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Namaste: The Traditional Indian Way of Greeting Goes Global during Coronavirus Disease (COVID-19) Pandemic

Namaste is an expression of goodwill and welcome to each other. There are various ways of greetings in different countries and cultures; however, the common one's are *Namaste*, handshake, and bowing forward.

The *Namaste* is a customary Hindu greeting in the Indian subcontinent, Southeast Asia, and Indian Diaspora, worldwide.[1]

Although this way of greeting is in existence since the ancient Vedic times, recently it grabbed the attention of the whole world due to rampant spread of coronavirus disease by physical contact, leading to huge toll of deaths across the geographies.

The *Namaste* is spoken with a slight bow of head and hands pressed together with palms touching and fingers pointing upwards and thumbs facing towards the chest of the person greeting, as in worship pose [Figure 1].

The other person also responds in the same fashion. The literal meaning of term *Namaste* is *"I bow to the divine in you"*. Thus, it is an attempt to unite the spiritual oneness among two people.

Since in this form of greeting, there is no physical contact. It reduces the chance of infection which could otherwise spread in the hospital and community environment. There is enough scientific evidence that microorganisms spread through the hands of patients, their relatives, and healthcare workers.[2]

The WHO had advised that hygiene is the first pillar of safety to patients.[2] It had been noted that hands get frequently contaminated with various microorganisms such as fecal bugs due to improper cleaning and nasal and oral droplets containing pathogens (bacteria and viruses) due to sneezing and coughing; further infection from hands is transferred to the door knobs, tables, and other surfaces you touch.

In many countries such as the United States of America, European countries, Russia, and Nigeria, handshake is the preferred way for greeting other people. During handshake, one clasps the hand of a person to be greeted, often giving a brief but firm up and down shakes [Figure 2].

Since during handshake, there is physical contact when two persons greet each other. This makes them prone to spread the infection among each other, which may lead to epidemic and even pandemic in the community. However, in the present era of emergence and re-emergence of various viruses, it is time to rethink about the form and manner of greeting so that unnecessary physical contact could be avoided. This along with regular handwashing with soap and water will play a great role in preventing the spread of infection in hospital and community settings.[3] Similarly, bowing forward to greet a person with some distance which is widely practiced by Japanese, Chinese, Tibetans, Koreans, Burmese, Indonesians, Vietnamese, Cambodians, and other descendants of yellow race is another foolproof way to maintain social distance and prevent spread of infection by physical contact.

The guidelines of the WHO to control the swine flu, influenza (by H_1N_1 virus) more or less pandemic in 2010 also include hand hygiene.[4]

Recently, due to rampant spread of the coronavirus (COVID-19) and huge toll of deaths, it caused across the geographies. Many world leaders felt that by shaking the hands with people who carry the microbes of coronavirus on their hands is a sure way of contacting corona infection.

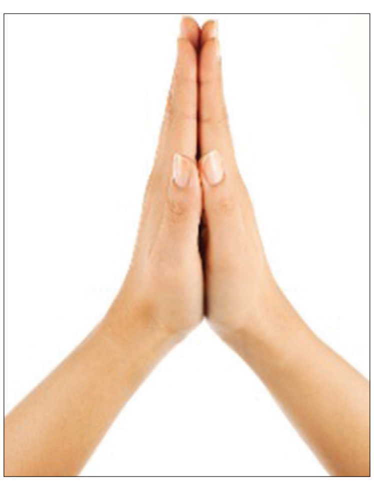

Figure 1: "*Namaste* pose" – the traditional Indian way of greeting

Figure 2: "Handshake" – the traditional Western way of greeting

Since in *Namaste*, there is no physical touching of the other person while greeting. There is no risk of contracting COVID-19 infection from other person.

As a result, the traditional Indian way of greeting, i.e., *Namaste*, has now grabbed the attention of world leaders as a potentially safe way of greeting people.

Recently, not only Indian leaders but also world leaders such as Mr. Donald Trump, the President of the United States of America, Mr. Prince Charles of the United Kingdom, and Mr. Benzamin Netanyahu chose *Namaste* to greet the people.[5-7] WHO official greeted Dr. Harsh Vardhan (Health and Family Welfare Minister of India) with '*Namaste*' as he took charge as its Executive Board Chairman.

Conclusion

Namaste, the traditional Indian way of greeting, is safe as it is not going to contract the infection from the person you are greeting and simultaneously can also follow social distancing of your comfort. On the other hand, shaking of hands with people who carry microorganisms in their hands is surely going to reduce the interpersonal distance to hazardous level and transfer the disease to you which, during the epidemic or pandemic, may cost dear to the whole nation and the entire world. Therefore, if you think that shaking hands is a friendly gesture toward each other, think again as it can be a serious life-threatening bargain. The *Namaste* could be the better option as it reduces the chances of spread of infection among community.

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Original Article

Radiological Study of the Adipose Tissue at the Para-Cavernous Region of Middle Cranial Fossa

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Abstract

Introduction: The cavernous sinus (CS) lesions are difficult to identify on computed tomogram (CT) film, and the subtle changes may help in the diagnosis. The objective of the present study was to examine the para-cavernous adipose tissue in the CT scan in the Indian population. **Material and Methods:** The study included 100 patients of all age groups, who were examined using a 16 slice multidetector CT. The axial images were analyzed for the presence of adipose tissue on either side of the CS. The intracranial pathology and atrophic changes, if any, were noted. **Results:** The present study observed that 17% of the patients had intracranial pathologies. Among the 83% of patients with no pathology, paracavernous adipose tissue was observed in 85.5% and 89.2% over the right and left sides, respectively. It was observed that the paracavernous fat was visualized in higher frequency in elderly adults. It was visualized in all the patients (100%) of over 60 years. In some patients, with mass effect, the paracavernous fat was obliterated over the ipsilateral side, but it was visualized on the contralateral side. **Discussion and Conclusion:** The present study suggests that the CS lesions are difficult to identify on the CT scan, and the subtle signs may help in making a diagnosis. The para-CS adipose deposit is one among these subtle changes; if there is the presence of adipose tissue on one side and its absence on the other side, then pathology should be suspected.

Keywords: *Cavernous sinus, computed tomogram brain, para-cavernous adipose tissue, parasellar fat*

Introduction

Neurosurgeons, radiologists, ophthalmologists, and anatomists are studying the cavernous sinus (CS), and it is the venous structure, which lies one on either side of the hypophyseal fossa. CS has the internal carotid artery (ICA) and cranial nerves in it.[1] CS extends from the superior orbital fissure until the dorsum sellae.[2] The CS receives the drainage of veins of orbit, and CS itself will drain into the petrosal sinuses.[3] The CS communicates with pterygoid venous plexus through an emissary vein. It receives the superficial middle cerebral vein, and central vein of the retina. The ICA passes medially within the CS, and the abducent nerve (sixth cranial nerve) is present in the middle of the CS inferolateral to the ICA. The oculomotor (III), trochlear (IV), ophthalmic (V1), and maxillary (V2) division of trigeminal nerves are located at the lateral wall of the CS.[4] The maxillary nerve enters the foramen rotundum after leaving the CS. The ophthalmic nerve is found in the entire lateral wall of the CS and it goes toward the superior orbital fissure.[2]

The CS is posteriorly related to the trigeminal ganglion, which is covered by a fold of dura mater known as Meckel's cave. The infratemporal fossa lies inferior to CS, and it is connected through the foramen ovale. The foramen rotundum connects the CS with the pterygopalatine fossa. Since many important vessels and nerves pass through these foramina and openings, any pathological changes in the adjacent locations can spread to the CS through these openings.[5] It is also true that the CS thrombus can compress the surrounding structures. The CS syndrome is because of the space-occupying lesions, infective diseases, vascular lesions, and inflammations.[6] The orbital congestion, proptosis, sensory loss in the face, sympathetic imbalance, and ophthalmoplegia are the clinical features of the CS syndrome.[2]

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The CS pathology may be missed during the routine computed tomogram (CT) examination, and magnetic resonance imaging (MRI) is considered as the best investigation by the radiologists. Under some circumstances, the CT scan is still advised because of some other reasons. In these situations, it is believed that the subtle changes around the CS will play a key role in suspecting the pathology. The CS may contain fatty deposits, which are considered as normal findings. The margins of the fissures and openings of the parasellar region at the middle cranial fossa are also surrounded by the adipose tissue deposits.[7] The absence of the adipose tissue is not considered as abnormal either,[8] however some lesions tend to widen the CS, causing obliteration of the adipose tissue at the parasellar region. The literature search revealed that there are not many studies available about the paracavernous adipose tissue in the Indian population.

Aims and objectives

The objective of the present investigation was to radiologically examine the adipose tissue in the paracavernous region in the Indian population.

Material and Methods

The present study included 100 consecutive patients of all age groups, who were examined using a 16 slice multidetector CT. Among them, 50 each was male and female patients. The CT examination of the head was performed with 5-mm slice thickness using the helical scanning technique in the axial plane, which was later reconstructed into 0.625-mm slice thickness images. Each image was observed for the presence of paracavernous fat on either side of the CS. Any intracranial pathology, if present, was noted. The atrophic changes in elderly patients were also noted.

Results

The present study observed that 17 (17%) of the patients had intracranial pathologies. The intracranial pathology included hemorrhage, infarction, and space-occupying lesions. The remaining 83 patients (83%) had no obvious pathology, except few elderly patients who had their age-related atrophic changes. Among these 83% of patients with no pathology, the paracavernous adipose tissue was observed in 85.5% (71 patients) and 89.2% (74 patients) over the right and left sides, respectively. In the rest of these patients, there was no discernible *Parasellar Fat*.

It was observed that paracavernous fat was visualized in higher frequency in adults with increasing age [Figure 1], and it was least visualized in the pediatric age group. In the age group of 1–10 years, only 1 among 5 patients (20%) presented with paracavernous fat, however after the age of 60 years, it was visualized in all the patients (100%) [Figure 1].The frequency of visualization of paracavernous adipose tissue in the CT examination of various age groups in the present study is represented in Figure 1. The present study observed no gender-based discrimination in the visualization of paracavernous adipose deposits. In 3 of the patients (3%), the paracavernous fat was observed unilaterally, and there was no pathology observed even on detailed radiological examination on both sides. This CT observation is suggestive of asymmetrical adipose tissue.

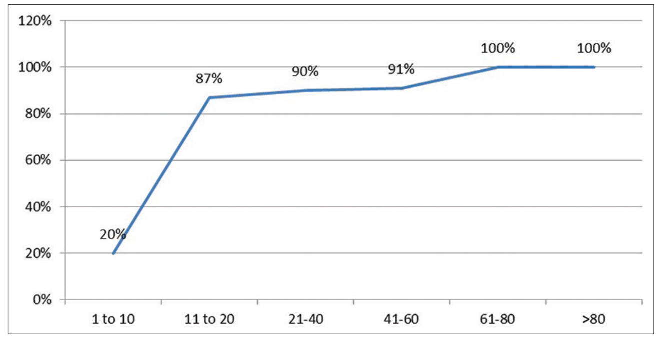

Figure 1: Frequency of visualization of paracavernous adipose tissue during the computed tomogram examination in different age groups of the patients of the present study (*n* = 100)

Among the 17 patients (17%) who had intracranial pathologies, the adipose tissue at the para sellar region was still visualized in a few of them. The paracavernous adipose tissue was observed in both right and left sides in 5 patients (28%). It was observed that these patients had intracranial lesion, which was not causing the mass effect. In few of the patients, with mass effect like uncal herniation due to large intracerebral bleed, huge infarct, space-occupying lesion, etc., the paracavernous adipose tissue was obliterated on the ipsilateral side, but the contralateral side paracavernous fat was always visualized. The paracavernous adipose tissue was visualized only on the right side in 6 patients (36%) and only on the left side in the remaining 6 patients (36%). These CT observations suggest that the intracranial pathology has no correlation with the presence or absence of paracavernous adipose tissue. Further the paracavernous fat was asymmetrical.

Figure 2 shows the axial CT image of a patient in the present study, which visualized the normal para-cavernous adipose tissue on the right side [double white arrows in Figure 2] and the obliteration of the adipose tissue on the left side [solitary black arrow in Figure 2]. The T2 weighted MRI image of the same patient has confirmed the extra-axial lesion at the left paracavernous region [solitary white arrow in Figure 3], which was histopathologically confirmed as the meningioma.

Discussion

The MRI is the investigation of choice if the CS pathologies are suspected.[9] However, many patients with CS lesions tend to present with nonspecific symptoms such as headaches or gradually diminishing vision. In such cases, the CT is the imaging modality, which is usually preferred

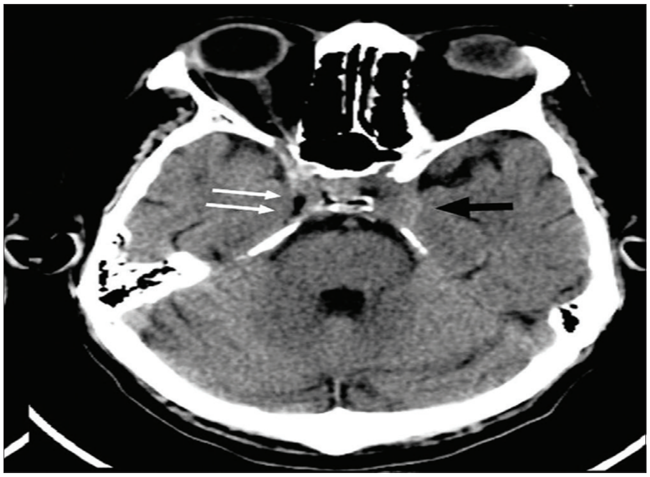

Figure 2: Axial computed tomogram image of a patient, visualizing the normal paracavernous adipose tissue on the right side (double white arrows) and the obliteration of the adipose tissue on the left side (solitary black arrow)

Figure 3: T2 weighted magnetic resonance imaging image of the same patient confirmed the extra-axial lesion at the left paracavernous region (solitary white arrow), which was histopathologically confirmed as the meningioma

taking the duration and cost factor into consideration. CT is also the preferred modality in oral and maxillo facial tumors to assess the tumor spread and bone involvement. The clinical history of one among our patients in the present study, an elderly gentleman, suggested that he presented to the hospital with the left orbital pain. He was also noted to have left third and fourth cranial nerve palsies. The proptosis was not observed over the left eye, and the ultrasound scan did not reveal any orbital or retro-orbital mass lesions. The plain CT of the head did not reveal any abnormality on the initial look. However, on the second look, there appeared to be an asymmetry of the adipose tissue, which is found lateral to the parasellar region. The para cavernous fat on the right side was distinctly visible, and there was the obliteration of the left para cavernous fat [Figure 2]. This gave us a clue to believe that the patient may have an underlying structural lesion. The MRI of the same patient revealed an extra-axial lesion at the left CS exactly at its lateral wall, which was apparent on the thin T2-weighted images [Figure 3]. The patient went for craniotomy and decompression by the neurosurgeon, and the tumor was sent for the histopathological examination. The histopathological report was that of meningioma.

The present study observed that the parasellar adipose tissue was very much obvious in elderly individuals [Figure 1]. This could be related to the occurrence of subtle brain atrophy as the age progresses. In some patients of the present study, the adipose tissue was observed only on one side. This adds a subtle clue to assess the level of mass effect on the CS in these patients. It is believed that the existence of fat in the parasellar space is important. The loss of adipose tissue around the superior orbital fissure is seen in orbital tumors spreading into the CS.[10] Whenever there is a perineural spread of tumor along the openings at the skull base, the obliteration of the fat at that opening is a subtle sign, which helps in assessing the extent of the tumor spread. Many CS pathologies such as CS hemangiomas or cavernous segment ICA aneurysm tend to expand the CS. The lesions which arise from the dura mater at the lateral wall of the CS like meningioma will expand the CS and make it appear bulkier. In these conditions, there is the loss of the adjacent fatty deposits, and the CS appears to lie in close approximation to the adjacent medial temporal lobe.[3]

The CS has no valves, which permits the blood to flow in both directions as per the requirement. The CS is prone to sepsis and thrombus formation because infection from multiple locations can reach it. CS has connections with the face and the infratemporal fossa. The inflammations at the sphenoid and ethmoid sinuses are the most common source of CS infection, which may be complicated as cavernous venous thrombosis (CVT). The inflammations at "dangerous area" of face, nasal cavity, tonsillitis, soft palate, dental caries, and otitis are not commonly leading to CS infection because of the widespread use of antibiotics.[11] The orbital inflammation very rarely cause CVT, although the CS drains the superior and inferior ophthalmic veins.[12] CS can also get involved in the malignancies; the carcinoma nasopharynx is the most common to metastasize into the CS through the skull base and the openings such as foramen rotundum, vidian canal, and foramen lacerum. However, it has been reported that the metastasis into the CS is rare.[3,13] However, the metastasis can arise from renal, gastric, thyroid, bronchogenic, and breast malignancies. This can lead to the enlargement of the CS, lateral bulge of its peripheral part, and eventually would lead to the replacement of Meckel's cave with the connective tissue.[3,13] The sphenoidal air sinus cancers would directly reach the CS by eroding the body of sphenoid.[3,10]

It is described that 5% of all cases of ophthalmoplegia are due to the CS pathology. The etiologies can be grouped into thrombosis, aneurysms, fistulas, and tumors.[2] Meningioma is quite commonly seen in the CS. It can arise within the CS or from the surrounding meninges. The pituitary tumors can invade the CS easily as they are very closely related. They can involve either one side or both the side CS and the ophthalmoplegia will be associated with the endocrine imbalances. This can include acromegaly, galactorrhea or hypopituitarism. The pituitary tumors, invading the CS often present with unilateral or bilateral visual field defects.[2]

The Tolosa-Hunt syndrome is diagnosed by excluding the other causes of the cavernous syndrome. The etiologies such as infective, vascular, neoplastic, metabolic, traumatic, and inflammatory causes, have to be excluded. This syndrome is caused by a granulomatous inflammation or pseudo-tumor at the ventral part of the CS closer to the superior orbital fissure. The patients with this syndrome suffer from the retro-orbital pain along with the ophthalmoplegia with or without optic nerve involvement. The patient will be having a chronic history of symptoms with spontaneous remissions.[2]

Conclusion

After the examinations of the CT films in the present study and while making a diagnosis, we observed that the CS lesions are difficult to identify on CT film, and the subtle signs may aid in making a diagnosis. One among them is the obliteration of the para-CS adipose deposit. Even though the paracavernous adipose tissue is not seen in every individual, if there is the presence of adipose tissue on one side and its absence on the other side, the pathology of the CS should be suspected. The patient needs careful reassessment to localize the pathology and to make the correct diagnosis. We believe that the present study highlighted the subtle, hidden sign of this paracavernous adipose tissue in evaluating the CS lesions and as an indirect sign of the mass effect of the lesion.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

A Comparative Analysis of Morphological Parameters in South Indian Hip Joints with Review of Literature

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Abstract

Introduction: The morphology of the proximal femur is an essential parameter in the design and development of implants for total hip replacement. Inappropriate implant design and size could affect the outcome of the surgery with reported complications such as stress shielding, micromotion, and loosening. Most of these implants are designed and manufactured in the European and North American regions, which are presumably based on the morphology of their respective populations. In this study, we try to demonstrate the significant variation in the morphology of South Indian hip joints compared to other ethnicities. **Material and Methods:** This prospective study includes the study of the morphology of 400 adult hip joints. The patients presented to our hospital with complaints other than that related to the hip joint. Various parameters were studied, comprehensively discussed, and compared with other studies done in different ethnic groups. **Results:** The hip joints of the South Indian population have a significantly smaller femoral head diameter and offsets, narrower neck width, and medullary canal diameter when compared to other ethnic groups. The neck-shaft angle was comparable to results from other studies. Gender- and laterality-based variations were observed as well. **Discussion and Conclusion:** Our study demonstrated that the South Indian hip joints are significantly smaller when compared to other Asian hip joints. There were significant gender- and laterality-based variations. This study also provides evidence that implants could be modified to replicate the morphology of the native hip joints.

Keywords: *Hip joint, India, morphometric analysis, population, radiology, total hip replacement*

Introduction

The proximal femoral anatomy differs from person to person based on their ethnicity, gender, age, bodyside, measurement methods, climate, clothing, and lifestyle. Ethnicity, however, is a crucial factor, and many studies have been conducted to prove the same.[1-11]

The variation of the anatomy of the proximal femur is due to a difference in the femoral head diameter (FHD), neck-shaft angle (NSA), neck width (NW), acetabular version (AV), and acetabular angle (AA).[1,3,12,13] The AV is a significant parameter during total hip replacement (THR) as potential complications such as early postoperative dislocation of the prosthesis may be avoided if measured accurately.[3,14,15] An abnormal AV predisposes the patient to osteoarthritis of the hip joint, developmental dysplasia of the hip joint,[3,16,17] and gluteal tendinopathy.[3,18]

NSA is another essential morphological characteristic of the proximal femur. Studies have shown that an increase in NSA renders the patient vulnerable to proximal femoral fractures.[19,20] On the contrary, lower NSA in females has been reported to cause greater trochanter pain syndrome.[3,21]

The commonly used implants for hip surgeries include a dynamic hip screw, cancellous screws, cephalomedullary proximal femoral nails, and prosthesis for hemiarthroplasty and THR.[1,22] These implants are designed based on the morphometry of proximal femur and hip joints of the Western population. Siwach and Dahiya[23] studied the Indian cadavers and found that the implants in the proximal femur were oversized with a mismatch of angles and orientation of the implant. This causes the implant to fail, along with splintering or fractures. Pathrot *et al.*[24] recommended customizing the cephalomedullary nails for Indian patients by reducing the NW. Leung *et al.* studied the need to modify the gamma nail to

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suit the Asian population due to narrow NW and smaller femoral head.[1,25]

During THR surgery, it is essential that the prosthesis matches the geometry of the native bone to avoid complications such as aseptic loosening, pain, and improper load distribution.[1,8] The secondary biological integration of the uncemented stem depends on the quality of primary stability. Any mismatch between the implant and the native bone will affect the bone ingrowth into the implant due to micromotion during the postoperative period. This micromotion causes aseptic loosening, osteolysis, and thigh pain.[1] It is also important that the prosthesis allows uniform load transfer through it to prevent stress shielding.[1]

Material and Methods

This prospective study was conducted at JSS Medical College and Hospital, Mysore, from August 2017 to January 2018. The institutional review board clearance was taken for this study (JSSMC/IEC/04/2007/2017–2018). This study included the morphometric study of 400 hip joints from 200 patients both male and female who underwent a computed tomography (CT) scan of the abdomen and pelvis/CT kidney, ureter, and bladder (KUB) for nonorthopedic complaints. All patients between 20 and 75 years of age were included in this study. Patients who underwent abdomen/KUB/pelvis CT scan for other reasons in JSS Medical College and Hospital with clinically normal hip joints on examination were included in the study. Patients with preexisting hip joint pathologies such as osteoarthritis, rheumatoid arthritis, old fractures, dislocation of the hip joint, fracture of the proximal femur or acetabulum, and deformities of the lower limb and spine were excluded from the study. Radiographic assessment of both the hip joints was done for each patient. PHILIPS 124 sliced CT scan with a 1-mm slice thickness was used for the study. The patients were placed in the supine position during imaging with both hip joints in neutral rotation. The superimposition of motion artifact was avoided.

Radiological analysis of the hip joints included measurement of FHD, NW, neck-shaft angle (NSA), horizontal offset (HO), vertical offset (VO), medullary canal diameter at LT, AA of sharp, and AV using picture archiving and communication system. The measuring process was optimized using a full-screen view, and the images would be magnified to maximize resolution and accuracy. Radiographic parameters were defined as follows.

Neck-shaft angle

It is the angle intersected between the long axis of the femur and the long axis of the neck of the femur. The femoral shaft axis is a line drawn by extending through two equidistant points from the mediolateral surface of the femoral shaft in the center of the medullary canal. Neck axis is drawn by joining two points equidistant from the superior and inferior surface of the femoral neck.[1,26]

Femoral head diameter

A perfect circle is drawn over the ideally spherical femoral head, and circle diameter is measured.[2,26]

Neck width

A perpendicular line to the neck axis at the narrowest part of the femoral neck is measured.[2,26]

The acetabular angle of sharp

The acetabular angle of sharp is the angle formed by the lateral margin of the acetabular roof, the inferior aspect of the pelvic teardrop and a horizontal line running between the inferior aspect of both pelvic teardrops. In the coronal sections of CT scan images, a horizontal line is drawn through the teardrop and another line drawn from the tip of the teardrop to the anterior edge of the acetabulum. The angle formed between these two lines is defined as the AA of sharp.[15,27,28]

Horizontal offset

Horizontal offset or femoral offset is the horizontal distance from the center of rotation of the femoral head to a line bisecting the long axis of the shaft of the femur.

Two lines were drawn: one along the center of the femoral head and another along the middle of the femoral medullary canal. The measured distance between the two lines gives the HO.[26]

Vertical offset

Vertical offset or femoral head position is the vertical distance from the center of the femoral head to the tip of the lesser trochanter.[1,26]

Medullary canal diameter at the level of lesser trochanter

Mediolateral width of the medullary canal was measured at the level of the middle of the lesser trochanter.[1,26]

Acetabular version

It is the angle measured between a line connecting both the posterior ischia and a line connecting the posterior lips of the acetabulum.[3,15,29,30]

The values were measured by two independent observers and were repeated after 2 weeks by the same observers to reduce the error of calculation. Statistical analysis was carried out using IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. (Armonk, NY: IBM Corp).

Results

Femoral head diameter

The mean value for our population is found to be 40.09 mm, with a confidence interval (CI) of 39.34–40.83. The mean value for males was 42.48 mm and for females 33.70, with the CI narrowed down to 42.27–42.69 in males and 36.85–37.93 in females, respectively. The gender difference between FHDs was statistically significant ($P < 0.001$). There was no statistical significance among right and left hip joints.

Neck width

The mean value for NW in our population was 28.29, with CI of 39.34–40.83. In males, it was 30.46, and in females, it was 25.85, with CI of 30.28–30.64 in males and 27.32–26.39 in females, respectively. Higher NW ($P < 0.01$) in males was statistically significant compared to female hip joints. However, there was no significant difference in NW between left and right hip joints.

Neck shaft angle

The mean value for NSA in our study population was 130.68, with CI of 129.61–131.75. The mean NSA in males was 131.22 and in females 130.06, with CI of 130.77–131.67 in males and 128.37–131.76 in females. There was no statistically significant difference between male and female NSA measurements. However, the left hip joint had a statistically significant higher ($P < 0.001$) mean NSA compared to the right hip joint.

Horizontal offset

The mean HO of our population was 36.50, with CI of 35.70–37.29. The mean value in males was 37.93 and in females 34.88, with CI of 37.63–38.22 and 33.89–35.87, respectively. There was a statistically significant higher ($P < 0.01$) HO among male hip joints compared to female hip joints. The mean HO of the right hip joint was significantly higher ($P < 0.01$) than that of the left hip joint.

Vertical offset

The mean VO in our study population was found to be 49.20 mm, with CI of 47.86–50.53. The mean values for males were 52.42, and in females were 45.56, with CI of 51.65–53.19 and 44.13–46.99, respectively. The male hip joint demonstrated a statistically significant higher ($P < 0.001$) mean VO compared to the female hip joint. However, no significant difference in VO was observed between the left and right hip joints ($P = 0.27$).

Medullary canal diameter

The mean value of medullary canal diameter in our population was 26.14 and CI was 25.27-27.00. The mean among males was 27.01, with CI of 26.76–27.27, and the mean among females was 25.15, with CI of 23.75–26.54. The canal diameter was significantly higher in male hip joints compared to female hip joints ($P < 0.01$). The left femur had a wider diameter of medullary canals compared to the right side ($P = 0.02$).

Acetabular angle of sharp

The mean value of AA in our population was found to be 37.50, with CI of 36.78–38.21. The mean value for males was 37.44, and for females, it was 37.56. The CI was 37.20–37.68 among males and 36.51–38.61 among females. There was no statistically significant difference between male and female hip joints ($P = 0.87$). There was no significant variation in AA between left and right hip joints.

Acetabular version

The mean value for AV in our population was 20.91, with CI of 20.05–21.78. In males, it was found to be 19.46 and in females 22.56, with CI of 19.08–19.84 and 21.53–23.58, respectively. The female hip joint demonstrated a statistically significant higher AV ($P < 0.001$) compared to male hip joints. Furthermore, left-sided hip joints showed a statistically significant higher AV ($P < 0.001$) compared to the right hip joint.

Discussion

Knowledge of the proximal femur and acetabular geometry is essential to understand the biomechanics of injuries, design of implants for various surgeries, and understanding joint-related pathologies such as arthritis. Due to regional and international migration, it is important to understand the subtle morphological variation existing in a given ethnic population set. Implant designs and measurements are generalized by extrapolating data of the Western population set. Our study aims to determine variation in anthropological data of a specific South Indian population set with the help of CT imaging technique such that the knowledge inferred from this can be used to design better-fitting implants that match the native bone geometry. The data from this study could help surgeons restore the normal biomechanics of the native hip joint during hip surgery.

Femoral head diameter

A correlation has been reported between FHD and height of the person Figure 1.[31] In our study, we measured the FHD and compared it to various other studies conducted in India as well as different ethnic population subsets of the Western countries. It was found that the mean FHD in our research is 40.09 ± 3.72 mm [Table 1]. Rubin *et al.*,[7] Mahaisavariya *et al.*,[32] Lin *et al.*,[4] and Noble *et al.*[33] studied the Swiss, Thai, Taiwanese, and the Caucasian population and found the mean FHDs to be 43.4 ± 2.6, 43.98 ± 3.47, 45.41 ± 3.20, and 45.9 mm, respectively. This allows the authors to conclude that Indian hip joints are significantly smaller in size when compared to European or Caucasian population subsets [Table 2].

Studies conducted by Rawal *et al.*,[1] Siwach and Dahiya,[23] and Roy *et al.*[22] revealed that the mean FHDs in the North Indian population are 45.41 ± 3.36, 43.53 ± 3.4, and 45.41 ± 3.36 mm, respectively [Table 2]. This allows us to conclude that the FHDs are larger in the North Indian population compared to the South Indian population. Another study done on 400 South Indian hip joints by Sengodan *et al*.[26] revealed that the mean FHD in their study was 42.6, which was comparable to our results. This study provides additional evidence of variation in the size of the North Indian and South Indian population subsets.

Asala *et al*.[31] studied 504 Nigerian hip joints and reported significantly higher FHD in males compared to the females. Sengodan *et al*.[26] reported a statistically significant ($P < 0.01$) higher FHD in males compared to females in their study of the South Indian hip joints, but there was no significant variation in the FHD of the right hip joint compared to the left. The FHD of the male hip joint (42.48) was significantly ($P < 0.01$) larger than that of the female hip joint (37.39) in our study as well [Tables 3 and 4]. Our investigation revealed that the mean FHD of the left hip joint (40.26) was higher than the right hip joint (39.92) [Table 5].

The FHD is of clinical significance when it involves designing an implant for total hip arthroplasty as a larger FHD of the implant prevents dislocation and reduces long-term morbidity postsurgery.[34] The functional significance is that it helps displace the femoral shaft from the joint to a greater extent such that the range of mobility is not restricted.[35]

Femoral neck width

In our study, the NW measured 28.29 mm Figure 2, with a standard deviation (SD) of 3.44 mm [Table 1]. Ravichandran *et al*.[13] studied the cadaveric femur and reported the mean NW to be 30.99 mm. Sengodan *et al*.[26] reported the mean NW to be 27.5 mm, which is comparable to our study [Table 2]. The male hip joints in our study showed a significantly higher NW compared to females by 4.61 mm [Tables 3 and 4]. A similar variation was observed by Sengodan *et al*.[26] with a gender variation in NW by 2.8 mm. There was no significant variation in NW between the right and left hip joints [Table 5]. The femoral NW has a clinical significance in predicting future risk of hip fractures in men and women. In our study, there was a statistical difference between NWs in men and women. This is of clinical significance because it was found that a cross-sectional moment of inertia, which is an index of bone rigidity, was declining in women at a much faster pace when compared to men. The net effect of this is that the mechanical stresses encountered by the femoral neck appear to increase three times per decade when compared with that of men. Hence, one of the factors of a higher fracture rate in women could be due to the aforementioned reason as well as lack of compensation through geometrical remodeling.[36]

Neck-shaft angle

Gómez Alonso *et al*.[37] and Gnudi *et al*.[19] studied that the NSA is an essential predictor of hip fracture risk. Tuck *et al* Figure 3.[5] studied the UK population and found that the female hip joint NSA was significantly lesser than that

Table 1: Standard values obtained from our study in South Indian population

Parameters	Mean+SD	Confidence interval
Femoral head diameter (mm)	40.09+3.72	39.34-40.83
Neck width (mm)	28.29+3.44	27.61-28.94
Neck shaft angle (0)	130.68+5.35	129.61-131.75
Horizontal offset (mm)	36.50+3.98	35.70-37.29
Vertical offset (mm)	49.20+6.67	47.86-50.53
Medullary canal diameter (mm)	26.14+4.32	36.78-38.21
Acetabular angle of sharp (0)	37.50+3.57	25.27-27.00
Acetabular version (0)	20.91+4.33	20.05-21.78

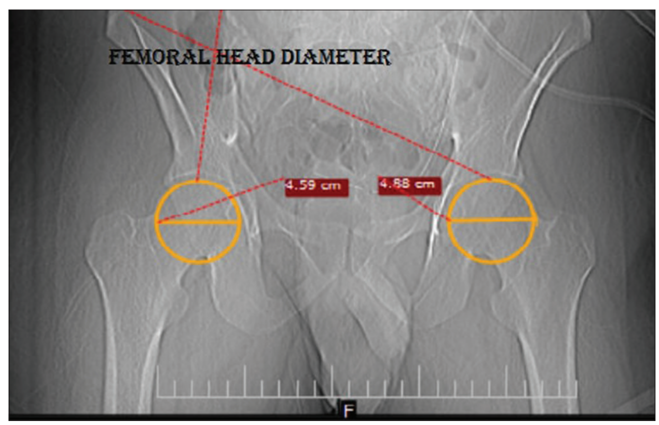

Figure 1: Femoral head diameter

Table 2: Gender-wise comparison of study parameters

Parameters	Male				Female				*P*
	Mean	SD	Range	CI	Mean	SD	Range	CI	
Femoral head diameter (mm)	42.48	3.31	33.50-49.00	42.27-42.69	37.39	1.85	33.70-41.50	36.85-37.93	<0.001
Neck width (mm)	30.46	3.07	22.00-36.00	30.28-30.64	25.85	1.83	23.00-31.50	27.32-26.39	<0.001
Neck shaft angle (0)	131.22	4.88	120.00-144.00	130.77-131.67	130.06	5.82	115.50-144.00	128.37-131.76	0.28
Horizontal offset (mm)	37.93	3.95	29.50-47.00	37.63-38.22	34.88	3.39	31.00-49.00	33.89-35.87	<0.001
Vertical offset (mm)	52.42	6.39	38.00-68.50	51.65-53.19	45.56	4.91	33.50-55.00	44.13-46.99	<0.001
Medullary canal diameter (mm)	27.01	3.69	19.50-34.00	26.76-27.27	25.15	4.78	14.50-45.50	23.75-26.54	0.03
Acetabular angle of sharp (0)	37.44	3.57	26.00-44.30	37.20-37.68	37.56	3.60	28.00-43.00	36.51-38.61	0.87
Acetabular version (0)	19.46	4.49	10.65-28.50	19.08-19.84	22.56	3.52	14.10-30.50	21.53-23.58	<0.001

Table 3: Anthropometric analysis of hip joint parameters in study population using paired *t* test

Parameter	Side	Mean	SD	Range	SEM	*P*
Femoral head diameter (mm)	Right	39.92	3.72	33.00-49.00	0.37	0.11
	Left	40.26	4.03	33.00-50.00	0.40	
Neck width (mm)	Right	28.22	3.66	22.00-37.00	0.37	0.45
	Left	28.37	3.49	22.00-36.10	0.35	
Neck shaft angle	Right	129.56	5.92	111.00-148.00	0.59	<0.001
	Left	131.80	5.78	114.00-146.00	0.58	
Horizontal offset (mm)	Right	37.25	4.27	30.00-50.00	0.43	<0.001
	Left	35.74	4.22	26.40-52.00	0.42	
Vertical offset (mm)	Right	49.41	6.78	33.00-68.00	0.68	0.27
	Left	48.99	7.08	31.00-69.00	0.71	
Medullary canal diameter (mm)	Right	25.79	4.57	15.00-46.00	0.46	0.02
	Left	26.48	4.54	14.00-45.00	0.45	
Acetabular angle (0)	Right	37.50	3.57	26.00-44.30	0.36	0.20
	Left	37.02	3.86	26.00-50.00	0.39	
Acetabular version (0)	Right	20.21	4.64	10.80-30.00	0.46	<0.001
	Left	21.62	4.78	10.00-32.00	0.48	

Table 4: Gender and Side wise comparison of study parameters with overall population values

Parameters	Study population mean value	Male				Female			
		Lowest value		Highest value		Lowest value		Highest value	
		Right	Left	Right	Left	Right	Left	Right	Left
Femoral head diameter (mm)	40.0870	33.00	34.00	49.00	50.00	33.20	33.00	42.00	43.00
Neck width (mm)	28.2960	22.00	22.00	37.00	36.10	22.00	22.00	32.00	31.00
Neck shaft angle (0)	130.6780	117.00	122.00	148.00	142.00	111.00	114.00	147.00	146.00
Horizontal offset (mm)	36.4960	30.00	29.00	50.00	45.00	30.00	26.40	46.00	52.00
Vertical offset (mm)	49.1970	39.00	37.00	68.00	69.00	33.00	31.00	56.00	56.60
Medullary canal diameter (mm)	26.1375	18.00	19.50	34.00	37.00	15.00	14.00	46.00	45.00
Acetabular angle of sharp (0)	37.4967	26.00	26.00	44.30	50.00	28.00	29.00	43.00	43.00
Acetabular version (0)	20.9143	10.80	10.00	28.70	32.00	15.00	11.60	30.00	32.00

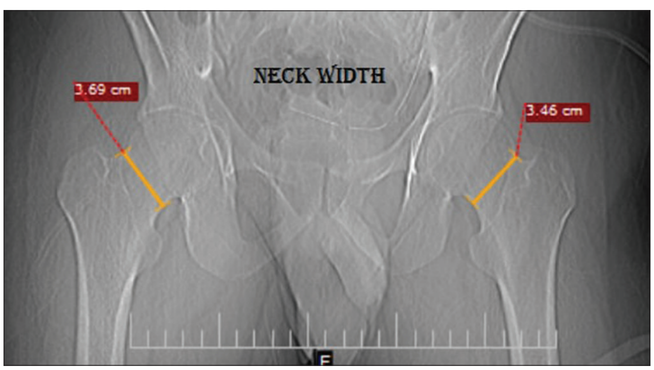

Figure 2: Femoral neck width

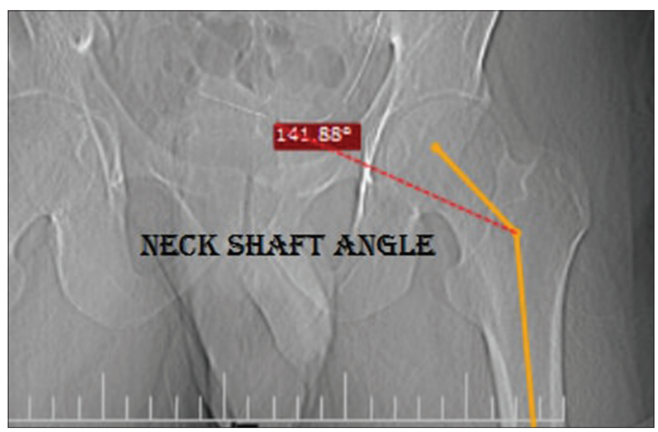

Figure 3: Femoral neck shaft angle

of males. They also correlated the NSA with vertebral fractures and distal forearm fractures and found that the mean NSA was considerably smaller in patients with vertebral fractures and larger in distal forearm fractures. Their analysis confirmed that the NSA was an essential predictor of hip joint injury.

Hoaglund and Low[12] reported that the average neck-shaft angle in adults is 135° among the Hong Kong population subset. Lin *et al*.[4] studied 100 CT scans of the hip joints of Taiwanese people and reported the mean NSA to be 129.88 ± 5.76. Jiang *et al*.[3] studied 466 CT scans of the Chinese population and published the mean NSA to be 133.02 ± 4.49. Mahaisavariya *et al*.[32] studied 108 hip joints of the Thai community and found the mean NSA to be 128.04 ± 6.14. In our study, the mean neck-shaft angle was 130.68 ± 5.35, which is comparable to the East Asian population [Table 2].

Studies were done in the North Indian population by Rawal *et al*.[1] (124.42 ± 5.49) and Roy *et al*.[22] which demonstrated a lower mean NSA when compared to the South Indian population. One study of the North Indian community done by Saikia *et al*.[2] revealed a higher mean NSA of 139.5 ± 7.5 when compared to our review of the South Indian population. Studies done in the South Indian community by Sengodan *et al*.[26] reported the mean NSA of 135.4° [Table 2]. Our investigation revealed a lower mean NSA of 130.68 ± 5.35.

Rubin *et al*.[7] (122.9 ± 7.6), Husmann *et al*.[8] (129.2 ± 7.8), Noble *et al*.[33] (125.4), and Tuck *et al*.[5] (128 ± 1.7 in females and 130 ± 3.3 in males) studied the Swiss, French, Caucasian, and British populations, respectively, and the mean NSA was lower than the mean NSA of our study [Table 2]. Nelitz *et al*.[38] reported that the mean NSA in the German population was 137.3 ± 9.0. Lequesne *et al*.[39] published that the mean NSA in the French population was 132.83 ± 4.37. Boese *et al*.[40] studied 800 German hip joints and reported the mean NSA to be 19.6 in males and 131.9 in females. Jalali Kondori *et al*.[6] studied 260 hip joints of the Iranian population and reported the mean NSA to be 139.5. These studies revealed a higher mean NSA compared to the NSA in the South Indian population. The above results make it almost impossible to predict whether a particular ethnic group is susceptible to hip fractures. East Asians, in general, have lower NSA like the South Indian population, and it can be inferred that these population subsets are at high risk for hip fractures.

In a study conducted by Gnudi *et al*.,[41] it was found that females with a lower femoral neck bone mineral density and higher neck-shaft angle were more prone to hip fractures. Thus, a radiographic analysis of the neck-shaft angle can be used as a predictor of hip fractures. However, in our study, there was no statistically significant difference in the mean NSA between males and females. However, there was a significantly ($P < 0.01$) higher mean NSA of the left hip joint (131.80) compared to the right hip joint (129.56). Sengodan *et al*.[26] similarly reported a significantly higher NSA in the left hip joint compared to the right by 1.6°. They also published a higher NSA in males compared to females by 2.6°.

A study correlating neck-shaft angle and hip fractures in males could be useful in helping us understand the predictability of hip fractures. It was also found in a study that an increase in 1 SD of NSA increased the odds ratio of developing a hip fracture in the future by 2.45 in men

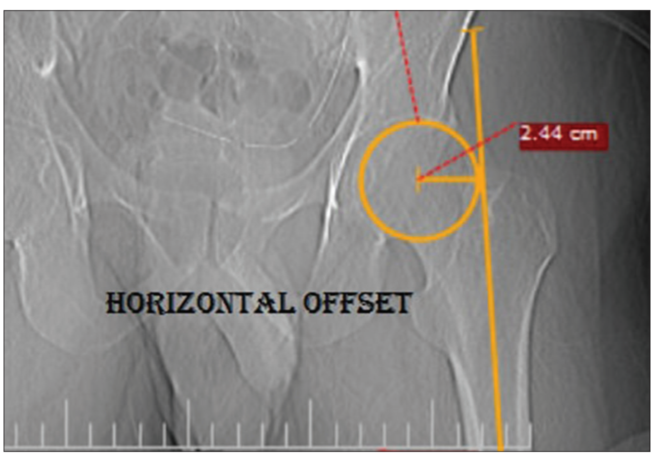

Figure 4: Horizontal offset

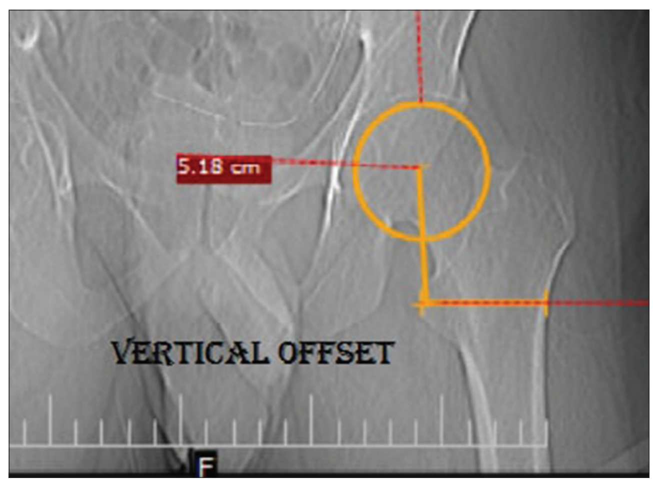

Figure 5: Vertical offset

Table 5: Comparison of present study parameters with results of other published studies

Parameters	Present study (Mean+SD)	Rawal *et al* (Indian) *n*=98 Mean±SD	Saika *et al* (Indian) *n*=104 Mean±SD	Ravichandran *et al* (Indian) *n*=578 Mean	Rubin *et al* (swiss) *n*=32 Mean±SD	Husman *et al* (france) *n*=310 Mean±SD	Mahaisavarita *et al* (thai) *n*=108 Mean±SD
Femoral head diameter (mm)	40.09+3.72	45.41±3.66	-	-	43.4±2.6	-	43.98±3.47
Neck width (mm)	28.29+3.44	-	-	30.99	-	-	-
Neck shaft angle (0)	130.68+5.35	124.42±5.49	139.5±7.5	126.55	122.9±7.6	129.2±7.8	128.04±6.14
Horizontal offset (mm)	36.50+3.98	40.23±4.85	-	-	47±7.2	40.5±7.5	-
Vertical offset (mm)	49.20+6.67	52.33±7.19	-	-	56.1±8.2	57.3±8.1	48.94±4.95
Medullary canal diameter (mm)	26.14+4.32	-	-	-	27.9±3.6	-	-
Acetabular angle (0)	37.50+3.57	-	39.2±4.9	-	-	-	-
Acetabular version (0)	20.91+4.33	-	18.2±5.6	-	-	-	-

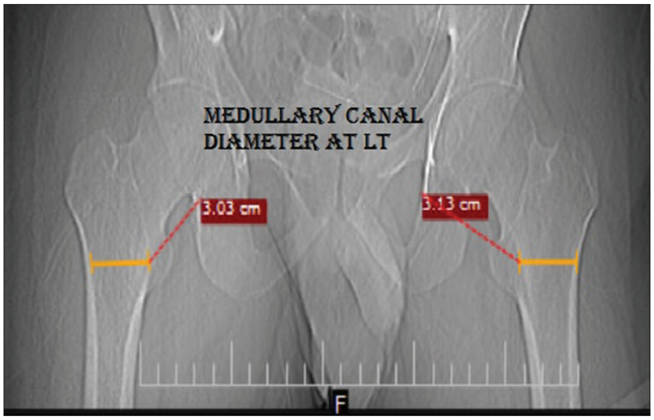

Figure 6: Medullary canal diameter

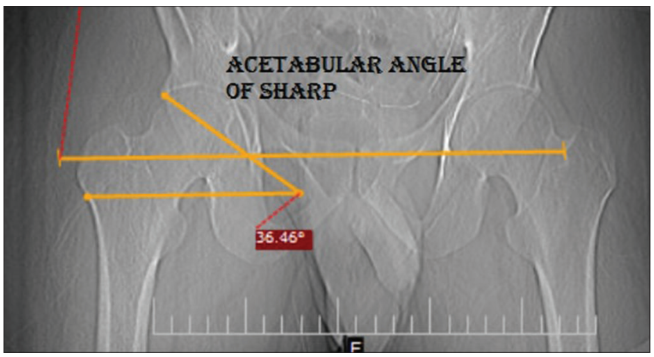

Figure 7: Acetabular angle of sharp

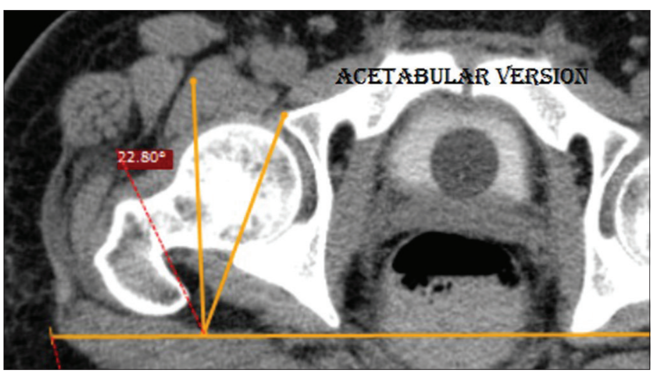

Figure 8: Acetabular version

and 3.48 in women.[37] Jiang *et al*.[3] described that the NSA decreases with age due to a decrease in areal bone mineral density (aBMD). As the aBMD declines with age, the support strength of the proximal femur decreases. Wang *et al*.[42] studied that the deterioration of aBMD without an inadequate compensatory change in the proximal femur geometry led to an increased risk of hip fractures in the elderly population and possibly in females as well.

Horizontal and vertical offsets

In our study, we compared the HO and VO [Figures 4 and 5] to various other studies conducted. The mean value of the HO in our study population was 36.50, with a CI of 35.70–37.29 [Table 1]. The mean value of HO in males was 37.93 and was significantly higher ($P < 0.01$) than HO in females (34.88) [Tables 3 and 4]. The HO was significantly ($P < 0.01$) higher in the right hip joint compared to the left [Table 5]. Other studies have not reported a significant side-based difference in HO. Gender-based differences in HO was observed by Sengodan *et al*.[26] They studied a difference of 4 mm in the HO in between males and females compared to 3-mm gender-based difference in our study [Table 2].

We found that HO was lower in our study (36.50 ± 3.98) when compared to studies conducted by Rawal *et al*.[1] (40.23 ± 4.85), Rubin *et al*.[7] (47 ± 7.2), and Husmann *et al*.[8] (40.5 ± 7.5). However, our results were comparable to Sengodan *et al*.[26] who also studied the South Indian population and found the mean HO to be 37.6 mm. The normal range of HO is 41–44 mm and increases as the size of the femur increases.[7] This further highlights the significant difference in the HO of the South Indian population from the other ethnic subsets around the world.

HO is of clinical significance as it helps improve abductor muscle strength,[43,44] reduces the need for crutches,[45] reduces the chances of limping,[46] enhances the range of motion,[43] and reduces the chances of dislocation of the implant post-THA.[43,47] Hence, femoral offset restoration is an essential part of THA. It can also be used to accurately measure the medullary canal width, which may be of use while designing implants.

The mean VO measured in our study was 49.20 ± 6.67 mm [Table 1]. The VO in our study was lower than that reported by Rawal *et al*.[1] (52.33 ± 7.9), Rubin *et al*.[7] (56.1 ± 8.2), and Husmann *et al*.[8] (57.3 ± 8.1). However, Sengodan *et al*.[26] (46.89) and Mahaisavariya *et al*.[32] (48.94 ± 4.95) reported lower values of VO compared to our study [Table 2]. The knowledge of VO is important during THR to restore limb length. The normal hip biomechanics can be restored only when a normal vertical and HO are maintained during surgery. Sengodan *et al*.[26] reported a significantly higher ($P < 0.01$) VO in males compared to females, which was concurrent with our results. In our study, male hip joints demonstrated a mean VO of 52.42 and females a mean VO of 45.56 [Tables 3 and 4]. There was no significant variation in the VO of the right hip joint compared to the left [Table 5].

Medullary canal diameter

The medullary canal diameter [Figure 6] computed in our study was 26.14 ± 4.32 mm, which was lower when compared to a survey conducted by Rubin *et al*.[7] (27.9 ± 3.6) [Table 2]. However, Sengodan *et al*.[26] reported a mean medullary canal diameter of 20.2. This probably provides evidence that South Indian femurs are narrower compared to the other ethnic subsets. There was no statistical difference in the medullary canal diameter between the right and left proximal femurs. There was no statistically significant variation of the medullary canal diameter between the male and female hip joints as well. This was concurrent with the findings of Sengodan *et al*.[26]

Acetabular angle and version

The AA [Figure 7] of sharp is the most crucial indicator in the diagnosis of dysplasia of the acetabulum.[29] An angle of more than 43° is considered dysplastic.[48] The AA measured in our study was 37.50 ± 3.57. However, this was lower when compared to a survey conducted by Saikia *et al*.,[2] which was 39.2 ± 4.9. Jalali Kondori *et al*.[6] described the mean AA in the Iranian population to be 37.1° which was comparable to our study. We observed the significantly higher AA ($P < 0.01$) in male hip joints compared to females. On the contrary, studies in German,[38] British,[5] Serbian,[49] Malawian,[50] and South Asian[51] populations reported higher AA than our study [Table 2]. These studies also reported higher AA in female hip joints compared to males. Studies in the Nigerian[29] and Korean[29] populations reported a mean AA comparable to our study. Oladipo *et al*.[29] studied the Nigerian hip joints and reported a higher AA in the left compared to the right in both males and females. On the contrary, we found the AA of the right hip joint to be higher than the left by 0.48° ($P = 0.20$).

The center-edge angle is closely related to the AA. It has been found that a center edge angle fewer than 20° is associated with acetabular hip dysplasia;[51] in turn, acetabular hip dysplasia is a factor in the causation of osteoarthritis of the hip.[52] However, there are also some studies that disprove the hypothesis and say that the relationship is irrelevant.[53]

Jiang *et al*.[3] studied that AV [Figure 8] and NSA were two crucial indicators of proximal femoral geometry. AV is essential to describe the orientation of the acetabulum during the insertion of the cup in the right position during THR.[29] Variations from the standard values predispose the patient to various hip disorders such as femoral-acetabular impingement (FAI), osteoarthritis of the hip, and fractures around the hip joint. This supports the evidence that identification of normal values of NSA and AV in a defined population and the various influencing factor is instrumental in issuing treatment protocols of the conditions above.

Stem *et al*.[27] reported that an increase in acetabular version >70 years of age rendered the patient vulnerable to osteoarthritis of the hip joint. Pincer-type FAI was studied to be associated with acetabular retroversion, which is usually seen in females.[54] This could also explain why females were susceptible to pincer-type FAI. This, however, is not the only explanation for the higher incidence of pincer FAI in females. Our also study showed that the AV was significantly higher ($P < 0.01$) in females compared to males by 3.1° which supports the above hypothesis [Tables 3 and 4].

The normal AV measured is 17°, with a SD of 6°.[55] The AV measured in our study was 20.91 ± 4.33. This value was significantly higher when compared to the survey conducted by Saikia *et al*.,[2] which was 18.2 ± 5.6. Various studies have shown that there is a wide variation in the AV in the Indian population, and one hypothesis suggested that such a large difference could be due to evolutionary reasons as Indians are more accustomed to floor-level activities with the increased external rotation of the hip.[56]

Our study also showed a higher AV in females (22.56) compared to males (19.46). Jiang *et al*.[3] found a similar gender-based variation of the AV, being higher in females (20.25 ± 5.28) compared to males (17.88 ± 5.07) in the Chinese population. Sengodan *et al*.[26] reported a higher AV in women compared to men by 1.6°, which was not significant. Murphy *et al*.[57] also published a significantly higher AV in females compared to males by 5° in the American population. Zeng *et al*.[58] reported a higher AV of the left hip joint in males compared to females by 0.5°. However, in their study of the right hip joint, they observed higher AV in females compared to males by 2.1°. Tallroth *et al*.[59] studied Finnish hip joints and found a significantly higher AV in males compared to females by 6°.

We observed a statistically significant higher AV ($P < 0.01$) of the left hip joint compared to the right by 1.41°. Sengodan *et al*.[26] reported a similar significant higher AV ($P < 0.01$) in the left hip joint compared to the right by 1.2°.

Conclusion

Morphology of the hip varies with different ethnic population groups. Our study demonstrated that the South Indian population has a significantly smaller FHD and offsets, narrower NW, and medullary canal diameter when compared to other ethnic population groups. The neck-shaft angle was comparable to results from other studies. Male hip joints demonstrated a larger head diameter, NW, and horizontal and VOs compared to females in our study. Females, however, demonstrated a larger AV angle compared to males. The neck-shaft angle and AV were significantly higher in the left hip joints compared to the right, and HOs showed similar results. This study confirms significant variations in morphometry of the hip joint of the South Indian population.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Association between the Pectoral Muscles and Rib Anomalies in Poland Syndrome

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Abstract

Introduction: The purpose of this study was to investigate the relationship between pectoralis major muscle (PMj) and rib defects in Poland syndrome (PS) and to evaluate the clinical findings and variabilities by the systematic review of all/current published articles on PS. **Material and Methods:** Based on our inclusion criteria, 86 patients were decided to be eligible for participating in this study. The data of the reviewed studies were classified according to the date of publication, age, sex, side of the deformity, defect type of PS, presence of other muscle or chest wall abnormalities, and dextrocardia. Further, other coexisting deformities and abnormalities were recorded. A logistic regression statistical analysis was carried out. **Results:** According to the reviewed cases, both left-sided presence-multiple muscle defects and left-sided presence-rib anomalies were found to be statistically significant (P = 0.007 and P = 0.04, respectively). The strength of the relationship between these two parameters was evaluated by binary logistic regression analysis, which revealed that multiple muscle defects and rib anomalies were associated with left chest side presence (P = 0.005 and P = 0.02, respectively). When the relationship between rib anomalies and PMj defect was analyzed, the association was found to be statistically significant (P = 0.03). Furthermore, the result of the strength analysis was also supported this association (P = 0.04). **Discussion and Conclusion:** Molecular and embryological development processes of the ribs and pectoral muscles are investigated to assess the presence of a structural relationship considering the causal connection between ribs and PMj in PS. As a supportive element to our study, the presence of a myogenic regulatory factor–Hox gene link was asserted in the animal experiments done by some researchers, showing a common development process of the rib and pectoral muscle. We believe that with the outcomes of this study, the clinical diversity and the etiopathogenesis of PS could be explained comprehensively.

Keywords: *Hox gene, myogenesis, myogenic regulatory factor 5, Poland syndrome, sclerotome*

Introduction

Poland syndrome (PS) is a rare congenital disorder that typically presents itself with the absence of the costosternal part of pectoralis major muscle (PMj) and ipsilateral brachysyndactyly of the upper limb.[1] Other commonly seen abnormalities in PS are skeletal malformations of the thoracic wall and breast anomalies. Dextrocardia, lung herniation, liver herniation, kidney anomalies and tumors, and other skeletal defects have also been described in rare cases.[2-6] Episodes of transient compression to the flow of the subclavian artery during the embryonic period are generally accepted etiopathogenesis of PS.[3] Unfortunately, this etiopathological approach is insufficient to explain the clinical variants and findings in PS. This clinical diversity has brought along some questions about the etiology, diagnosis, and treatment of this disorder, and this approach could do no consensus or an accurate classification. In this study, we attempted to explain the pathogenesis of PS by investigating its association with the clinical outcomes of other comorbidities and aimed to evaluate this syndrome in an etiopathological point of view through a systemic review of case reports.

Material and Methods

A systematic literature search was performed. Web of Science, PubMed, Medline, and Google Scholar databases were employed for the studies on PS. The Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines were followed while conducting this study [Appendix A]. The systematic review protocol was registered in the PROSPERO (CRD42017069888). The

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search strategies used are listed in Appendix B. The eligibility criteria were established before the data gathering from the full-text articles, including thorax computed tomography, published in Medline, Web of Science, PubMed Publisher, and Google Scholar databases.

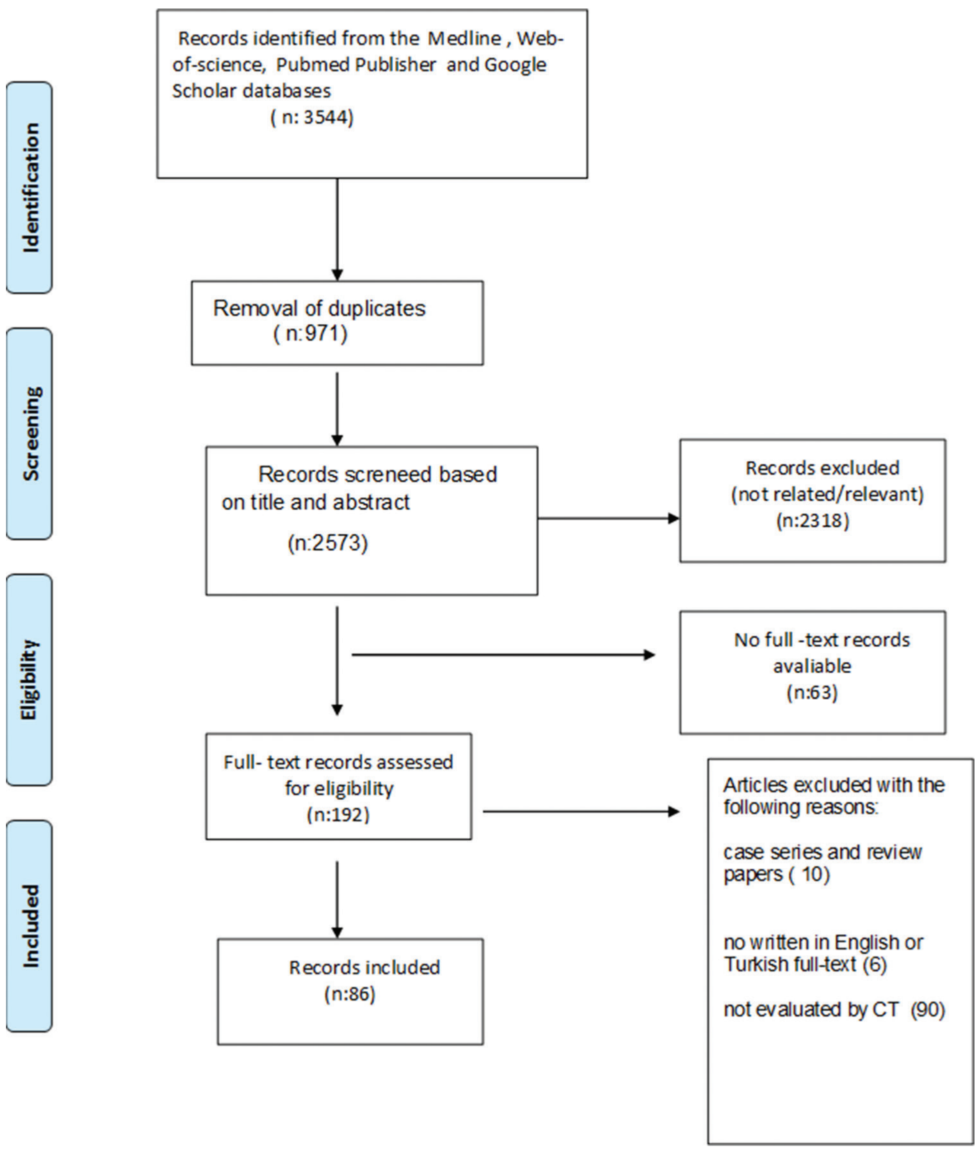
The article screening for inclusion was carried out by two reviewers (M.A and R.Ö.B). The needed data regarding the characteristics and outcomes of the studies were collected independently by the reviewers through a standardized extraction table. Based on our inclusion criteria, 86 patients were included in our study. From the patient population of our clinic, two cases were selected to be eligible for this study [Figures 1-5]. The data from the included studies were categorized according to the name of publication, year of publication, age, sex, side of the deformity, defect type of PS, presence of other muscle or chest wall abnormalities, and dextrocardia.

The frequency of the disease, the correlation among chosen variables, and the significance of the results were statistically analyzed. The statistical significance was assessed with Fisher's exact test using the logistic regression method. The results were considered statistically significant when $P < 0.05$.

Results

A total of 3544 articles related to PS were reported in the Medline, Web of Science, PubMed, and Google Scholar databases. Based on our inclusion criteria, 86 patients were included in our study [Flow Chart 1].

Patient demographics were as follows: 74.4% of the patients (n = 64) were male, 25.6% (n = 22) were female, and their age ranged between 11 and 30 years (50%, n = 43). Other accompanying findings in the patients with PS were defined as 51.2% (n = 42) extremity



Flow Chart 1: Flow diagram of the study

Figure 1: The absence of anterior costal ribs observed with an inspection in an adult patient

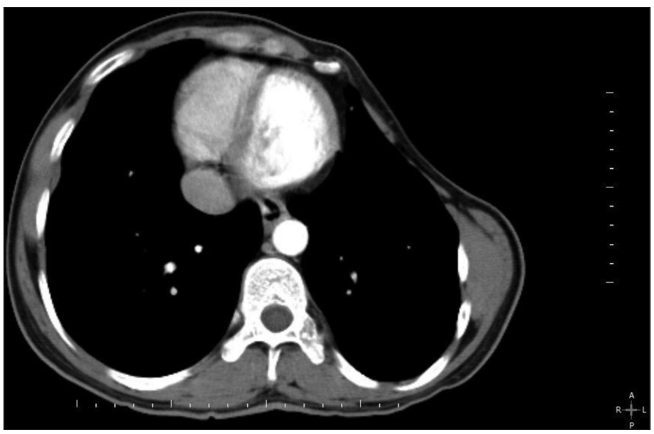


Figure 3: Total absence of left pectoral major muscle were observed by computed tomography

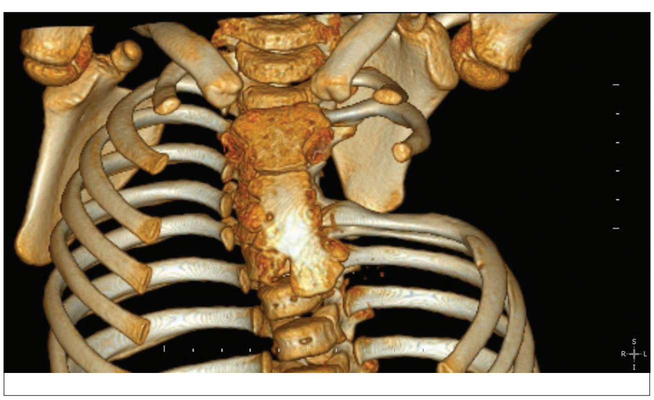


Figure 5: Three-dimensional tomographic scan of the child's thorax skeletal structure

malformation, 87.9% (n = 67) breast and nipple anomalies, and 26.7% (n = 23) dextrocardia with situs solitus. Overall clinical findings of the patients are given in Table 1.

PS was more frequent in male subjects (74.4%) than in female subjects (25.6%), with a ratio of 3:1. Right hemithorax involvement was present in 42 (50%) patients.

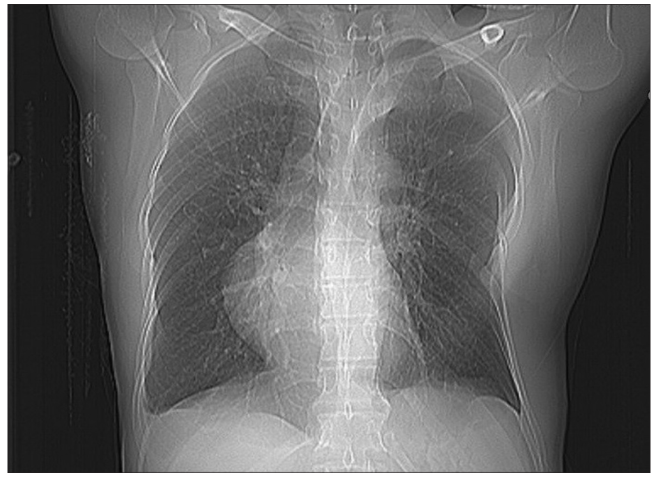


Figure 2: Dextrocardia was observed in the chest X-ray of the adult patient

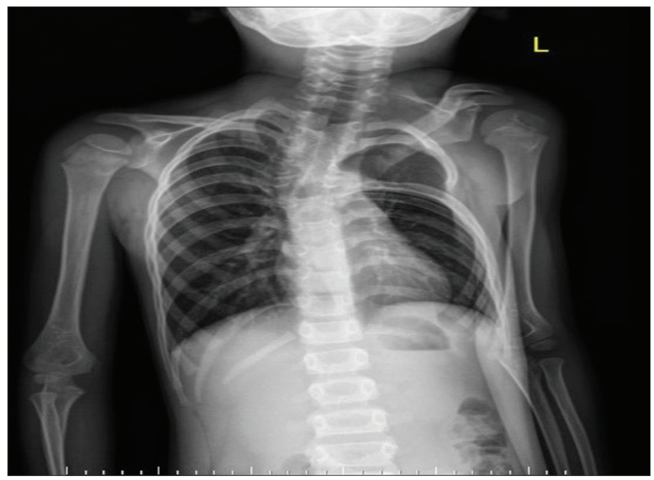


Figure 4: Total rib defects were observed in the pediatric patient's radiographs

Sixty-seven of the 86 patients had the complete defect, while 17 patients had the partial defect of the PMj. Other muscle anomalies accompanying PMj defect have also been reported in various studies, and the number of patients with this specification was 41 in our study. The pectoral minor muscle (PMi) defect was one of the most frequently observed other concomitant muscle defects. Muscle defects are divided into two categories according to the involvement of other muscle deficiencies. Presence of other muscular defects, besides PMj defect, is named as multiple muscle defect. The correlation between the left side and multiple muscle defects was found to be statistically significant, P = 0.007. The strength of the relationship between these two parameters was evaluated by binary logistic regression analysis, which revealed that multiple muscle defect was associated with left chest side, P = 0.005 [Table 2].

Rib anomalies were detected in 50 patients (58.1%), and the mean value for deficient ribs was found as 2. *The cases were divided into two groups according to the number of deficient ribs: one groups have number of deficient*

Table 1: Overall clinical findings of the patients

Author	Chest side	Gender	Age	Type of PMj defect	Type of muscle defect	Rib defect	Dextroposition	Extremity anomalies	Rib defect number
Perrotta and Zubrytska[4]	Left	Male	11-30	PMj partial absence	Multiple	Absent	Absent	Absent	<2 the other group; ≥2
Yadav *et al*.[5]	Right	Male	11-30	PMj totally absence	Multiple	Present	Absent	Present	>2 rib defects
Deniz *et al*.[6]	Right	Male	11-30	PMj totally absence	Multiple	Present	Absent	Present	>2 rib defects
Sharma *et al*.[7]	Left	Male	0-10	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Yiyit *et al*.[8]	Left	Male	31-50	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Baban *et al*.[9]	Left	Female	0-10	PMj totally absence	Multiple	Present	Absent	Present	<2 or 2 rib defects
Rossello M[10]	Right	Male	11-30	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Calevo, M[11]	Left	Male	11-30	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects
Ahn *et al*.[12]	Right	Male	51 and over	PMj totally absence	Multiple	Present	Absent	Absent	>2 rib defects
Shaham *et al*.[3]	Right	Female	51 and over	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Delay *et al*.[14]	Left	Female	11-30	PMj totally absence	Multiple	Present	Absent	Present	<2 or 2 rib defects
Zhou *et al*.[15]	Left	Female	0-10	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects
Kabra *et al*.[16]	Left	Male	11-30	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Luh *et al*.[17]	Right	Male	11-30	PMj totally absence	Single	Present	Absent	Present	<2 or 2 rib defects
Cingel *et al*.[18] Case 1	Left	Male	0-10	PMj totally absence	Multiple	Present	Present	Present	>2 rib defects
Cingel *et al*.[18] Case 2	Right	Male	0-10	PMj totally absence	Single	Present	Absent	Absent	>2 rib defects
Okamo *et al*.[19]	Right	Female	51 and over	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Kurt *et al*.[20]	Left	Male	11-30	PMj totally absence	Multiple	Absent	Absent	Absent	<2 or 2 rib defects
Caksen *et al*.[21]	Right	Male	11-30	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Athale and Warrier[22]	Right	Male	11-30	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Arango Tomás *et al*.[23]	Right	Male	11-30	PMj totally absence	Multiple	Present	Absent	Present	>2 rib defects
Legbo[24]	Right	Female	11-30	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Vélez and Moreno[25] Case 1	Right	Male	11-30	PMj partial absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Vélez and Moreno[25] Case 2	Right	Male	11-30	PMj partial absence	Multiple	Absent	Absent	Absent	<2 or 2 rib defects
Zeybek A supplement Case 1	Left	Male	31-50	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects

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Table 1: Contd...

Author	Chest side	Gender	Age	Type of PMj defect	Type of muscle defect	Rib defect	Dextroposition	Extremity anomalies	Rib defect number
Zeybek A supplement Case 2	Left	Male	0-10	PMj totally absence	Multiple	Present	Absent	Absent	>2 rib defects
Ailiwadi *et al*.[26]	Left	Male	51 and over	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Akyol *et al*.[27]	Left	Female	11-30	PMj partial absence	Multiple	Present	Absent	Absent	<2 or 2 rib defects
Atasoy *et al*.[28]	Right	Male	0-10	PMj partial absence	Single	Absent	Present	Present	<2 or 2 rib defects
Avci *et al*.[29]	Right	Male	11-30	PMj partial absence	Single	Present	Absent	Absent	>2 rib defects
Aytaç, *et al*.[30]	Right	Male	51 and over	PMj totally absence	Single	Present	Absent	Absent	>2 rib defects
Hadley and Bösenberg[31]	Left	Male	0-10	PMj totally absence	Multiple	Present	Present	Present	>2 rib defects
Biçakçi[32]	Right	Male	11-30	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Karnak[33]	Bilaterally	Female	0-10	PMj totally absence	Multiple	Present	Absent	Present	>2 rib defects
Çelik[34]	Right	Male	11-30	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Özer *et al*.[35]	Left	Male	31-50	PMj totally absence	Multiple	Present	Absent	Present	>2 rib defects
Anar *et al*.[36]	Right	Female	51 and over	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Cordero *et al*.[37]	Left	Male	11-30	PMj partial absence	Multiple	Present	Present	Absent	>2 rib defects
Demos *et al*.[38]	Left	Female	11-30	PMj partial absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Tokur[39]	Left	Male	11-30	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects
Tomos *et al*.[40]	Right	Male	51 and over	PMj totally absence	Single	Present	Absent	Absent	>2 rib defects
Tos *et al*.[41]	Left	Male	11-30	PMj totally absence	Single	Present	Absent	Present	>2 rib defects
Dingeldein *et al*.[42]	Right	Male	11-30	PMj totally absence	Single	Present	Absent	Present	>2 rib defects
Dustagheer *et al*.[43]	Right	Male	11-30	PMj partial absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Elli *et al*.[44]	Left	Male	11-30	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Flores *et al*.[45]	Left	Male	0-10	PMj totally absence	Single	Present	Present	Absent	>2 rib defects
Beer *et al*.[46]	Left	Female	11-30	PMj totally absence	Multiple	Absent	Absent	Absent	<2 or 2 rib defects
Gan *et al*.[47]	Right	Male	0-10	PMj totally absence	Single	Present	absent	Absent	>2 rib defects
Gerlinger *et al*.[48]	Right	Male	51 and over	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Santra *et al*.[49]	Right	Male	11-30	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Mutlu *et al*.[50]	Left	Male	11-30	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects
Kabukcu *et al*.[51]	Left	Male	11-30	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects

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Table 1: Contd...

Author	Chest side	Gender	Age	Type of PMj defect	Type of muscle defect	Rib defect	Dextroposition	Extremity anomalies	Rib defect number
Kamburoğlu *et al*.[52]	Right	Male	0-10	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Drebov and Katsarov[53]	Left	Male	0-10	PMj totally absence	Single	Present	Absent	Absent	>2 rib defects
Koizumi *et al*.[54]	Left	Female	0-10	PMj totally absence	Multiple	Present	Absent	Absent	>2 rib defects
Lasko *et al*.[55]	Left	Male	0-10	PMj totally absence	Single	Present	Present	Absent	>2 rib defects
Lee *et al*.[56]	Right	Male	0-10	PMj totally absence	Single	Present	Present	Absent	>2 rib defects
Li *et al*.[57]	Left	Male	11-30	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects
Lieber *et al*.[58]	Right	Male	11-30	PMj partial absence	Multiple	Present	Absent	Absent	>2 rib defects
Gocmen *et al*.[59] Case 1	Left	Male	11-30	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Gocmen *et al*.[9] Case 2	Right	Male	11-30	PMj totally absence	Single	Present	Absent	Present	>2 rib defects
Gupta *et al*.[60]	Left	Male	0-10	PMj totally absence	Multiple	Present	Present	Present	>2 rib defects
Junior *et al*.[61]	Left	Male	0-10	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Martinez-Ferro *et al*.[62]	Right	Female	11-30	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Masia *et al*.[63]	Right	Female	11-30	PMj totally absence	Single	Present	Absent	Absent	>2 rib defects
Baltayiannis *et al*.[64]	Left	Female	31-50	PMj partial absence	Single	present	Present	Absent	>2 rib defects
Riyaz and Riyaz[65]	Right	Female	0-10	PMj partial absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Çalpur and Aktas[66]	Right	Male	0-10	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Iyer and Parisi [67]	Left	Female	0-10	PMj totally absence	Multiple	Present	Present	Present	>2 rib defects
Raval *et al*.[68]	Left	Male	51 and over	PMj totally absence	Single	Present	Present	Present	>2 rib defects
Rodriguez *et al*.[69]	Right	Female	11-30	PMj totally absence	Multiple	Present	Absent	Present	>2 rib defects
Rocha *et al*.[70]	Left	Female	11-30	PMj totally absence	Single	Present	Present	Absent	>2 rib defects
Rosa *et al*.[71]	Right	Male	0-10	PMj partial absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Rupam *et al*.[72]	Right	Male	11-30	PMj partial absence	Single	Present	Absent	Present	>2 rib defects
Seifarth, *et al*.[73]	Right	Male	0-10	PMj totally absence	Single	Present	Absent	Absent	<2 or 2 rib defects
Sepulveda[74]	left	Male	0-10	PMj totally absence	Multiple	Present	Present	Absent	>2 rib defects
Sethuraman *et al*.[75]	Left	Male	0-10	PMj totally absence	Single	Present	Present	Present	>2 rib defects
Sinopidis *et al*.[76]	Right	Male	0-10	PMj partial absence	Single	Present	Absent	Absent	<2 or 2 rib defects
Srivastava *et al*.[77]	Left	Male	51 and over	PMj totally absence	Single	Present	Present	Present	>2 rib defects

Contd...

Table 1: Contd...

Author	Chest side	Gender	Age	Type of PMj defect	Type of muscle defect	Rib defect	Dextroposition	Extremity anomalies	Rib defect number
Sucuoglu *et al*.[78]	Right	Male	11-30	PMj totally absence	Single	Absent	Absent	Present	<2 or 2 rib defects
Hacıevliyagil *et al*.[79]	Right	Male	31-50	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects
Samuels *et al*.[80]	Right	Female	31-50	PMj totally absence	Multiple	Present	Absent	Absent	>2 rib defects
Deveci *et al*.[81]	Left	Female	11-30	PMj partial absence	Single	Present	Present	Present	<2 or 2 rib defects
Yiyit and Saygin[82]	Right	Male	11-30	PMj totally absence	Multiple	Absent	Absent	Present	<2 or 2 rib defects
Yoo *et al*.[83]	Left	Female	0-10	PMj totally absence	Single	Absent	Absent	Absent	<2 or 2 rib defects

PMj: pectoral majoris muscle

Table 2: Statistical analyses

	Chest side			Dextrocardia		Rib defect		Correlation (*P*)		Binary logistic regression (*P*, [Exp B])
	Left	Right	Bilateral	Present	Absent	≤2	>2	Chi-square test	Fisher's exact	
Rib defect										
Present	29	23	1						0.04	0.02 (2.68)
Absent	13	20	0							
Rib defect										
<2 rib				2	41			<0.001		<0.001 (19.5)
>2 rib				21	22					
Multiple muscle defect										
Present	26	14	1						0.007	0.005 (3.52)
Absent	16	29	0							
Type of PMj defect										
Totally						30	38	0.03		0.04 (3.29)
Partially						13	5			

PMj: Pectoralis major muscle

ribs more than two and other group have number of deficient ribs equal to and fewer than two. The left-sided presentation and rib anomalies were found to be significant, $P = 0.04$.

The presence of dextrocardia was found in 22 of 50 patients with rib anomalies, and the analysis supported the relationship between these variables [OR = 0.036, 95% confidence interval, 0.005–0.287 $P = 0.002$, Table 2].

Rib anomalies were mostly detected in patients with a complete absence of PMj ($P = 0.03$), and the association between the variables is shown in Table 3 ($P = 0.04$).

Discussion

PS was first described by Alfred Poland in 1841. Other commonly used definitions could be listed as Poland sequence, Poland's anomaly, and Poland's syndactyly. Classical PS is characterized by hypoplasia or partial absence of the sternocostal head of PMj and ipsilateral brachysyndactyly.[1]

While the majority of PS cases are sporadic, there are documented cases of inheritability which display an autosomal dominant inheritance pattern with incomplete penetrance. A wide range of frequencies from 1/30,000 to 1–9/100,000 has been estimated.[2,3,18]

Males are more commonly affected than females, with a 3:1 ratio. In 75% of the cases, the right side of the chest is involved. However, in our study, we investigated the severity of the combination of rib anomaly and PMj defect on the left side of the thorax.

During our review, other pathological components such as rib defect, upper or lower limb hypoplasia/aplasia, digital structure, digital webbing, cardiac anomalies, nipple and axillary hair anomalies, diaphragmatic hernia or eventration, gonadal chromosomal anomalies such as turner syndrome, central nervous system and vertebral anomalies, liver and kidney anomalies, skin-related diseases, lack of subcutaneous fat tissue, hematologic disorders, optic lens anomalies, and urogenital tumors were reported in various studies.[4-83]

According to the results of our study, rib anomalies were commonly associated with left-sided involvement, and it is supported by the study of Torre *et al*.[84] However, the real cause behind this fact is not fully explained, such as the etiology of PS.

For explaining the pathogenesis of PS, the most commonly accepted theory is the vascular injury during the 6th week of embryogenesis due to an interruption to the blood flow in the branches of subclavian and vertebral arteries when the pectoralis muscle is developing. Other possible causes could be listed as teratogens, intrauterine trauma, infections, and malformation of lateral plate mesoderm.[2,3,18]

The main criterion for the diagnosis of PS is aplasia or hypoplasia of PMj. Moreover, in addition to the PMj anomaly, other muscular anomalies such as PMi, serratus anterior, trapezius, latissimus dorsi, external oblique, and peroneal muscle defects were reported in studies.[4-83]

In this study, it is observed that the incidence for the presentation of multiple muscle anomalies with left hemithorax involvement is significantly high. Binary logistic regression analysis is used for the evaluation. To explain this close relationship between rib anomalies and PMj defect, structural relationship and molecular and embryological development process of chest wall had been searched.

A common pathway during the development process of both pectoral muscle and skeletal structure of the chest wall is reported in the results of animal experimentations of some studies.[85-87] As generally known, pectoral muscles originate from hypaxial myotome, while ribs develop from sclerotome. Furthermore, the myogenic regulatory factor 5 (Myf 5) gene is responsible for the development of the pectoral muscle, and the Hox gene is responsible for the development of ribs. Interestingly, the placement of the Hox protein receptors is suggested to be in the hypaxial myotome instead of sclerotome. It has been reported that the rib development in the thoracic vertebral levels was triggered by the activation of the Hox 6 gene through regulation of the Myf5/Myf6 gene expression in the hypaxial myotome. The information is transmitted to the sclerotome through platelet-derived growth factor-alpha subunit, and fibroblast growth factor 4 signaling by a cell nonautonomous mechanism had been asserted.[87] This reported Myf-Hox gene link is upheld with the results of our study.

Conclusion

In light of these results, this study that we have conducted would be beneficial for explaining the clinical diversity and, even more importantly, the etiopathogenesis of PS. Investigating the role of Myf5 by advanced genetic research may enlighten the etiopathogenesis of many diseases concerning the thoracic wall anomalies.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Appendix

Appendix A: Preferred Reporting Items for Systematic Review and Meta-Analysis 2009 Checklist

Section/topic	#	Checklist item	Reported on page#
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both	Title page separate from manuscript
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS)	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated	4
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis)	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made	4-5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis	NA
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means)	5-6
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis	5-6
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies)	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified	5-6
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram	5-6, Table 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations	6
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12)	NA
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot	NA
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15)	NA

Section/topic	#	Checklist item	Reported on page#
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16])	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policymakers)	6-7
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias)	7
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research	8
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review	8

From: Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6 (7):e1000097. doi: 10.1371/journal.pmed1000097. For more information, visit: www.prisma-statement.org.

Appendix B: Search strategy

PubMed Publication

((((“Poland Syndrome/analysis”[Mesh] OR “Poland Syndrome/anatomy and histology”[Mesh] OR “Poland Syndrome/blood”[Mesh])) AND (“Poland Syndrome/chemically induced”[Mesh] OR “Poland Syndrome/classification”[Mesh] OR “Poland Syndrome/complications”[Mesh] OR “Poland Syndrome/congenital”[Mesh] OR “Poland Syndrome/diagnosis”[Mesh] OR “Poland Syndrome/diagnostic imaging”[Mesh] OR “Poland Syndrome/embryology”[Mesh] OR “Poland Syndrome/epidemiology”[Mesh] OR “Poland Syndrome/etiology”[Mesh] OR “Poland Syndrome/genetics”[Mesh] OR “Poland Syndrome/history”[Mesh] OR “Poland Syndrome/pathology”[Mesh] OR “Poland Syndrome/physiology”[Mesh] OR “Poland Syndrome/physiopathology”[Mesh] OR “Poland Syndrome/surgery”[Mesh] OR “Poland Syndrome/therapy”[Mesh])) AND (“Pectoralis Muscles/abnormalities”[Mesh] OR “Pectoralis Muscles/analysis”[Mesh] OR “Pectoralis Muscles/anatomy and histology”[Mesh] OR “Pectoralis Muscles/blood supply”[Mesh] OR “Pectoralis Muscles/chemistry”[Mesh] OR “Pectoralis Muscles/diagnosis”[Mesh] OR “Pectoralis Muscles/diagnostic imaging”[Mesh] OR “Pectoralis Muscles/drug effects”[Mesh] OR “Pectoralis Muscles/embryology”[Mesh] OR “Pectoralis Muscles/etiology”[Mesh] OR “Pectoralis Muscles/growth and development”[Mesh] OR “Pectoralis Muscles/pathology”[Mesh])) AND (“Bone Diseases, Developmental/analysis”[Mesh] OR “Bone Diseases, Developmental/anatomy and histology”[Mesh] OR “Bone Diseases, Developmental/classification”[Mesh] OR “Bone Diseases, Developmental/congenital”[Mesh] OR “Bone Diseases, Developmental/embryology”[Mesh] OR “Bone Diseases, Developmental/genetics”[Mesh] OR “Bone Diseases, Developmental/history”[Mesh] OR “Bone Diseases, Developmental/surgery”[Mesh])

Medline

((((“Poland Syndrome/analysis”[Mesh] OR “Poland Syndrome/anatomy and histology”[Mesh] OR “Poland Syndrome/blood”[Mesh])) AND (“Poland Syndrome/chemically induced” OR “Poland Syndrome/classification” OR “Poland Syndrome/complications”[Mesh] OR “Poland Syndrome/congenital”[Mesh] OR “Poland Syndrome/diagnosis”[Mesh] OR “Poland Syndrome/diagnostic imaging”[Mesh] OR “Poland Syndrome/embryology”[Mesh] OR “Poland Syndrome/epidemiology”[Mesh] OR “Poland Syndrome/etiology”[Mesh] OR “Poland Syndrome/genetics” OR “Poland Syndrome/history”[Mesh] OR “Poland Syndrome/pathology”[Mesh] OR “Poland Syndrome/physiology”[Mesh] OR “Poland Syndrome/physiopathology”[Mesh] OR “Poland Syndrome/surgery”[Mesh] OR “Poland Syndrome/therapy”[Mesh])) AND (“Pectoralis Muscles/abnormalities”[Mesh] OR “Pectoralis Muscles/analysis”[Mesh] OR “Pectoralis Muscles/anatomy and histology”[Mesh] OR “Pectoralis Muscles/blood supply”[Mesh] OR “Pectoralis Muscles/chemistry”[Mesh] OR “Pectoralis Muscles/diagnosis ‘’ OR “Pectoralis Muscles/diagnostic imaging”[Mesh] OR “Pectoralis Muscles/drug effects”[Mesh] OR “Pectoralis Muscles/embryology”[Mesh] OR “Pectoralis Muscles/etiology”[Mesh] OR “Pectoralis Muscles/growth and development”[Mesh] OR “Pectoralis Muscles/pathology”)) AND (“Bone Diseases, Developmental/analysis”[Mesh] OR “Bone Diseases, Developmental/anatomy and histology”[Mesh] OR “Bone Diseases, Developmental/classification”[Mesh] OR “Bone Diseases, Developmental/congenital”[Mesh] OR “Bone Diseases, Developmental/embryology”[Mesh] OR “Bone Diseases, Developmental/genetics”[Mesh] OR “Bone Diseases, Developmental/history”[Mesh] OR “Bone Diseases, Developmental/surgery”)

Web of Science

("Poland Syndrome/analysis" OR "Poland Syndrome/anatomy and histology" OR "Poland Syndrome/blood")) AND ("Poland Syndrome/chemically induced" OR "Poland Syndrome/classification" OR "Poland Syndrome/complications" OR "Poland Syndrome/congenital" OR "Poland Syndrome/diagnosis" OR "Poland Syndrome/diagnostic imaging" OR "Poland Syndrome/embryology" OR "Poland Syndrome/epidemiology" OR "Poland Syndrome/etiology" OR "Poland Syndrome/genetics" OR "Poland Syndrome/history" OR "Poland Syndrome/pathology" OR "Poland Syndrome/physiology" OR "Poland Syndrome/physiopathology" OR "Poland Syndrome/surgery" OR "Poland Syndrome/therapy")) AND ("Pectoralis Muscles/abnormalities" OR "Pectoralis Muscles/analysis" OR "Pectoralis Muscles/anatomy and histology" OR "Pectoralis Muscles/blood supply" OR "Pectoralis Muscles/chemistry" OR "Pectoralis Muscles/diagnosis"OR "Pectoralis Muscles/diagnostic imaging" OR "Pectoralis Muscles/drug effects" OR "Pectoralis Muscles/embryology" OR "Pectoralis Muscles/etiology" OR "Pectoralis Muscles/growth and development" OR "Pectoralis Muscles/pathology")) AND ("Bone Diseases, Developmental/analysis" OR "Bone Diseases, Developmental/anatomy and histology" OR "Bone Diseases, Developmental/classification" OR "Bone Diseases, Developmental/congenital" OR "Bone Diseases, Developmental/embryology" OR "Bone Diseases, Developmental/genetics" OR "Bone Diseases, Developmental/history" OR "Bone Diseases, Developmental/surgery")

Google Scholar

Poland Syndrome, Poland Syndrome classification, Poland Syndrome congenital, Poland Syndrome diagnosis, Poland Syndrome diagnostic imaging, Poland Syndrome epidemiology, Poland Syndrome etiology, Poland Syndrome genetics, Pectoralis Muscles/abnormalities, Pectoralis Muscles/anatomy and histology Pectoralis Muscles embryology, Pectoralis Muscles etiology, Pectoralis Muscles/growth and development, Bone Diseases, Developmental/anatomy and histology, Poland Syndrome pathology.

Supplementary Data

Poland syndrome

Case 1

A 29-year-old male patient was accepted to our outpatient clinic with blunt trauma to the right side of the chest. After a physical examination and radiological evaluations, no trauma-related complications on the right side of the chest were detected; however, an asymmetry in the left chest wall, an upward-positioned nipple at the left side, and collapsed left chest wall and abdomen were noted. When palpated, the absence of costal cartilage of the 5th–10th rib on the left chest wall and muscle weakness on the chest wall and anterior abdominal wall were identified, and a 20 cm × 15 cm area of hypopigmentation on the left chest wall – the area that was separated by a sharp border on the same level as the skin was noted [Figure 1]. No pathological findings or symptoms were found in the rest of the physical examination. There was no paradoxical respiration or dyspnea in the patient. Respiratory reserves were found to be within normal limits.

On the thoracic computed tomographic (CT) scan, total agenesis of the left pectoralis major muscle (PMj), pectoralis minor muscle hypoplasia, left rectus abdominis xiphoid adnexa head aplasia, and left 5th–10th costal cartilage defects were detected. These findings implied Poland syndrome (PS) and accompanying dextrocardia [Figures 2 and 3]. No congenital heart disease was detected by echocardiographic evaluation performed by a cardiologist. No decrease or change in the arterial bloodstream was reported in the upper left extremity or left subclavian arterial Doppler ultrasonography (USG). A moderate level of hepatosplenomegaly was noted in the abdominal USG. There was no abnormality in the vertebral or skeletal structure. In addition, the patient had no family history of PS.

Case 2

A 6-year-old boy was referred to our outpatient clinic with a preliminary diagnosis of chest wall deformity. Our examination confirmed a deformity in the left chest wall and shoulder, while respiratory and cardiac assessments indicated normal results. In the upper left extremity, the hyperabduction was limited and the left scapula was located in an upward position, the muscle structure in the left chest wall was weak, and two nipples on that side were positioned upward [Figure 4].

According to the chest X-ray, abdominal USG, the thoracic magnetic resonance imaging and CT, the left third and fourth ribs had total agenesis, and the fifth and sixth ribs showed fusion with the vertebrocostal joint and had anterior defects; the patient was described with aplasia of the left PMj muscles and the serratus anterior, and his scapula was directed upward. The patient had a 15° thoracic scoliosis facing the left at the first lumbar vertebra and distal diastematomyelia, which was determined to be in a 5-mm confined area [Figure 5].

Original Article

Assessment of Accessory Mental Foramen Using Cone-Beam Computed Tomography and its Clinical Relevance

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Abstract

Introduction: Accessory mental foramen (AMF) is defined as any additional opening on the anterior surface of the mandible body that is connected to the mandibular canal. The presence of AMF is an important anatomical parameter when planning the therapy to avoid neurovascular bundle injury and other complications. Cone-beam computed tomography (CBCT) provides an accurate, three-dimensional determining of the position, its dimensions and the relation of AMF to the mental foramen (MF), as well as the distinction from nutritive openings. **Material and Methods:** The research was carried out at the Department of Dentistry, Faculty of Medical Sciences, University of Kragujevac, as a retrospective study where 148 CBCT images were analyzed. The analysis of the position of AMF, the relation to and the distance from the MF were made on cross-sectional and axial images. Only those openings that have had a clear connection with the mandibular canal were counted as AMF. **Results:** AMF was present in 12 (8.11%) patients. In most cases, AMF was positioned superior to MF, in 27% of patients. There was no significant statistical difference between sex and the jaw side. The average distance of AMF from MF was 4.52 ± 2.21 mm. In most cases, AMF is round shaped (60%). The average value of the surface area is 1.62 ± 1.14 mm^2. **Discussion and Conclusion:** Timely detection of AMF using CBCT contributes to the diagnosis and planning of appropriate dentures, surgical technique, preventing possible damage to adjacent anatomical structures, or some other therapy.

Keywords: *Accessory mental foramen, anatomical variations, cone-beam computed tomography, mental foramen*

Introduction

Knowing the anatomical characteristics of the orofacial region is a necessary factor for the adequate implementation of both preventive and therapeutic procedures in that region. Anatomical variations, which are often present, are an important role in the planning of these procedures, and they can easily be overlooked. Cone-beam computed tomography (CBCT) has a great clinical significance in the detection of anatomic variations. The most important use of CBCT in the orofacial region is the three-dimensional (3D) reconstruction of the anatomical characteristics of the region. This allows for the detection of all anatomical variations and pathological conditions, such as changes in soft and bone tissue, as well as variations in the number, shape, structure, and size of the teeth.

Mental foramen (MF) is a bilateral anatomical structure on the anterior surface of the mandible body through which exits mental nerve, terminal branch of the inferior alveolar nerve, and the corresponding artery and vein.[1-3] Intraosseous part of the inferior alveolar nerve, after the variable separation of the lateral branches, is usually divided into two final branches (mental nerve and incisive nerve), which diverge in the form of letters Y or T.[4] The mental nerve that passes through MF is, in most cases, posteriorly oriented, and it subdivides out into three branches, below depressor anguloris.[1,5] Hu *et al*. describe four branches of the mental nerve: angular to the angle of the lip, the outer branch of the lower lip (often separated from the angular branch), the inner branch of the lower lip, and the branch of the chin.[1,5,6] A variation marked as "anterior loop," with a length range of 0.5–5 mm, approximately 1 mm, on average describes that mental nerve passes under MF, proceeding to the

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midline, after which it creates the arc to the top and returns to MF.[5,7]

MF is most commonly round or oval shaped and is usually located between the apices of mandibular first and second premolars. It is possible for MF to be positioned in the periapical projection of canine and extremely rarely, in the area of the first molar.[8] In dental practice, the importance of MF refers to the use of this structure as a reference point in the implementation of local anesthesia, in the insertion of dental implants and in the implementation of prosthetic, endodontic, and other dental procedures in that region.[3,9-13]

Anatomical variations of MF can occur in a certain number of cases in the form of differences in shape, size, position, and number of openings. In some cases, there are one or more additional openings, which are called accessory mental foramen (AMF).[8] It is stated in the literature that the frequency of AMF is 1.4%–20%.[2,5,6] The presence of AMF is the consequence of the branching of mental nerve and the presence of its accessory branch, which passes through this opening. Other, mostly smaller openings, which may occur near MF and AMF and which are not in direct contact with the mandibular canal, are nutritive. An additional branch of the mental nerve that comes out of AMF mainly innervates the part of the mucous membrane of the cheek, the skin of the corner of the lips, and the mucous membrane of the lower lip on that side and can have anastomoses with buccal nerve and facial nerve.[8] The persistence of pain after the mental nerve neurectomy is explained by the presence of an additional branch that passes through AMF, which is one of the trigger points of the trigeminal neuralgia emergence.[14] There are also described the cases of the presence of two mental nerve openings, which are the same dimensions and are observed next to each other, on the same side of the mandible. An anterior location of AMF relative to MF can also be a re-entry point of mental nerve to the mandible, which goes to the incisors (crossed innervation).[4,5]

The presence of AMF is often overlooked during oral surgery interventions. The detection of AMF is especially important from the aspect of implant therapy planning to avoid neurovascular bundle injury during surgical, prosthetic, endodontic, and other dental procedures.[3,12,15]

On the 2D orthopantomogram, it is not possible to diagnose the presence of AMF, as well as its distance and position relative to MF due to the distortion of the image, superposition of anatomical structures and an inadequate resolution. The method of choice is CBCT which provides a 3D reconstruction in the high resolution and without superposition of anatomical structures.[8,16-19] Timely diagnosis of AMF enables avoiding complications during and after therapeutic procedures which can directly affect the outcome of the therapy.

The study aimed to determine the presence of AMF, the position and relation to MF, by using CBCT.

Material and Methods

This research was conducted as a retrospective study. Ethical approval was obtained from the Local Ethical Committee. The study included 200 CBCT images from the existing database. Scans that do not show mandibular canal completely or with deformity, pathological changes and previous surgical interventions in the region of the mental opening were excluded. All CBCT scans were made at the Department of Dentistry at the Faculty of Medical Sciences, University of Kragujevac, in the period from October 25, 2014, to September 20, 2018.

Scans were made on Orthophos XG 3D device (Sirona Dental Systems GmbH, Bensheim, Germany), with the field size 8 cm × 8 cm, and three-dimensionally reconstructed by the software GALAXIS version 1.9.4 (Sirona Dental Systems GmbH, Bensheim, Germany), with a high image definition (100 μm). The CBCT scans were made because of implantological, prosthetic, endodontic, surgical, or orthodontic indications. The images were viewed on a Philips light-emitting diode monitor of 23 inches with a resolution of 1920 × 1080 pixels. Brightness and contrast were customized by the software, and images were viewed in a room with a dimmed light.

The presence of AMF was proven by 3D image analysis. The positions of all AMFs were presented in eight groups depending on the relation to MF [Figures 1 and 2]. Software built-in meter was used to take all the measurements. The size of AMF, the distance and the ratio between AMF and MF in horizontal and vertical dimensions were performed. Vertical and horizontal dimensions were acquired measuring foramen's edge to edge distance in cross-sectional and axial section, respectively. The distance between MF and AMF was also measured in cross-sectional and axial section [Figure 3]. As reference points, AMF and MF centers were used in both sections. Furthermore, the distance of AMF from the inferior border of the mandible was measured.[20,21] Any additional opening that did not come into contact with the mandibular canal was considered a nutritive opening and was excluded from the analysis. The shape was defined as an oval if the difference between the horizontal and vertical dimensions of the foramen was >0.5 mm and round if it was <0.5 mm. The surface of AMF was calculated by the following formula. $\prod = \frac{А \times Б \times \pi}{4}$ The AMF location relative to MF at the sagittal section was recorded along with its shortest distance to MF.[20,21] All the measurements were repeated twice in an interval of 7 days to ensure the objectivity of the measurement. The reproducibility value was $k = 0.846$.

Statistical data were analyzed by using the statistical software SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). For the

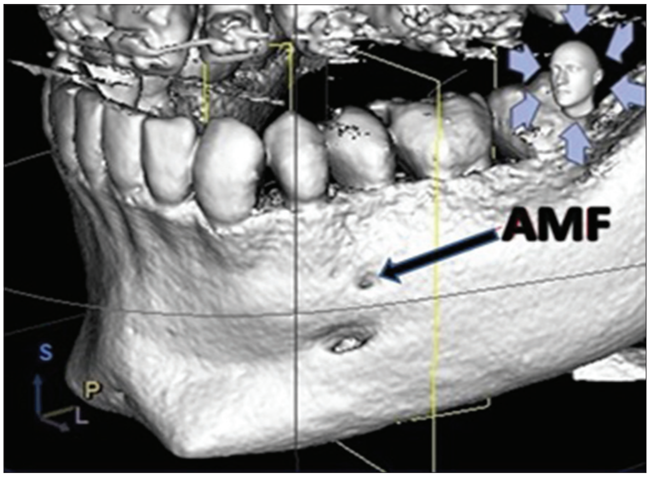

Figure 1: A three-dimensional view of the mandible with the presence of an accessory mental foramen

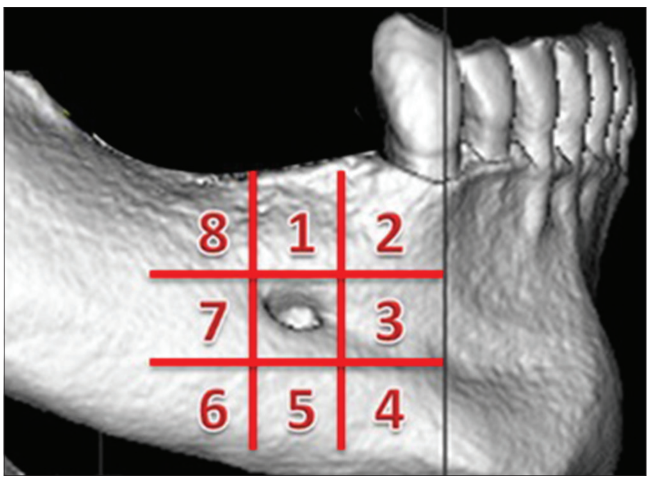

Figure 2: Graphical display of accessory mental foramen position relative to mental foramen in eight fields: 1 – Superior; 2 – Anterosuperior; 3 – Anterior; 4 – Anteroinferior; 5 – Inferior; 6 – Posteroinferior; 7 – Posterior; 8 – Posterosuperior

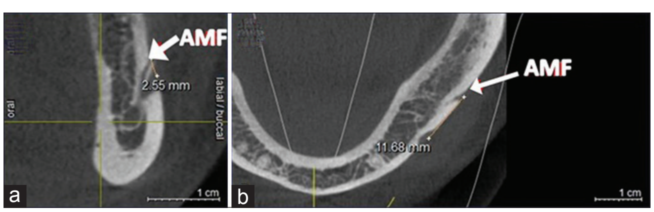

Figure 3: Display of distance measurement of accessory mental foramen in cross-sectional (a) and axial (b) view

evaluation of the relation between sex and anatomical variations, Pearson Chi-square was used at a significance level $P < 0.05$.

Results

Within this study, 200 CBCT images were analyzed. Based on the inclusion criteria, 148 images were included in the study, 71 (48%) of male and 77 (52%) of female patients. A total of 15 AMFs were found in 12 (8.11%) cases, 2.70% of males and 5.40% of females [Table 1].

Table 1: Accessory mental foramen presence in relation to gender and Chi-square value

Gender	AMF presence	Chi-square test (*P*)
Male	4/71 (2.70)	0.290
Female	8/77 (5.40)	

AMF: Accessory mental foramen

The presence of one AMF was observed in 6.76%, two AMFs in 0.67% and three AMFs in 0.67% of cases. AMF was present on the right side of the mandible in 50% of cases, on the left side in 33% while, on both sides, AMF was present in 17% of cases [Figure 4].

The average values of the horizontal and vertical AMF diameters were 1.72 ± 1.02 mm and 1.18 ± 0.38 mm, respectively. The average surface area of AMF was 1.62 ± 1.14 mm^2. In most cases, AMF was round shaped (60%). The position relative to MF was analyzed as well [Figure 5]. There was no statistically significant difference in the position of AMF between genders (P = 0.186). The AMF's most prevalent position was superior to MF, accounting for 27%. Posterior and posteroinferiorly positioned AMFs were present in 20% of cases [Table 2].

The mean diagonal distance between AMF and MF was 4.52 ± 2.21 mm. Mean horizontal distance between AMF and MF was 3.38 ± 2.60 mm, whereas mean vertical distance was 2.15 ± 1.68 mm [Table 3]. Distance from the inferior border of the mandible and AMF was measured, and its mean value was 14.44 ± 1.14 mm.

Discussion

Diagnostic issue or a predisposition for the complications after dental procedures is often caused by the anatomical variations of the mandibular canal and its openings. Knowing the exact topography of the inferior alveolar nerve and the mandibular canal is important for preventing impairment of the neurovascular bundle.[17,22]

Because of the relatively small percentage of AMF presence (1.4%–20%), it is often overlooked in standard 2D radiographic images. Accessory openings of the mandibular canal can be observed at lingual position, at retromolar position, and near MF, when the opening is designated as AMF.[1] The presence of AMF may indicate a variation of the mandibular canal, formed during embryonic development due to a branching of the inferior alveolar nerve prior 12^{th} gestational week, before the complete formation of MF.[23] Variations in MF position, as well as the presence of AMF, show significant ethnic differences, although they also depend on individual variations in the development of mandible.[18] The position and direction of the inferior alveolar nerve can be altered in people with alveolar bone atrophy.[4]

The direction of the accessory mental nerve canal was mainly posterosuperior or posteroinferior.[20] The position

Table 2: Accessory mental foramen localization in relation to medial mental foramen and Chi-square value

Gender	Position					Total
	Superior	Posterosuperior	Posterior	Posteroinferior	Inferior	
Male	2	0	0	2	0	4
Female	2	2	3	0	1	8
Total	4	2	3	2	1	12
Chi-square test (*P*)			0.112			

Table 3: Comparison of horizontal and vertical dimensions of accessory mental foramen and his distance from mental foramen by gender

Gender	Vertical dimension of foramen	Horizontal dimension of foramen	Vertical distance	Horizontal distance
Male (mm)	1.22±0.58	1.51±1.04	3.22±2.08	2.58±0.58
Female (mm)	1.16±0.27	1.83±1.06	1.62±1.24	3.78±3.11
P	0.595	0.626	0.500	0.454

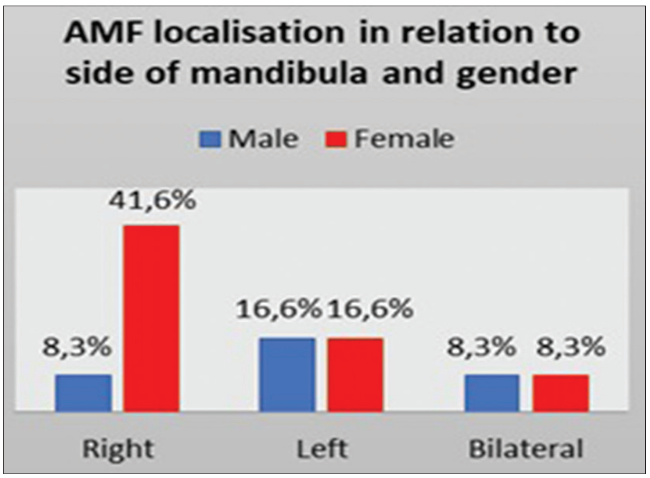

Figure 4: Graphical display of accessory mental foramen in relation to side of mandible and gender

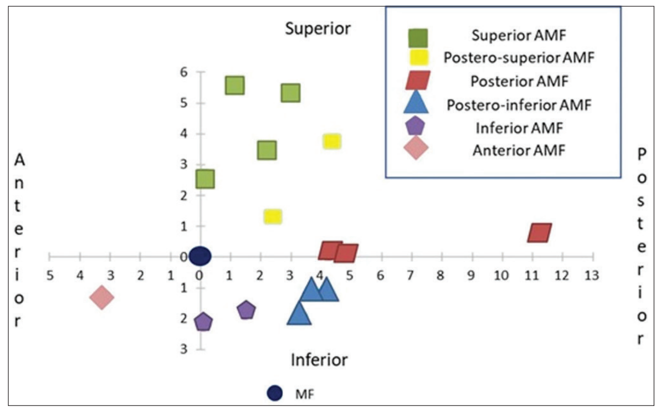

Figure 5: Display of each accessory mental foramen location and distance (accessory mental foramen) in relation to mental foramen shown in millimeter scale

of AMF depends on the separation site and length of the accessory mental nerve. Variation in the relative position of AMF to MF is greater in horizontal than in the vertical direction.[24] Given the significance of this opening, Iwanaga *et al*. (2015) proposed the definition of AMF according to which it refers to each opening detected on the computed tomography image, which is in continuity with the mandibular canal and smaller than MF, regardless of whether blood vessels and/or nerves that pass through it are detected, which the authors of the current study agree with.[1]

The frequency of AMF varies among ethnic groups ranging from 1.4% to over 20%.[20] Caucasian race shows the lowest prevalence of AMF.[7,25,26] The presence of bilateral AMF is rare and is observed in <1% of the population.[27] Apart from the ethnic variations, a large difference in frequency may be due to the diversity of methodology and the definition of AMF.

The findings of the current study prove that AMF was represented in 8.11% of cases. This frequency is similar in the study of Han *et al*. where a frequency of 8.1% was shown.[28] In the study of Li *et al*.,[20] the frequency of AMF was 7.3%, while in the study of Muinelo-Lorenzo *et al*. it was 13.08%.[21] Zmysłowska-Polakowska *et al*. demonstrated in their study the presence of AMF on 7% of cases, and Kumari *et al*. on 10% of cases.[3,29]

The authors also determined that the difference in the frequency of AMF was present among the sexes. The frequency was higher in women (5.40%) than in men (2.70%). Muinelo-Lorenzo's *et al*. and Naitoh *et al*.'s studies showed a higher prevalence of AMF in women,[21,30] which findings of the present study support. Opposite results were shown in the study of Zmysłowska-Polakowska *et al*.,[3] where the frequency of AMF was higher in male subjects, as well as in other studies.[3,10,20,23,28,31]

In the current study, the presence of AMF on the right side of the mandible was in 50% of cases, on the left side of mandible in 33% of cases, while on both sides AMF was present in 17% of cases. Kumari *et al*. analyzed the frequency of AMF localization on both sides.[29] AMF was more often localized on the right side of the mandible.[18]

In most cases, these findings suggest that AMF was set superior (27%) to MF. Posterior and posteroinferior localizations are equally present both in 20% of cases. In the study of Naitoh *et al*., AMF is most often positioned posteroinferior.[32] A study of Kumari *et al*. showed that in all cases when AMF was on the right side of the mandible, it was positioned anterior to MF.[29] In cases where AMF was on the left side, there was an equal frequency in inferior, superior, posterior, and posteroinferior localization, 25% each localization.[29] Katakami *et al*.[24] showed posteriorly positioned AMF to MF as the most common in 41% of cases, and inferior position in 29% as the second according to the frequency. In the study by Gümüşok *et al*.,[8] it was shown that AMF was most often placed in a posteroinferior position to MF. Kalender *et al*. state that AMF is most frequently placed anteroinferior to MF. No statistically significant difference was found in the localization between the sexes.

The average diagonal distance between AMF and MF in the present study was 4.52 ± 2.21 mm. The mean value of horizontal distance between AMF and MF was 3.38 ± 2.60 mm, and vertical distance was 2.15 ± 1.68 mm. The values of horizontal and vertical AMF diameters were 1.72 ± 1.02 mm and 1.18 ± 0.38 mm, respectively. The mean AMF surface area was 1.62 ±1.14 mm^2. In 60% of cases, AMF was round shaped. Unlike our data, in the study of Iwanaga *et al*., the distance between MF and AMF was between 0.67 mm and 6.3 mm on average. The surface of AMF was on average 1.7 mm^2,[1] which is similar to our results. Data can be found that the average value of MF surface area is greater in the absence of AMF.[3,29] Mean AMF surface area in Muinelo-Lorenzo *et al*. and Saranaka study.[21] was 1.5 mm^2, which is similar to other studies.[32,33]

The distance of AMF from the inferior border of the mandible was also analyzed. The mean distance from the inferior border of the mandible in our study was 14.44 ± 1.14 mm. In the study of Muinelo-Lorenzo *et al*., the mean distance of AMF from the inferior border of the mandible was 11.72 ± 4.14 mm.[21] The results shown in the study by Li *et al*.,[20] where the mean distance of AMF from the inferior border of the mandible was 13.36 ± 1.77 mm, are similar to the values in this study.

Conclusion

The presence of anatomical variations in the upper and lower jaw is still often overlooked. Better examination of orofacial structures is accessible using CBCT imaging helping in the early and accurate diagnosis of lesions. Timely detection of AMF using CBCT contributes to diagnosis and planning appropriate dentures, surgical technique, preventing possible damage to adjacent anatomical structures or some other therapy. Using advanced software and hardware systems, CBCT can be improved to make more reliable images with better contrast resolution, improved bone density information and less or no artifacts, which will have better use in oral and maxillofacial surgery, implantology, endodontic, orthodontic, prosthetic, and forensic dentistry.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

JASI

A Study on Differences in the Obliteration of Cranial Sutures and Their Clinical Significance

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Abstract

Introduction: There are very few studies on the patency of cranial sutures, and this study analyzes the difference in sutural patency. The objective was to study the difference in the patency of coronal, sagittal, and lambdoid sutures in Indian human adult skulls. **Material and Methods:** This study involved 120 Indian human adult skulls. The suture patency was graded in accordance to a classification proposed by Sabini and Elkowitz on a scale of 0–4. An open suture was classified as 0; fused but not obliterated as 1; and Grades 2, 3, and 4 represented <50%, >50%, and 100% of obliteration, respectively. **Results:** The lambdoid sutures were observed to be the most patent and least obliterated. Grade 1 sutures were observed to be 44.71% in lambdoid, 8.4% in sagittal, and 7.3% in coronal sutures. Grade 2 sutures were observed to be 42.6% in lambdoid, 49.3% in sagittal, and 46.7% in coronal sutures. Grade 3 sutures were observed to be 10.1% in lambdoid, 32.1% in sagittal, and 36.2% in coronal sutures. Grade 4 sutures were observed to be 2.6% in lambdoid, 10.2% in sagittal, and 9.8% in coronal sutures. No open sutures were observed. **Discussion and Conclusion:** Lambdoid sutures are more patent than coronal and sagittal sutures. This can be attributed to the presence of more muscular contractile forces acting on the lambdoid suture when compared with other sutures. The mechanisms involved in suture closure are complex and involve genetic and environmental factors, age, and tissue interactions. Therefore, more advanced research is essential for a clearer insight on this subject, which has immense clinical implications in neuroscience.

Keywords: *Cranium, lambdoid, morphology, obliteration, suture*

Introduction

The term suture is coined from the Latin word "sutura," symbolizing serrated fibrous interdigitations.[1] Such interdigitations are found in the craniofacial skeleton, and their complexity increases with age.[2] Facial sutures are more patent than cranial due to greater tensile forces and more movement in the face.[2,3] Suture obliteration has diverse clinical implications as early obliteration results in craniosynostosis.[4] Obliteration is a multifactorial phenomenon depending on age, genetic factors, tensile stresses, brain growth, tissue interactions, and biochemical signaling.[5-7] Therefore, age estimation using only suture obliteration is unreliable.[8] However, suture obliteration can be used with other cranial indicators to conclusively determine the age.[9,10] The role of transforming growth factor-beta (TGF-β) in cranial suture obliteration is now conclusively established in physiological mouse models.[11] Lambdoid suture is reported to show prolonged patency and least obliteration compared to other sutures.[3,12] Because suture obliteration is a complex multifactorial phenomenon, more research is needed in this field to have a clearer insight. The age of the skull was not known in this study and therefore is a limitation. In this study, only the ectocranial aspect of the suture was studied. The authors believe that in future, the endocranial aspect of sutures and their microscopic and radiological evaluation can be performed in skulls in different age groups for better understanding on the subject.

Material and Methods

The study involving 120 skulls was conducted in the department of anatomy in three medical institutes in India. This includes Maharishi Markandeshwar

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Institute of Medical Sciences and Research, Mullana, Ambala; Career Institute of Medical Sciences, Lucknow; and Kanachur Institute of Medical Sciences, Mangalore. The degree of obliteration of cranial sutures was studied in 120 Indian human adult skulls. Skulls with deformities and damaged sutures were excluded from the study. The age and sex of crania were not known in this study. Only the ectocranial surface of sutures was studied. The endocranial surface of the sutures was not studied, and microscopic evaluation was not performed. The coronal, sagittal, and lambdoid sutures were graded in accordance to the grading pattern proposed by Sabini and Elkowitz.[3] An open suture was classified as 0; fused but not obliterated as 1; and Grades 2, 3, and 4 represented <50%, >50%, and 100% obliteration, respectively. The criteria used for grading obliteration are shown in Table 1.

The degree of obliteration of sagittal suture is noted and graded accordingly as shown in Figures 1-4. A Grade 1 sagittal suture which is fused but not obliterated is shown in Figure 1. A Grade 2 suture which is <50% obliterated is shown in Figure 2. A Grade 3 suture which is >50% obliterated is shown in Figure 3. A Grade 4 suture which is 100% obliterated is shown in Figure 4. Similarly, coronal and lambdoid sutures were also graded, and the frequency of different grades was recorded. The data obtained were analyzed statistically using the Statistical Package for the Social Sciences (SPSS) software (SPSS, IBM Co., Armonk, NY, USA, version 20.0) with Chi-square test. $P < 0.001$ was considered statistically significant.

Results

No Grade 0, open sutures were observed. The lambdoid sutures were observed to be the least obliterated and most patent. Grade 1 sutures were 44.71% in lambdoid, 8.4% in sagittal, and 7.3% in coronal sutures. Grade 2 sutures were 42.6% in lambdoid, 49.3% in sagittal, and 46.7% in coronal sutures. Grade 3 sutures were 10.1% in lambdoid, 32.1% in sagittal, and 36.2% in coronal sutures. Grade 4 sutures were 2.6% in lambdoid, 10.2% in sagittal, and 9.8% in coronal sutures. The frequency of different grades is summarized in Table 2.

In lambdoid sutures, Grade 1 had the highest frequency, followed by Grades 2, 3, and 4. In sagittal and coronal sutures, the highest frequency was exhibited by Grade 2, followed by Grades 3, 4, and 1. It was observed that the coronal and sagittal sutures tend to be more obliterated and less patent. Therefore, the highest frequency of Grade 3 and 4 sutures was observed in coronal and sagittal sutures, respectively. In contrast, the highest frequency of Grade

Table 1: The grading pattern used in the study. The pattern is in accordance to the grading pattern proposed by Sabini and Elkowitz[3]

Grade of suture	Patency
0	Open
1	The suture is fused but not obliterated.
2	The suture is fused and < 50 % obliterated.
3	The suture is fused and > 50 % obliterated.
4	The suture is fused and 100 % obliterated.

Figure 1: A Grade 1 suture which is fused but not obliterated

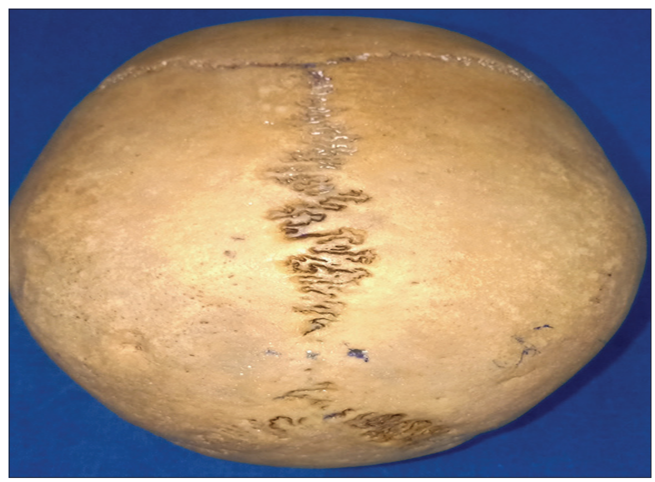

Figure 2: A Grade 2 suture which is <50% obliterated

Figure 3: A Grade 3 suture which is >50% obliterated

1 and 2 sutures was observed in the lambdoid suture, suggesting that these sutures tend to be more patent and least obliterated.

The frequency of different suture grades observed is summarized in Figures 5-7. The observed data were analyzed using the Chi-square test, and the results of the test are summarized in Table 3. Statistical analysis showed that all observations were statistically significant with $P < 0.001$. This conclusively establishes that lambdoid sutures are more patent than the coronal and sagittal sutures.

Figure 4: A Grade 4 suture which is 100% obliterated

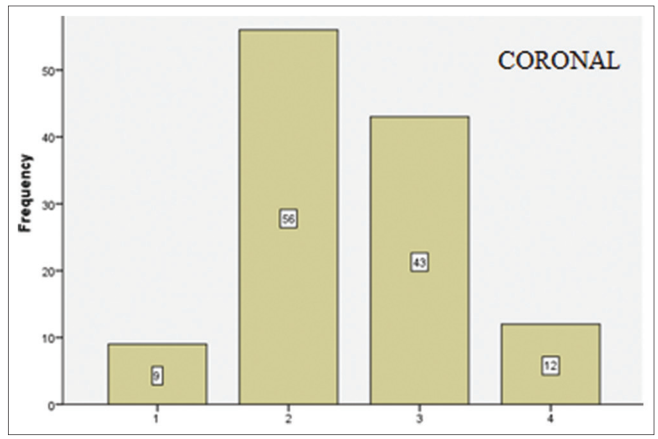

Figure 5: The frequency of different suture grades observed in the coronal suture

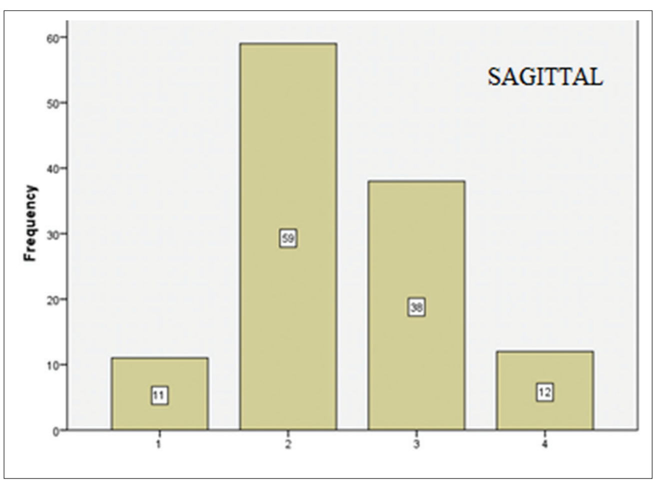

Figure 6: The frequency of different suture grades observed in the sagittal suture

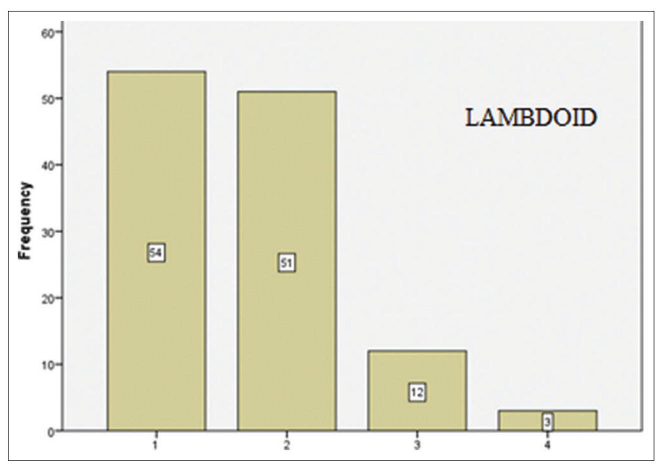

Figure 7: The frequency of different suture grades observed in the lambdoid suture

Discussion

Sutures are fibrous joints in the craniofacial skeleton and are simple at birth.[1] They develop complex interdigitations due to constant growth and resorption of the surrounding bones.[13] Over the years, sutures become completely obliterated with a calcified tissue.[2] Patency of sutures during the early period of development allows brain growth without raising intracranial tension, and, hence, early obliteration of sutures leading to craniosynostosis can be fatal.[14]

The morphology of the sutures depends on multiple factors, both extrinsic such as the muscle tension and intrinsic

Table 2: The observed frequency of different grades of cranial sutures

Suture	*n*	Patency (%)				Mean	SD
		Grade 1	Grade 2	Grade 3	Grade 4		
Coronal	120	9 (7.3)	56 (46.7)	43 (36.2)	12 (9.8)	2.48	0.778
Sagittal	120	11 (8.4)	59 (49.3)	38 (32.1)	12 (10.2)	2.43	0.796
Lambdoid	120	54 (44.7)	51 (42.6)	12 (10.1)	3 (2.6)	1.70	0.751

SD: Standard deviation

Table 3: The test statistics

	Coronal	Sagittal	Lambdoid
χ^2	53.667[a]	53.000[a]	69.000[a]
df	3	3	3
P	*P*<0.001 and is statistically significant		

a stands for all which means χ^2 values of all 3 cranial sutures are statistically significant

such as brain growth and genetics.[15-17] In an experiment on rats, when their temporalis muscle was removed, the regional skull growth reduced and the sutures became more simple.[16] This proves that suture complexity is directly proportional to the tensile forces acting on the suture. These interdigitations increase the surface area of contact of the cranial bones and transfer the tensile forces acting on the suture.[18] It is believed that reduced bone growth and bone movement is associated with early obliteration of the regional sutures.[19] Moreover, sutures transplanted from one location to another in rats were successfully taken up at the new site.[20] Therefore, suture patency and obliteration is a phenomenon with several lacunae available for researchers to explore.

Sabini and Elkowitz examined 17 female and 19 male skulls in the age range of 56–101 years. They concluded that there is no association between grade of the suture and sex and age of the individual. It was also observed that the lambdoid sutures show prolonged patency compared to other sutures.[3] Murlimanju *et al*. examined 78 human dry skulls of unknown age and sex in the Indian ethnic group. They observed a high frequency of Grade 2, followed by Grades 1, 3, and 4 among lambdoid sutures. Statistical analysis conclusively established that the lambdoid suture has prolonged patency compared to other cranial sutures.[12] Bolk examined 1820 skulls and reported delayed obliteration of lambdoid sutures. In their study, the suture obliteration was 0.27% in lambdoid, 0.65% in coronal, and 3.9% in sagittal sutures.[21] Parsons and Box also stated that the lambdoid sutures were the last among the cranial sutures to obliterate completely.[22] All the above-mentioned studies imply that lambdoid sutures remain more patent and less obliterated. Different studies have used different methods, statistics, and grading patterns. In our study, we observed that in lambdoid sutures, Grade 1 exhibited the highest frequency, followed by Grades 2, 3, and 4. The highest frequency of Grade 1 and 2 sutures was observed in the lambdoid suture, suggesting that these sutures tend to be more patent and least obliterated. In contrast, the highest frequency of Grade 3 and 4 sutures was observed in coronal and sagittal sutures, suggesting that these sutures tend to be more obliterated and less patent.

Suture patency and obliteration depends significantly on the tensile forces acting on the suture.[1,2] The pull of muscles and ligaments attached around the suture delays obliteration.[3] The lambdoid suture experiences maximum stress from muscular pull when compared to other sutures. This is because a large number of muscles are attached to the occipital bone such as rectus capitis posterior major, rectus capitis posterior minor, semispinalis capitis, rectus capitis anterior, rectus capitis lateralis, longissimus capitis, obliquus capitis superior, occipitalis, splenius capitis, and sternocleidomastoid. The ligamentum nuchae also plays a significant role as it is attached to the spines of the cervical vertebrae and the external occipital protuberance.[23] A concept called "myofascial continuity" states that muscles that cross joints while moving from their origin to insertion exert significant action at the sites of insertion. This is very much true with muscles in the back of the neck that cross the cervical vertebrae and are attached to the occipital bone. These muscles and ligaments that move the cervical vertebrae produce an enormous tensile stress on the lambdoid sutures as a result of which the lambdoid suture has a prolonged patency.[24] In contrast, the number of muscles acting on the coronal and sagittal sutures is fewer such as the frontalis and temporalis. This explains the early obliteration of these sutures.[3]

The knowledge of suture patency has clinical implications in osteopathic medicine and biomedical science.[3] The prolonged patency of the lambdoid suture is also an important factor for normal autonomic functioning considering the fact that the vagus nerve passes through the jugular foramen which can get compressed in cases involving early suture obliteration.[25] The mechanism of suture obliteration is multifactorial and therefore still not understood completely. It depends on age, genetic factors, tensile stresses, and tissue interactions.[5-7] The role of TGF-β in cranial suture fusion is now conclusively demonstrated in physiological mouse models.[11] The tensile forces of the muscles and ligaments attached near the suture delay the obliteration of the suture.[3] Fibroblast growth factor signaling, bone morphogenetic protein signaling, Wnt signaling, polycystins, mechanical stimuli, and several signaling interactions influence suture obliteration.[26]

Suture closure is often used to determine the age of the individual.[27] The concept of increased suture closure with advancing age was understood in the 16th century.[28] Cranial sutures can be used as a tool for age determination in individuals aged between 30 and 60 years with accuracy in the range of 5–10 years.[29] Khandare *et al*. conducted a postmortem study on cranial sutures and observed that the ectocranial obliteration of the sutures is inconclusive for age estimation, whereas the endocranial obliteration is useful and more accurate. The authors reported complete closure of sagittal suture between 61 and 65 years, coronal suture between 56 and 60 years, lambdoid suture between 66 and 70 years, and temporoparietal suture between 66 and 70 years. The endocranial fusion of sagittal suture starts at the end of 26 years and completes itself by the age of 61–65 years. The endocranial fusion of coronal suture starts as early as 25–30 years and completes itself by the age of 56–60 years. The endocranial fusion of lambdoid suture starts at the age of 25–30 years and completes itself by the age of 66–70 years.[22,30] In another study on suture closure involving 150 Indian skulls, it was observed that the obliteration occurs rapidly on the endocranial aspect and that the endocranial obliteration is more useful in age estimation than ectocranial obliteration.[31] Sahni *et al*. studied suture closure in 538 males and 127 females during autopsy in North West India. The authors reported that obliteration begins earlier in males than in females and is earlier on the endocranial aspect than ectocranial. The authors concluded that the phenomenon of suture obliteration is erratic and not useful for accurate age estimation.[32] In another study by Kumar *et al*. involving seventy autopsy cases in the third, fourth, and fifth decades of life, it was observed that endocranial fusion was more regular than ectocranial. The authors also concluded that suture closure is not useful for age estimation.[33] Some researchers are of the opinion that age estimation using sutures can only be given in a range of decades.[34] Most research studies conclude that the endocranial suture fusion is straighter, more uniform, rapid, and complete. In contrast, the ectocranial fusion is irregular, serrated, slower, and more incomplete.[35-37] In another radiological study involving 104 individuals, the sagittal, coronal, and lambdoid sutures were studied. The study concluded that if suture closure is completely absent, then the age of the individual is below 30, and if there is complete fusion of all the three sutures, the age of the individual is above 40 years.[38]

In our study, the age of the skull was not known. Moreover, the suture was studied only on the ectocranial aspect, and it was not observed as to whether the patency extends throughout the entire extent of the suture till the endocranial aspect. These were the limitations of the study, and the authors believe that there is a lot of scope for researchers to study suture obliteration more appropriately taking into consideration all factors. A literature review reveals that the endocranial obliteration is rapid, uniform, and more accurate for age estimation. The ectocranial obliteration is irregular, slow, and not accurate for age estimation. Future studies can also involve microscopic evaluation of sutures which can determine the extent of suture obliteration from ectocranial to endocranial aspect more accurately.

Conclusion

In our study, we observed that the lambdoid sutures are more patent and less obliterated when compared to coronal and sagittal sutures. This is believed to be due to the larger number of muscles and ligaments of the cervical vertebrae attached to the lambdoid suture when compared to those of the coronal and sagittal sutures. The time of obliteration of sutures has immense clinical implications in neuroscience as early closure leads to craniosynostosis, impairing brain development. In contrast, a Grade 0 patent suture must be thoroughly evaluated by neurologists to assess the extent of patency and its clinical implications.

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Conflicts of interest

There are no conflicts of interest.

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Review Article

A Review of Flaps and Their Uses in Reconstructive Surgery

Abstract

The field of reconstructive surgery is rapidly advancing with advances in the techniques of anatomical dissection, understanding of the neurovascular physiology, and improvements in surgical instrumentation. Flaps are composite units of tissue which have their own blood supply or an intact arteriovenous system to receive vascular inflow when transferred to a site of defect. Due to a wide array of flaps being used in reconstructive surgery, numerous terminologies can be found in use by reconstructive surgeons. Skin flaps are flaps that are composed of skin and subcutaneous tissues. Composite flaps are those which contain more than one component within the flap substance, and perforator flaps are those based on a cutaneous perforator. The angiosome concept has aided in understanding the vascular basis of flaps and increases their utility. Further research and insights are needed at the moment to have a finer understanding of the tissue neurovascular anatomy and flap behavior.

Keywords: *Flaps, microsurgery, perforators, reconstructive surgery, wound management*

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Introduction

The word "flap" is derived from the original 16th-century Dutch word "flappe" which means anything hanging broad and loose, attached only on one side. In contrast, the word graft is derived from "gryft" which is a horticultural word referring to a piece of shoot inserted into a slit in the stem of another plant to derive nutrition from it. In reconstructive surgery parlance, graft refers to a unit of tissue devoid of its own blood supply when used to reconstruct a defect receives its blood supply from the recipient site. In contrast, flaps are composite units of tissue which have their own blood supply or intact arteriovenous system to receive vascular inflow when transferred to a site of defect.

History of Flaps

The earliest mention of flaps for the restoration of body parts can be traced to 700 BC in the Sushruta Samhita where the sage Sushruta describes the use of the facial tissues in the correction of deformity of the nose. During AD 1440, the use of pedicled forehead flap for the correction of nose deformity in the Indian subcontinent was done routinely. However, it was discovered by two Englishmen and reported in the Madras Gazette and The Gentleman's Magazine as the Indian method of nose reconstruction in 1794.[1] This led to a resurgence of flap procedures in England as well as Europe.

Tagliacozzi was among the first surgeons in Europe to describe his method of rhinoplasty using the distally based upper arm flap which was published in 1597.[2] Significant advances in flap surgery were reported by Delpech, Labat Dieffenback, Blasius, and Volkmann in Europe and Mutter in the United States. The introduction of tube pedicled flap was done independently by Filatov, Hugo Ganzer, and Major Harold Delf Gillies during the period from 1916 to 1917.[3] Further refinement in flap procedures came from the experiences of reconstructive surgeons like Kazanjian, Smith, R H Ivy, Sheehan, Bunnell, and Sir Harold Gillies during World War I.[4]

In 1882, Theodore Dunham of New York reported the two-stage island pedicled flap for the reconstruction of a defect following excision of a large epidermoid cancer of the cheek and eyelid where the vascular pedicle of the flap based on the superficial temporal artery was dissected out and buried in the skin of the cheek.[5]

Jacques Joseph, in 1931, described the vascular pattern of the deltopectoral flap which was later popularized by V Y Bakamjian, in 1965.[6]

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With further understanding of flap anatomy and physiology, numerous refinements came into the flap design. McGregor and Jackson in 1972 published a landmark paper on the groin flap based on the superficial circumflex iliac artery and introduced the terms axial and random pattern flaps.[7]

Tanzini, in 1906, introduced the latissimus dorsi muscle flap for the first time, however the detailed anatomy of the latissimus dorsi musculocutaneous flap and axial flap of the skin from the same area was explained by Professor Steffanod'este in 1912.[8] Over the course of the next 50 years, further understanding of the vascular anatomy of muscle led to refinements in the type and usage of such flaps. By the turn of the century with the advent of the operating microscope, vascular repair techniques of Carell, and the development of microvascular instruments and sutures, an era of free tissue transfer began. The flaps which were up till now tethered to the donor sites could be transferred to the distant sites along with their vessels and nerves. The first report of free flap was the free groin flap by Kaplan *et al*. in 1971 for an intraoral defect.[9]

Harii *et al*., in 1976, reported the use of free gracilis muscle flap with microvascular and microneurotization techniques for the reanimation of facial paralysis.[10] With this, started an era of functional muscle transfers which has become an important technique of reconstruction in the armamentarium of plastic surgeons today.

In 1994, Taylor *et al*. published a seminal work on the vascular territories of the skin which was based on preliminary work of Salmon and Manchot. Taylor introduced the concept of "Angiosome" which formed the foundation for more refinements in flap surgery.[11]

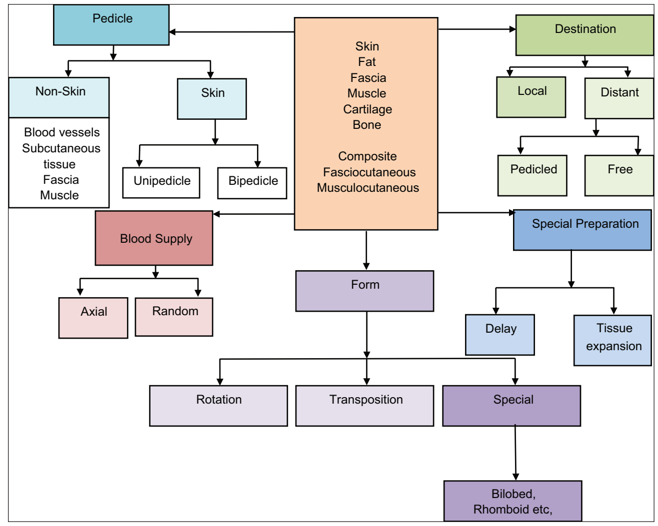
Classification of Flaps

There is no system that can classify all the types of flaps considering that a wide variety of flaps that can be used in reconstructive surgery exist. However, authors have designed comprehensive classification systems which can broadly categorize these flaps. Tolhurst designed an atomic system [Table 1] of flaps wherein he included composition characteristics of flaps.[12] In contrast, Cormack and Lamberty gave a comprehensive flap classification [Table 2], including the composition as well as circulation characteristics.[13] As the understanding of vascular basis and anatomy of flaps improved, authors started suggesting flap classification schemes based on vascular supply [Table 3].

Terminology of Flaps

Due to a wide array of flaps being used in reconstructive surgery, numerous terminologies can be found in use by reconstructive surgeons. Central to utility of any flap is the vascular supply. Random pattern flaps are flaps perfused by dermal vascular plexus without any known vascular

Table 1: Tolhurst "atomic" classification of flaps



pedicle. In contrast, axial pattern flaps are flaps which are raised based on a known vascular axis. Pedicled flaps are those which are transferred to a defect with the vascular supply still attached to the donor site. The attachment which is known as a pedicle may contain skin and subcutaneous tissue, only subcutaneous tissue, or just the arteriovenous axis within it. In contrast, free flaps are separated from the donor site and transferred to the defect to be reconstructed along with the arteriovenous structures. These are then sutured to the arteriovenous structures on the recipient site using microvascular suture techniques. When a flap is used to cover a defect adjacent to it, it is termed as a local flap; when the flap is used to cover a defect in the same anatomical region, it is termed as regional flap. Distant flaps are referred to flaps which are used to cover defects away from the donor site. Local flaps may be transferred to the defect by advancing the flap when they are known as advancement flaps. If the flaps move to the defect in a sideward manner, these will be called as transposition flaps. Frequently, local flaps may move to the defect to be covered by rotating along an arc, when they will be termed as rotation flaps [Figure 1]. Geometric flaps are random pattern local flaps which are generally based on dermal vascular plexus and marked according to geometric shapes. Examples include bilobed flap, rhomboid (Limberg) flaps [Figure 2], VY flaps, etc., If the movement of the flap to an adjacent defect involves the movement under an intact bridge of the skin between the flap donor site and the recipient site, they are known as islanded flaps. Propeller flaps [Figure 3] are a variety of local flaps that are pedicled on an arteriovenous system, designed like a propeller blade, and can be rotated at 180° to cover an adjacent defect.[14,15]

Skin flaps are flaps that are composed of skin and subcutaneous tissues, whereas fasciocutaneous flaps include deep fascia also in the flap composition. The inclusion of deep fascia improves the vascularity and

Table 2: Cormack and Lamberty's 6 C's of flap designbased classification .

Cormack & Lamberty's 6 C's of flap design		Flap Characteristics					
		Primary Characteristics		Secondary Characteristics			
		Circulation	Constituents	Contiguity	Construction	Conformation	Conditioning
Flap Type	Pedicled Flap	Direct Vessels Axial Septocutaneous Endosteal Indirect Vessels Myocutaneous Periosteal	Fasciocutaneous Myocutaneous Visceral Nerve Bone Cartilage Others	Local Regional Distant	Unipedicled Bipedicled Orthograde Retrograde Turbocharged Supercharged	Special configurations Tubed Combined	Delay Tissue Expansion Prefabrication
	Free Flap	Direct Vessels Axial Septocutaneous Endosteal Indirect Vessels Myocutaneous Periosteal	Fasciocutaneous Myocutaneous Visceral Nerve Bone Cartilage Others	Free	Orthograde Retrograde Turbocharged Supercharged	Tubed Combined	Delay Tissue Expansion Prefabrication

Table 3: Different approaches to flap classification

	Name	Basis	Type	Description	Example
Skin Flap	Cormack and Lamberty	For fasciocutaneous flaps based on origin of circulation to fascial plexus	Type A	Multiple fascial feeders which cannot be identified	Ponten lower limb flaps
			Type B	Large solitary septocutaneous perforator	Medial arm flap
			Type C	Multiple segmental septocutaneous perforator	Radial forearm flap
			Type D	Multiple small perforators raised as osteomyofasciocutaneous flaps	Fibula osteocutaneous flap
	Mathes and Nahai	For fasciocutaneous flaps based on type of deep fascial perforators	Type A	Direct cutaneous perforator	Groin flap
			Type B	Septocutaneous perforator	Anterolateral thigh flap
			Type C	Musculocutaneous perforator	Median forehead flap
	Nakajima	For fasciocutaneous flaps based on subtle arrangements of fasciocutaneous and musculocutaneous perforators	Type I	Direct cutaneous perforator	Superficial circumflex iliac artery flap
			Type II	Direct septocutaneous perforator	Superior ulnar collateral artery flap
			Type III	Perforating cutaneous branch of muscular vessel	Flap based on cutaneous branch of thoracodorsal artery
			Type IV	Direct cutaneous branch of muscular vessel	Latissimus dorsi flap
			Type V	Septocutaneous perforator flaps	Radial forearm flap
			Type VI	Musculocutaneous perforator	Gracilis myocutaneous flap
	Taylor	Angiosome concept and perforator distribution	Direct perforators	Perforators with primary cutaneous supply	Fasciocutaneous flaps
			Indirect Perforators	Perforators supplying primarily to deeper structures and secondarily to cutaneous structures	Neurocutaneous flaps

Cont....

Cont....

Muscle Flap	Mathes and Nahai Muscle Flap classification	Vascular supply of muscle	Type I	One vascular pedicle	Vastus lateralis
			Type II	One dominant vascular pedicle and additional smaller pedicles	Brachioradialis
			Type III	Two vascular pedicles each arising from separate regional artery	Rectus abdominis
			Type IV	Multiple pedicles of similar size	Sartorius
			Type V	One dominant vascular pedicle and several secondary segmental pedicles	Latissimus dorsi
	Taylor's classification	Motor neural supply of muscle	Type I	Single unbranched nerve entering muscle	Latissimus dorsi
			Type II	Single nerve that branches just before entering muscle	Vastus lateralis
			Type III	Multiple branches from same nerve trunk	Sartorius
			Type IV	Multiple branches from different nerve trunk	Rectus abdominis
Others	Serafin Classification	Vascularization of osseous component in osseous flaps	Endosteal	Nutrient artery directly supplying the bone	Fibular flap
			Periosteal	Bone nourished by the periosteal branches	Calvarial osseo-periosteal flap
Combined	Based on physical relationship of component parts		Conjoined flaps	Multiple flaps which have physical continuity but are perfused by their own vascular axis	Bipedicled flaps based on thoracodorsal and superficial circumflex iliac artery pedicles
	Chimeric flaps		Multiple flaps without physical continuity perfused by their own vascular axis from common source vessel	Flaps based on subscapular system	
VCA	Adaptation for vascular composite allotransplantation (VCA)			VCA added as suffix to regular flap nomenclature in order to clarify the source	Face composite VCA

survival of these flaps by incorporating the facial vascular plexus within it. Flaps composed of muscle and its blood supply are termed as muscle flaps. Compound flaps are those that incorporate diverse tissue components into one interrelated unit. These may be composite or combined flaps [Figure 4].

Composite flaps are those which contain more than one component within the flap substance as, for example, musculocutaneous flaps, osteocutaneous flaps, and neurocutaneous flaps and depend on a solitary source of vascular supply for the survival of all components. Combined flaps have multiple tissue components supplied by multiple source vessels. These may be conjoined, multiple flaps which have physical continuity but each perfused by their own vascular axis or chimeric, multiple flaps without physical continuity perfused by their own vascular axis, but the vascular axis is connected with a common source mother vessel.[16,17]

Perforator flaps are those based on a cutaneous perforator (direct, septocutaneous, or musculocutaneous). Angiosomes are three-dimensional blocks of tissue, including skin and deeper tissue layers that are supplied by specific source arteries.[18,19]

Visceral structures along with their blood supply, for example, ileal flaps, colonic flaps, and omental flaps are termed visceral flaps.

Figure 1: Rotation flap to cover a forehead defect

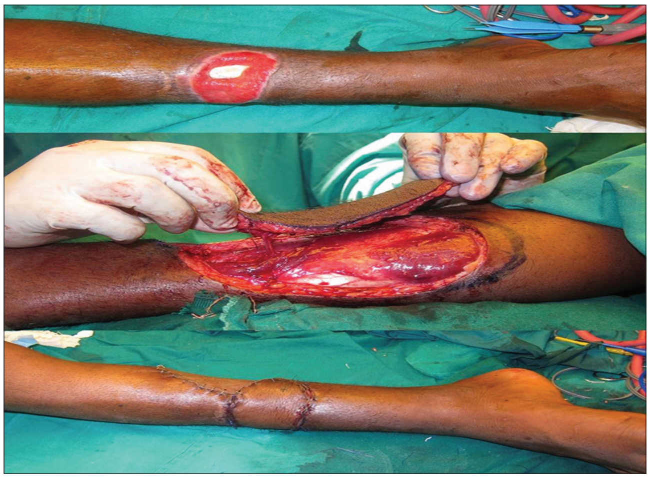


Figure 3: Propeller flap rotated 180° to cover an adjacent defect over the leg. Note the flap supported by a vascular pedicle

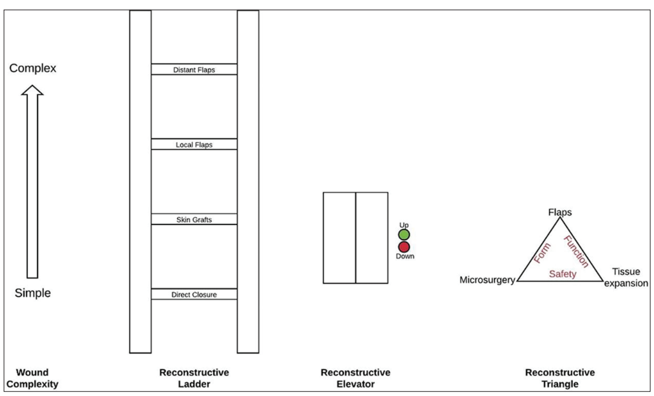


Figure 5: Choosing a suitable reconstruction based on the complexity of the wound

Uses of flaps

"… losses must be replaced in kind--bone for bone, cartilage for cartilage, and skin for skin "

Harold DelfGillies, 1917.[20]

The overarching goal of all reconstructive surgeons is to restore the anatomy as close to normal as possible. This has led to the discovery of new vascular territories, innovative flap designs, and efficient surgical techniques. The principles of reconstruction were governed for a long time by what is known as a reconstruction ladder. Reconstruction was planned in a gradual manner depending on the complexity of the defect and tissues lost. This was later modified into a reconstruction elevator where the most suitable option was selected irrespective of the complexity of defect [Figure 5].[21]

Figure 2: Rhomboid flap used to cover a defect in the sacral region

Figure 4: A pectoralis major myocutaneous pedicled flap used to cover a defect created after excision of a buccal carcinoma

Figure 6: Flap planning is done using a lint piece to estimate the amount of flap required to cover a defect. Here, a reverse sural artery flap is used to cover a defect of the foot

More recently, reconstruction principles are based on the reconstructive triangle where ideal reconstruction technique depends on providing optimal form and function with maximum safety.[22]

Geometric flaps are used for coverage of small-to-medium size defects, for example, defects following excision of basal cell cancer of the cheek or forehead. Bigger size defects as in cases of traumatic soft-tissue losses of the scalp or limbs are covered by pedicle flaps, notably transposition or rotation flaps. Complex defects with loss of multiple tissue components such as bone, muscle, and skin are better reconstructed with osteocutaneous flaps using microvascular techniques.[23-25]

Flap dimensions are planned according to the measurement of the cutaneous defect. In case of pedicled flaps, the reach of the flap should be measured in addition to flap dimensions [Figure 6]. Special situations demand special flaps as in case of osteomyelitis of tibia following trauma; a well-vascularized muscle flap with graft will help in controlling infection faster by increasing blood flow to tissues. Lymphedema control of the lower limbs can be achieved with vascularized lymph node transfer which involves the transfer of flaps containing lymph nodes such as the submental or supraclavicular flaps.[26] Vascularized joint transfers are utilized to restore joint anatomy and function in the hands.[27,28] Visceral flaps are utilized for the restoration of the esophageal, larynx, urethral or vaginal anatomy, etc.[29,30] More recently, perforator-based free flaps with their innate ability to cover any kind of defects are being used extensively in reconstruction.[31] Improvement in microsurgical instrumentations has led to a widespread adoption of perforator flaps in reconstructive practice.[32]

Dynamic muscle transfers are done to restore function to a specific part as, for example, eyelid closure in facial nerve palsy using the temporalis muscle flap. Function can be also achieved using free functioning muscle transfers as done for severe crush injuries of the limb where gracilis muscle transfer with nerve cooptation is done to achieve finger flexion in cases of nerve injuries of the upper limb.[33]

Conclusion

The field of reconstructive surgery is rapidly advancing with advances in techniques of anatomy, understanding of the neurovascular physiology, and surgical instrumentation. More refinements are being carried out at a regular basis to provide the most optimal form and function. Further research and insights are needed at the moment to have a finer understanding of tissue neurovascular anatomy and flap behavior, using newer anatomical and imaging techniques.

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Conflicts of interest

There are no conflicts of interest.

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Case Report

Superficial Course of the Radial Artery in the Anatomical Snuffbox and Course of Princeps Pollicis and First Dorsal Metacarpal Arteries

Abstract

Variations of the radial artery (RA), in its course and branching pattern in the anatomical snuffbox, are clinically significant during vascular and reconstructive surgeries of the hand. During the course of routine dissection of RA in the forearm and hand, an important variation was noted. In one of the cadaver RAs, at a short distance above the wrist, it gave superficial palmar artery and turned laterally passed superficial to the tendons to the thumb forming the boundaries of anatomical snuffbox and entered the hand by passing between two heads of the first dorsal interosseous muscle and terminated in the deep palmar arch. At the anatomical snuffbox, RA gave arteria princeps pollicis and first dorsal metacarpal arteries. The knowledge about this variation is to be noted carefully because this artery used as a graft during the cardiac surgery, which when missed might lead to many complications.

Keywords: *Anatomical snuffbox, deep palmar arch, origin of arteria princeps pollicis, radial artery*

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Introduction

Accurate and detailed knowledge about the course of the radial artery (RA) and variations in origin and course of its branches has been reported and surgeons should be aware before doing a hand surgery. In addition, iatrogenic trauma due to occurrence of superficial branches of the RA may lead to a life-threatening hemorrhage.

The brachial artery divides into a larger ulnar artery and a smaller RA. From the origin, RA runs superficially downward medial to the brachioradialis. After giving superficial palmar branch, RA winds around the radial aspect of the forearm in the lower part and enters into the anatomical snuffbox.[1] It passes deep to the abductor pollicis longus and extensor pollicis brevis and enters the palm of the hand by passing between the two heads of the first dorsal interosseous muscle. In the anatomical snuffbox, it usually gives off the dorsal carpal branch which ends the dorsal carpal arch. Before its entry to the palm, on the dorsum of the hand, it gives slender branches to the lateral side of the dorsum of the thumb and first dorsal metacarpal artery. In the palm, it lies at first between the first dorsal interosseous and adductor pollicis where it gives off the arteria radialis indicis and arteria princeps pollicis (APP) and becomes continues as the deep palmar arch. According to Hollinshed,[2] the APP may alternatively arise directly from the deep palmar arch or by a common trunk with the arteria radialis indicis both of which are the branches of the RA.

RA is used for common surgical procedures during harvesting. Although there are articles reported the variation in the origin of the RA around 15% as cited by McCormack *et al*. 1953,[3] there are only very few reports about the variation in its superficial course with about 0.52% incidence.[4] For radiological assessment of the arteries during angiographic procedures, cardiac catheterization, or during the hand surgeries prior to the procedure, a detailed history of the arterial pattern is needed. Entire course of the artery and its relations to the structures in the forearm and hand have to be clearly noted, because when a surgeon misses to note, it would result in complications during hand surgery or after surgery its relation with the adjacent structures in the lower part of the front of the forearm and wrist also has to be noted. In the current report, we present a rare case of "very superficial course" of the RA in anatomical snuffbox and course of APP through thenar muscles and discuss

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clinical and surgical importance. Anatomical knowledge on the variant branching pattern of RA in the hand is of considerable importance during several surgical approaches and therapeutic practices. During coronary angiography and any coronary interventions, it is important to clearly learn about the RA course.

Case Report

During routine dissection for undergraduate MBBS students at Kasturba Medical College, Manipal, we came across a variation in the course of the RA and the APP in the right upper limb in one male cadaver out of 50 formalin-fixed adult cadavers. Origin of RA was normal. At a short distance above the wrist, it gave superficial palmar artery and turned laterally passed superficial to the tendons to the thumb forming the boundaries of the anatomical snuffbox [Figure 1]. Later, the course of the artery was between the two heads of the first dorsal interosseous muscle in the dorsal aspect and entered the palm of the hand and gave off the arterial radialis indicis and terminated in the deep palmar arch.

The RA, while passing superficial to the anatomical snuffbox, gave off the princeps pollicis and first dorsal metacarpal arteries [Figure 2]. This variant superficial course of RA and other branches arising at this level were covered only by skin and superficial fascia and were thus very vulnerable to injury.

Discussion

The brachial artery divided into ulnar and radial arteries. Awareness of RA variation in its origin and branching pattern has great importance in various clinical fields and basic medical studies. Reports on its variant origin and in its proximal course are quite common compared to its distal course in the forearm and termination in the hand.[5] Higher origin of RA associated with its complete superficial course termed as superficial brachioradial artery as cited by Sharmila Bhanu *et al*.[6] Manners-Smith[7] classified the variations in the course of the RA into two categories in relation with the tendons forming the boundaries of the anatomical snuffbox on the dorsal aspect of the hand. When the RA undergoes a superficial course in relation to these tendons, it was considered one category and named as the superficial dorsal artery of the forearm. In the second category division in the anatomical snuffbox, the RA divides into superficial and deep branches – called the partial duplication of RA[3] or duplication of the RA.[8] The present case belongs to the first class category of Manners-Smith Classification.[7] An extremely superficial course of the RA in the anatomical snuffbox has been reported by Jyothsna *et al*.[5] Chandni *et al*.[9] reported a superficial course of RA in the anatomical snuffbox in one of 75 specimens studied. However, an occurrence of anomalous superficial course of APP through the thenar muscles of the hand is seldom reported. Abdullah *et al*.[10] reported divisions of RA into dorsal and palmar branches 5.5 cm above the styloid process of the radius. Dorsal branch was running superficial to the tendons forming the boundaries of anatomical snuffbox and ended by perforating first dorsal interosseous muscle, while the palmar branch passed superficial to the flexor retinaculum and deep to the abductor pollicis brevis and anastomosed with ulnar artery forming the superficial palmar arch.

The arteries that are superficial in the upper limb may be misinterpreted as veins because of its appearance, which may become a basis for intra-arterial injections instead of intended intravenous injections.[11,12] It might be also noticed during forearm flaps in plastic surgery[13] or misinterpreted in contrast radiographs.[14] During most of the cardiac surgical procedures, the RA is the most preferred graft[15] because it is easily accessible and arteries always have a greater success rate when compared to veins. Veins such as saphenous graft are also used for cardiac bypass grafting. The very superficial course of the RA in the anatomical snuffbox and its close relation to the cephalic vein are also a predisposing factor for its inadvertent injuries. It might get punctured instead of the cephalic vein while setting an

Figure 1: Superficial course of the Radial artery and the origin of first dorsal metacarpal artery in the hand from the RA.RA: Radial artery, DM: First dorsal metacarpal artery

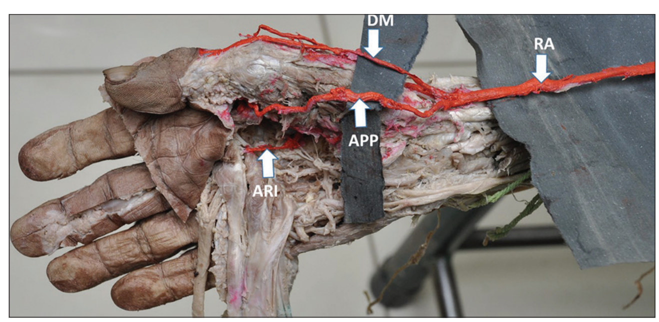

Figure 2: Dissection of the hand showing radial artery and superficial course of arteria princeps pollicis, first dorsal metacarpal artery and origin of arteria radialis indicis in deeper part of palm of hand. RA: Radial artery;DM: First dorsal metacarpal artery;APP: Arteria princeps pollciis:ARI: Arteria radialis indicis

intravenous line. Superficial cuts in the anatomical snuffbox might result in significant bleeding when the artery is very superficial as the one being reported here.

Conclusion

The variations observed in our case with an anomalous superficial course of RA at anatomical snuffbox and course of APP through the thenar muscles may be of significance clinically for microsurgeons in surgeries of the hand and during vascular surgery. The superficial arteries of the upper extremity are thin and might give an appearance like that of veins, and hence, any intravenous injection that is supposed to be given may be misinterpreted and given as an intrarterial injection which may produce complications.

The superficial arteries of the upper extremity are thin and might give the appearance like that of veins, and hence, any intravenous injection that is supposed to be given at that level may be misinterpreted as veins and given as an intrarterial injection which may produce complications later. It is a chance of finding during the routine dissection process. Knowledge of this type of variation is important during surgical procedures of the hand such as cardiac catheterization, arterial grafting, and other angiographic procedures.

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Conflicts of interest

There are no conflicts of interest.

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Case Report

Cartilaginous Choristoma at Nasopharynx

Abstract

A 26-year-old man attended the outpatient department of Otorhinolaryngology with complaint of nose block. He was presented with nonspecific clinical presentations except nasal block. Mass was present at the nasopharynx and completely excised and sent for biopsy which confirmed the diagnosis of cartilaginous choriostoma. The histopathological report revealed cartilaginous tissue with surrounding of seromucous salivary glands under cover of respiratory epithelium. The choristoma is a tumor like lesion consisting of normal cells present in the abnormal site. It is most often seen in oral cavity structures such as tongue, gingival, buccal mucosa and soft palate. Cartilage choristoma is rarely found at the nasopharynx. It is developmental in origin. Definite diagnosis is done by histopathological findings. The treatment is usually done by the surgical excision.

Keywords: *Cartilage, choristoma, endoscopic excision, nasopharynx*

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Introduction

Choristoma is a benign lesion consisting of normal tissue found in abnormal location. It is found in different sites of the head and neck area like oral cavity, oropharynx, hypopharynx and middle ear.[1] Choristoma may originate in bone, cartilage, glial tissue, salivary gland and thyroid gland. Most common site for origin of this lesion is the tongue followed by gingiva, buccal mucosa of the oral cavity and soft palate.[2] Cartilaginous choristoma at the nasopharynx is extremely rare. It is usually developmental in origin, few of them occurs due to local trauma. It is reported in infant of 1 day age to 90-year-old lady, with mean age of 47 years.[3] The clinical presentation of this lesion is often painless mass and may give rise to local dysfunction. The definite diagnosis is done from histopathological examination. Due to the rarity of the cartilage choristoma at the nasopharynx, the diagnosis is unsuspected until the excised mass is sent for pathological report. Treatment of this lesion is complete surgical excision. Here, we report a case of cartilaginous choristoma at the nasopharynx.

Case Report

A 26-year-old man attended the outpatient department of Otorhinolaryngology with complaints of chronic postnasal discharge and nasal block. He had also frequent throat irritation due to postnasal drip. He had no history of nasal bleeding, headache and swallowing difficulty. He had specific past surgical or medical history except adenotonsillectomy underwent during childhood. The patient had no history of any other trauma to the nasopharyngeal area. Diagnostic nasal endoscopy was done which revealed a mass of 15 mm × 5 mm on the undersurface of the soft palate. Computed tomography (CT) scan of the nose and paranasal sinus was done which showed a mass at the nasopharynx without any extension beyond the nasopharynx [Figure 1]. The patient was explained about details of the lesion including site and size of the mass.

Then with the help of endoscope, mass [Figure 2] was excised under general anesthesia. Macroscopically it appears as polypoidal mass with dimension of 1.5 cm × 0.5 cm × 0.4 cm. Mass was excised and sent for histopathological examination. Grossly the mass was firm to hard in consistency and globular in shape. The outer surface was glistening and shiny. The cut surface of the specimen was showing myxoid areas. The histopathological picture revealed respiratory epithelium over the surface and matured hyaline cartilage tissue beneath the epithelium and cartilage surrounded by sero-mucous glands. Chondrocytes varied from small to large size

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without presence of nuclear atypia [Figure 3]. The lesion was diagnosed as cartilage choristoma originating from the minor salivary gland of the nasopharynx. Postoperative endoscopic examination showed normal anatomical appearance at the nasopharynx and undersurface of the soft palate after 3 months of surgery. There was no recurrence in follow up visit after 6 months of surgery. Patient consent was obtained and this case report was also approved by Institutional Ethical Committee for publication.

Discussion

Heterotopia is a phenomenon where the normal tissue is found in an abnormal anatomical location. These mass are usually benign in nature. Choristoma is a type of heterotopias where histologically normal tissue is seen in an embryologically abnormal site. So, Choristoma is characterized as presence of the tissue or mass which not normally found in a site. It is often found in the distal extremities but rarely seen in the head and neck region.[4] The cartilaginous choristoma was documented by Berry in 1890.[5] There is certain confusion regarding the names of similar types of lesions like choristoma. The names of these lesions were used variably such as hamartoma, hairy polyp, epiganthus, true teratoma, teratoid and dermoid. Teratomas and teratoids are derived from all the three germinal layers whereas teratoids are poorly differentiated.[6] Presence of teratoma in the oral cavity is called as epignathus. Hamartomas are focal, excessive and over growth of the cells natural to the body part in which they occur. Dermoid consists of ectodermal and mesodermal germ cells. Choristoma is often called as a hairy polyp where mesodermal layer is covered by ectoderm. Present medical literature support that choristoma and hairy polyp are developmental malformations than teratoma.[7] The classification of choristoma is based on the tissue it contains. Our case such as cartilaginous choristoma is not described as salivary type or mixed type as minor salivary glands are expected to be seen in this anatomical site whereas a mature hyalaine cartilage is not to be present. There are multiple theories for explaining the origin of cartilaginous choristoma. Embryonic theory support towards heterotopic cartilage is due to fetal remnants.[8] The origin of the choristoma from embryonic rests postulates that the lesion arise from heterotopic cartilage remnants of the first four branchial arches. Metatplastic theory suggests trauma may be a cause for heterotopic cartilage from mesenchymal cells. Few support vestigial remnants as the origin for this choristoma.[9] There are different types of choristomas such as cartilage, bone, glial tissue, thyroid tissue and salivary gland.[10] Choristoma of cartilaginous tissue is usually called as cartilaginous choristoma.[11] Cartilage choristoma at the nasopharynx is incidentally found in adult age as in our case, which might may be due to origin of metaplastic theory due to injury by previous adenoidectomy surgery during pediatric age.

The clinical presentations of cartilaginous choristoma are often seen in adult age group. It is often seen in oral cavity as submucosal mass and clinically asymptomatic. It is often present with painless mass and may shows local discomfort. In present case, the mass was present in the nasopharynx

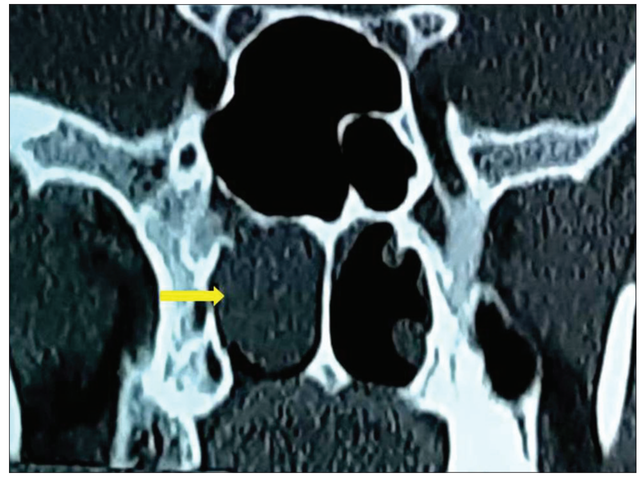

Figure 1: Computed tomography scan picture showing nasopharyngeal cartilage choristoma (yellow arrow mark)

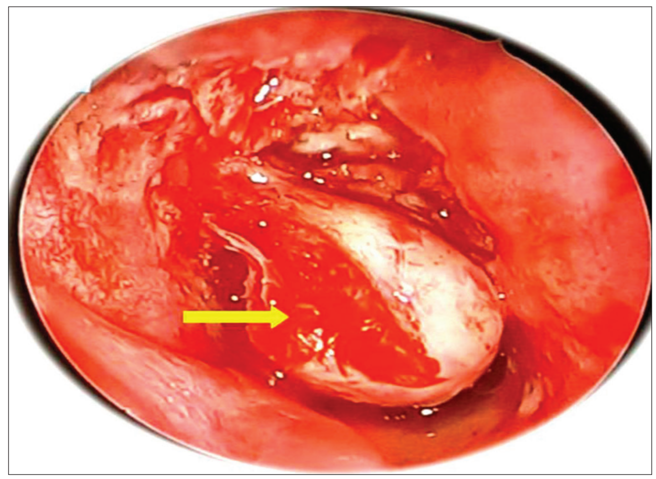

Figure 2: Endoscopic picture showing mass of cartilage choristoma at the nasopharynx (yellow arrow mark)

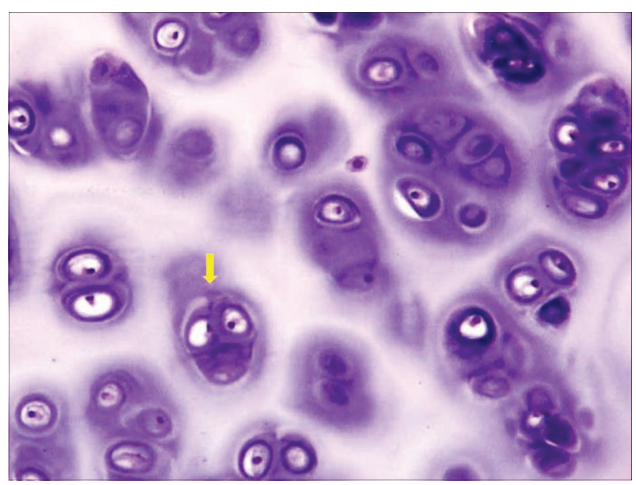

Figure 3: Photomicrograph of the histopathological study showing hyaline cartilage (yellow arrow mark) (H and E, ×50)

causing nasal block and sometimes nasal discharge with postnasal drip. Congenital cartilaginous choristoma at the nasopharynx often present with emergency respiratory difficulty. The diagnostic nasal endoscopy is helpful for assessment of the nasopharyngeal mass and its exact location. CT scan is the ideal imaging to find out the site of the mass and its extension. The endoscopic biopsy can be done under local anesthesia in adult and general anesthesia in children. The definitive diagnosis of cartilaginous choristoma is done by biopsy and histopathological examination. Histopathological picture shows mixture of mature adipocytes or myxoid tissue with islands of cartilage inside a well defined capsule. Although most of the cases show pure cartilaginous proliferations, few lipocartilaginous and osteocartilaginous lesions also have been documented.[12] The differential diagnosis of cartilaginous choristoma is soft tissue chondroma, pleomorphic adenoma, traumatic chondroid tumor and ectomesenchymal chondromyxoid tumor.[13] The difference between the cartilage choristoma and true neoplasm is a challenging issue for clinicians. It can be easily misdiagnosed and can be reported as a true neoplasm.[14] Cartilaginous choristoma sometimes mimics with cartilaginous metaplasia which often seen in soft tissue due to long standing minimal trauma as beneath ill-fitting denture in the oral cavity.[15] The histological characteristics of the cartilaginous metaplasia is deposition of the calcium and scattered cartilaginous cells arranged in different stages of maturation in cluster or single focus. But in present case the histopathological picture shows no metaplasia and was almost entirely hyaline cartilage.

Treatment of this pathology is surgical excision. In pediatric cases with inadequate nasopharyngeal airway, immediate surgery is required. In our case, endoscopic excision of the mass was done without any evidence of remnant. If the mass is very large, along with trans-nasal route, trans-oral rout is also approached without damaging the soft palate. Complete removal of this mass along with perichondrium and adjacent soft tissue is the treatment of choice. Removal of the perichondrium is required to stop recurrences as perichondrium may develop new cartilage. Damage to soft palate may lead to velopharyngeal insufficiency. Cartilage choristomas are extremely rare at the nasopharynx but the distinct clinical features and should be differentiated from neoplasms as o their developmental origin and benign nature of the lesion. They usually do not show recurrence after complete removal of the mass.

Conclusion

Cartilage choristoma at the nasopharynx is an extremely rare and benign lesion which should be kept in mind during examining a mass at the nasopharynx. It is developmental in origin. Although the cartilage choristoma is an uncommon lesion at the nasopharynx but it is not an unheard clinical entity. It is usually diagnosed by histopathological report as many times it mimics to other lesions at the nasopharynx. The treatment of choice is surgical excision. During the excision of the mass, the perichondrium should be excised. It should be differentiated from the neoplasms.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Prof. Asim Kumar Datta (1927–2020)

Dr. Asim Kumar Datta was born on January 1, 1927, at Brahmanbaria of erstwhile East Bengal (now in east-central Bangladesh). He was the eldest son of Mr. Sushil Chandra Datta and Mrs. Kalyani Datta. His father was a highly reputed advocate in the district. However, it was Dr. Datta's grandfather, Mr. Gokul Chandra Datta – attorney and philanthropist, who was the moving force behind his academic pursuit.

Dr. Datta grew up in a primarily rural environment as an extremely hardworking and dedicated student with the singular ambition of becoming a doctor as inspired, encouraged, and motivated by his grandfather. He was a student of Annada Government High School, Brahmanbaria. Later, he shifted to Vidyasagar College, Kolkata, to complete his higher secondary education.

Thereafter, Dr. Datta got admitted in R. G. Kar Medical College, which was then called Carmichael Medical College (affiliated to the University of Calcutta), and passed MBBS in 1949. As an undergraduate student, he received the first certificate of Honor in Anatomy. He worked as a junior and senior medical officer between 1950 and 1952, in the Department of Surgery at R. G. Kar Medical College with Prof. Mr. L. M. Banerjee, who had the distinction of having operated on Kabiguru Rabindranath Thakur and Dr. Sarvepalli Radhakrishnan.

In 1953, Dr. Datta started working as a demonstrator in the Department of Anatomy in Calcutta National Medical College, where he soon gained immense popularity among the undergraduate students, who were mesmerized by his unique style of teaching. Thereafter, Dr. Datta completed MS (Anatomy) in 1965, from the Dr. B. C. Roy Postgraduate Institute of Basic Medical Sciences, University College of Medicine in Kolkata. He was awarded the Gold Medal from the university for his performance.

Dr. Datta, later, joined Dr. B. C. Roy Postgraduate Institute of Basic Medical Sciences as a lecturer and eventually became a professor and Head of the Department of Anatomy. He served this institute as a very popular teacher of postgraduate students of different disciplines from various medical colleges of West Bengal. Many medical faculties also used to attend his classes. He continued teaching there as a visiting faculty for a couple of years after his superannuation due to the demand of the postgraduate students from across disciplines and various parts of the state. During his service at this institute, he developed different disciplines in the department of anatomy. He guided a host of postgraduate (MD/MS) and PhD students. He was the principal investigator in several extramurally funded research projects and published a series of research papers and review articles in various peer-reviewed, indexed medical journals of international repute. He also started conducting coaching classes for anatomy. His private tuition in anatomy was extremely popular and famous and attended by numerous medical students (mostly undergraduate) from various medical colleges of West Bengal.

Prof. Asim Kumar Datta (1927–2020)

In 1996, Dr. Datta joined as a professor of Anatomy in College of Medical Sciences, Bharatpur in Chitwan District of Nepal. Here too, he was extremely popular among both undergraduate and postgraduate students. Here, he was made Emeritus Professor of Anatomy. However, he had to leave this institution in 2015 due to his health issues. Prof. Datta completed 50 years of teaching in 2003. His total teaching experience covers a period of more than 60 years.

Dr. Datta wrote as many as nine books on human anatomy which gained much popularity in India and abroad. In these, he covered all facets of anatomy with wonderful sketch diagrams, lucid language, recent advances, functional correlation, and clinical integration. These books are being utilized by the students of medical, dental, and allied biosciences, both at undergraduate and postgraduate levels across the globe.

Prof. Datta was teacher of teachers, a legend who infused romance into learning anatomy among four generations of students. He was a stalwart, a perfect amalgam of honesty and modesty; a calm and composed, yet a towering personality, an iconic figure in the fraternity, with unfathomable knowledge, and yet a sempiternal quest for it. He was an author of international repute and a magnanimous human being. He was very down to earth by nature, easily accessible and approachable by the students, and always ready to clear any doubts in the subject. Till the last day of his life, Prof. Datta maintained relentless efforts to study anatomy in the pursuit of collecting updated information and including these in his books. He was a lifelong learner.

Dr. Datta was a recipient of several professional awards, honors, and distinctions. In the late 1980s, Prof. Datta delivered orations to the learned bodies of the United States on Clinical Anatomy of Coronary Circulation. In 1988, he worked as a visiting professor of Anatomy on invitation from the University of Papua New Guinea. In 2001, he was honored as Fellow of State Medical Faculty of West Bengal for academic excellence. In 2008, West Bengal Chapter of Anatomical Society of India honored Dr. Datta with Pandit Madhusudan Gupta Memorial Lifetime Achievement Award in Anatomy during the bicentenary celebration of Pandit Gupta. In 2011, the Asim Datta Distinguished Chair in Clinical Anatomy, and Surgery was created in KPC Medical College, Jadavpur, Kolkata. In September 2013, Rajiv Gandhi Institute of Medical Sciences, Srikakulam, Andhra Pradesh, named its Anatomy Department as Datta's School of Anatomy.

The vacuum created following the demise of Prof. Datta will take a long time to be filled up. However, his philosophy will be cherished and fostered by all his students across the globe. He was a loving husband who always praised his wife, the late Gayatri Datta for her tolerance, permissiveness as he has to curtail many social and family commitments while writing the books. He is survived by his son Kaustuv and daughter Kausturi and three grandchildren.

We pray to the almighty to give solace to the soul of this great teacher.

Ranjit Guha

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Roddy P, Goiri J, Flevaud L, Palma PP, Morote S, Lima N. *et al*., Field Evaluation of a Rapid Immunochromatographic Assay for Detection of Trypanosoma cruzi Infection by Use of Whole Blood. J. Clin. Microbiol. 2008; 46: 2022-2027.

3. Volume with supplement: Otranto D, Capelli G, Genchi C: Changing distribution patterns of canine vector borne diseases in Italy: leishmaniosis vs. dirofilariosis. Parasites & Vectors 2009; Suppl 1:S2.

Books and Other Monographs

1. Personal author(s): Parija SC. Textbook of Medical Parasitology. 3rd ed. All India Publishers and Distributors. 2008.
2. Editor(s), compiler(s) as author: Garcia LS, Filarial Nematodes In: Garcia LS (editor) Diagnostic Medical Parasitology ASM press Washington DC 2007: pp 319-356.
3. Chapter in a book: Nesheim M C. Ascariasis and human nutrition. In Ascariasis and its prevention and control, D. W. T. Crompton, M. C. Nesbemi, and Z. S. Pawlowski (eds.). Taylor and Francis,London, U.K.1989, pp. 87–100.

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Journal article on the Internet: Parija SC, Khairnar K. Detection of excretory *Entamoeba histolytica* DNA in the urine, and detection of *E. histolytica* DNA and lectin antigen in the liver abscess pus for the diagnosis of amoebic liver abscess. *BMC Microbiology* 2007, **7**:41. doi:10.1186/1471-2180-7-41. http://www.biomedcentral.com/1471-2180/7/41

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