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Original Article

Radiology Section

MDCT Appearance of Human Xiphoid Process in 114 Patients Co-existent with Midline Congenital Sternal Foramina

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ABSTRACT

Introduction: Sternal Foramina (SF) are a congenital midline defect in sternum due to incomplete fusion of sternal ossification centres. The morphology of Xiphoid Process varies in patients with or without congenital midline sternal foramina.

Aim: To evaluate various morphology of xiphoid process in patients with co-existent midline congenital SF by Multi-Detector Computed Tomography (MDCT).

Materials and Methods: This retrospective study was carried out on 114 patients having midline congenital sternal foramina from March 2018 to April 2019. The MDCT scan images were evaluated in axial and reformatted planes. Morphometry of xiphoid process was evaluated. Data were presented in terms of percentage, mean and standard deviation and calculations were done using SPSS programs.

Results: Morphometry of xiphoid process was evaluated in 114 patients having midline congenital SF. Type-I (oval shaped) xiphoid process was noted in 41 patients (36%), Type-II (pointed shaped) in 29 patients (25.4%) and Type-III (forked shaped) in 44 patients (38.6%). The shape of xiphoid process in sagittal plane noted as ventrally deviated in 78 patients (68.4%), reversed S-shaped (initial dorsal then ventral) in 25 patients (21.9%), dorsally deviated in 9 patients (7.9%), S-shaped (initial ventral then dorsal) in 1 patient (0.9%) and hook shaped in 1 patient (0.9%). Xiphoid process foramen detected in 20 patients (17.5%). Xiphoid process foramen pattern L (a larger foramen with diameter more than 5 mm) appeared in 11 patients (9.6%), pattern S (a foramen with diameter smaller than 5 mm) in 6 patients (5.3%) and pattern SS (two or more smaller sternal foramina) in 3 patients (2.6%). No statistical correlation was obtained between the various xiphoidal process morphology and various locations of congenital sternal body foramina in One way ANOVA test with p-value of 0.43.

Conclusion: Variable morphological appearance of human xiphoid process was noted in association with congenital midline sternal foramina, however no gross morphological difference was observed in patients not having SF. But presence of xiphoidal foramina is more common in patients with SF. The anatomic appearances, degree of ossifications and xiphoido-sternal fusion were well evaluated with MDCT. The bifid, duplicated or trifurcated xiphoid process may be mistaken for fracture on imaging, hence detailed morphological knowledge of xiphoid helps in such situation.

Keywords: Ossification, Xiphoido-sternal fusion, Xiphoid fracture

INTRODUCTION

Sternal Foramina (SF) are a congenital midline defect in sternum due to incomplete fusion of sternal ossification centres [1]. SF can be found in manubrium, body and xiphoid process, however most common location is in the lower sternal body [1]. Xiphoid process is a cartilaginous process in lower most portion of sternum. Few ligaments and muscles are inserted into the xiphoid process [2]. The xiphoid process articulates with lower sternal body. Medial fibers of rectus abdominis muscle, external and internal oblique abdominis muscles attached anteriorly into the xiphoid process, linea alba attached inferiorly and diaphragmatic slips posteriorly [3].

Because of hyaline cartilage composition of xiphoid process is invisible on plain radiograph unless it has been calcified or ossified and therefore it is difficult to reveal detail morphology of xiphoid process. However, MDCT display the detail morphology of xiphoid process and ossifications [4].

Initial literatures showed morphological variability of xiphoid process in cadaver and in patients on MDCT [5]. However according to our knowledge, no dedicated study investigated the variable appearance of xiphoid process in presence of midline congenital sternal body foramina. The present study was conducted with an aim to evaluate the morphology of xiphoid process by MDCT in patient's co-existence with midline congenital sternal body foramina.

Distribution of various sternal anomalies differs in between the populations, but data of various xiphoidal process morphology in presence of sternal body foramina from Assam is scarcely reported.

MATERIALS AND METHODS

A retrospective study was conducted in which a total of 114 patients having midline congenital SF during a one year period from March 2018 to April 2019 were evaluated. Repeat CT scans, Patient's CT scan with gross sternal deformities, prior sternotomy, sternal fractures, sternal masses and infections were excluded from the sample. Patients not having SF were also excluded from the study sample. A total of 114 chest CT scans met these criteria. All these 114 chest CT scans were reviewed for the variable morphological appearance of xiphoid process. The MDCT chest scans were included in study sample which were done for other indications such as to investigate primary or metastatic tumors, trauma, vascular and airway pathologies.

CT Protocol

MDCT examinations were performed using a 128-slice scanner (Philips Ingenuity 128 CT scanner, Amsterdam, Netherlands). The same parameters (120 kV, 100mAs, 1 mm slice thickness, and automatic exposure control) were used in all patients. MDCT chest scans were acquired during breath hold in deep inspiration. Analysis of the MDCT image data were based on axial and reformatted images. All images were evaluated in axial plane followed by sagittal and coronal Multi Planar Reconstruction (MPR). Maximum Intensity Projection (MIP) and Surface Shaded Display (SSD) images were also evaluated. Two experienced radiologists evaluated the images with a consensus for the presence of midline sternal body foramen and various morphometry of xiphoid process.

Appearance of xiphoid process like Type-I (oval shaped), Type-II (pointed shaped) and (Type-III forked shaped) were evaluated. Sagittal shape of xiphoid process was evaluated as ventrally deviated, dorsally deviated, S-shaped, reversed S- shaped and hook shaped. Xiphoid process foramen was noted in 20 patients (17.5%). Presence of xiphoid process foramen and foramen patterns were evaluated as pattern L having a larger foramen with diameter more than 5 mm, pattern S having a foramen with diameter smaller than 5 mm, pattern LS having combination of both larger and smaller foramina and pattern SS having two or more smaller foraminae. The length, width and thickness of xiphoid process were evaluated in coronal and sagittal MPR images. Distal ending of xiphoid process was evaluated as single ending, double endings or triple endings. Presence and pattern of xiphoid process calcifications/ ossifications were evaluated. xiphoido-sternal fusion was also evaluated.

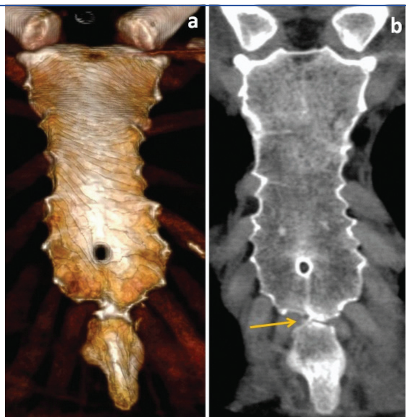
STATISTICAL ANALYSIS

The collected data were presented in terms of percentage, mean and standard deviation. Calculations were done using SPSS programs (Statistical Package for the Social Science version 16.SPSS Inc. Chicago, USA).

RESULTS

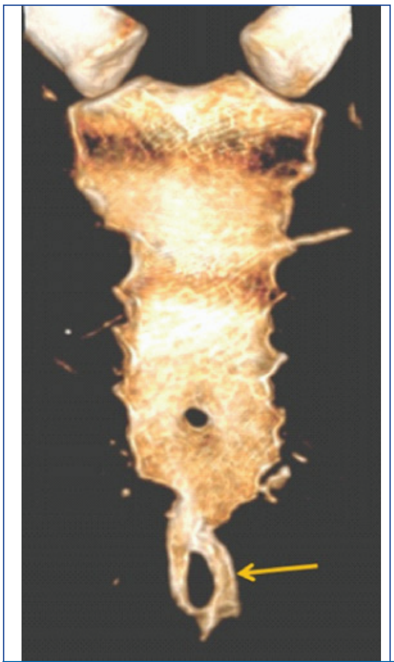
The mean age was 45.9±16.1 years and Male: Female ratio was 2.5:1. The majority of SF were located in a typical position in lower sternal body at the level of 5th Costo-Chondral Junction (CCJ) in 92 patients (80.7%), 11patients (9.6%) at 4th and 6th CCJ.

Morphometry of xiphoid process was evaluated in 114 patients with co-existent midline congenital SF. Type-I (oval shaped) xiphoid process was noted in 41 patients (36%) [Table/Fig-1,2], Type-II (pointed shaped) in 29 patients (25.4%) [Table/Fig-3,4] and Type-III (forked shaped) in 44 patients (38.6%) [Table/Fig-5]. The shape of xiphoid process in sagittal plane was noted as ventrally deviated in 78 patients (68.4%) [Table/Fig-6], reversed S-shaped (initial dorsal then ventral) in 25 patients (21.9%), dorsally deviated in 9 patients (7.9%), S-shaped (initial ventral then dorsal) in 1 patient (0.9%) [Table/Fig-7] and hook shaped in 1 patient (0.9%). Xiphoid process foramen detected in 20 patients (17.5%). Xiphoid process foramen pattern L (a larger foramen with diameter more than 5 mm) appeared in 11patients (9.6%) [Table/Fig-3,4], pattern S (a foramen with diameter smaller than 5 mm) in 6 patients (5.3%) [Table/Fig-8] and pattern SS (two or more smaller sternal foramina) in 3 patients (2.6%). The mean length of xiphoid process was 34.8±9.5 mm, mean width was 18±3.8 mm and mean thickness was 5.7±0.98 mm. The ending of xiphoid process was single in 68 patients (59.6%), double in 44 patients (38.6%) [Table/Fig-5,9] and triple in 2 patients (1.8%) [Table/Fig-9]. Xiphoid process calcifications were noted in 70 patients (61.4%) where 43 patients (37.7%) had partial calcifications and 27 patients (23.7%) had full calcifications. Xiphoido-sternal fusion was noted in 74 patients (64.9%) [Table/Fig-1,2].

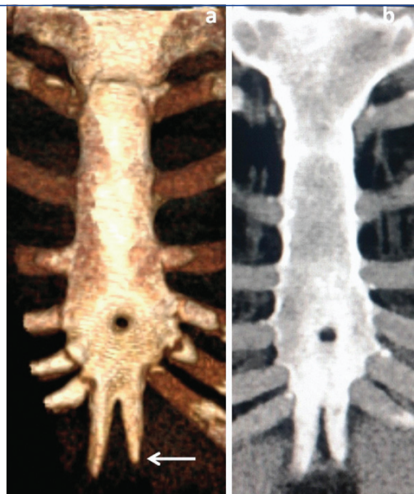


[Table/Fig-1]: A 22-year-old female with Type-I xiphoid process (oval shaped) with SF. The coronal SSD and coronal reconstructed MIP images (a and b) showed partial xiphoido-sternal fusion (yellow arrow in image b).

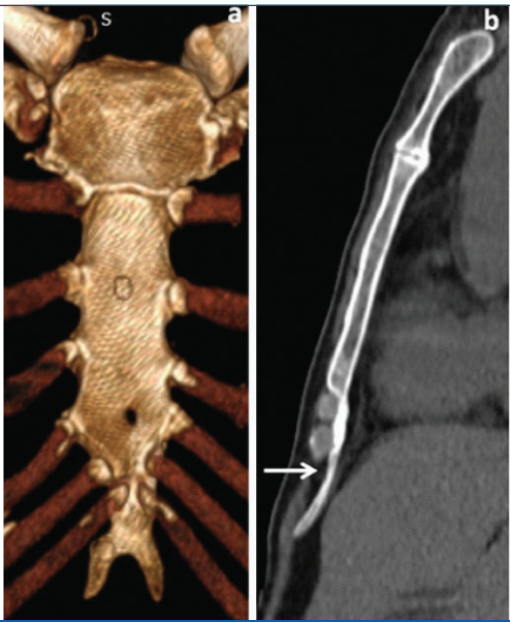
[Table/Fig-2]: A 29-year-old male with Type-I xiphoid process with SF. Coronal SSD and coronal reconstructed MIP images (a and b) showed bilateral para-median suprasternal bones (yellow arrow in image b) with complete xiphoido-sternal fusion.




[Table/Fig-3]: 35 year female with Type-II (Pointed shaped) xiphoid process with midline SF. The coronal SSD image showed "pattern L" xiphoid process foramen (yellow arrow).
[Table/Fig-4]: A 35-year-old male with Type-II Xiphoid process with SF. The reconstructed coronal MIP image pointed shaped xiphoid process with "pattern L" of xiphoidal foramen. (Images for left to right)



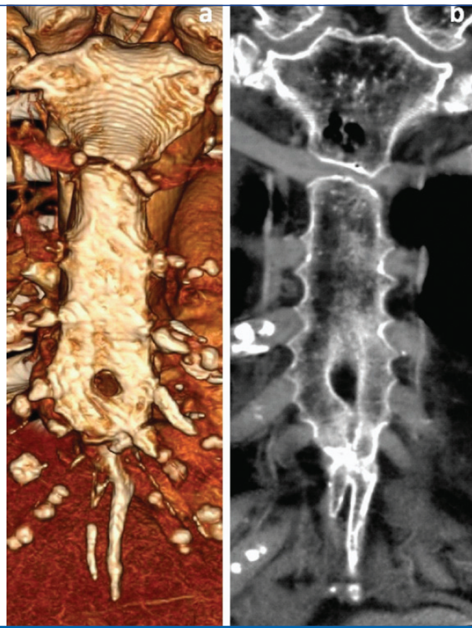
[Table/Fig-5]: A 30-year-old male with Type-III xiphoid process with SF. Coronal SSD image (a) and coronal reconstructed MIP image (b) showed complete xiphoido-sternal fusion and dragger shaped sharp bifurcated endings of xiphoid process (white arrow in image a).



[Table/Fig-6]: A 60-year-old male with Type-III xiphoid process with SF. The Coronal SSD image (a) and reconstructed sagittal MIP image (b) showed bifid endings of xiphoid process with ventrally deviated xiphoid process in sagittal plane (white arrow in image b).

[Table/Fig-7]: A 32-year-old male with Type-II xiphoid process with SF. Reconstructed coronal and sagittal MIP images (a and b) showed "S shaped" (initial ventral then dorsal) appearance of xiphoid process in sagittal plane which indenting the underlying liver (yellow arrow in image b).


[Table/Fig-8]: A 45 year-old male with Type-III xiphoid process with SF. The Coronal SSD image showed "pattern S" xiphoid process foramen (white arrow) and trifurcated endings of xiphoid process.



[Table/Fig-9]: A 65-year-old female with Type-III xiphoid process (forked shaped) with SF. The coronal SSD image (a) and coronal reformatted MIP image (b) showed asymmetrical bifidity of the xiphoid process endings.

No statistical correlation obtained between the various xiphoidal process morphology and various locations of congenital sternal body foramina in One-way ANOVA test with p-value of 0.43.

DISCUSSION

No strong correlation is there in patients with presence of congenital sternal body foramina and various xiphoid morphology, however we tried to show various xiphoid morphology in those patients who already have midline sternal defect. The most common sagittal plane morphological variation of Xiphoid process noted in our study was ventral deviation in 78 patients (68.4%). Elongated tip of xiphoid process sometime resembled a hook and which might mimic an epigastric mass and causes chest pain [6-8].

Xiphoid ossifications are usually completed in middle and older age. Xiphoid ossification may be absent below 30 years of age [9]. Ossification of xiphoid ligament either unilateral or bilateral usually occurs in more than 50 years of age [9]. Advancement in MDCT technology helps in detail evaluation of xiphoid process by using post-processing tools like MPR, MIP and SSD [9,10]. The variable shape of the xiphoid process varies from rhomboid to triangular or oval as first described by Goodman LR et al. by using axial CT scan images [4]. Akin K et al., studied 577 patients and found three different xiphoid process ending as single, double or triple [10].

In present study the shape and outline of xiphoid process was divided as Type-I (oval shaped) in 41 patients (36%), Type-II (pointed shaped) in 29 patients (25.4%) and Type-III (forked shaped) in 44 patients (38.6%).

The mean length, width and thickness of Xiphoid process was 34.8±9.5 mm, 18±3.8 mm and 5.7±0.98 mm respectively. The result were comparable to the report of Akin K at el., as is described in [Table/Fig-10] [5,9,10].

The sternal body and xiphoid process foramen occur due to developmental defect during embryogenesis [11]. Any defect or failure in this midline fusion process leads to sternal body or xiphoidal foramina [12-15]. An incomplete fusion of the inferior ends of the sternal bars results in variant xiphoid morphology like bifid, duplicated or triplicated xiphoid endings [14].

In present study, we found simultaneous presence of midline sternal body and xiphoid process foramen in 17.5% of patients. This result was comparable with study conducted by Yekeler E et al., which found presence of xiphoidal foramen in 27.5% of patients out of studied 1000 sternums by MDCT [9].

Author/year	Number of cases	Sex ratio	Morphological type of xiphoid (%)	Shape of xiphoid in sagittal plane	Xiphoidal foramen pattern	Length, width and thickness of xiphoid	Endings of xiphoid
Yekeler E et al., 2006 [9]	1000 MDCT	M:F (1.4:1)	Not described	Not described	Xiphoidal foramen found in 274 (27.4%) patients Pattern not described	Not described	1. Single-71% 2. Double-27.2% 3. Tripple-0.7%
Akin K et al., 2011 [10]	500 MDCT	M:F (2.9:1)	Not described	1. Ventrally deviated-65.4% 2. Same plane with sternum body(no deviation)-33.2% 3. Reversed S shaped-0.8% 4. Dorsal hooked shaped-0.6%	Xiphoidal foramen found in 216 (43.2%) patients Pattern not described	1. Mean length-50 mm (range 20.6-81.5) 2. Mean Width-22 mm (range 6.5-46.7) 3. Mean Thickness-7.3 mm (range 3.6-18.1)	1. Single-62.6% 2. Double-32.8% 3. Tripple-4.6%
Xie YZ et al., 2014 [5]	902 MDCT and 41 cadavers	902 patients M:F (1.6:1) 41 cadavers M:F (1.9:1)	1.Type-I (41.04%) 2.Type-II (44.75%) 3.Type-III (14.21%)	1. Ventrally deviated-23% 2. Dorsally deviated -20.25% 3. S shaped-2.23% 4. Hooked shaped- 14 in ventrally deviated and 19 in dorsally deviated patients	Xiphoidal foramen found in 544 (57.7%) patients 1. Pattern L-55.5% 2. Pattern S-28.5% 3. Pattern SS-9.19% 4. Pattern LS-6.8%	1. Mean length-60.3±3.7 mm 2. Mean Width-23.42±2.37 mm 3. Mean Thickness-8.25±1.84 mm	Not described
Present study	114 MDCT in presence of sternal foramina	M:F (2.5:1)	1.Type-I (36%) 2.Type-II (25.4%) 3.Type-III (38.6%)	1. Ventrally deviated-68.4% 2. Dorsally deviated-7.9% 3. S shaped-0.9% 4. Reversed S shaped-21.9% 5. Hooked shaped-0.9%	Xiphoidal foramen found in 20 (17.5%) patients 1. Pattern L-9.6% 2. Pattern S-5.3% 3. Pattern SS-2.6% 4. Pattern LS-0	1. Mean length-34.8 ±9.5 mm 2. Mean Width-18 ±3.8 mm 3. Mean Thickness-5.7±0.98 mm	1. Single-59.6% 2. Double-38.6% 3. Tripple-1.8%

[Table/Fig-10]: Literature review of xiphoidal process morphology [5,9,10].

Common medical treatment options for Xiphodynia are an injection of local anaesthetic and steroid [16]. Xiphoid injection is often curative, but it may rarely be associated with complications like pleural, pericardial or peritoneal perforation, pneumothorax or infection [17,18]. Hence prior MDCT knowledge of xiphoid process is important before undergoing xiphoid injection. Xyphoidectomy may be considered after failure of medical management in some situations [19].

Various previous literature evaluated the various morphology of xiphoid process [5,9,10], described in [Table/Fig-10]. However in present study, we evaluated the morphology of xiphoid process in patients with co-existent midline sternal body foramina.

LIMITATION

Sample size was less. A prospective study in future including a larger sample size and comparing the xiphoidal morphology in those patients also who do not have sternal body foramina should be conducted.

CONCLUSION

Xiphoid process showed variable morphological appearances and significant inter-individual variations in patients with or without midline sternal body foramina. MDCT can evaluate various xiphoidal morphology. However, no statistical correlation was obtained between the presence of congenital SF and various xiphoidal morphology.

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