenoid labrum were significantly associated with age. Labral depth was significantly associated with age in the superior and anterior regions. The underlying reasons are unknown, but some studies suggest that the variation in size is due to aging.[1,17] Drury et al.[17] applied an anterior force at different degrees of external rotation and abduction and observed that radial thickness and tensile modulus of the glenoid labrum varied, for example the peak strains of a thinning glenoid labrum in the axillary region increase at 600 external rotation, which goes some way to explain the aetiology of thinning of the glenoid labrum with age.[17]

The elastic modulus and stiffness of the glenoid labrum have been evaluated, with significant differences between the superior and inferior aspects, but were similar when comparing all superior or all inferior labrum.[3] In contrast, Smith et al.[20] reported that the mean elastic modulus and yield stress of the glenoid labrum are 22.8 and 2.5 respectively, which were both lower in the anterosuperior aspect of the glenoid labrum compared to the anteroinferior. Prodromos et al.[1] reported regional differences in labral consistency. This is in line with the observations of the current study in which the consistency of the superior half of the labrum was rubbery in 97.9% and firm in 2.1% of specimens, with a significant difference between males and females, whereas the entire inferior half was firm.

The shape of the glenoid labrum has been variably described in the literature. According to Smith et al.[9] and Soames and Palastanga[10] it has triangular cross-section with the base attached circumferentially to the rim of the glenoid fossa. De Maeseneer et al.[5] reported that the labrum is usually rounded or triangular, with the appearance of its anterior part being triangular, undersized, blunt-tipped or crescentic. These studies describe the labrum as a whole, with differences in shape between regions not being considered. In contrast, Cooper et al.[6] reported regional differences stating that the anterosuperior region is triangular and the inferior region rounded. Earlier McNeish and Callaghan[21] observed the anterior part of the glenoid labrum to be cleaved, notched or redundant, while both Haynor and Shuman[7] and Rafii et al.[8] reported the posterior labrum as being rounded and the anterior either rounded or triangular. Other studies have commented that the shape of the glenoid labrum is not regionally consistent; however, the shape in each region differs among studies. Park et al.[2] observed the labrum as being triangular anteriorly in 64% and posteriorly in 47%, rounded anteriorly in 17% and posteriorly in 33%, flat anteriorly in 2% and posteriorly in 17%, cleaved in 11%, and notched in 3%. The labrum was reported by Longo et al.[22] to be triangular anteriorly and posteriorly in 50%, crescent-shaped in 14%, rounded in 14%, flat in 8%, cleaved-shaped in 2% and absent posteriorly in 6%. In contrast, the current study found the superior half of the glenoid labrum as being triangular in 95.7%, flat in 2.1% and flat to triangular in 2.1% of specimens, whereas

the shape of the inferior half was rounded in 99.3% and flat in 0.7% of specimens. To some extent these observations agree with Cooper et al.,[6] but disagree with Rafii et al.,[8] McNiesh and Callaghan,[21] Longo et al.[22] and Park et al.[2] The difference in observations between the current and other studies may be due to: (1) other studies were based on MRI and double contrast CT arthrograms, while the current study used gross dissection which is more accurate and reliable, (2) patients in other studies suffered from glenohumeral instability in which the shape of glenoid labrum could be changed, and (3) sex, race and age could have a significant association with the shape of the glenoid labrum. In the current study, severe osteoarthritic changes were associated with a flattened glenoid labrum: such shape changes were not associated with aging. Cleaved, notched, redundant or an absent posterior aspect of the glenoid labrum were not observed. A major advantage of the current study was the sample size (140 shoulders) and gross dissection: these two elements enhance the investigation decreasing the risk of bias.

One of the limitations of the current study is the age of the study group. Therefore, further study in younger individuals is recommended. The other limitation is to investigate the correlation between the histological changes of the glenoid labrum with age, side and sex. The third limitation to study the association between the glenoid labrum thickness, depth, consistency and shape with glenohumeral joint instability.

Conclusion

The current study is the first to correlate glenoid labrum thickness, depth, consistency and shape with age, sex and side. Labrum thickness in the superior, anterior, inferior and posterior aspects of the glenoid labrum were significantly associated with age. Labral depth was also observed to become significantly associated with age in the superior and anterior regions. There was no association between the shape of glenoid labrum and age, sex and side. However, there were differences in consistency of the superior half of the glenoid labrum between males and females. The association between the glenoid labrum thickness, depth, consistency and shape with glenohumeral joint instability is still unknown and further studies are therefore recommended.

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

AMA, ARA, RS: collection and processing of material; AMA: data analysis and interpretation; AMA: writing manuscript; RS: Supervision and proofreading the manuscript.

Ethics Approval

The specimens were obtained from Centre for Anatomy and Human Identification. All studies carried out in the Centre for Anatomy and Human Identification are regulated and approved by the Anatomy Scotland Act (2006).

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Angular measurements of the mandible in adults with temporomandibular joint disorders: a CBCT study

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Abstract

Objectives: Temporomandibular disorder (TMD) is a degenerative musculoskeletal disease of unknown etiology, associated with morphological and functional deformities. The present study aimed to evaluate the angular parameters of the mandible in TMD patients with cone-beam computed tomography (CBCT) and to compare with healthy controls.

Methods: A total of 107 patients (54 in the TMD group and 53 in the control group) were included in the study. Ten angular measurements including right and left sides and 4 different length measurements were evaluated on CBCT images of both groups to eliminate individual differences. The differences between the two groups were examined using the significance test or Mann-Whitney U test. Multiple linear regression analysis was used for a detailed examination of the relationship between parameters.

Results: The upper face width was significantly higher in the TMD group ($p=0.004$). After correcting for the upper face width value, there was a significant difference between the groups in terms of the right β angle values ($p=0.001$). The other differences were not significant ($p>0.05$).

Conclusion: The decrease in the right β angle in the TMD group can be interpreted as a result of the mechanical effect of masticatory muscle hyperactivity on the angular properties of the mandible in these patients.

Keywords: CBCT; mandibular angles; mandibular morphometry; temporomandibular disorders

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Introduction

The human body works like a puppet; deviations and distortions in any part of the structural system create ripple effects elsewhere.[1] The temporomandibular joint (TMJ), is the only movable joint in the skull that connects the skull to the mandible and is responsible for jaw movements.[2]

The temporomandibular joint (TMJ) is a bicondylar joint formed between mandibular condyle of mandible and mandibular fossa of the temporal bone.[2,3] Important functions such as eating and speaking are achieved through four different movements in two different axes in the TMJ. The factors that affect the TMJ include disorders of chewing muscles, joint disorders, chronic mandibular hypo-mobility, and developmental disorders. Temporomandibular disorder (TMD) is one of the degenerative musculoskeletal disorders associated with morphological and functional deformities.[4]

TMD affects important daily functions, such as feeding, and decrease the quality of daily life. Symptoms and signs of TMD include painful or painless joint sounds, deviation or deflection during movement, cranial, and/or muscular pain.[4,5] Due to its multifactorial etiology, the treatment of TMD is still unclear. It can be thought in line with the data in the literature that; angular differences in the mandible may transmit the masticatory force to the TMJ in different unwanted ways, and this may cause joint disease due to the formation of abnormal

forces in the joint area.[6–8] Studies on TMJ patients have been focused on the mandibular condyle, mandibular morphology, and morphological changes in the joint disc.[6–8] However, the studies on the relationship of mandibular angular differences with TMD are limited. The aim of this study, therefore, was to evaluate the relationship between mandibular angular parameters and TMD via cone-beam computed tomography (CBCT) and show whether certain angles of the mandible will differ in the TMD patients from the healthy individuals.

Materials and Methods

CBCT images of 107 patients (23 males, 84 females) who admitted to the Bolu İzzet Baysal University Faculty of Dentistry, Oral and Maxillofacial Outpatient Clinic with complaints of pain and/or dysfunction in the TMJ region were examined. The patients had a suspicious bone-related pathology in the TMJ region. The patients who diagnosed as TMD but had no pathology that would affect the mandibular parameters were included in the patient group. The patients who neither had TMD nor any pathology that would affect the mandibular parameters were included in the control group. Accordingly, CBCT images of 54 patients (11 males and 43 females) were included in the TMD group and CBCT images of 53 patients (12 males and 41 females) were included in the control group.

The CBCT images were obtained with an I-CAT 3D Imaging System (Imaging Sciences International, Hatfield, PA, USA). All images were scanned with the same exposure parameters (120 kVp, 7 mA, 26.9 sec. scan time, 0.3 mm3 voxel size, and 10×16 mm field of view; FOV). Images were combined with i-CAT Vision 1.9 software program (Imaging Sciences International LLC. Hatfield, PA, USA). The raw data of the images were transferred to the personal computer. All the images were evaluated with the same computer (Lenovo legion y520 laptop computer with 1920×1080 pixel resolution, 15.6-inch monitor, 7th generation Intel®Core™ i7 and i5 processor). A single maxillofacial radiologist has reviewed all the images. A two-step controlled measurement was performed for each parameter, and the age and sex of each patient were also recorded.

Ten angles of the mandible were measured according to the landmarks reported previously[9–12] and with slight modifications as:

- Right Gonion (Go) angle (**Figure 1**),
- Left Gonion angle (**Figure 1**),
- Gnathion (Gn) angle (between the transverse axis and mandibular line) (**Figure 1**),
- Mentomandibular angle (**Figure 1**),
- The angle between the right condylion (Co)-Go and Co-Gn (α angle) (Co-Go-Gn triangle) (**Figure 2**),
- The angle between the left Co-Go and Co-Go (α angle) (Co-Go-Gn triangle) (**Figure 2**),
- The angle between the right Go-Gn and Gn-Co (β angle) (Co-Go-Gn triangle) (**Figure 2**),
- The angle between the left Gn-Co and Go-Gn (β angle) (Co-Go-Gn triangle) (**Figure 2**),
- The angle between right mandibular condyle - left mandibular condyle (Co-Co) (**Figure 3a**), and
- Go-Gn-Go angle (**Figure 3b**).

In addition to these measurements, the following length measurements were done to consider the individual differences.[10,13,14]

- Mandibular length (total length of the mandible),
- Bigonial width (Go-Go),
- Maximum cranial width (distance between right eurygon (eu) and left eu), and
- Upper face width (distance between right frontomalar temporal point (fmt) and left fmt).

The sample size was calculated by power analysis. Using the hypothesis that there will be a moderate effect size between the two groups and the significance test of the difference between the two averages, Prior power is accepted as 80% and Type-I error is 5% for the effect size w=0.50. It was determined that there should be at least 52 people in each group and at least 104 in total. G Power 3.1 program was used for sample size determination. Finally, 107 patients; 54 in TMD group and 53 in control group were included in the study.

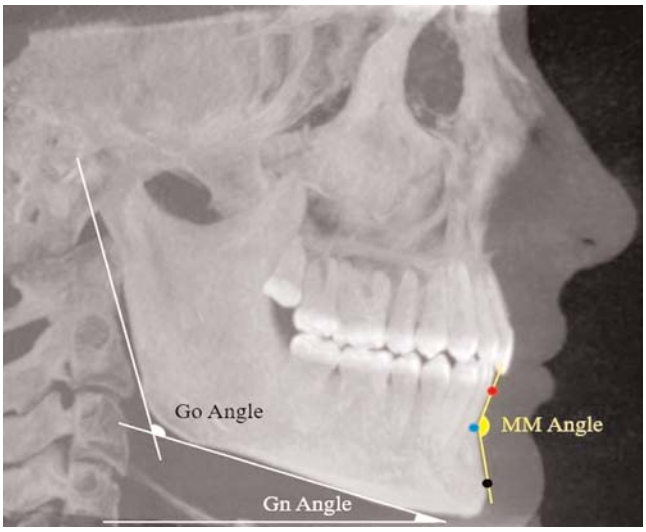

Figure 1. Right lateral cephalometric view. **black dot:** pogonion; **blue dot:** B point; **Gn angle:** gnathion angle; **Go angle:** gonion angle; **MM angle:** mentomandibular angle; **red dot:** infradentale point.

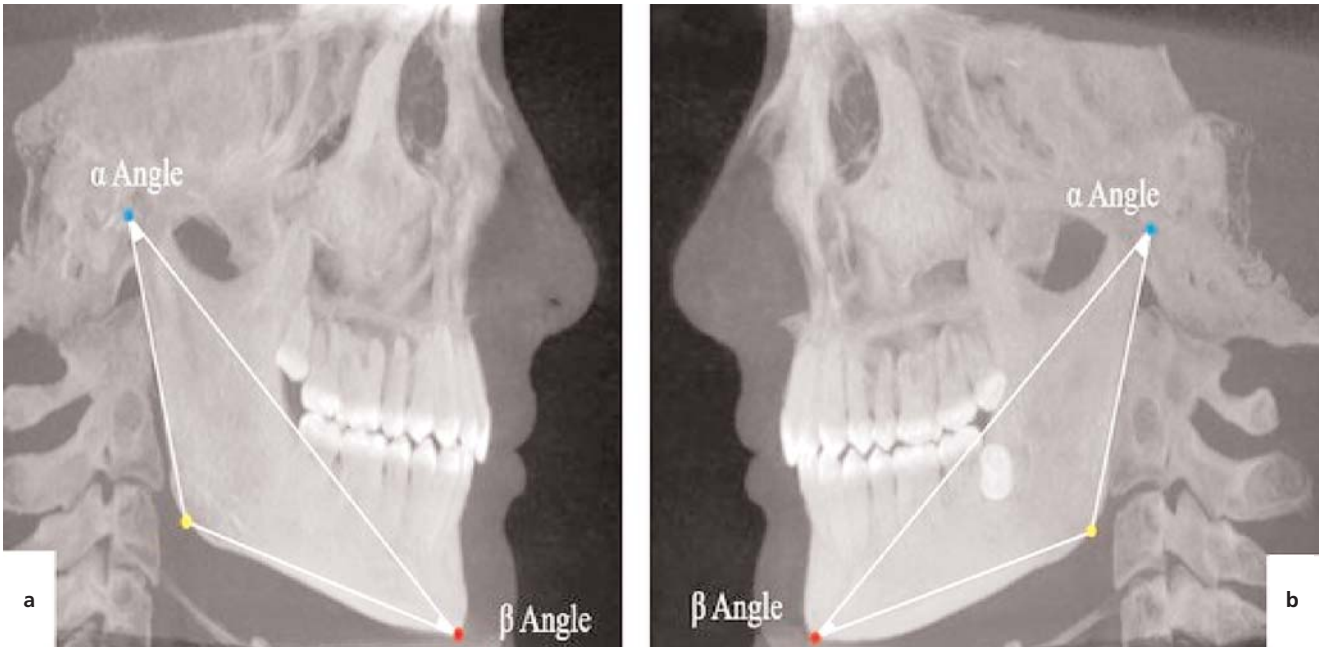

Figure 2. α and β angles on right (**a**) and left (**b**) lateral cephalometric views. **Blue dots:** condlyon; **red dots:** gnathion; **yellow dots:** gonion.

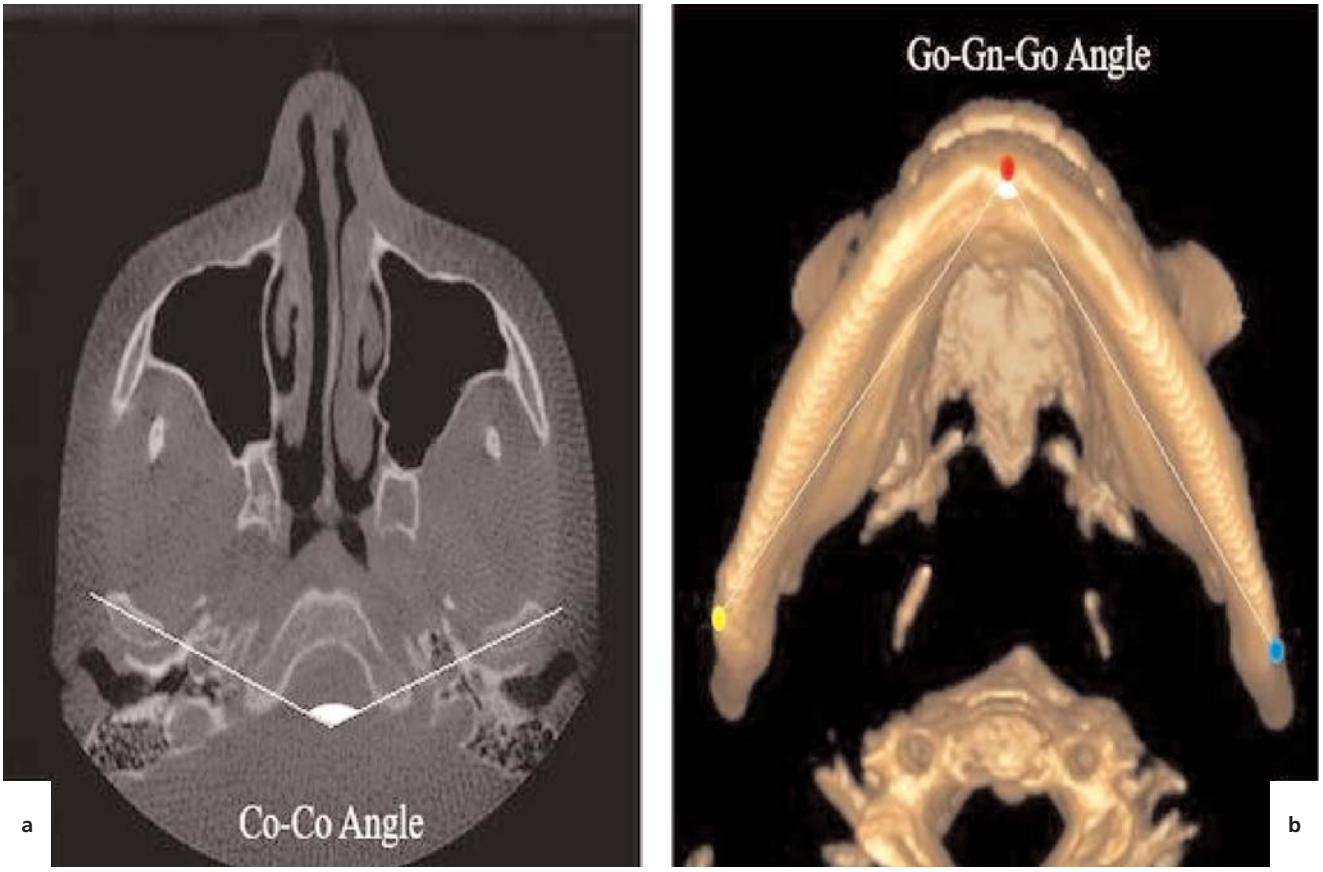

Figure 3. (**a**) axial section CBCT image; (**b**) 3D reconstruction image of CBCT obtained by i-CAT Vision 1.9 software program (Imaging Sciences International LLC. Hatfield, PA, USA), **blue dot:** left gonion; **Co-Co angle:** condylion-condylion angle; **Go-Gn-Go angle:** gonion-gnathion-gonion angle; **red dot:** gnathion; **yellow dot:** right gonion.

Descriptive statistics of the obtained data were calculated as mean, standard deviation (SD), or median, and frequencies (n, %). The compatibility of numerical features to normal distribution was examined with the Kolmogorov-Smirnov test. Independent samples t-test was used to compare the two groups in terms of normally distributed features, and others we used Mann-Whitney U test. A Chi-square test was used to examine the relationship between groups and categorical variables as gender. Pearson correlation coefficient was used to examine the relationship between numerical variables. Multiple linear regression analysis was used for a detailed examination of the relationship between parameters. All statistical analyses were made using SPSS (Statistical Package for Social Sciences) for Windows (Version 22, Chicago, IL, USA). The significance level was taken as $p<0.05$.

Results

The mean age of patients in the TMD group was 31.5 years (range: 25.5–41.0 years) and the control group was 35 years (range: 28.0–44.0 years) years. There was no significant difference between the groups in terms of gender and age distribution (p=0.775 and p=0.141 respectively).

Descriptive values of the measured angles by groups and comparison results of the two groups are given in Table 1. The statistical analyses showed that mean right β angle was significantly higher in the control group (p=0.006) and upper face width was significantly higher in the TMD group (p=0.004). The other differences were not significant.

Multiple regression analysis results corrected for upper face width values were shown in Table 2. There was a significant difference between the groups in terms of the right β angle values (p=0.001), after correcting for the upper face width value.

Discussion

In this retrospective study, we measured 10 different angles of the mandible in a group of TMD patients, including the right and left side of the mandible, and compared the measurements with healthy individuals to comment on whether these parameters differ among these two groups. There are numerous studies made on exploring the cause of the TMD,[3,15–17] however the etiology of TMD is still unclear and numerous factors can predispose this disorder.

Individual factors such as age, hormonal changes, and systemic status play a role in the etiology of TMD by affecting the host adaptive capacity.[18] Systemic diseases may affect the fibrocartilage structure of TMJ. Therefore, the present study group was composed of individuals who did not have any disease that would affect bone metabo-

Table 1
Descriptive values of linear and angular measurements.

	Group		
	TMD (n=54) Mean±SD or median [25th-75th]	Control (n=53) Mean±SD or median [25th-75th]	p-value
Right gonion angle°	125.62±6.78	124.50±7.42	0.417
Left gonion angle°	125.63±4.97	128.06±7.65	0.055
Gnathion angle°	20.29±4.35	20.91±4.51	0.472
Mentomandibular angle°	141.04±7.69	139.78±8.97	0.436
Right (β) angle°	26.19±3.31	27.99±3.38	**0.006**
Left (β) angle°	26.51±3.78	27.42±3.86	0.221
Right (α) angle°	32.40±3.22	33.02±5.31	0.468
Left (α) angle°	30.91±3.22	31.72±4.53	0.288
Co-Co angle°	136.67±16.65	137.09±12.23	0.881
Go-Gn-Go angle°	76.49±5.78	76.05±5.76	0.698
Mandibular length (mm)	88.33±5.95	88.55±5.47	0.849
Bigonial width (mm)	97.04±6.42	97.91±8.17	0.540
Maximum cranial width* (mm)	144.25 [142.18–148.65]	144.6 [141.75–149.6]	0.955
Upper face width* (mm)	108.41 [104.5–111.3]	103.8 [99.45–109.95]	**0.004**

*Data were not normally distributed.

lism. Age is seen as a predisposing factor that increases the severity and frequency of the disease.[19,20] In a study conducted on patients aged between 59–91 years old, Takano et al.[19] revealed that the calcium content in articular disc increased with age and this may trigger pathologies of TMJ. Therefore, the age distribution in the present study were selected to minimize the age factor as; between 25.5 and 41.0 years in the patient group and between 28.0 and 44.0 years in the control group.

In a study conducted in 100 cases between the ages of 20–80, it was reported that the Go angle was 125.19±6.27° on the right side and 125.61±5.98° on the left side.[21] In another study, the mean Go angle was examined according to age groups and it was found as 122.45±5.34°.[22] Although the Go angle in our study was compatible with the study of Acar et al.,[21] we saw that it was higher than the results of Sapanci et al.[22] We think that this difference may be due to the different age ranges and different numbers of cases.

In another study conducted in 106 Koreans, the Go angle was found to be 118.68±14.39° on the right side and 116.21±8.54° on the left side with a mean age of 32.20±9.08.[23] Although the mean age of the cases in this study was similar to our study, the mean Go angle value in our study was found to be higher. The cases were of similar ages in those studies but the effect of ethnic origin may be a significant factor explaining the reason of different results. Different angular parameters of the mandible have been evaluated in various studies with different measurement techniques thus; the comparability of the study results may not always possible.

In the present study, upper face width was found to be higher in patients with TMD. Due to the effect of bruxism, excessive functioning of the masseter and temporal muscles may result in expansion of the zygomatic bone in the transverse direction and make a difference in the craniofacial skeletal structure. The idea of bone apposition in areas where the demand to withstanding bending force is increased has been demonstrated in many human and animal studies.[24] In a morphometric study conducted on different populations, the upper face width was examined on dry skulls belonging to 100 males and 100 females with known gender and age at death. This value was found to be 92.04±4.76 mm in males with a mean age of 65.65 (n=89) and 87.14±4.73 in females with a mean age of 66.81, and a difference between genders was reported ($p<0.001$).[14] The result of the present study showed that the upper face width was larger than previously reported. We think that this situation may be caused by the difference in age and ethnic origin of the individuals among the studies.

According to Costen's mechanical displacement theory; occlusal derangement with consequent functional disturbance of the joint may lead to the direct eccentric positioning of the condyle in the glenoid fossa resulting in TMD.[25] According to Reade's biomedical theory, TMD starts with trauma.[26] As said by the neuromuscular theory of Ramjford, occlusal problems cause TMDs, loss of occlusal balance leads to uncoordinated muscles and spasms.[3] Morphological features and dimensional differences in the dentomaxillofacial region could trigger TMD by causing trauma or indirectly by affecting chewing, myofascial activity. Based on these theories, we suggest

Table 2

Multiple regression analysis results corrected for upper face width.

		%95 CI		
The dependent variable	**b**	**Lower**	**Upper**	**p-value**
Right gonion angle°	-1.004	-3.974	1.965	0.504
Left gonion angle°	1.679	-0.981	4.338	0.214
Gnathion angle°	0.785	-1.059	2.629	0.400
Mentomandibular angle°	-1.426	-4.917	2.066	0.420
Right (β) angle°	2.372	1.024	3.719	**0.001**
Left (β) angle°	0.908	-0.680	2.495	0.260
Right (α) angle°	0.265	-1.532	2.063	0.770
Left (α) angle°	0.140	-1.430	1.709	0.860
Co-Co angle°	1.270	-4.729	7.268	0.676
Go-Gn-Go angle°	0.448	-1.912	2.808	0.707

that the vertical dimensions of the occlusion may be affected due to tooth erosion resulting from temporal or masseter muscles hyperactivity caused by unilateral chewing or clenching in the TMD group, so that the angle β decreased and these conditions may cause TMD by causing eccentric forces to be transmitted to the TMJ.

In juvenile idiopathic arthritis patients with unilateral TMJ involvement, Hsieh et al.[27] reported that vertical and transverse asymmetry is more common, similarly Demant et al.[28] revealed a significantly greater amount of asymmetry. Although unilateral or bilateral TMJ involvement is not known due to the retrospective design of this study, the results of the present study support these ideas. While the left β angle did not differ, the right β angle was lower in the TMD group and we suggest this condition may be due to the dominant chewing activity on the dominant side in chewing function, and this may be a sign of asymmetry and unilateral joint complaint in TMD group.

Conclusion

Although the pathophysiology of TMD is not fully understood, we think that the hyper-function of the masticatory muscles may have a mechanical effect on the angular properties of the mandible, In order to clarify this situation, more morphometric studies are needed in which the patient's symptoms, unilateral or bilateral joint involvement, presence of malocclusion, and the duration of TMD are evaluated in details.

Conflict of Interest

The authors have no conflicts of interest to declare regarding the materials or methods in this study or the findings specified in this paper.

Author Contributions

SSM: project development, writing the manuscript, critical revision of the text; DGB: project development, writing the manuscript, editing and critical revision of the text; ATÖK: data collection, writing the manuscript; HA: data analysis.

Ethics Approval

This study was approved by the Bolu Abant İzzet Baysal University, Clinical Researches Ethics Committee (Decision No: 2020/82, Date: 07.04.2020).

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Investigation of the femoral inclination and Alsberg angles according to age and gender in adults

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Abstract

Objectives: The objective of our study was to examine the changes in the inclination and Alsberg angles of the femur in terms of age and gender.

Methods: The present study was conducted on X-Ray images of 208 healthy individuals (103 males and 105 females) admitted to Bolu Abant Izzet Baysal University, Orthopedics and Traumatology Clinics. Both genders were separated into 3 different age groups. Statistical analyses were made to determine the difference between the gender and age groups.

Results: The mean inclination angle of the femur was 132.88±7.08° on the right-side and 130.27±7.81° on the left. The mean Alsberg angle of the femur was 42.07±7.04° on the right-side and 41.43±7.03° on the left. The inclination angle was significantly higher in males than females on both sides and was significantly lower in 41–60 age group. The Alsberg angle was also significantly higher in males than females in 21–40 age group.

Conclusion: The Alsberg angle is positively related with inclination angle, and subject to change by age. Knowing how IA and AA will be affected by age and gender and knowing the relation between these two angles will help to take a more accurate approach while evaluating and managing the follow up of a patient undergoing total hip arthroplasty, reconstructive surgery or planning physical theraphy.

Keywords: age; Alsberg angle; gender; inclination angle; proximal femur

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Introduction

Femur is the longest and the strongest bone in our body contributing to hip and knee joints. The neck of the femur is approximately 5 cm long, and connects the head to the body with an average angle of 127°, that is called as the inclination angle (IA). IA is an important determinant of vulnerability of an individual to osteoarthritis and femoral neck fractures[1–3] and pathological conditions such as coxa vara and valga.[4] These significant pathological conditions and injuries among the elderly mostly require expensive hip replacement surgery.[4] The angle that occurs between the line drawn from the base of the epiphysis plaque and the anatomical axis of the femur is called the Alsberg angle (AA). AA is 41.5° in average and is directly proportional to IA.[2,5] Similar to IA, it was reported that the deviation of AA from normal degree might cause coxa vara or valga resulting in lateral growth disorder of the proximal femoral epiphysis.[6]

These angles in the proximal part of the femur are important to detect pathological conditions in orthopedics and planning surgical interventions.[7] For this reason, understanding whether these angles of the femur change with age or gender and determining normal range in healthy adults will contribute to explain pathological conditions more accurately and will help planning the surgical approaches. Although the age and gender differences of IA is relatively well-known,[1] there are few studies on AA with suggestion of conducting further research on showing the age and gender differences in this respect.[2,5,6,8] For that reason, we aimed to the evalu-

ate age and gender changes in IA and AA in healthy individuals, and thus, help the physicians to take more accurate measures while evaluating and managing the follow up of a patient undergoing total hip arthroplasty, reconstructive surgery or planning physical theraphy.

Materials and Methods

Pelvic anterior-posterior (AP) radiography of 208 patients (103 males, 105 females, mean age: 52.32±16.89 years) who admited to Department of Orthopaedics and Traumatology, Bolu Abant Izzet Baysal University Faculty of Medicine with low back pain or minor trauma were investigated retrospectively. Those who had any pathologies that would affect the angular parameters of the proximal femur in pelvis AP radiography and those with inflammatory arthritis, coxarthrosis, lower extremity fractures, Perthes Disease, avascular necrosis, traumas, previous joint surgeries, congenital skeletal system hematologic diseases, etc. and the radiographies that were not taken in appropriate position were not included. For inclusion to the study, the minimum age was set as 21 and maximum as 80 years old. Accordingly, the radiographies were divided into 3 groups according to the age of the patients as; Group 1: aged 21–40 years old (30 males, 30 females), Group 2: aged 41–60 years old (30 males, 31 females), and Group 3: aged >61 years old (45 males, 42 females) (**Table 1**).

The IA and AA was evaluated bilaterally in pelvic AP radiographies of patients (**Figure 1**). A standard protocol with patellae facing vertically (when allowed by internal rotation of the hip) was used for χ-ray technique digital AP view χ-rays. The pubic symphysis was the source of the focus of χ-ray. The distance between the source and the patient was 900–1200 mm to include minimum 8 inches proximal femur in all images.[9] All parameters were measured by two experienced researchers with three repetitions, and the averages were taken.

Mean and standard deviations were given in numerical variables for descriptive statistics of the measurements, and number and percentage values were given in categorical variables. Normality assumption was examined with the Kolmogorov Smirnov Test and graphic methods. Whether there were differences between two independent groups was examined with the significance test between two mean values, and whether there were differences between the two dependent groups was examined with the t-test in dependent groups. Whether there were differences between gender and age groups was examined with two-way variance analysis. When differences were detected, the group/groups that differed were examined by using Bonferroni correction. Pearson correlation coefficient was used for the relations between numerical variables. Linear regression analysis was used to make corrections according to age. Intraclass correlation coefficient was employed to evaluate parallel measurement compliance and to examine the reliability coefficients of in-person and inter-person compliances. Analyses were made by using IBM SPSS (SPSS Version 21, Armonk; NY, USA). The significance level was taken as $p<0.05$.

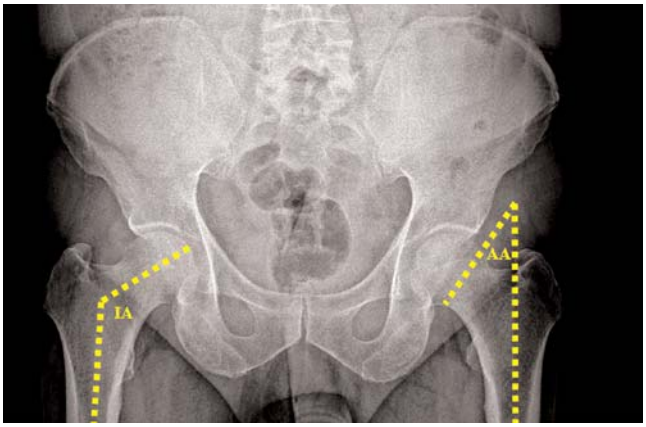

Figure 1. The inclination (IA) and Alsberg angle (AA) of the proximal femur measurements in radiography.

Results

According to the inclusion criteria a total of 208 radiographies were evaluated bilaterally (**Table 1**). The mean IA of the femur on the right-side was 132.88±7.08° and on the left 130.27±7.81°. The mean AA of the femur on the right-side was 42.07±7.04° and on the left 41.43±7.03° (**Table 2**) The difference between the right and left sides was not statistically significant ($p>0.05$).

The age and gender interaction of the femoral IA was not significant on the right-side when the age groups examined based on gender ($p=0.782$). Therefore, age groups were not compared among males and females. However, the mean IA was significantly higher in males ($p<0.001$), and there was a significant difference between

Table 1
Characteristics of the participants (n=208).

		Number	Percent	Mean±SD	Min-Max
Gender	Female	105	50.5		
	Male	103	49.5		
Age	21–40	60	28.8		
	41–60	61	29.3	52.32±16.89	21–80
	> 61	87	41.8		

overall age groups (p=0.001). The IA was significantly lower in Group 2 (130.09±5.32º) than Group 1 (133.73±5.32º) and Group 3 (134.26±7.64º). No significant difference was present between Group 1 and Group 3 (p>0.05).

The age and gender interaction of the femoral AA was also not significant on the right-side (p=0.098). Therefore, likewise IA, age groups were not compared among males and females. The AA was significantly higher in males (p=0.034), and there was a significant difference between overall age groups (p<0.001). The AA was significantly higher in Group 1 (46.28±7.93º) than Group 2 (40.62±6.03º) and Group 3 (40.19±5.78º). And no significant difference was present between Group 2 and Group 3 (p>0.05).

The age and gender interaction of the femoral IA was significant on the left-side (p=0.047). Therefore, the age groups compared seperately between males and females. Although no significant difference was detected between age groups in females (p=0.105), the difference was significant between age groups in males (p<0.001). The difference was significant between Group 2 and 3 among males, being higher in Group 3 (p=0.001). Although no differences were detected between gender in Group 1 (p=0.483) and Group 2 (p=0.618), the mean IA of males (135.20±8.64º) was significantly higher than females (129.04±7.44º) in Group 3 (p=0.001) (**Table 3**).

Table 2
Descriptive statistics (n=208).

	Mean±SD
Right-side femur inclination angle	132.88±7.08
Right-side femur Alsberg angle	42.07±7.04
Left-side femur inclination angle	130.27±7.81
Left-side femur Alsberg angle	41.43±7.03

The age and gender interaction of the femoral AA was significant on the left-side (p=0.004). Although no significant differences were detected between the age groups in females (p=0.233), the difference was significant between age groups in males (p<0.001). The AA in males was highest in Group 1 and lowest in Group 2. When age groups analysed seperately, the mean AA on the left-side was significantly higher in males (47.91±8.86º) than females (40.32±7.17º) in Group 1 (p=0.001), but no significant difference was found among Group 2 (p=0.963) and Group 3 (p=0.129) (**Table 3**).

There was a positive, high-level and statistically significant relation at 73.7% between right-side femur IA and right-side AA (p<0.001). A positive, moderate and statistically significant relation was also detected at 69.2% between the left-side femur IA and the left-side AA (p<0.001) (**Table 4**).

Table 3
Distribution of angles among gender and age groups.

		Total	Age groups			p-value (gender)	p-value (interaction)
			Group 1 (age: 21–40 years)	Group 2 (age: 41–60 years)	Group 3 (age: >61 years)		
Right-side femur inclination angle	Female	130.69±6.11	132.03±6.46	127.77±4.34	131.86±6.33	**<0.001**	0.782
	Male	135.11±7.34	135.43±7.42	132.49±5.22	136.71±8.14		
	Total		133.73±7.11^{A}	130.09±5.32^{B}	134.26±7.64^{A}		
	p-value (age)			**0.001**			
Right-side femur Alsberg angle	Female	41.19±6.17	43.88±6.74	40.37±6.10	39.94±5.19	**0.034**	0.098
	Male	42.97±7.79	48.67±8.39	40.88±6.05	40.45±6.38		
	Total		46.28±7.93^{A}	40.62±6.03^{B}	40.19±5.778^{B}		
	p-value (age)			**<0.001**			
Left-side femur inclination angle	Female		130.23±6.36	126.69±5.39	129.04±7.44	0.105	0.004
	Male		131.63±8.77$^{A, B}$	127.42±5.97^{A}	135.20±8.64^{B}	<0.001	
	p-value (age)		0.483	0.618	**0.001**		
Left-side femur Alsberg angle	Female		40.32±7.17	38.39±5.94	40.76±5.20	0.233	**0.004**
	Male		47.91±8.86^{A}	38.46±5.19^{B}	42.61±6.03^{C}	**<0.001**	
	p-value (age)		**0.001**	0.963	0.129		

^{A,B,C}The groups that differ according to post-hoc results are shown with different letters, groups that are not different are shown with the same letter.

The relation between right-side femoral IA and right-side femoral AA was also found to be significant after the correction made according to age (p<0.001). The relation between left-side femoral IA and left-side femoral AA was also significant after the correction according to age (p<0.001) (**Table 5**).

The IA on the left-side was not statistically different than the right-side and did not differ according to age groups (p>0.05). The AA on the left-side was not statistically different than the right-side (p>0.05), however when analyzed according to the age groups, the AA was significantly higher in Group 3, than Groups 1 and 2 (p<0.001).

Discussion

The angles of the femur are especially important for planning total hip arthroplasty. Knowing how IA and AA will be affected by age and gender, and understanding their relations will ensure that a more accurate approach is adopted towards pathological cases.

Gilligan et al.[4] reported the mean IA as 135° by a study made on 8000 femurs. This value was simply measured with a goniometer on dry bones and was larger than classically known as 127°. When compared with our study, our results seem in between these two values. The difference may come from the method used and also from the characteristics of the population and even age of the specimens. In an other study made by Oguz,[2] the mean right-side IA was revealed as 123.72°, left-side IA as 125.96°, right-side AA as 39.92°, and left-side as AA 40.61° on dry bone specimens. Our study trusted on measurements made on radiographies and suggested to provide more reliable and repeatable data.

In a study examining IA and AA angles together on dry femur specimens, it was reported that AA would change in the same way with IA.[2] In our study, we observed that right-sided IA and right-sided AA changed at significantly high levels, and left-sided IA and left-sided AA changed in positive directions. These results suggest that our data is coherent with the results reported by Oguz.[2]

Table 4
Releation between right-side and left-side femur inclination and Alsberg angle.

		Femur Alsberg angle			
		Right-side		Left-side	
		r	p	r	p
Femur inclination angle	Right-side	0.737	<0.001		
	Left-side			0.692	<0.001

No bilateral asymmetry was found in a study examining dry femurs of 20 cadavers for right and left-sided asymmetry.[10] In another study, the IA value of 148 healthy individuals was examined with pelvic radiography in different age groups for bilateral asymmetry. No differences were detected between right and left-sided IA in all individuals and between genders (p>0.05). It was also found that the average IA was 132.47° on the right-side, and 128.84° on the left-side in individuals who were over 60. The right-sided average IA was reported to be higher than the left-side; however, this was not at statistically significant levels.[1] Likewise, in our study, the IA without considering the gender and age groups (n=208), seems higher on the right-side than the left, but the difference was not statistically significant (p>0.05). When examined according to gender groups, no significant difference was found as well (p>0.05), but bilateral asymmetry was detected in AA in the group >61 years of age (p<0.001). Body laterality and considering the dominant foot as covariates would be helpful for further studies exploring bilateral asymmetry.

When the angles were compared according to gender, it was found that the angles in males were higher than those of females, which was statistically significant. Some of the previous studies such as the study by Tahir et al.[11] also reported statistically significant differences among females and males, but Shrestha et al.[1] reported no difference. The reason for this discrepancy may be the ethnic differences of the study groups.

Table 5
Univariate and multiple linear regression analysis results.

		Univariate			Multiple*		
		b	t	p	b	t	p
Right-side	Femur Alsberg angle	0.883 (0.743–1.023)	12.466	<0.001	0.779 (0.647–0.912)	11.621	<0.001
Left-side	Femur Alsberg angle	0.778 (0.638–0.918)	10.972	<0.001	0.773 (0.663–0.912)	10.944	<0.001

*Age corrected, femur inclation angle was taken as dependent variable. **b:** regression coefficient, **t:** t-statistic value.

When IA and AA were evaluated according to the age groups, it was found that the right and left sided IA of the femur seems to decrease with age until the age of 60 and then increase after 61 slightly. The right and left-side IA angles were examined in a study conducted with the same age groups as in our study, and it was reported that, although the left-side IA angle values were found to be low, no differences were detected between all age groups.[1] Another study that considered age groups reported that the IA value was higher in young people in growth process, and generally reached adult values in adolescence, and then remained stable. However, there might be a small decrease after 60 years of age. Moreover, significant increases were detected in mean IA values among populations with increasing sedentary and mechanical life styles.[12] Another study reported a modest trend towards increasing IA with the transition from forager to agricultural life and urban lifestyles, and to a lesser extent, from a mobile to a sedentary existence.[4] Both studies support that sedentary lifestyle increases IA values.[4,12] When we compared our results with studies reporting increased IA with sedentary life style, it can be concluded that the results of our study points a more sedentary life before 40 and after 60 years of age. Although, the most active age group seems to be between 41 and 60, longitudinal studies should be conducted on same people proving this hypothesis. An interesting study by Anderson and Trinkaus[12] made on modern, historic and prehistoric human population samples, showed no evidence for geographic differences, but showed significant increase in IA across populations with an increasingly sedentary life style. This view supports the developmental plasticity of femur with respect to habitual load levels during ontogeny of the hip region.

There are studies showing that bone structure and metabolism are affected by many factors in aging process, such as by different hormones, age, body composition, lifestyle, body laterality, leg dominance and bilateral asymmetry, and by different climates and related clothing styles.[4,13–15] The limited morphometric studies that consider the factors affecting bone metabolism with aging focus on bone mineral density.[8,16–18] In a study conducted on bone morphometry, proximal femur parameters were examined by considering the gonadal hormone levels of surgical and natural postmenopause females, and no differences were found between the two groups.[8] Sertel Meyvaci et al.[8] reported the right and left-side IA as 143.87±7.33° and 134.73±7.87°, and right and left-side AA as 50.60±8.24° and 43.35±8.82°, respectively in the natural postmenopause group. According to the results of our study, the mean right and left-side IA was 130.87±5.32° and 127.05±5.65°; and left and right-side AA was 40.62±6.03° and 38.43±5.54° respectively in females between the ages of 41 and 60. It can be noted that although age groups were close to each other in the same society, the mean IA reported by Sertel Meyvaci et al.[8] was higher than in our study. We believe that this is because of the non-standardized factors affecting bone metabolism such as body composition, menopausal status, life style and socio-economic status.

The major limitations of the present study are that the evaluations were made without considering the bone metabolism, body laterality, and leg dominance.

Conclusion

The results of our study showed that the age and gender factors have effects on IA and AA of femur. It was found that the right-side femoral AA change directly proportional to IA, as reported in literature. The relation of AA and IA can help to take more accurate measures while evaluating and managing the follow up of a patient undergoing total hip arthroplasty, reconstructive surgery or planning physical theraphy. We suggest conducting further studies taking the bone metabolism, body laterality, and leg dominance into account as co-variants.

Conflict of Interest

The authors declare that no conflict of interest.

Author Contributions

SSM: Project development, data collection and analysis, manuscript writing, editing; YEK: Data collection and analysis, manuscript writing.

Ethics Approval

This study was conducted with the ethical approval given by Ethics Board of Clinical Research at Bolu Abant Izzet Baysal University (approval number 2020/78).

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Anatomy education in traditional and complementary medicine: who should teach anatomy?

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Abstract

Objectives: The aim of this study was to emphasize the amount of anatomy courses in the regulation titled, "Traditional and Complementary Medical Implementations" and to make anatomists think of the question who should teach anatomy in traditional and complementary medicine?

Methods: The anatomy courses in the standards of education for traditional and complementary therapies organized by the Turkish Republic Ministry of Health were investigated. The number of anatomy courses for teaching complementary medicine without standards of education were taken from the draft regulation for traditional and complementary therapies.

Results: Clinical anatomy is the practical application of anatomical knowledge to diagnosis and treatment. Up to date, there is no regulation defining who is authorized to give anatomy lectures in the workshops or courses permitted by the Ministry of Health of Turkey. It was seen that, theoretically, any health practitioner in workshops could give anatomy lectures.

Conclusion: Anatomists are experts of the structure and relationship of all parts of the body. A great number of anatomists are practicing traditional and complementary medicine in Turkey. The anatomists who are qualified in both anatomy and complementary medicine may be the ideal lecturers in the education of these methods.

Keywords: anatomy; complementary; education; medicine; traditional

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"Doctors without anatomy are like moles: they work in the dark and their daily tasks are mole hills"– German anatomist and physiologist Friedrich Tiedemann

Introduction

Anatomy has been a keystone in medical education throughout history. For medical doctors, the human body is the focus of investigation and intervention on a daily basis.[1] For this reason, the study of anatomy in some form will continue to be essential to safe medical practice. The knowledge of anatomy is necessary for all doctors to practice safely.[1,2]

Since 1990's The World Health Organization (WHO) has supported "Traditional and Complementary Medicine" in terms of practice and research primarily in the universities. In recent years, traditional and complementary medical therapies have come into clinical practice in developed countries. Traditional and complementary therapies have also gained importance in our country due to its wide health benefits, safety and minimal side effects compared to chemical agents. Recently, the Ministry of Health constituted the Department of Traditional and Complementary Medicine for determining the traditional and complementary therapies, setting standards for education of these therapy methods, standardization of the education levels of the practitioners and determining the ethical issues and legal liabilities. A regulation has been published by the Turkish Ministry of Health to regulate the certifications of traditional and complementary medicine practitioners with the

This study was a poster presentation at 16th National Anatomy Congress, September 11–14, 2014, Malatya, Turkey.

aim of reducing health costs in Turkey.[3] The government introduced a regulation for establishment of Turkish National Institute for Traditional and Complementary Medicine.[4]

In the regulation titled "Traditional and Complementary Medical Implementations (Geleneksel ve Tamamlayıcı Tıp Uygulamaları Yönetmeliği)", the therapy methods regulated by the Turkish Republic Ministry of Health are acupuncture, apitherapy, phytotherapy, hypnosis, hirudotherapy, homeopathy, chiropractic, cupping, maggot therapy, mesotherapy, prolotherapy, osteopathy, ozone therapy, reflexology, and musical therapy. The regulation also sets out the curriculum of these therapy methods.[3]

Anatomy constitutes an important part in the acupuncture, chiropractic, prolotherapy and osteopathy trainings.[5,6] However there is not a standard telling the content and amount of the anatomy lectures.

The aim of this study was to emphasize the amount of anatomy courses in the regulation titled, "Traditional and Complementary Medical Implementations" and to make anatomists think of the question "who should teach anatomy in traditional and complementary medicine?"

Materials and Methods

The anatomy courses in the standards of education for traditional and complementary therapies were investigated in the Traditional and Complementary Medical Implementations of the Turkish Republic Ministry of Health. The amount of anatomy courses in complementary methods without standards of education were taken from the draft regulation for traditional and complementary therapies.

Results

In the education standards of traditional and complementary medicine methods, there are anatomy courses related to topographic anatomy, spinal anatomy, radiographic anatomy, neuroanatomy, functional anatomy, and anatomy of the locomotor system (**Tables 1** and **2**).[7–18]

Table 1 provides a summary of the anatomy courses and their hours for the physicians. In the curriculum of acupuncture, the hours of anatomy courses are not mentioned in modules 1 and 6. The total hours for module 1 were 30 and the total hours for module 6 are 80.[7] In apitherapy, there were 2 hours of topographic anatomy.[8] For osteopaths, the knowledge of the anatomy of nervous, locomotor and lymphatic system is crucial. Correspondingly, the courses of functional anatomy, neuroanatomy and anatomy of the lymphatic system were included in the curriculum for 10, 10 and 5 hours respectively.[9] In the curriculum of ozone therapy skin anatomy and physiology is included in total 16 hours of the module 6.[10] In prolotherapy, which is an interventional therapy method, the functional anatomy of joints, connective tissue, ligaments, and tissues took part in module 1 consisted of 8 hours.[11] And finally, 4 hours of neuroanatomy and neurophysiology was planned for the reflexology course attendees.[12]

In the draft regulation, assistant health professionals should take 30 hours of anatomy, 25 hours of neuroanatomy and 70 hours of spinal anatomy for chiropractic certification. In reflexology education, there were introduction to anatomy and physiology for 4 hours and human anatomy and systems for 10 hours. A total of 35 hours of basic and functional anatomy, 25 hours of neuroanatomy and 30 hours of spinal anatomy and biomechanics was planned for

Table 1

Anatomy courses in the traditional and complementary medicine education for physicians.

TCM method	Total hours of anatomy lectures	Content of the anatomy course
Acupuncture	? (Module 1: 30 hours)	Topographic anatomy
Ear acupuncture (in acupuncture)	? (Module 6: 80 hours)	Ear anatomy
Apitherapy	2	Topographic anatomy
Chiropractic	10	Spinal anatomy
	9	Normal radiological anatomy
	10	Neuroanatomy
Ozone therapy	? (Module 6: 16 hours)	Skin anatomy and physiology
Prolotherapy	? (Module 1: 8 hours)	Functional anatomy of joints, connective tissue, ligaments and muscles
Reflexology	4	Neuroanatomy (with neurophysiology)
Osteopathy	10	Functional anatomy
	5	Neuroanatomy

TCM: traditional and complementary medicine; **?:** unspecified hours of anatomy lectures.

osteopathy training. Table 2 provides a summary of the anatomy courses and their hours for the assistant health professionals.[13]

Discussion

Knowledge of anatomy is essential for all health care professionals. Especially in acupuncture, chiropractic, prolotherapy and osteopathy trainings knowledge of anatomy is crucial to apply proper therapy. In acupuncture, the therapist should always know where the tip of their needle lies with respect to the relevant anatomy so that injury to the vital structures can be avoided and the main target for stimulation can be reached.[5,6] A prolotherapist should know the anatomy of the region to be treated in order to protect the vital structures during injections. Chiropractors and osteopaths should have a strong knowledge of neuroanatomy and spinal anatomy so as not to cause damage to the patient.

Anatomists are the experts of the structure and relationship of all parts of the body and clinical anatomy is the practical application of anatomical knowledge to diagnosis and treatment. The education staff in most of the training courses do not involve any anatomists who are certified in traditional and complementary medicine. A lack of adequate anatomy training in education of traditional and complementary methods will restrain the progress of the course attendee. Trainees educated by an anatomist with a knowledge of clinical anatomy in traditional and complementary therapies can implement these methods successfully.

The amount of anatomy courses in the standards of education for traditional and complementary therapies was investigated in this viewpoint. The amount of anatomy courses in complementary methods without standards of education were taken from the draft regulation for traditional and complementary therapies. The education standards of the chiropractic have not been published yet. Based on the draft regulation of Traditional and Complementary Medical Implementations, anatomy education is planned to be given in three different courses in the training of chiropractic.[13] The curriculum of chiropractic for physicians was planned as 10 hours of education for spinal anatomy, 9 hours for normal radiographic anatomy and 10 hours for neuroanatomy.

According to the draft regulation, the assistant health professionals can attend to the courses of chiropractic, reflexology, osteopathy, and cupping therapy.[13] However, they can perform the methods under the supervision of a certificated physician. Since the publication of the draft regulation there has been no training for the assistant health professionals.

Conclusion

In Turkey, some private and state universities have constituted research and education centers under different titles for traditional and complementary medicine. The anatomy education takes an important part in the workshops or courses of these therapy methods. Anatomy education is obviously essential for any health practitioner who performs an invasive procedure on a patient. According to anecdotal evidence gathered in the field, long-term retention of anatomy knowledge may be deficient. Anatomy education is an important element of the medical curriculums of the traditional and complementary medicine trainings. But the point is by whom these anatomy lectures would be given. The answer of this question is not specified in the regulations. A great number of anatomists have certified in traditional and complementary medicine in Turkey. The anatomists who are qualified both in anatomy and complementary medicine may be the ideal lecturers in the education of these methods.

Table 2

Anatomy courses in the traditional and complementary medicine education for assistant health professionals.

TCM method	Total hours of anatomy lectures	Content of the anatomy course
Chiropractic	30	Anatomy
	25	Neuroanatomy
	30+40	Spinal anatomy
Reflexology	4	Introduction to anatomy and physiology
	10	Human anatomy and systems
Osteopathy	35	Basic and functional anatomy
	25	Neuroanatomy
	30	Spinal anatomy and biomechanics

TCM: traditional and complementary medicine.

The shortage of cadavers is a main problem for all anatomy departments in Turkey. Some departments solve this problem by organizing cadaver workshops on imported cadavers with the surgical departments. After the workshops, the cadavers can be used for undergraduate and postgraduate education in these departments. There is an increasing number of complementary medicine workshops. Especially for the invasive methods, anatomy training on cadavers is popular. A secondary benefit for anatomy departments is providing cadavers for education.

New and different fields of education and employment may develop for the Turkish anatomists if the anatomists will be authorized for anatomy education in traditional and complementary medicine. The Turkish Society of Anatomy and Clinical Anatomy can vindicate the benefits of anatomists in the education of anatomy in traditional and complementary medicine.

Conflict of Interest

The author declares that there is no conflict of interest.

Ethics Approval

Ethics approval was not required since the study was not performed in humans or animals and no personal data was used.

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The view of medical students on the anatomy course given by distance education during Covid-19 pandemic

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Abstract

Objectives: The Covid-19 pandemic has caused serious problems all around the world. Face-to-face education in universities had shifted to the distance learning including medical schools. Our aim in this study was to understand the problems faced by medical students during pandemic period, as well as to determine the possible benefits of distance learning through a web-based questionnaire system, and to compare it with face-to-face learning.

Methods: This cross-sectional study was conducted with a structured internet-based questionnaire. The sample of the study consists of 335 medical students who volunteered to participate in the study. The students took the anatomy course remotely during the Covid-19 and had access to the internet-based questionnaire.

Results: Medical students thought that the online theoretical and practical anatomy lectures were not sufficient for their medical profession. Most of the students were opposed to providing practical lectures in the form of distance learning. Students were not satisfied with the anatomy lectures they took during this period.

Conclusion: This study showed that the medical students did not look positively towards distance learning. Further studies should be conducted to assess the effectiveness of various distance learning strategies for better anatomy education.

Keywords: anatomy; Covid-19; distance education; medical students

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Introduction

In December 2019, a large number of pneumonia with unknown cause was detected in a seafood market in Wuhan, China. Following the rapidly increasing number of cases, the World Health Organization (WHO) announced in January 2020 that the reason for these complaints in patients is a new type of coronavirus (SARS-CoV-19). An international emergency has been declared due to the spread of the disease first to all regions of China and then to other countries. In February 2020, in the report published by WHO, the official name of the new disease was announced as "Coronavirus Disease 2019" and the abbreviation was named as "Covid-19". As Covid-19 spread to many countries in a very short time and became a global epidemic, on March 11th, 2020, WHO declared the epidemic as a "pandemic" and asked all countries to take serious measures.[1]

The disease has started to spread immediately all over the world since March. The first case in Turkey was detected on March 11, 2020 and following the first case, number of the cases had rapidly increased. After detection of the first case, the Turkish Government has taken various precautions to fight against the pandemic. The Council of Higher Education (CoHE) suspended face-to-face education in all universities during the pandemic period. In this context, it was announced that distance education at universities will be provided with digital facilities as of March 23th, 2020.[2,3]

Distance education (including technology-assisted learning that includes online, offline or both) is defined as the use of computer technology to provide education.[4] Although its importance increases today with the pandemic, distance education has a history spanning almost two centuries. E-learning, web-based learning, computer-

based learning, online learning, internet-based learning and distance learning are widely used interchangeably. These terms represent concepts with very small consequential differences.[5,6]

Before the pandemic, higher education and secondary education institutions had very limited online education programs in developed and developing countries. Even though education is not provided directly online, applications such as sharing lecture notes, homework tracking, attendance schedule, and education-training program calendar sharing can also be included in online education.[7] With its developing and still developing technology, distance education projects have started to be put into service with virtual reality. Due to the high quality and realism of the content of distance education projects, the technological equivalent of experiential education today is defined as virtual reality and connected technologies.[8]

Distance education gives medical students the flexibility and option to do their own self-learning at home at times that suit them. It allows medical students to control how much time they spend on any subject. This not only prevents overloading of information, but also allows them to spend more time on issues they find difficult.[9] Distance education is one of the newest way of teaching supported by digital technologies. Using new multimedia technologies and the internet to develop and collaborate the quality of learning by facilitating access to different kind of resources and services.[10]

Considering how dynamic medical education and medical practices are, various studies have been conducted on how to deliver medical education in the most efficient way.[11] Similar to these studies, different education models are adopted and implemented in medical schools around the world.[12] The aim of medical education is to train qualified physicians with full theoretical knowledge for the needs of the society. Anatomy is considered the basis of the medical sciences, which physicians acquire basic knowledge to practise their professions.[13] Anatomy is the oldest branch of medicine that investigates the normal shape and structure of the human body, the organs that compose the body, and the structural and functional relationships between these organs.[11] Anatomy knowledge has a very important place in medical education. In some specialties such as orthopedics, radiology, general surgery and neurosurgery, good knowledge of anatomy is essential for both correct diagnosis and treatment.[12] It has become important to evaluate the efficiency and effectiveness of medical education based on data. In particular, obtaining the opinions and thoughts of students about medical education is a method that is widely used in directing education.[14] In addition to measuring students' learning and progress, evaluating their satisfaction during learning experiences is one of the requirements of student-centered education.[15]

It is crucial to get direct feedback from medical students in determining the difficulties, deficiencies or possible benefits that occurred during the transformation of a model planned for face-to-face learning into distance education. By evaluating student feedbacks and developing and improving the distance learning delivery model, it can enable the crisis to be turned into opportunities.[16]

With the decision of CoHE, Afyonkarahisar Health Sciences University, Faculty of Medicine had given the remaining course of the spring term as online education. Within the curriculum of the medical faculty, locomotor system anatomy course is given in the first year, and circulatory, respiratory, digestive, nervous, urinary and genital system anatomy courses are given in the second year. The aim of the present study was to understand the problems faced by 1st and 2nd grade medical students during online anatomy course, as well as to determine the possible benefits of online education through a web-based questionnaire, and to compare it with face-to-face learning.We also aimed to evaluate the classes individually to see if this had anything to do with different anatomy topics.

Materials and Methods

This cross-sectional study was conducted in September 2020 with a structured web-based student feedback questionnaire. The sample of the study consists of 335 medical students who had access to the web-based questionnaire, volunteered to participate in the study, and took the both anatomy theoretical and practical lectures online during the Covid-19 pandemic period.

Two forms were used in the study, namely "student information form" and "web-based student feedback questionnaire". The categories in the questionnaire were determined as the evaluation of the anatomy theoretical and anatomy practical lectures taught by distance learning. The level of agreement with the expressions was graded from 1 to 5 with Likert type scaling as; "1=completely disagree", "2=disagree", "3=no idea", "4=agree", "5= completely agree" (**Appendix 1**).

The 12-question questionnaire form was prepared and delivered to volunteers using the "Google Forms" application (Google Inc., Mountain View, CA, USA) sharing the link through the participants' email addresses. The survey was conducted entirely on a voluntary basis, and students who did not want to participate in the survey were not included in the study. In order to increase the reliability of the feedback, it was stated that

it was not necessary to write names to the students who filled out the questionnaire. The possible effect of exam anxiety on students was also considered, and the questionnaire was conducted after the exam period was over.

During the pandemic period, online anatomy theoretical lectures were given both synchronously and asynchronously. All anatomy lectures were conducted using the university's own internet-based system (https://mergen.btk.gov.tr/). To facilitate the online education, the slides were shared with all of the students. Videos of anatomical models explained by research assistants separately for each practical classes were shared with the students over the internet.

The questionnaire included questions that evaluate students' feedback about the online anatomy education model. The students were asked about their opinions on the statements given about the online theoretical and practical anatomy lectures. Finally, their opinions about whether they want to continue online education after the pandemic period was also asked and evaluated.

Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0 (IBM Corp., Armonk; NY, USA). Categorical data were expressed as numbers and percentages. A $p<0.05$ was considered as statistically significant. Pearson's chi-square (χ^2) test of significance was used in order to make comparison between 1st grade versus 2nd grade medical students answers. The actual counts from the sample data were compared with the expected counts, given the null hypothesis of no relationship.

Results

Totally, 335 medical students participated the survey. There were 211 1st grade and 124 2nd grade students among the respondents. The distribution of the students according to their gender and grades is shown in **Table 1**. The majority of the students attended the anatomy theoretical and practical lectures in distance learning (**Table 2**).

Table 1
Distribution of students by gender and grade (n=335).

	1st grade n (%)	2nd grade n (%)
Theoretical	202 (95.7%)	108 (87.1%)
Practical	186 (88.6%)	114 (91.9%)

Table 2
Students' participation in anatomy theoretical and practical lectures (n=335)

	1st grade n (%)	2nd grade n (%)
Females	134 (63.5%)	72 (58.1%)
Males	77 (36.5%)	52 (41.9%)
Total	211	124

The answers given by the students to the statements in the questionnaire are shown in separate tables as theoretical and practical lectures (**Tables 3** and **4**).

61% of respondents "completely disagreed" or "disagreed" to the statement "I think that the online anatomy theoretical lectures I have taken during the pandemic period are sufficient for my medical profession", while 26% "completely agreed" or "agreed". On the other hand, 74% of the students answered as "completely disagree" or "disagree" to the statement "I think that the online anatomy practical lectures I have taken during the pandemic period will be sufficient for my medical profession", while 14% of the students as "completely agree" or "agree". In both cases, 10% of the students had no idea. In general, most of the students thought that the both online theoretical and practical anatomy lectures they take during the pandemic process will not be sufficient for their future medical profession.

While 28% of the students answered as "completely disagree" or "disagree" to the statement "I think that the

Table 3
Students' responses to the statements about anatomy practical lectures.

	Completely disagree	Disagree	No idea	Agree	Completely agree
Statement 2	%48	%26	%10	%8	%6
Statement 4	%35	%33	%14	%10	%6
Statement 8	%6	%5	%7	%28	%50
Statement 9	%7	%5	%10	%25	%51
Statement 10	%12	%15	%17	%34	%19

Table 4
Students' responses to the statements about anatomy theoretical lectures.

	Completely disagree	Disagree	No idea	Agree	Completely agree
Statement 1	%38	%23	%10	%18	%8
Statement 3	%28	%24	%15	%23	%7
Statement 5	%35	%21	%15	%13	%15
Statement 6	%21	%17	%16	%30	%14
Statement 7	%5	%12	%21	%26	%34

anatomy theoretical lectures should be online but anatomy practical lectures should be in the laboratory environment in the future", 46% of the students responded as "completely agree" or "agree". However, 21% of them had no idea. Approximately half of the students thought positively towards online theoretical lectures but they prefer practical lectures to be face-to-face in the laboratory.

In terms of the future education period, 61% of the students "completely disagreed" or "disagreed" to the statement "I think that the anatomy course should be given both theoretically and practically online", while 18% of them thought exactly the opposite. And, 16% of them had no idea. The majority of students opposed to online anatomy practical lectures.

The comparison of answers of 1st and 2nd grade students are shown in **Table 5**. The 2nd grade students found the theoretical lecture materials more inadequate compared to 1st grade students (statement 3) (p=0.006). In terms of listening to the recorded lectures again (statement 6), 1st grade students think more positively about distance learning compared to 2nd grade students (p=0.008).

Discussion

The Covid-19 pandemic had caused serious problems all around the world. During the Covid-19 pandemic period, face-to-face learning at universities was suspended as of March 2020 and the online education process was rapidly switched to prevent interruption of the education and training process. After the health system, the education system was affected by the lifestyle changes experienced in this extraordinary period and it forced academics to use technological fascilities. There is no doubt that medical students are also living through extraordinary times and there has been a crucial change in their teaching methods of anatomy.

Anatomy necessitates a three-dimensional comprehension of the subjects. Therefore, use of new technologies in anatomy education still remains challenging and play an important role in the future of anatomy education. Traditional approaches such as cadaver dissection allow direct assessment of the shape and spatial relationships between adjancent anatomical structures. In order for new technologies to be successfully integrated into the anatomical curriculum, such technologies must have a comprehensive understanding of the three-dimensional nature of anatomy and body structures.[17] It is important how the sudden change in the education system affects both medical student performance and satisfaction and future of anatomy education. For anatomy education in medical schools, these decisions were more important in that they disrupted access to cadaver resources and anatomical models. Delivering anatomy education through online, if only for a short period, effects both anatomists and medical students.[18]

Opinions about online education are not only a matter of discussion specific to the pandemic process, and but had been focus of interest in previous years as well. The positive aspects of distance education that have been reported include; not having space and time limitations in education, providing equal opportunities for everyone, using the opportunities of technological devices, eliminating the age limit in education, ease of accessing international education opportunities, the opportunity to learn at their own pace and the student's self-responsibility in learning.[19]

Although online education has many advantages, it also has some limitations. For example, restriction of socialization, reduced effectiveness of the courses that require practice, decreased interest and motivation, difficulty in access to technological devices or problems in internet connection.[20]

Different education models are adopted and implemented in medical faculties all over the world. The classical education approach that has been going on for years in medical faculties leaves its place to integrated, interactive and active applications. In addition, thanks to the developing technology, more active applications such as online education have emerged in recent years.[21,22] Anatomy a visual discipline, is given to students of 1st and 2nd year under the basic sciences in medical faculties. The effec-

Table 5

The responses of 1st and 2nd grade students to the statements separately. Pearson's chi-square (χ^2) test of significance was used in order to compare proportions between 1st grade versus 2nd grade medical students answers. Actual counts from the sample data were compared with expected counts, given the null hypothesis of no relationship.

Statement			Completely disagree	Disagree	No idea	Agree	Completely agree	df	p-value
1.	1st grade	count	79	44	20	44	24	4	0.063
		expected count	80.6	50.4	22.0	39.7	18.3		
	2nd grade	count	49	36	15	19	5		
		expected count	47.4	29.6	13.0	23.3	10.7		
2.	1st grade	count	103	48	21	19	16	4	0.209
		expected count	99.4	55.7	21.3	18.1	12.5		
	2nd grade	count	56	41	13	10	4		
		expected count	59.6	33.3	12.7	10.9	7.5		
3.	1st grade	count	62	46	24	57	21	4	**0.006***
		expected count	60.4	52.2	32.1	49.0	16.3		
	2nd grade	count	34	37	27	21	5		
		expected count	35.6	30.8	18.9	29.0	9.7		
4.	1st grade	count	79	58	28	25	17	4	**0.031***
		expected count	73.2	69.4	29.4	21.9	13.1		
	2nd grade	count	38	53	19	10	4		
		expected count	43.8	41.6	17.6	13.1	7.9		
5.	1st grade	count	68	42	28	30	41	4	**0.025***
		expected count	74.1	44.6	31.4	27.6	31.4		
	2nd grade	count	50	29	22	14	9		
		expected count	43.9	26.4	18.6	16.4	18.6		
6.	1st grade	count	39	29	35	67	39	4	**0.008***
		expected count	43.9	37.0	34.5	63.4	30.1		
	2nd grade	count	31	30	20	34	9		
		expected count	26.1	22.0	20.5	37.6	17.9		
7.	1st grade	count	14	21	50	46	78	4	**0.041***
		expected count	11.9	25.1	44.6	55.2	72.2		
	2nd grade	count	5	19	21	42	37		
		expected count	7.1	14.9	26.4	32.8	42.8		
8.	1st grade	count	18	11	19	54	107	4	0.235
		expected count	14.5	12.0	16.4	60.4	105.8		
	2nd grade	count	5	8	7	42	61		
		expected count	8.5	7.0	9.6	35.6	62.2		
9.	1st grade	count	17	9	25	52	106	4	0.689
		expected count	15.7	10.7	22.0	53.3	107.3		
	2nd grade	count	8	8	10	33	65		
		expected count	9.3	6.3	13.0	31.7	63.7		
10.	1st grade	count	26	30	34	69	49	4	0.222
		expected count	26.9	32.6	35.7	72.0	40.7		
	2nd grade	count	17	22	23	46	16		
		expected count	16.1	19.4	21.3	43.0	24.3		
11.	1st grade	count	37	26	45	43	57	4	0.434
		expected count	34.5	25.7	45.7	49.5	52.6		
	2nd grade	count	18	15	28	36	27		
		expected count	20.5	15.3	27.3	29.5	31.4		
12.	1st grade	count	89	43	34	18	23	4	0.268
		expected count	83.2	50.0	34.4	19.4	20.0		
	2nd grade	count	44	37	21	13	9		
		expected count	49.8	30.0	20.6	11.6	12.0		

df: degrees of freedom. *p<0.05.

tiveness of visual methods compared to auditory and other methods in the teaching-learning process reveals the importance of practical lectures in learning Anatomy.[23]

In the present study, it was observed that medical students did not look positively towards online education. It is understood that the students were not satisfied with the anatomy lectures they took during this period. Most of the students are opposed to online anatomy practical lectures. As a result, the students think that it is more beneficial to learn the practical lectures interactively in the laboratory environment by touching the visual anatomical models.

It has been observed that univesity students prefer formal education to online education in different studies conducted in Turkey. In a study in which student feedbacks about online education during the pandemic period were obtained, 90.3% of the physical therapy and rehabilitation students participating in the survey stated that they preferred face-to-face education and only 9.7% stated that they preferred online education.[20] In another study that online education methods and students' feedback were evaluated, most of the students (84.4%) stated that online education was not as effective as face-to-face education. As a result, face-to-face courses in the classroom environment continue to be considered as valuable by students.[24] In some studies conducted with nursing students prior to the Covid-19 pandemic, no significant difference was reported between online education and face-to-face education in terms of student satisfaction.[25,26]

In a study conducted in Turkey that evaluated postgraduate anatomy education during pandemic period, it was reported that the students favored theoretical education to be partly online however, preferred face-to-face education in practical lectures. This study, which evaluates graduate students' view of anatomy education, has similar results with our study.[27] In another study evaluating physiotherapy students' attitudes towards online anatomy education, the is view of the studens were nearly almost similar with our study. When they were asked whether they wanted to follow to the Anatomy course online or not, most of the students answered as "completely disagree". In addition to this, less than 20% of the students found theorotical and practical online anatomy lectures as effective as face to face education.[28]

There are also studies showing the positive aspects of distance education. For example; in a study conducted on dentistry students during the Covid-19 pandemic, it was shown that distance education promotes self-learning independence and improves their ability to use online resources[29] and supports students' critical thinking and high-level learning.[24] In a study conducted in the pharmacy faculty, students reported that online education is valuable.[30] In some studies conducted on nursing students, it has been shown that students are more satisfied with online education than face-to-face learning.[31–33]

Conclusion

The limited availability of cadaver, time, and resources has encouraged anatomists to adopt new technologies such as online education for years. Sometimes constraints can turn into opportunities to develop innovations and creative solutions. The Covid-19 crisis could bring anatomists together to apply alternative forms of education to improve anatomy education in medical schools.[34] In this respect, we think that our study will lead the way to create awareness for the development of the online anatomy education model and to conduct similar studies in other branches. Further studies should be conducted to assess the effectiveness of various online education strategies for better anatomy education. The effects of Covid-19 may forever change future physicians' medical education.

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

All authors equally contributed to concept, design and writing manuscript.

Ethics Approval

This study was approved by Afyonkarahisar Health Sciences University Clinical Research Ethics Committee with the protocol number 2011-KAEK-2 meeting number 2020-10.

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Appendix 1

The view of medical students on the anatomy courses given by distance education during the covid-19.

Questionnaire

Dear Participant,

As of March 16, 2020, due to the measures taken due to the Covid-19 virus pandemic across the country, classroom (face-to-face) learning at universities was stopped and distance learning was started. Our aim in this study is to understand the problems faced by the medical students while taking anatomy courses, as well as to determine the possible benefits of distance learning through a web-based questionnaire system, and to compare it with formal classroom learning. Therefore, your participation in the study is valuable in order to contribute to the development of anatomy education and determine the distance learning model from the students' perspective.

You are asked to mark the degree to which you adopt each of the statements below. It should be noted that there are no right or wrong answers for your answers. It is important to state what you think about the subject and what your approach is. For this reason, your answers are required to be sincere. The information you provide will be protected and evaluated according to confidentiality principles. The data obtained from this study, for which your personal information is not requested, will only be used in scientific environments.

It is not mandatory for you to participate in this survey study. Your willingness to participate is essential. There is no risk that you will be exposed to any corporate or personal criticism, negative perception or situations that may affect your education opportunities because of your participation in the study. Please do not hesitate to contact us for more detailed information and any questions you may have. Thank you for your interest and participation.

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Student Information Form

Gender: ☐ Female ☐ Male

Class: ☐ 1 ☐ 2

I have listened to anatomy theoretical lectures taught by distance learning ☐ Yes ☐ No

I have listened to anatomy practical lectures taught by distance learning ☐ Yes ☐ No

Web-Based Student Feedback Questionnaire

1. I think that the online anatomy **theoretical lectures** I have taken during the pandemic process will / will be sufficient for my medical profession.

Completely disagree	Disagree	No idea	Agree	Completely agree

2. I think that the onilne anatomy **practical lectures** I have taken during the pandemic process will / will be sufficient for my medical profession.

Completely disagree	Disagree	No idea	Agree	Completely agree

3. I think that the materials used in online anatomy **theoretical lectures** are sufficient.

Completely disagree	Disagree	No idea	Agree	Completely agree

4. I think that the materials used in online anatomy **practical lectures** are sufficient.

Completely disagree	Disagree	No idea	Agree	Completely agree

5. I think that distance learning is more beneficial in terms of teaching than the **theoretical** lesson given in crowded classroom environment.

Completely disagree	Disagree	No idea	Agree	Completely agree

6. I think that the anatomy **theoretical lectures** given by distance learning are more efficient than the classroom lectures in terms of the opportunity to listen to the lecture again.

Completely disagree	Disagree	No idea	Agree	Completely agree

7. I think it is more appropriate to teach the anatomy **theoretical lectures** in a student-centered interactive manner in the classroom atmosphere.

Completely disagree	Disagree	No idea	Agree	Completely agree

8. I think it is not appropriate to learn anatomy **practical lectures** without touching the cadaver and the anatomical model.

Completely disagree	Disagree	No idea	Agree	Completely agree

9. In terms of anatomy **practical lectures**, I think it is more efficient to work interactively with assistants and friends in the laboratory environment.

Completely disagree	Disagree	No idea	Agree	Completely agree

10. I think that the visual presentation of the anatomy **practical lecture** contents in the form of videos and the chance to watch it again, make it easier for me to learn in the distance learning process.

Completely disagree	Disagree	No idea	Agree	Completely agree

11. I think that the anatomy theoretical lectures to be given in medical schools in the following years should be online and the practical lectures should be in the laboratory environment.

Completely disagree	Disagree	No idea	Agree	Completely agree

12. As a medical student, I think that the courses (especially the anatomy course due to the high course hours) should be given both theoretically and practically in online after the pandemic period.

Completely disagree	Disagree	No idea	Agree	Completely agree

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Retrograde cerebral venous air embolism and the anatomical pathway of air bubbles: a case report

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Abstract

Pneumocephalus due to cerebral venous air embolism is an uncommon phenomenon. It results from retrograde progression of low weight air bubbles into dural venous sinuses during manipulation of a venous catheter, more frequently a central venous catheter through the subclavian and the jugular veins. However, it may also occur in relation with a peripheral intravenous catheter as in our case. We report a 91 year old female patient with congestive heart failure who had been examined in our emergency department two days previously due to dyspnea and received diuretic treatment through a peripheral intravenous line. She presented with vomiting and headache without obvious neurological deficits. Non-contrast cranial CT scan revealed wide spread punctate air bubbles inside and outside the cranial vault (pneumocephalus), within the venous system. The pneumocephalus was considered as iatrogenic due to the previous peripheral venous catheterization that resulted in retrograde migration of air bubbles through various venous connections into dural venous sinuses and extracranial veins. Since cerebral venous air embolism is a potentially serious complication of various medical procedures, it should be considered in differential diagnosis of nontraumatic headache and vomiting especially when there is a recent manipulation of venous lines. Cranial CT scan is helpful for early diagnosis.

Keywords: computed tomography; pneumocephalus; retrograde cerebral venous air embolism

Anatomy 2020;14(3):210–215

Introduction

Cerebral venous air embolism (CVAE) is a potentially serious complication of various medical procedures performed in almost all clinical specialties such as in neurosurgery during posterior fossa operations, invasive pulmonary procedures (eg. percutaneous lung biopsy) or intravenous (IV) catheterization (central or peripheral).[1–3] The true incidence of CVAE as a result of venous catheterization is unknown since it is usually asymptomatic. Although it has been revealed to develop during manipulations of central venous catheters (CVCs), it may also develop rarely in association with a peripheral IV line.[4,5] It is formed when the air bubbles overcome the gradient between the external atmospheric pressure and the intravenous pressure to enter the blood stream. This concept of retrograde passage of air bubbles was first described in a letter to the editor by Ploner et al.[6] in 1991.

Clinical presentation and prognosis in patients with CVAE varies depending on the volume and territory of the air bubbles in the cerebral vasculature. In most of the cases, patients have nonspecific sysmptoms such as headeache, nausea, vomiting, vertigo and confusion. However, it may also be accompanied by more severe neurological findings such as decreased consciousness or seizure. In addition, it can act like a thrombotic emboli and cause ischemic stroke by occluding the end arteries resulting in focal neurological deficits.[5] Therefore, prevention should be the priority by properly positioning the patients and keeping the lumens of venous catheters filled with saline prior to any manipulations.

Case Report

A 91-year old female patient with congestive heart failure (CHF) secondary to ischemic heart disease presented to our emergency department with the chief complaint of vomiting and headache. There was no recent head trauma or history of any surgical procedures. She was first examined in our emergency department for shortness of breath two days ago and was discharged with relief of symptoms after receiving diuretic therapy through a peripheral IV line. On neurological examination, the patient was well oriented without obvious neurological deficits. She had undergone a non-contrast cranial computed tomography (CT) in order to exclude intracranial hemorrhage. On CT, the brain parenchyma was normal but there were wide spread small punctate air bubbles inside and outside the cranial vault. The air bubbles were observed to spread into right transverse sinus (**Figure 1**), the right sigmoid sinus and bilateral cavernous sinuses (**Figure 2a**), the right inferior petrosal sinus (**Figure 2b**), cervical epidural venous plexus at the level of foramen magnum (**Figure 3a**) and at the level of cervical spine (**Figure 3b**), the right vertebral venous plexus (**Figure 3b**), venous plexus of the right hypoglossal canal (**Figure 4a**), bilateral ophtalmic veins (**Figures 4b** and **4c**), the right pterygoid venous plexus (**Figures 3a**, **4a** and **4d**) and the right superficial temporal vein (**Figure 2a**). When compared with the CT scan performed 2 months ago the air bubbles were found to be a new finding. Concerning the typical distribution of air bubbles throughout the venous vasculature and the lack of any fracture involving the cranial vault or air spaces of the head, the pneumocephalus was considered to happen due to IV injection of air through the peripheral venous catheterization performed two days ago. She was positioned in Trendelenburg position and received 100% oxygen therapy. During close follow up at the emergency department, no clinical deterioration was observed. A follow up examination was planned in our neurology department and she was discharged with improvement of the complaints.

Discussion

Pneumocephalus also known as pneumocranium refers to the presence of air or gas within the cranial vault either extraaxial (epidural, subdural, subarachnoid) or intraaxial (parenchymal, intraventricular, intravascular). Localization of the air bubbles to a specific compartment and assessment of the entryway is important in diagnosis and management of the patients in emergency departments.

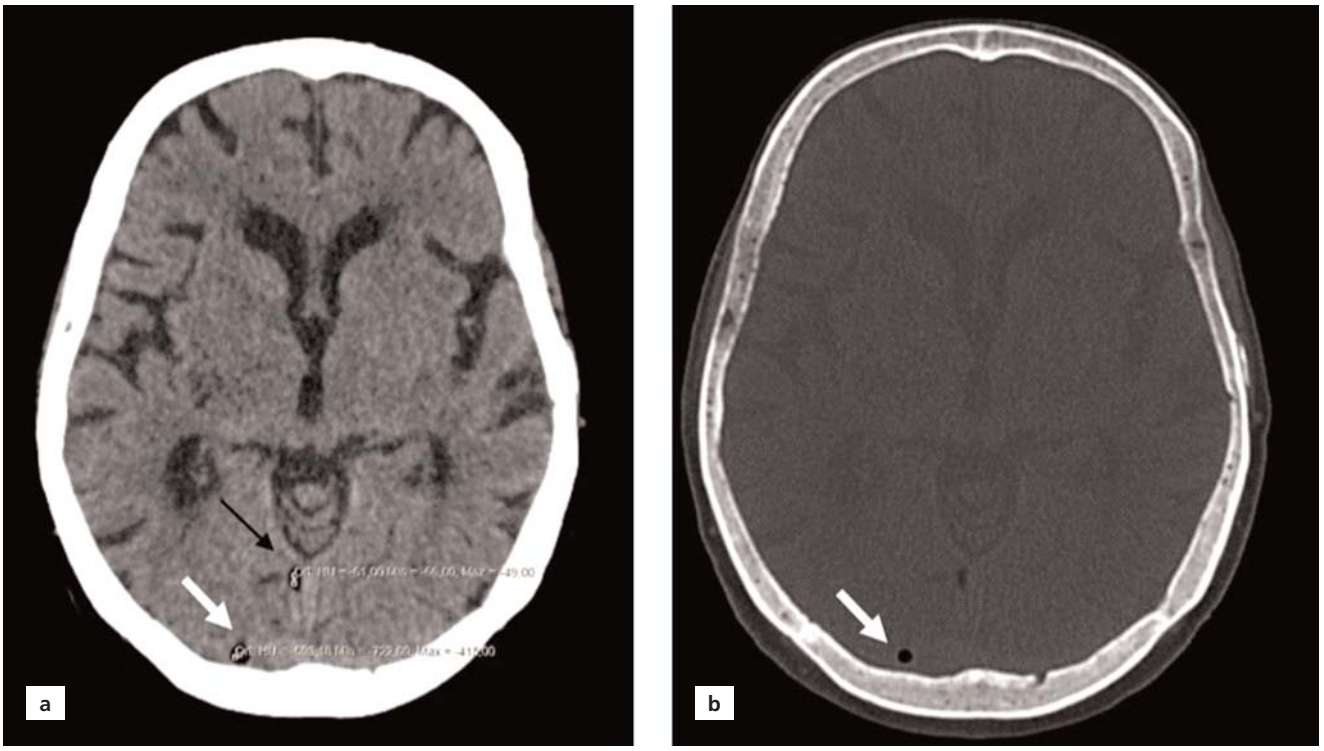

Figure 1. Parenchymal window (**a**) and bone window (**b**) images of non-enhanced cranial CT showing air bubbles in the transverse sinus (**white arrows**). A small midline lipoma is pointed by black arrow.

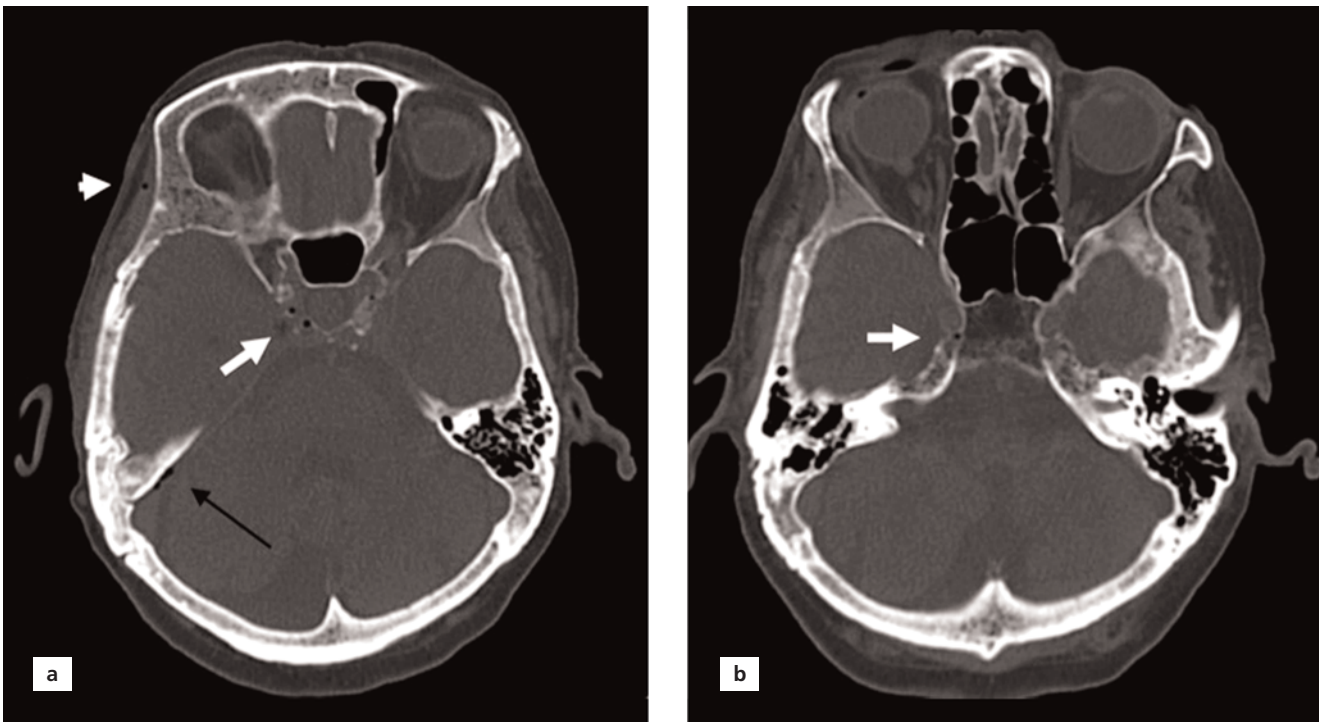

Figure 2. Bone window images of non-enhanced cranial CT. (**a**) Air bubbles in the cavernous sinus (**white arrow**), right sigmoid sinus (**black arrow**) and right superficial temporal vein (**short white arrow**); (**b**) air bubbles in the right inferior petrosal sinus (**white arrow**).

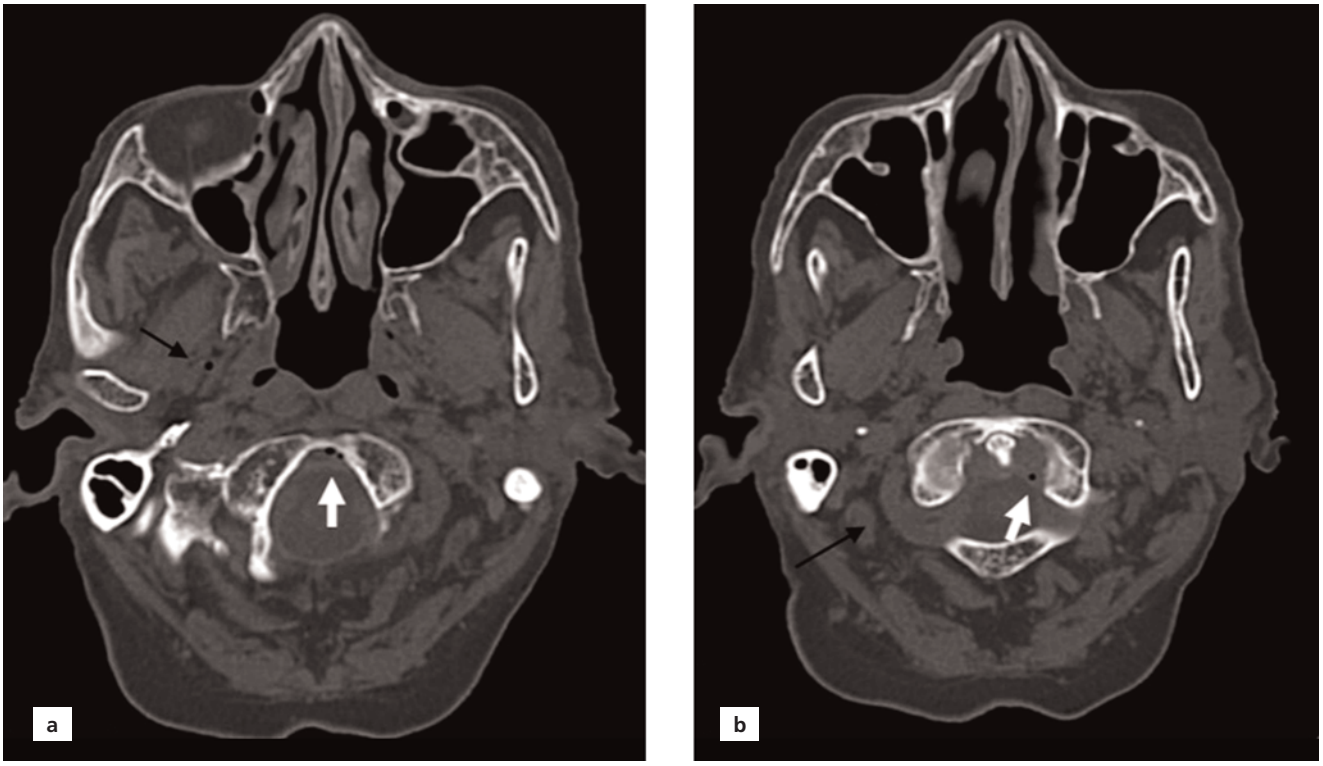

Figure 3. Bone window images of nonenhanced cranial CT. (**a**) Air bubbles in cervical epidural venous plexus at the level of foramen magnum (**white arrow**) and in the right pterygoid venous plexus (**black arrow**); (**b**) air bubbles in cervical epidural venous plexus at the level of cervical spine (**white arrow**) and in the right vertebral artery venous plexus (**black arrow**).

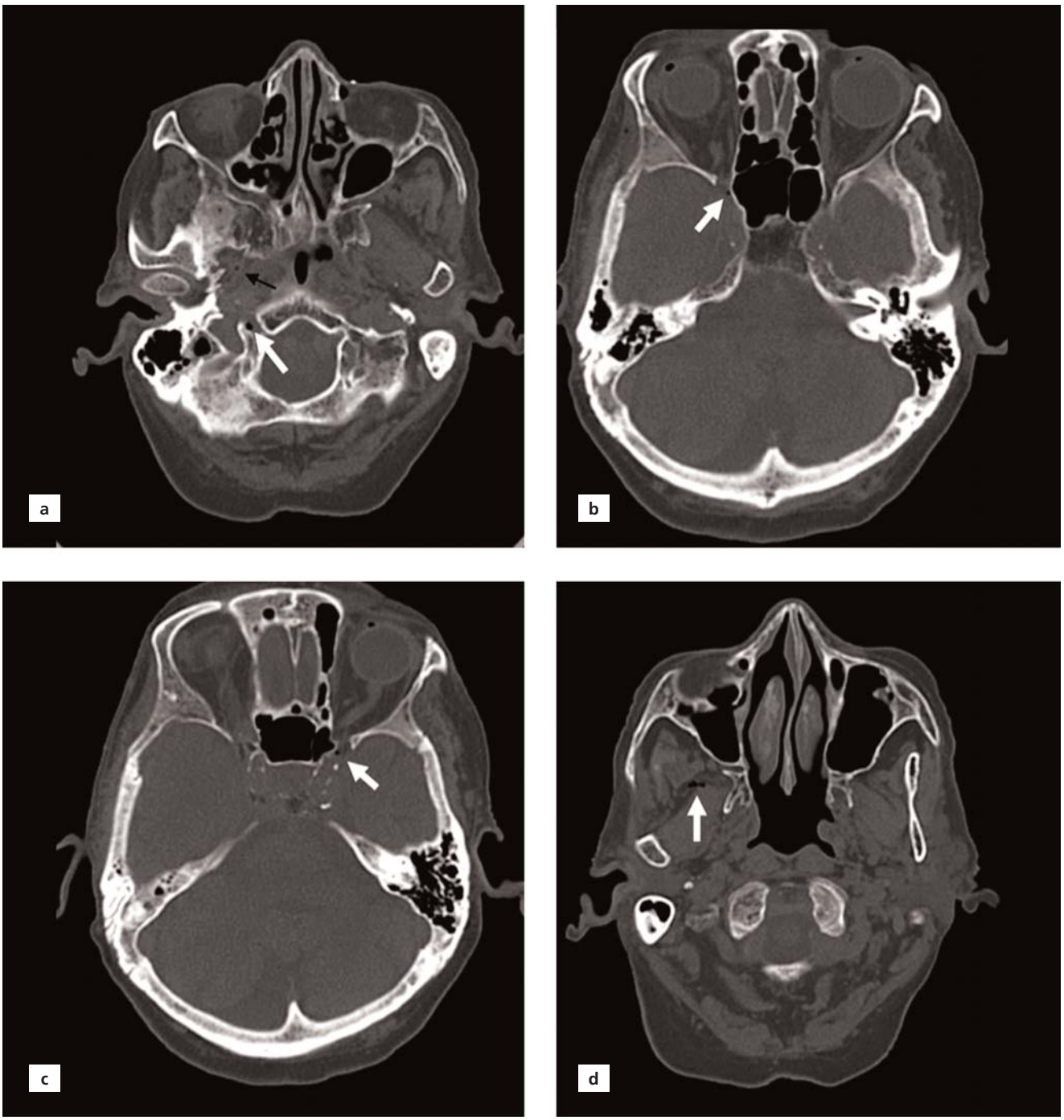

Figure 4. Bone window images of nonenhanced cranial CT. (**a**) Air bubbles in the venous plexus of the right hypoglossal canal (**white arrow**) and in the right pterygoid venous plexus (**black arrow**); (**b**) air bubble in the right ophtalmic vein (**white arrow**); (**c**) air bubble in the left ophtalmic vein (**white arrow**); (**d**) air bubbles in the right pterygoid venous plexus (**white arrow**).

Pneumocephalus associated with CVAE preasumbly due to IV injection of air is an uncommon phenomenon and occurs during the placement or removal of a venous catheter. It mainly develops in association with a central venous catheter rather than a peripheral IV line. In a retrospective study, covering 24 months period and analyzing total of 8747 cranial CT scans, intracranial air bubbles presumably due to the injection of air through peripheral IV lines was established in 3 cases with an incidence of 0.034% (3/68) among 68 cases of pnemocephalus.[7]

Unlike the systemic venous system, cerebral venous system does not precisely follow the cerebral arterial system. The cortical veins lie superficially and drain to the nearest dural venous sinuses.[8] Dural venous sinuses are connected to each other via various venous plexuses like cervical epidural venous plexus, vertebral venous plexus that surrounds the vertebral artery in the transverse foramen or venous plexus of the hypoglossal canal. The emissary veins provide a venous communication between the dural venous sinuses and the extracranial venous system by passing through foramina in the skull.[9]

CVAE is assumed to be resulted from retrograde progression of low weight air bubbles through the subclavian vein into the jugular vein against to the blood flow and then pass into the dural venous sinuses. Besides the air volume, the type of medical procedure and the position of the patient are among other contributing factors. For example, increased intrathoracic pressure during valsalva maneuvers, jugular vein insufficiency and low flow states like in heart failure, as in our case may result in venous air embolism.[3] Venous air embolism can also involve the cerebral arterial vasculature by paradoxical air embolus with the entry of the air from the venous system to the arteries via a right-to-left shunt, such as a patent foramen ovale.[1] In our patient, it seems that after traversing the subclavian vein and reaching the internal jugular vein (IJV), air bubbles migrated on a retrograde course and arrived to the right sigmoid and transverse sinuses. From the IJV, they also migrate through the inferior petrosal sinus to enter the cavernous sinuses and then the ophtalmic veins. Epidural venous air embolism (pneumorrhachis) located in the cervical epidural venous plexus can be explained with its connections to the sigmoid sinus within the skull. This venous plexus also have a connection with the vertebral venous plexus via a venous network at the level of foramen magnum. Epidural venous air embolism has been more frequently described as a complication of epidural anesthetic procedures causing injury of the plexus and resulting in the inadvertent entry of the air into the veins.[10] The air bubbles associated with the venous plexus of the hypoglossal canal in our case could be provided via its relation with the cervical epidural venous plexus, the inferior petrosal sinus and also the IJV.[9] The extracranial air bubbles in the right pterygoid venous plexus and the right superficial temporal vein was thought to be migrated from the dural venous sinuses via emissary veins. In our case, we thought that the emissary vein of Vesalius which is a well known important route for spread of infections to the cavernous sinuses, was responsible for the passage of air from the cavernous sinuses into the pterygoid venous plexus and the superficial temporal vein.[11]

The most useful radiological imaging modality to detect intracranial air bubbles is conventional CT scan without contrast. However, as air is absorbed rapidly, it may be only diagnostic in the acute period. Air bubbles appear as extremely dark with Hounsfield unit (HU) of around -1000. Intracranial lipomas have a similar contrast in parenchymal window, but can easily be differentiated by their lower HU (-50 to -100). In our patient, there was a small midline lipoma adjacent to the falx cerebri with HU of average -61, which has similar contrast with the air within the right transverse sinus (**Figure 1a**).

The treatment of CVAE consists Trendelenburg positioning to facilitate the return of air bubbles into the central venous system and high concentration (100%) oxygen to reduce the volume of air in the circulation. Hyperbaric oxygen therapy should be considered for more severe cases.[2] Intravascular volume expansion to prevent further entry of air into the circulation may be considered in appropriate settings. In our patient, with the consideration of her recent and ongoing congestive status, IV hydration was not administered. In addition, avoidance of Valsalva maneuver like coughing or forceful sneezing in order not to increase the intratoracic pressure is recommended. Our patient became symptom free with improvement of the complaints without any deterioration in her clinical status during the follow up at the emergency department.

Conclusion

CVAE is an unusual but potentially serious complication of various medical procedures. It may occur even after injection of IV fluids at routine peripheral venous lines and result in widespread air bubbles in various locations of the cerebral venous vasculature, as in our case. It should be considered in differential diagnosis of nontraumatic headache and vomitting especially when there is a recent insertion of venous catheters (central or peripheral). CT is gold standard in early diagnosis and management especially during acute phase.

Conflict of Interest

No conflict of interest.

Author Contributions

BE: concept, design, analysis, literature search, manuscript writing; KK: design and analysis; AÖA: concept, design and analysis.

Ethics Approval

Signed consent was obtained from the patient to publish her data however; ethical approval of the institution was not required.

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Glomus coccygeum in pilonidal sinus surgical specimens: report of two rare cases with special reference to SOX10 expression

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Abstract

We report two new cases of glomus coccygeum in pilonidal sinus excision specimens. The positive expression of glomus coccygeum cells for SOX10 is used for the first time. SOX10 is a useful immunohistochemical marker for identifying this microanatomical structure, confirming the diagnosis and may help the differential diagnosis. The glomus coccygeum cells are probably neural crest-derived from multipotent Schwann cell precursors.

Keywords: glomus coccygeum; pilonidal sinus; SOX10; vestigial structure; sacral area

Anatomy 2020;14(3):216–219

Introduction

Glomus bodies (including coccygeal glomus) consist of modified smooth muscle cells arranged in layers around small vascular channels.[1] They are a modified arteriovenous anastomosis in which innervation is similar to the canals of Sucquet-Hoyer of the distal phalanges of the toe.[2] When found in distal extremities, they generally do not represent a diagnostic problem.

The glomus coccygeum (GC) is a vestigial structure in the deep layers of the skin that is removed from the lumbosacral region. Its function in this area is still unknown.[3]

The GC may be an incidental finding in the tissue surrounding a pilonidal sinus cyst in surgical specimens.[4] The frequency of this topographic combination is low with only 11 cases (including our two cases) reported in the English literature.[3–5] It may represent a diagnostic challenge to the surgical pathologist.[2,5,6]

Immunohistochemically, the glomus cells express smooth muscle actin (SMA), vimentin, neuron-specific enolase (NSE) but do not express desmin, S100 protein or endothelial cell markers: CD31 and FVIIIR: Ag. Both S100-positive (nerve sheath) cells and CD31/FVIIIR: Ag-positive endothelial cells are typically present within the glomus body.[7]

The SOX10 transcription factor is known to be important in the development and maintenance of the peripheral nervous system.[8,9] The SOX10 nuclear protein is widely expressed in glial cells, melanocytes, Schwann cells, and myoepithelial cells.[10] To our knowledge, SOX10 has not been reported in GC in the medical literature so far.

Case Report

Case 1 was a 20-year-old man presented with symptoms of a pilonidal sinus cyst. Grossly, the local excision surgical specimen was 6×1×3 cm in size and contained a cyst with diameter of 1.8 cm.

Case 2 was a 45-year-old woman presented with an infected cutaneous lesion for 6 months with a recurrent abscess. Grossly, the cutaneous fragment was 2.5×1.5×1

cm in size, the surface of which was raised by a 1.5 cm cyst, with a creamy content.

Histological examination of both lesions showed the presence of a pilonidal sinus cyst. In both specimens, when a deep cut section of the fragments was done, glomus structures measuring 0.3 cm (case 1) and 0.5 cm (case 2) along the long axis were found. The lesions were recognized as sharply circumscribed complex structures composed of clusters and nests of small to medium-sized epithelioid cells associated with small vascular channels and with small nerve bundles (**Figure 1a**).

Immunohistochemistry of both lesions showed that glomus cells expressed SMA (**Figure 1b**), NSE and vimentin and were negative for desmin, cytokeratin, CD31 and CD34 (data not shown) and S100 protein (**Figure 2a**). Proliferative activity was low. Besides, in both cases, SOX10 - staining was presented in cellular nuclei of most of glomus cells (**Figure 2b**). The H-score was used for the interpretation of the SOX10 expression.[8] The median H-score for SOX10 in both cases of GC was 50 (40–60) (a marker was considered positive when its H-score was ≥10).[8]

Discussion

The GC is a non-pathologic structure that exhibits significant variations in size and proportion ofits constitutive elements. It is presented in every completely excised specimen of the coccyx.[1] This structure is composed of modified smooth muscle cells (glomus cells) arranged in concentric layers around blood vessels.[1,2] Immunohistochemical expression of SMA and NSE in glomus cells may be beneficial for accurate identification of a diagnosis. The results we have obtained for PS100- /SOX10+ immunophenotype of GC-cells support the fact that they are neural crest-derived, similar to glomus cells in the carotid body.[3] The very close association of these cells with Schwann cells probably supports their origin from multipotent Schwann cell precursors.[3,4]

Our observation contains a practical aspect in the differential diagnosis of normal or hyperplastic GC versus glomus tumor and paraganglioma. In the latter cases, SOX10 is not expressed or expressed only in the sustentacular cells, but not in the tumor cells. Apart from that, they originate from the neural crest, the positive spectrum of SOX10 in GC can probably be explained by the available myoepithelial component in these structures, which is also SOX10 positive. The lack of expression of SOX10 in the glomus tumor may be due to a P46S mutation which is not available in normal or hyperplastic GC.[11]

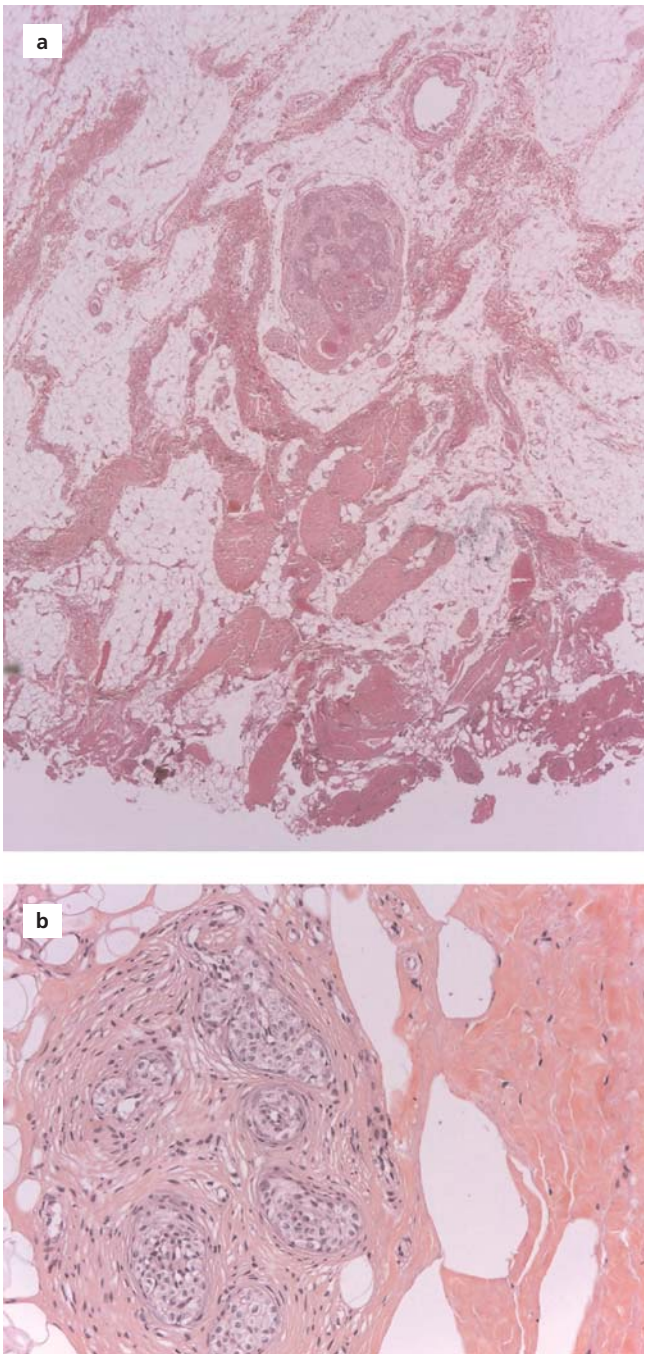

Figure 1. Sections stained with hematoxylin-eosin-saffron (HES) showing a sharply circumscribed complex structure (glomus body) situated deep in the connective tissue. (**a**) Case 1 with clusters and nests of small to medium-sized epitheloid cells associated with a small vascular channel, ×25 magnification; (**b**) Case 2, ×200 magnification.

In conclusion, we describe two new cases of the GC in pilonidal sinus excision specimens. SOX10 is a helpful marker for identifying this microanatomical structure and confirming the diagnosis. Adding our two cases to the lit-

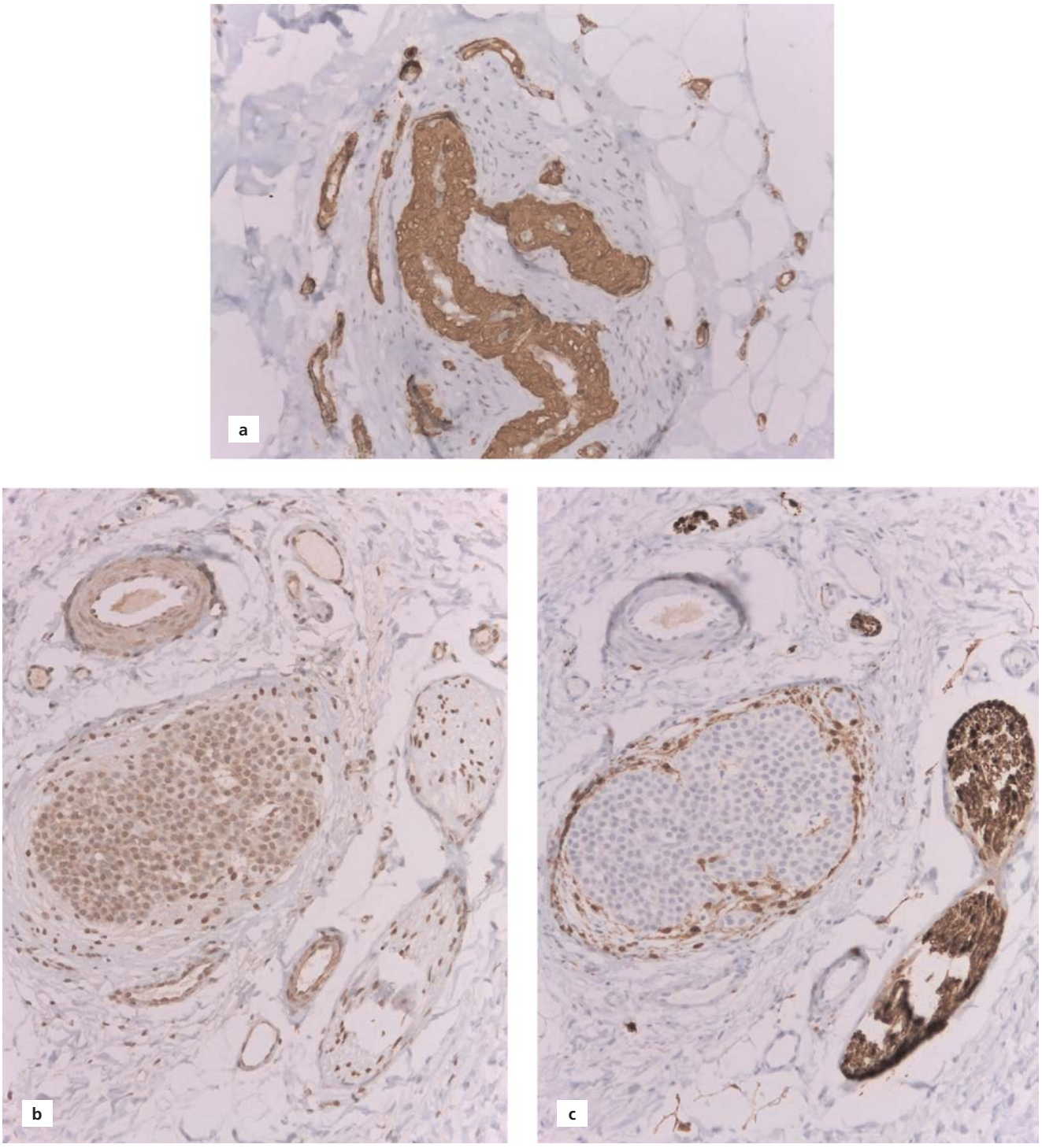

Figure 2. Immunohistochemical staining of glomus cells for smooth muscle actin. (**a**) Case 1, x200 magnification; (**b**) hyperplastic glomus cells lack expression of S100 protein; note S100 protein accentuated peripheral Schwann cells (Case 2), ×100 magnification; (**c**) glomus cells show variable intensity of SOX10 intranuclear staining (Case 2), ×100 magnification.

erature provides novel clinicopathological data, useful for precise diagnosis and avoids confusion with glomus tumors in the sacral area. To the best of our knowledge, the positive expression of GC- cells for SOX10 is used for the first time as a reliable immunohistochemical marker that may aid the diagnosis and the differential diagnosis.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

SP: evaluation of the cases, writing the manuscript; IM: design of the study; MKI: writing the manuscript; DD: design of the study, supervision, critical revision of the manuscript.

Ethics Approval

The study was performed following the aid of the ethical standards down in the 1964 Declaration of Helsinki and its later amendments. Written and signed consent was obtained from the patients.

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A proposal for body donation forms in Turkey: study of the Committee for Body Donation and Cadaver Monitoring

On behalf of the Committee for Body Donation and Cadaver Monitoring of the Turkish Society of Anatomy and Clinical Anatomy

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Abstract

Informed consent is an integral part of daily anatomical practice. Providing adequate information regarding body donation process and emphasizing the importance of use of donated bodies in anatomy education will help the individuals who consider body donation. Current legislation that regulates body donation in Turkey does not provide details on the consent process. Additionally, recent research showed that registered Turkish body donors have various opinions on the use of their bodies, sharing their personal information with the departments and medical students, and retention time of their bodies or body parts. This resulted in non-standard or modified donation forms across different institutions. Therefore, the Turkish Society of Anatomy and Clinical Anatomy (TSACA) decided that a standard and more comprehensive body donation form that addresses contemporary topics was necessary. The newly established Committee for Body Donation and Cadaver Monitoring has been assigned with this task. As of May 2020, the Committee had finalized the updated body donation form according to departmental feedback and donors' opinions. This paper outlines the existing data and reasons along with the legal grounds for the current update.

Keywords: body donation; body donation form; informed consent; legislation; Turkey

Anatomy 2020;14(3):220–226

Importance of Anatomy Education and Body Donation

Anatomy is a fundamental part of modern undergraduate medical education[1] and frequently preferred for postgraduate medical training.[2] Using human bodies in anatomy education helps students to acknowledge the three dimensional structure of the body,[3] acquire basic medical skills,[4] and reflect on the concepts such as normality, pathology, and variation.[5] Additionally, hidden curricular processes such as professionalism,[6] team-work abilities,[3] and human skills[7] are also gained. Nevertheless, hidden curricular gains of using cadavers are usually associated with the use of donor cadavers.[8] This aspect of anatomy practice emphasizes the importance of body donation programs throughout the world.[9,10]

Body Procurement and Legislation in Turkey

Unclaimed bodies still constitute the major source of bodies for anatomy education and scientific research in Turkey.[10,11] Sporadic cases of body donation continued

since the enactment of the Act 2238.[11,12] Therefore, the Turkish Society of Anatomy and Clinical Anatomy (TSACA) implemented a National Anatomy Week in 2012 and started a campaign that aimed to promote body donation among the general population.[13] The campaign seemed to have an effect because a promising increase was present in body donation registrations and donations since 2012.[11]

The first legal regulation on body procurement in Turkey was enacted in 1979 as the Act 2238.[14] Although initially the Act aimed to regulate organ and tissue donation and transplantation, article 14 included the use of unclaimed bodies of individuals who passed away in state hospitals as cadavers. In 1982, willing donation of one's body before death had been added with an amendment,[14] probably following the first ever-recorded body donation case of Cavit Cav.[15] Same year, an accompanying regulation was issued that exclusively authorized anatomy departments for body procurement in Turkey.[16] With the increasing number of medical faculties and declining body sources, importation of bodies was allowed with another amendment in 2014.[14]

As in all medical procedures, obtaining informed consent is also crucial for anatomy practice.[17,18] Despite unclaimed bodies constituting the major source of bodies in Turkey, encouraging and promoting body donation resulted in increased interest of the public in body donation.[11] Nevertheless, current legislation and body donation forms do not cover detailed information as suggested by the literature.[19,20] Given the recent data on donor opinions in Turkey regarding contemporary topics such as sharing personal information and retention time of bodies[12] and discussions on updating current body donation forms,[19,20] the TSACA was aimed to address this situation.

Establishment of the Committee for Body Donation and Cadaver Monitoring

At the Extraordinary General Assembly of the TSACA during the 2019 Winter Meeting in Denizli, the Committee for Body Donation and Cadaver Monitoring (CBDCM) that consists of thirteen members was created.[21] The Committee organized two meetings during the National Anatomy Congress in August 2019 and agreed upon a variety of topics to work on. One of these topics was the need for an update on body donation forms.

Initially, a substantial search was done to outline the formats of existing body donation forms around the world and local studies that provide information on donors' opinions.[12,19] The first draft with wider consent options of the form was distributed to committee members and the form was revised according to their feedback. This version was found to be confusing and limiting for the departments, therefore a second version with consent sections on vital topics and an additional information leaflet was created. Following the second feedback session, a donor card section was added to the form. This version was agreed upon as the final version of the body donation form.

Updated Body Donation Form

Article 7 of the Act 2238 gives the responsibility to the physicians for informing the individuals who wish to donate their bodies.[14] Therefore, the first component of the updated body donation form is the information leaflet, which aims to help anatomy departments to provide adequate information regarding body donation (**Appendix 1**). This document is not a guideline but only provides a framework for important information that is suggested to be disclosed to all individuals who consider body donation. It provides information on the definitions of body donation and cadaver, importance and use of human cadavers, embalming and storage procedures, dissection and research activities, protection of the donor's memory during these activities, and transportation of bodies following death and before burial. The activities that would be performed on bodies such as dissection and research activities, was not provided as an optional consent section due to donors' tendencies. Current literature shows that 88% to 98.9% of registered body donors either consented to both activities or left the decision to anatomy departments.[12,22] One section that was removed from the initial draft of the form to the leaflet is the acquisition and use of digital images. Since all procured bodies are expected to be used in educational or research activities, documentation of relevant data through images (including photographs, videos, 3D images, and 3D print-outs) is very important. Therefore, instead of obtaining consent for this from all potential donors as an opt-in option, detailed information of acquiring and using digital images of donor-cadavers for educational and scientific purposes have been included in the leaflet. Adhering to ethical rules and respecting personal rights during this practice was highlighted. The leaflet also encourages donors to disclose their health records for anatomical education and research. Currently, the legislation regarding body procurement in Turkey does not define rejection criteria such as infectious diseases or obesity.[14,16] Therefore, the leaflet warns potential donors for any existing rejection criteria of the institution, including current Covid-19 pandemic, that they should be informed beforehand. All institutions should keep in mind that the information leaflet is just a consensus framework of basic information to be disclosed. Therefore, departments could expand or modify its content if needed.

The second component of the updated form is the detailed informed consent form (**Appendix 2**). It provides a main consent section similar to the previous donation

form and incorporates a donation statement and the names and signatures of the donor, two witnesses, and a department staff. The contact information of the donor, donor relatives, and the institution are also incorporated. The main section is mandatory due to the Act 2238.[14] Declaration of body donation could be considered as a final will.[18,23] According to Article 538 of Act 4721 (Turkish Civil Code),[24] the written will must be hand written and signed by the individual. Therefore, any form of printed document is invalid and has no legal value.[25] On the other hand, Article 6 of Act 2238 states that the individual can consent to body donation in two ways. First, one requires a signed handwritten statement in the presence of two witnesses. Secondly, the individual can sign a printed document following a verbal declaration in the presence of two witnesses and the confirmation of a physician.[14] Therefore, the current form recommends the signatures of relatives as witnesses so that the document might gain the legal status of a will. According to the Turkish Civil Code,[24] although the person loses all personal rights when they die,[26] some aspects of the personality such as the memory, dignity, and confidentiality of the person continues.[25,26] In order to protect these aspects, the body of a person gains the status of heritage to the surviving relatives.[24] This gives the surviving relatives the right to decide what will happen to one's body following her/his death. This legal aspect of body donation is crucial for realizing the final wish of a body donor. Therefore, the Committee advises all departments to encourage all possible donors to inform their relatives. Involving donor relatives to the donation process as witnesses is also encouraged because by doing this families and relatives are to be consulted during the donation procedure.[12,23]

Apart from the main consent section, the updated form obtains optional donor consent regarding contemporary topics including disclosing personal or health information of the donor, public display, and retention time of anatomic specimens. This section aims to provide an opt-in opportunity for possible donors regarding aforementioned topics. Turkish donors have shown to be open with the idea of their personal and health information to be shared with public and/or medical students.[12] Health information could be used in daily anatomy education and research, while personal information could be used to promote body donation. Only 5.1% and 17.7% of Turkish donors wished their health and personal information, respectively, to be kept confidential. In order to adapt to donor wishes, these information were provided as optional consent sections.

It is known that the retention time of anatomical specimens may reach up to 25 to 50 years in some Turkish anatomy departments.[12] Similarly, 94.7% of registered Turkish body donors either approved the indefinite use of their bodies or left this decision to the institutions.[12] Therefore, this option was also provided in the consent form.

Currently, public access to anatomical collections and anatomical museums within departments in Turkey is not permitted. Nevertheless, with the increasing public interest in human anatomy[27] and methods such as plastination to support this,[28] publicly open collections or museums might considered in the future. In order to provide a legal basis for this practice, the updated form incorporated an optional consent section regarding public display of anatomical specimens for increasing an awareness on body donation and promoting the science of anatomy.

The detailed informed consent form also has an embedded donor card for donors' personal use. Since the actual donation form is bulky and is nearly impossible to be carried in a wallet or purse, a smaller donation card is prepared following previous examples[29] and the feedback of registered body donors at different institutions. This card provides ID and contact information of the donors, registration number at the given institution, a shorter consent section, and detailed contact of the institution, if needed. Although it should be kept in mind that this document is not the actual donation document and does not have legal value,[25] but only serves as a more efficient information and contact source.

Current update achieved to create a standard and more comprehensive body donation form that addresses recent topics and donors' opinions. Nevertheless, institutional needs and expectations should be evaluated prior to incorporating the updated form into daily practice. Therefore, modifications to the updated form could be done if needed by the institutions. Additionally, departmental and individual feedback along with possible future legal regulations will result in a continuous improvement of the body donation form. Turkish and English versions of the information leaflet and body donation form are provided as supplemental files or can be downloaded from the official website of the TSACA (http://www.anatomidernegi.org.tr/).

Conflict of Interest

No conflict of interest was declared by the authors.

Author Contributions

All authors commonly participated in all steps of this work.

Ethics Approval

Ethics approval was not required since the study was not performed in humans or animals and no personal data was used.

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Appendix 1a

Body donation information leaflet in English.

UNIVERSITY AMBLEM	..... UNIVERSITY ..... FACULTY OF MEDICINE DEPARTMENT OF ANATOMY BODY DONATION INFORMATION LEAFLET	FACULTY AMBLEM

- Bodies of deceased individuals that beeing used for learning the structure of the human body duringAnatomy courses are called as cadavers.
- Cadavers are widely used in undergraduate education of medical, dentistry, nursery, physiotherapy,and health sciences students. Additionally, they are vital for postgraduate education and scientificresearch studies.
- After your death, the Department will embalm and store your body in order to halt the decompsitionprocedure and facilitate education and research.
- Organs or limbs may be removed during educational or research activities performed on the body. Allthese procedures will be done by according to the highest care and attention all the time and respectingthe self-devotion of the donor.
- Organ and tissue samples may be collected from the body and evaluated with scientific methods foreducational and research purposes.
- Information gathered during these evaluations may be used in scienific publications, including articles,case presentations, reviews, and thesses.
- Digital images of the body, parts of the body, organs, and tissues may be acquired. These includephotographs, videos, three dimentional (3D) images, and 3D print-outs. Acquired images may be usedin scientific research studies and their subsequent scientific publications (articles, case reports, reviews,thesses, etc.), atlases/textbooks/lectures/presentation materials prepared with educational purposes, andcould be shared for academic purposes. Above mentioned activities will be done under ethicalguidelines in respect to the memory of the donor.
- Following required institutional permissions, the body may be transferred within or outside theinstitutions on condition that it will be returned to the Department.
- If death occurs at a place other than your residence, donation procedures may be performed bytransfering the body to the involved Department quickly or to the nearest institution with adequatefacilities for embalming.
- Sharing a copy of your health records with the Department is recommended for archiving, scientific,and safety purposes.
- Your donation may be declined by the Department due to predetermined reasons. The Department willexplain these reasons in detail before the donation aplication.

Appendix 1b

Body donation information leaflet in Turkish.

ÜNİVERSİTE LOGO	..... ÜNİVERSİTESİ ..... TIP FAKÜLTESİ ANATOMİ ANABİLİM DALI BEDEN BAĞIŞI BİLGİLENDİRME FORMU	FAKÜLTE LOGO

- İnsan bedeninin yapısını öğretmek amacı ile Anatomi dersleri kapsamında kullanılan cansız insan bedeninekadavra adı verilir.
- Kadavralar başta tıp, diş hekimliği, hemşirelik, fizyoterapi ve sağlık bilimleri öğrencilerinin lisanseğitiminde kullanılır. Ayrıca, uzmanlık ve uzmanlık sonrası eğitimleri ile bilimsel araştırmalarda dakullanılırlar.
- Eğitim ve araştırma yapılabilmesini sağlamak amacıyla bedeniniz bozulmasını engelleyecek ve AnabilimDalının uygun gördüğü bir yöntem ile tahnit edilir ve saklanır.
- Beden üzerinde yapılacak eğitim ve araştırma faaliyetleri sırasında organ ve uzuvlar çıkartılabilir. Ancak bu işlemler, bağışı gerçekleştiren kişinin fedakârlığını akılda tutarak gerekli özen ve saygıdan taviz vermeden gerçekleştirilir.
- Bedeninizden, eğitim ve araştırma amacıyla organ veya doku örnekleri alınabilir ve bilimsel yöntemlerlearaştırmalar yapılabilir.
- Araştırma sürecinde elde edilen veriler bilimsel yayınlarda (makale, olgu, derleme, tez vs.) kullanılabilir.
- Bedenin tamamının, bir bölümünün, organların ve dokuların dijital görselleri (fotoğraf, video, üç boyutlu(3B) görseller, 3D baskılar vs.) elde edilebilir. Elde edilen görseller; kişinin hatırasına saygı göstererek veetik kurallar çerçevesinde, bilimsel araştırmalar ve bunların sonucunda ortaya çıkacak bilimsel yayınlarda(makale, olgu, derleme, tez vs.) ve/veya eğitim amacı ile hazırlanan atlas/kitap/ders/sunum materyallerindekullanılabilir veya akademik amaçlarla paylaşılabilir.
- Gerekli kurumsal izinler alındıktan sonra bedeniniz, Anabilim Dalı'na geri getirilmesi şartı ile eğitim veaaştırma amacıyla kurum içinde veya kurum dışına nakledilebilir.
- Yaşamın, bağış işlemlerinizi yaptığınız şehirden çok uzak bir şehirde son bulması halinde, bağışınızıngerekleri bağış yaptığınız kuruma hızlıca nakledilmek sureti ile veya bedeninizin nakledilebileceği en yakınüniversitede gerçekleştirilebilir.
- Anabilim Dalı çalışanlarının sağlığı, arşivleme ve bilimsel araştırmalarda kullanım amacıyla sağlıkbilgilerinizin bir kopyasının Anabilim Dalı ile paylaşılması gerekmektedir.
- Ayrıca bağışınız, Anabilim Dalının belirlediği çeşitli nedenlerle kabul edilmeyebilir. Kabul edilmemesebepleri Anabilim dalı tarafından size ayrıntılı olarak anlatılacaktır.

Appendix 2a

Body donation form in English.

UNIVERSITY AMBLEM

..... UNIVERSITY
..... FACULTY OF MEDICINE
DEPARTMENT OF ANATOMY
BODY DONATION FORM

FACULTY AMBLEM

PROTOCOL NO: .....

SURNAME	:	T.C. ID NO	: .....
NAME	:	DATE OF BIRTH	: .....
MOTHER'S NAME	:	SERIAL NO	: .....
FATHER'S NAME	:	VALID THROUGH	: .....
TELEPHONE	:	E-MAIL	: .....
ADDRESS	:		

☐ I approve
☐ I DO NOT approve

- the display of specimens prepared from my body, body parts, organs or tissues at public museums and exhibitions, for increasing the awareness on body donation and promoting the science of Anatomy.

- For promoting body donation and helping students to learn ethical pricipals, my personal information that has been shared with the Department
  - ☐ if needed, could be shared publicly.
  - ☐ could be shared with students.
  - ☐ I wish them to remain confidential.
- For increasing the quality of education, my health record that has been shared with the Department
  - ☐ if needed, could be shared with students.
  - ☐ I wish them to remain confidential.
- I approve the use of my body, body parts, organs, tissues, or skeleton for education and research
  - ☐ for a period ……of years.
  - ☐ indefinitely.
- Regarding funeral procedures following the declared time period for educational and research activities,
  - ☐ I wish my body to be delivered to my family.
  - ☐ I wish my body to be delivered to the Municipality.
  - ☐ if possible, I wish to be burried at the ..... Cemetary.

This section will remian with the Department

This section will remain with the donor

NOTE: *Please carry this card next to your ID card.*

AMBLEM

..... UNIVERSITY
..... FACULTY OF MEDICINE
DEPARTMENT OF ANATOMY

AMBLEM

NAME-SURNAME	:	SERIAL NO	: .....
T.C. ID NO	:	TELEPHONE	: 0 (....) ....
DOB	:	E-MAIL	: .....

DONOR PROTOCOL NO : .....

BODY DONATION CARD

With this card, I declare that I have donated my body to the ..... Faculty of Medicine Department of Anatomy for education and research.

SIGNATURE : ..... DATE : ...../...../20.....

Contact:

..... Faculty of Medicine, Department of Anatomy

Phone : 0 (....) ....
Fax : 0 (....) ....
E-mail : .....@.....edu.tr
Extension : .....

I, who have stated my ID openly with this minute, hereby declare that, I understood the information provided to me according to the Act on Organ and Tissue Harvesting, Storage, and Transplantation, dated 20.05.1979 and numbered 2238, and the Regulation on Performing Scientific Research on Human Corpse published in the Official Gazette dated 17.05.1982 and numbered 17727; with paying regard to all abovementioned declarations, following my death, I voluntarily donate my body to ..... University, ... Faculty of Medicine Department of Anatomy, with my free will and without any pressure or expectation of any financial gain.

I have read this document and signed two copies in the presence of two witnesses. DATE : ...../...../20.....

Donor	Name-Surname:	Signature: .....
Witness #1	Name-Surname:	Signature: .....
Witness #2	Name-Surname:	Signature: .....
Attending physician	Name-Surname:	Signature: .....

Individuals to be contacted if requested who are informed by the donor:

Name-Surname:	Relationship:	Phone	: 0 (....)	E-mail	: .....
Name-Surname:	Relationship:	Phone	: 0 (....)	E-mail	: .....

Contact information for ..... University ..... Faculty of Medicine Department of Anatomy:

Departmental Phone	: 0 (....)	Extension	: .....
Contact Person Phone	: 0 (....)	E-mail	: .....@.....edu.tr
Address	:		

This section will remian with the Department

This section will remian with the donor

Appendix 2b

Body donation form in Turkish.

ÜNİVERSİTE LOGO

..... ÜNİVERSİTESİ
..... TIP FAKÜLTESİ
ANATOMİ ANABİLİM DALI
BEDEN BAĞIŞI FORMU

FAKÜLTE LOGO

PROTOKOL/KAYIT NO: .....

SOYAD	:	TC KİMLİK NO	: .....
AD	:	DOĞUM TARİHİ	: .....
ANNE ADI	:	SERİ NO	: .....
BABA ADI	:	SON GEÇERLİLİK	: .....
TELEFON NO	:	E-POSTA	: .....
ADRES	:		

- Anatomi bilimini ve beden bağışını halka tanıtmak ve yaygınlaştırmak amacı ile bedenimin tamamından, bir bölümünden, organ ve dokulardan çeşitli yöntemler ile hazırlanacak örneklerin halka açık bir müze veya sergide sergilenmesini
  - ☐ onaylıyorum.
  - ☐ onaylamıyorum.
- Toplumda beden bağışı farkındalığının arttırılması ve tıp öğrencilerinin etik sorumluluklarını öğrenebilmesi amacı ile Anabilim Dalı ile paylaştığım şahsi bilgilerimin
  - ☐ gerekirse halkla paylaşılmasını kabul ediyorum.
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Examination of pelvic anatomy by section plastination technique

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Abstract

Objectives: The aim of this study was to provide long-term preservation of the pelvic coronal cross-sections using plastination technique. Thus, we intended to provide a better understanding of the three-dimensional anatomy of the pelvis for education and research purposes.

Methods: The standard plastination method was combined with the section plastination technique. The coronal pelvis sections of 8mm thickness were passed through the plastination stages. At these stages, unlike the techniques in the literature, surgical aspirator was used for cleaning the surfaces of the sections and xylene was used for lightening the plastinates.

Results: At the end of the plastination stages, the sections preserved the real color and texture extremely well. Sections were dry, odorless, hygienic and could be handled without special precaution. Moreover, anatomical details were very clear and understandable, so that any structure could be measured photogrammetrically.

Conclusion: Examination of the pelvic anatomy with coronal sections via plastination method could be very effectively used in education and research. In this way, a technological and up-to-date innovation can be provided for the development and understanding of three-dimensional anatomy. Real examination of cross-sectional anatomy instead of virtual radiological images can provide a useful and effective tool for both students and researchers.

Keywords: 3D anatomy; plastination; pelvis; sectional anatomy

Anatomy 2020;14(3):227–230

Introduction

Plastination is a preservation technique which was developed by Gunther Von Hagens in Heidelberg, Germany in 1978.[1,2] The importance of dissection in anatomy education is well known for long years.[3] Combining traditional cadaver dissection with plastination technique provides a more effective education and research.[2]

The plastination technique relies on replacement of tissue water and lipids by cured polymers in four steps: dehydration, degreasing, forced impregnation and curing.[4,5] Plastinated specimens are easy to handle, durable, hygienic and convenient to use in the laboratory practice, combining reality with modernity.[3] Since it is an educational tool that can keep up with developing technology, it has succeeded to be an interesting educational tool preferred by students.[2,6] Recent studies showed that plastinated specimens are useful materials not only for the anatomy but also in other fields such as histology, pathology, radiology and microsurgery.[7–11]

The anatomy of the pelvis is very important for surgical interventions in both men and women.[12] Operations such as tumor surgeries made within the pelvic fasciae requires a detailed pelvic anatomy knowledge.[13,14] Orientation to three-dimensional and cross-sectional anatomy of the pelvis is crucial to provide a comprehensive adaptation to the pelvic region.[13,15] Examination of the cross-sectional anatomy of the pelvis with the plastination technique can be beneficial for both education and research purposes.[12,13,15]

In this study, the pelvis of a male cadaver was sectioned into 8 mm thick coronal slices and plastinated using silicone plastination technique. The benefits of the cross-sectional plastination technique has been revealed by previous studies in terms of understanding the three-dimensional anatomy.[12,15–18] Therefore, the aim of this study was to show the effectiveness of the cross-sectional plastination technique on pelvis for to provide a better

understanding of the three-dimensional pelvic anatomy for education and research purposes.

Materials and Methods

The study was conducted on a single pelvis of a male cadaver previously embalmed by 10% formalin. The specimen was first washed under running tap water for 24 hours. After draining excess water, the sample was kept at +4°C overnight, and freezed for two days at -20°C and 5 days at -80°C. A band saw was used to get 8 mm thick coronal slices. Using a surgical aspirator and manual water spray, sawdust adhering to the section surface during cutting was removed.

Before dehydration step, sections were placed in a tight-cap container in the coronal order from front to back, using thin separators between them. Cold acetone is preferred to minimize the shrinkage.[13,19] At the end of three months, in a graded series (95% - 97% - 100%) of cold acetone baths (-20°C), dehydration was finished. The specimens were kept in its last acetone bath for one week at room temperature for degreasing.

In impregnation step we followed up two different protocols: First, we used xylene added (S/X ratio: 1/0.6) silicone reaction mixture (S10+S3, Biodur Products GmbH, Heidelberg, Germany) as described by Steinke et al.;[20] second, the impregnation was performed intermittently at room temperature as described by Tianzhong et al.[21] Curing of impregnated slices carried out in a gas-curing chamber in which the specimens exposed to silicone hardener (S6 Biodur Products GmbH, Heidelberg, Germany) vapor again at room temperature. The added xylene removed out from the slices using vacuum chamber (Kena-Tek Inc., Izmir, Turkey) after the curing process.[22]

Figure 1. Sectioning stage (coronal).

Results

After curing and removing out the xylene, a series of coronal sections of pelvis were obtained (**Figure 1**). The sections had clearly determined details of many anatomical structures comparable with radiological images. The articular relations, cartilaginous surfaces, muscles with their origins and/or insertions and neuro-vascular structures were clearly observed (**Figure 2**). Sections were dry, odorless, hygienic and can be handled without spoiling. Cleaning surfaces by using surgical aspirator and water spray has enabled anatomical structures and details to be revealed more clearly and uniformly. There were no rough field or artefacts due to residual sawdust on the final products. It was shown that measurements can made directly on samples, as well as more detailed measurements on the computer from the photographs taken (**Figure 3**).

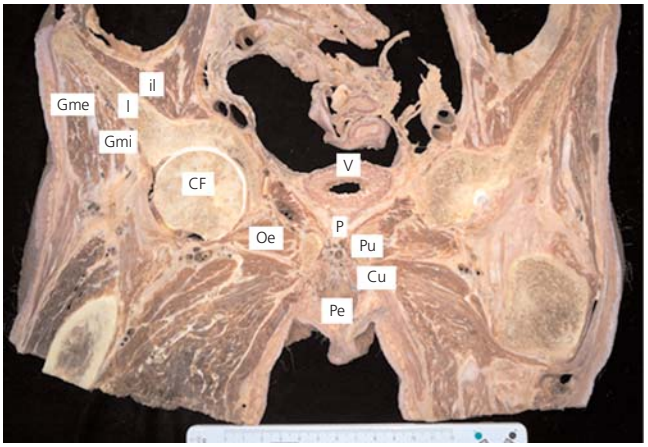

Figure 2. Anatomical details on a coronal section. **CF:** head of the femur; **Cu:** crus penis; **I:** ileum; **il:** iliacus; **Gme:** gluteus medius; **Gmi:** gluteus minimus; **Oe:** obturatorius externus; **P:** prostate; **Pe:** penis; **Pu:** pubis; **V:** urinary bladder.

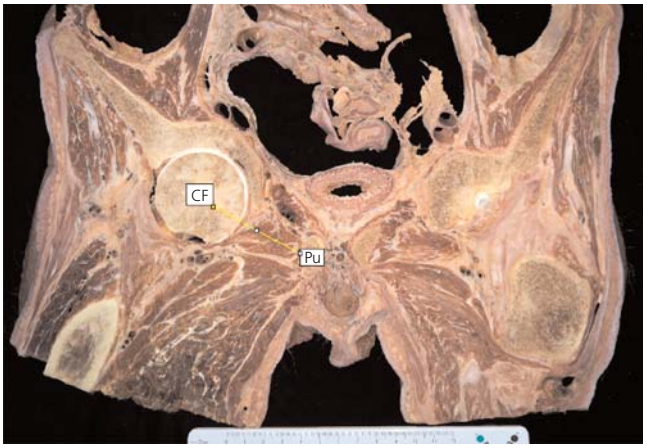

Figure 3. Photogrammetric measurement on a cross section (for example: measuring the distance between femur and pubis). **CF:** head of the femur; **Pu:** pubis.

Discussion

Anatomy is taught in a traditional systematic way in most of the medical schools or faculties.[23,24] Along with clinic and surgical education in advanced classes, the students are also expected to adapt cross-sectional anatomy particularly when interpreting radiological images. Adaptation to cross sectional anatomy necessitates understanding and comprehending the structures beyond the systematic anatomy thus may cause anxiety to students who learned anatomy with a traditional approach. Therefore, it is suggested to acquire new and diverse tools in accordance with the developing technology.[25,26]

One of the most popular methods demonstrating three-dimensional anatomy is the plastination technique.[3] This technique has some advantages and disadvantages.[6] The advantages of plastination are that the whole body, parts or organs can be made palpable, hygienic, odorless and durable, preserving the perception of reality.[6,19] Plastinating especially the parts of the cadavers that have complex anatomy enables the three-dimensional understanding of the anatomy with a more comfortable training tool.[13]

Anatomical structures begin to deteriorate after a certain time in cadavers or cadaveric parts preserved in embalming solutions. It is very difficult to preserve the cross-sectioned structures in an embalming solution since their integrity breaks down in a very short time. Particularly, the parts of the thin sections in the solution can easily be separated from each other and it becomes difficult to demonstrate. Plastination is suggested to be one of the best preservation methods for the cross-sectional anatomical structures.[2] When compared to learn the cross-sectional anatomy from atlases and radiological images, plastinated materials provide better orientation to adapt the three dimensional anatomy with the comfort of seeing, holding and examining the real structure. In this way, learning the relationships of the structures within a given section becomes more satisfying.[6,13,15,19] The disadvantages of the plastination method are that the materials and devices used are expensive.[6,19] In addition, the toxic effects of the chemicals used during the procedure should not be ignored.[27]

Clinical significance of pelvic region is different in women and men.[12] Knowledge of anatomy of the pelvis is very important especially for the surgeons operating within the pelvis.[13] Plastinated specimens are useful tools for comprehension of the detailed anatomy of the body regions. Sheet plastination materials are prepared using epoxy and polyester resins.[11,12,28] In this study, the plastination of 8 mm coronal sections of a male pelvis, inspired by the sheet plastination technique, was performed by silicone plastination of the body parts. Silicone plastination is a convenient option to prepare cross-sectional materials for laboratories that do not have adequate equipment or experience to make epoxy and polyester sheet plastinates. One of the important details of our method is adding xylene to the silicone mixture that provides low cost and low weight. Cleaning slices with a surgical aspirator provided a clean and artifact-free surface much more easily. In addition to this, taking photographs from the samples with a scale may allow to morphometric studies and researches relying on photogrammetric measurements through appropriate software on the computer.

Conclusion

The use of plastinated products have significant contributions to both education and research. In this way, the cross-sectional anatomy displayed in the virtual area can be perceived with a real material. We suggest that the examination of the pelvis sections in the coronal plane with the silicone plastination technique will provide a useful tool for adaptation to three dimensional anatomy of the pelvic region.

Conflict of Interest

No conflict declared by the authors.

Author Contributions

All authors equally contributed to concept, design and writing manuscript.

Ethics Approval

The study was approved by the ethics committee of Ege University Faculty of Medicine (Approval number: 2018-12.1/38). The study was performed following the aid of the ethical standards down in the 1964 Declaration of Helsinki and its later amendments.

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Letter: what is new about triticeal cartilage?

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Anatomy 2020;14(3):231

Dear Editor,

I would like to make comments and contributions to the article about the triticeal cartilage conducted by Koca et al.[1] I have read this study with great interest and curiosity.

Koca et al.[1] aimed to investigate prevalence of the triticeal cartilage with its morphometric properties such as length, width and shape. There are some examples focusing on same purpose with different methods.[2–4] The number of participants included the current study seems lower than other prevalence studies. Increasing participant number may be beneficial for improving the strength of study.

Koca et al.[1] aimed to evaluate morphometric properties of the triticeal cartilage. The authors completed length and width measurements, and recorded the distribution of cartilage shapes to achieve this purpose. Alqahtani et al.[3] was the first to describe variable shapes of the triticeal cartilage. Then, Vatansever et al.[4] reported another study based on Alqahtani's classification. Koca et al.[1] used similar classification system but have described three new shapes of the cartilage; hook, double circle and ring. Describing those new shapes makes a great contribution to the current literature. Since those shapes were described for the first time by Koca et al.,[1] a clear description of those shapes may be required to avoid misdiagnosis with pathologies which could appear in that region, such as atherosclerosis. However, calcification status of the triticeal cartilage was not mentioned in this study. The triticeal cartilages may or may not calcified. When they calcified, the calcification pattern could demonstrate differences between individuals. Calcification could begin from outside of the cartilage and continue to its center or vice versa. Calcification situation of this cartilage may affect its appearance on radiologic images. For example, definition of double ring shaped triticeal cartilage could be better explained in more details. Does it mean that there were two different triticeal cartilages on one side or the cartilage began to calcify in a different way? Detailed definition for hook and ring shaped triticeal cartilage is also needed for same concerns.

As conclusion, strength of the study can be improved with clear explanation of new anatomical or clinical facts of the triticeal cartilage. Especially, completing evaluation of calcification status would make the impact of the study stronger. I hope Koca et al.[1] get those opinions positively and improve their further studies about the triticeal cartilage with these aspects.

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In reply to: what is new about triticeal cartilage?

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Anatomy 2020;14(3):232

Dear Editor,

We would like to thank Dr. Vatansever[1] for his interest in our paper and for spending time to express his contributions. His valuable comments provided us significant insight regarding the content and the analysis of our study.[1] We would like to kindly provide further details regarding the newly observed shapes of triticeal cartilages taking the calcification pattern into account.

The study on triticeal cartilage primarily aims to prevent confusion with atheroma plaques, which may occur in the common carotid artery. The atheroma plaques are important to recognize since they have a potential risk of causing stroke and can easily be mixed with calcified triticeal cartilage during the evaluation of radiological images since they both have similar anatomical location. Triticeal cartilage measurements of Koca et al.[2] were made on computed tomography images. The measurements made by Alqahtani et al.[3] and Vatansever et al.[4] were examined on computed tomography angiography and triticeal cartilage was classified according to its shape in a similar pattern. Joshi et al.[5] studied the triticeal cartilage on cadavers and classified the cartilage according to its shape as oval, circular, pyramidal, spindle and cylindrical.[5] However, as shown in the tables and figures of the study by Koca et al.,[2] different types of triticeal cartilage were reported as hook, double circle and ring, which were not previously identified. These cartilages were named according to the shapes in which they were observed.

"Ring-shaped triticeal cartilage" was observed in 12 (7.19%) out of 167 males, while it was not detected in 65 females (p=0.02).[2] In the post hoc G-power analysis performed to determine the strength of this difference, the statistical power was calculated as 98.8%.[6] Ring-shaped cartilage with a cavity may be due to the calcification which started from the outside of the cartilage while the middle was not yet calcified. On the other hand, "double circle-shaped triticeal cartilage" was viewed as if the two cartilages were placed on top of one another, although it was actually single. Furthermore, in "hook-shaped triticeal cartilage", the calcification of the cartilages might have started unilaterally from the right or left side as a thin, incomplete round shape like a crescent.

To sum up, triticeal cartilage variations were investigated more comprehensively and new shapes of cartilages were added to the already known types by Koca et al.[2] We suggest that histological studies in large series of cadavers will be more effective to identify new types and make comment on calcification status of triticeal cartilage.

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On the Front Cover:
(**a**) Axial (**b**) coronal and (**c**) sagittal MSCT sections of a 35-year-old female patient, bilateral aberrant ICA on the right is more prominent and in contact with the tympanic ossicles (**white arrows**). From Burakgazi G, Bayaroğulları H. Non-inflammatory and non-neoplastic soft tissue lesions of the tympanic cavity. *Anatomy* 2020;14(3):157–164.

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