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Research Article

The Rhomboid Fossa in Turkish Children: A Comprehensive Analysis of Chest CT

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ABSTRACT

Objective: This study aims to determine the incidence, dimensions and side distribution of excavated-type rhomboid fossa (RF) in the Turkish pediatric population.

Methods: Thoracic computed tomography scans of a total of 5985 pediatric patients performed between January 2016 and July 2024 were evaluated retrospectively. The presence of RF was evaluated by consensus by two radiologists on axial, coronal, and sagittal sections obtained in bone window settings. Size measurements were taken on coronal sections for transverse and craniocaudal diameters, and on sagittal sections for anteroposterior diameters. For statistical analysis, gender distribution was evaluated with the chi-square test, and size differences between sides were evaluated with an independent and paired t-tests. $P < 0.05$ was considered significant.

Results: The excavated type RF was detected in 2.77% (166 patients; 124 men, 42 women). It was significantly more common in men ($P < 0.001$). RF was most frequently seen bilaterally (56%), followed by the right side (25%) and the left side (19%) ($P < 0.001$). In bilateral cases, although there was no significant difference in the transverse dimension between the right and left diameters ($P = 0.572$), the anteroposterior ($P = 0.042$) and craniocaudal diameters ($P = 0.018$) were found to be significantly larger on the right side. In all patients, the anteroposterior ($P = 0.034$) and craniocaudal ($P = 0.025$) diameters of the right RF were significantly larger than the left RF. It was also shown that larger RFs were significantly associated with bilateral localization ($P < 0.001$).

Conclusion: This study is the first to reveal the incidence of excavated type RF in the Turkish pediatric population. Findings show that RF occurs bilaterally and more frequently on the right side, and is significantly more common in men. Additionally, it has been found that the size of the RF may be an effective factor in bilateral localization. Our study shows that RF is a criterion that can be used to ascertain gender.

Keywords: Children, CT, rhomboid fossa

INTRODUCTION

Unidentified human skeletal remains are located in several regions worldwide, including Türkiye. Skeletal remains are usable for identification, including sex, age, and size in forensic medicine.[1] They were used for sexual dimorphism assessment, including the pelvis, skull, upper and lower limb bones, sternum, patella foot bones, and clavicles.[2] Various parameters, such as length, mid-shaft circumference, sternal end, acromial end, and rhomboid fossa (RF), have been utilized to identify sex in anthropology and forensic sciences.[3]

The ligamentum costoclaviculare (LCC), or rhomboid, is inserted into the lower portion of the clavicle. On its insertion point, it can produce impressions, tuberosities, depressions, and a fossa, which is referred to as the RF in anatomical and anthropological research.[4] The LCC was initially characterized as comprising a single plane of fibers. The bilaminar structure was first formally described, with the anterior and posterior fiber layers reported to incline upward and outward.[5,6] The region of the robust LCC insertion attachment to the inferior surface at the proximal end of the clavicle occasionally contains excavations of irregular shape, varying depths, and are complete with sclerotic

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manifestations. These cavities, known as RF, should be regarded as variations of the LCC insertion. Such relationships have been identified in both children and adults of all genders; however, they occur more frequently in males, particularly young males.[7]

The excavated RF of the clavicle is an overlooked anatomical feature that may lead to diagnostic challenges. The untrained viewer may misinterpret specific anatomical features, such as the RF, as diseases ranging from mild fibrous dysplasia to chronic osteomyelitis. Its unilateral manifestation may be mistaken for a malignancy.[3]

As demonstrated by previous studies that assessed the correlation between the presence of the clavicular RF and sex,[8,9] the prevalence of the RF was significantly higher in males than in females in skeletons of diverse populations worldwide. In order to ascertain the sex of unidentified skeletons, Prado et al.[3] successfully investigated the presence of the RF in relation to the sex and age of individuals. The RF was more frequently associated with males than with females (63.6% of males and 2.9% of females' left clavicles).

The incidence and anthropological investigation of the clavicular RF in childhood, have never been reported in the Turkish population. Consequently, the aim of this study was to determine the prevalence, size, and side distribution of the excavated type RF in the Turkish population, specifically among individuals aged 0-18.

MATERIAL AND METHODS

The presented retrospective study was approved by the Biomedical Research Ethics Committee of Koç University with a reference number: 2024.311.IRB2.140, date: 24.09.2024 and was conducted in accordance with the Declaration of Helsinki. In compliance with our institution's protocol, written informed consent is acquired from all patients or their parents prior to computed tomography (CT) scans, encompassing permission to utilize images for research purposes.

We analyzed 5985 chest CT examinations of pediatric patients from January 2016 to July 2024 to identify the excavated type RFs. Chest CT scans were performed with 64-slice and 128-slice scanners (Somatom Definition AS and Somatom Definition Flash, Siemens Healthineers). The indications of chest CT were predominantly pneumonia, trauma, and oncological follow-up. The examinations were conducted during a single breath hold while in the supine posture, with arms elevated above the head. The thoracic cavity, from the superior aspect of the lungs to the inferior aspect of the posterior costophrenic sulci, was imaged with a collimation of 0.625 mm, parameters of 80-120 kVp and 20-150 mAs. The kVp and mAs were automatically selected. The application of contrast medium was varied according to the indication of the examination. The evaluation of clavicular RF was performed on the 1.5 mm thick axial bone window images, as well as sagittal and coronal reformat images.

The evaluation of the patients included in the study was performed by two radiologists with 5 (H.Ö.A.) and 11 (G.T.Y.) years of experience. After screening the patients, a consensus decision was made on patients who had RF. In these patients, RF size measurements were made in bone window settings on CT images. Measurements were made primarily on coronal reformatted sections, specifically assessing the transverse and craniocaudal dimensions. Then, anterior-posterior dimension measurements were made on the sagittal reformatted images (Figure 1, Figure 2 and Figure 3). All measurements were

MAIN POINTS

- Excavated-tip rhomboid fossa (RF) was detected in 2.77% of the Turkish pediatric population and was found significantly more common in males. This suggests that RF may serve as a useful anatomical marker in sex estimation.
- RFs were most frequently observed bilaterally (56%), followed by right-sided (25%) and left-sided (19%) occurrences. The right fossae were significantly larger in both anteroposterior and craniocaudal dimensions.
- Recognizing RF as a normal anatomical variant is important to avoid misdiagnosis in pediatric imaging. Moreover, it may provide valuable insights in forensic and anthropological assessments.

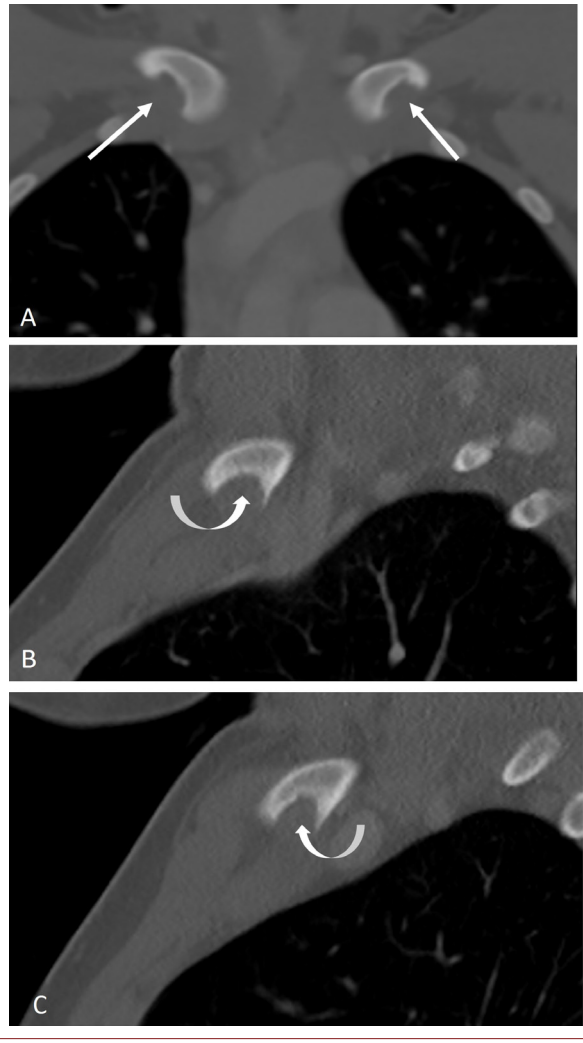

Figure 1. CT imaging of clavicula at the level of the sternoclavicular joint. (A) coronal reformat image; large bilateral excavated type of rhomboid fossa's (arrows). (B) and (C) sagittal reformat image; right and left excavated type RFs (curved arrows).

CT, computed tomography; RF, rhomboid fossa.

recorded through consensus among radiologists. In addition, the patients' ages, patients' gender, and the reasons for the CT examination were also noted.

Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) 26.0 (IBM SPSS Corp.; Armonk, NY, USA). Descriptive statistics were calculated for each RF diameter (transverse, anteroposterior, and craniocaudal), and mean values were noted for both right- and left-sided RF. The distribution of lesions by sex (male vs. female) was assessed using the chi-square test to determine statistical significance. For bilateral cases, paired t-tests were used to compare right and left lesion dimensions within the same patients. For overall comparisons across all patients including unilateral and bilateral cases, independent t-tests were applied to assess differences in the size of right and left RFs for each diameter separately. Additionally, all RF sizes from the right and left sides were combined, and an independent t-test was conducted to compare overall RF size distributions. *P* values below 0.05 were considered statistically significant.

RESULTS

Among 5985 pediatric patients, a total of 166 patients (124 males and 42 females) have an excavated type of RF (2.77%). To explore age-related differences in the incidence of excavated type RF, the study population was stratified into four age groups: 0-5 years (n=1490), 6-10 years (n=1525), 11-15 years (n=1510), and 16-18 years (n=1460). Excavated type RF was detected in 1.8% (27/1490) of patients in the 0-5 age group, 2.2% (33/1525) in the 6-10 age group, 3.1% (47/1510) in the 11-15 age group, and 4.1% (59/1460) in the 16-18 age group. Lesions were statistically more common in males, indicating a significant sex distribution difference ($P < 0.001$). Also, 36 patients (22%) had a history of malignancy, and CT examinations were performed for treatment response evaluation.

The excavated type of RFs was most commonly observed bilaterally in 93 patients (56%), followed by right-sided in 42 patients (25%) and left-sided in 31 patients (19%). The distribution of the type of excavated RF was statistically significant ($P < 0.001$) (Table 1).

Among unilateral localized excavated types of RF, the right-sided versions had larger mean diameters across all measured parameters. The mean transverse diameter was 10.21 mm for the right-sided excavated type of RF, and 9.04 mm for the left-sided excavated type of RF. The size difference between right-sided and left-sided excavated RF did not reach statistical significance ($P = 0.275$). The mean anteroposterior diameter was 3.87 mm for right-sided excavated type of RF and 3.18 mm for left-sided excavated type of RF; the difference between sizes was not statistically significant ($P = 0.075$). The mean craniocaudal diameter was 3.86 mm for right-sided

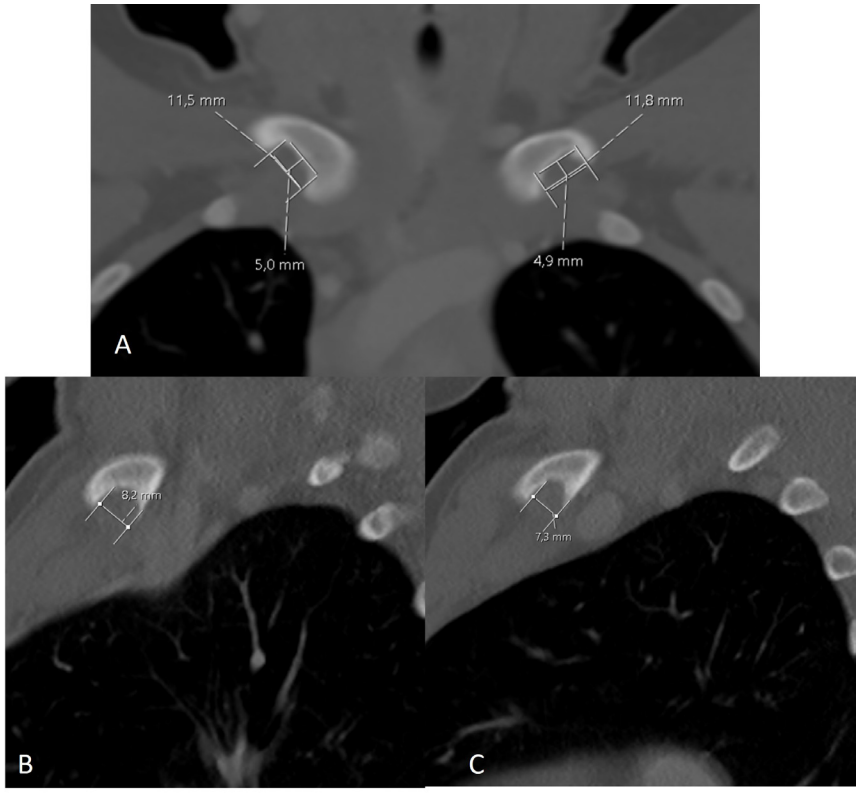

Figure 2. CT imaging of clavicula at the level of the sternoclavicular joint. (A) coronal reformat image and (B) and (C) sagittal reformat images; shows RF measurements.

CT, computed tomography; RF, rhomboid fossa.

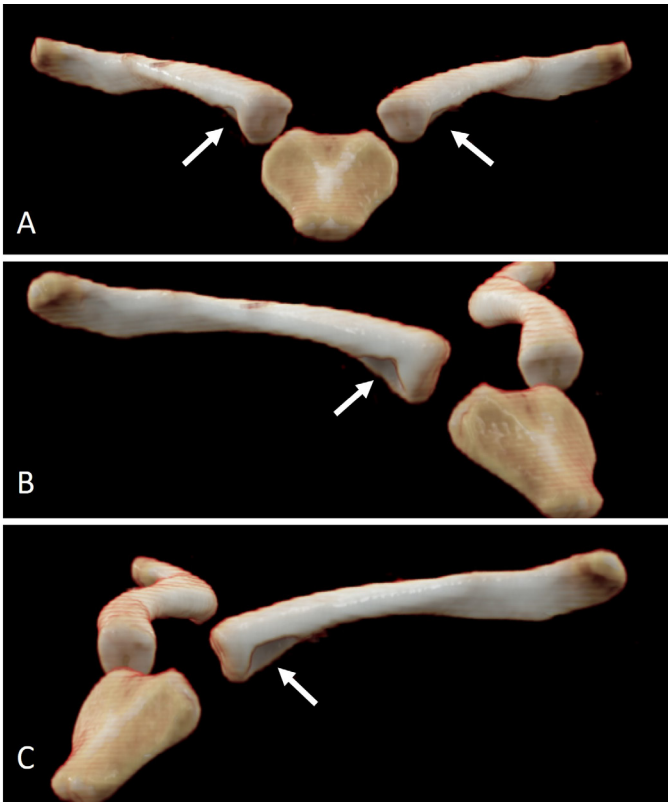

Figure 3. Computed tomography 3D (three dimensional) image, posterior-anterior and lateral projection; bilateral excavated type of RFs (arrows).

RFs, rhomboid fossas.

excavated RF and 3.32 mm for left-sided excavated RF, and the difference between the two groups was not significant (P = 0.109) (Table 1).

In cases with bilateral excavated type of RF, the comparison of right and left sizes showed no significant difference in the transverse diameters (P = 0.572). However, the anteroposterior (P = 0.042) and craniocaudal (P = 0.018) sizes were significantly larger on the right side, revealing an asymmetry between the two sides (Table 1).

In the evaluation of all right and left excavated type of RFs' sizes among all patients, including both unilateral and bilateral cases, right-sided RFs were significantly larger in the anteroposterior diameter (P = 0.034) and the craniocaudal diameter (P = 0.025). However, no significant difference was observed in the transverse diameter (P = 0.806). These findings show that the right-sided RF tends to be larger in the anteroposterior and craniocaudal diameters (Table 1).

The correlation between the excavated RF size type and the rate of bilateral localization was determined. The statistical analysis showed that larger RFs were significantly associated with bilateral localisation (P < 0.001), suggesting that fossa size may play a role in their distribution pattern.

DISCUSSION

The present study has demonstrated the incidence of the excavated type RF of the clavicles in the Turkish population for the first time. The excavated type RF was detected in 2.77% of 5985 pediatric patients in our study. This rate shows a lower incidence compared to other studies in the literature.

Table 1. Location, Sex and Size Distribution of Excavated Type RFs in Study Cohort

			Patient number/size	*P* value
Sex		Female	42 (25.3%)	**< 0.001**
		Male	124 (74.7%)	
Localization	Bilateral		93 (56%)	**< 0.001**
	Unilateral	Right	42 (25%)	
		Left	31 (19%)	
Unilateral RF	Transverse size	Right	10.21 mm	0.275
		Left	9.04 mm	
	Anteroposterior size	Right	3.87 mm	0.075
		Left	3.18 mm	
	Craniocaudal size	Right	3.86 mm	0.109
		Left	3.32 mm	
Bilateral RF	Transverse size	Right	10.41mm	0.572
		Left	10.59 mm	
	Anteroposterior size	Right	3.99 mm	**0.042**
		Left	4.62 mm	
	Craniocaudal size	Right	3.91 mm	**0.018**
		Left	3.52 mm	
All RF	Transverse size	Right	10.34 mm	0.806
		Left	10.2 mm	
	Anteroposterior size	Right	3.96 mm	**0.034**
		Left	3.51 mm	
	Craniocaudal size	Right	3.89 mm	**0.025**
		Left	3.47 mm	

RF, rhomboid fossa.

For example, Paraskevas et al.[10] detected excavated-type RF in 26.88% of 80 chest radiographs. Parsons'[9] study examined 183 adult English clavicles and reported that excavated-type RF incidence was 10%. However, the scope of our study is wider, and the results could be more reliable because the study includes 5985 pediatric patients and CT examinations. The low incidence rate obtained may be explained by the exclusive examination of the pediatric patient group. We believe that in this age group, excavated type RF may not yet be developed enough to have deeper fossae. This highlights the impact of age group differences on incidence. In support of this, our subgroup analysis revealed a slightly increased incidence in older children, particularly those aged 11-18 years, suggesting a potential influence of skeletal maturation on RF development.

In our study, excavated type RF, which was detected in 74.6% of male clavicles and 26.4% of female clavicles, showed a significant difference between sexes. Similarly, previous anthropological and anatomical studies have reported a significant association between the presence of excavated-type RF and male sex. Prado et al.[3] in a study of 209 Brazilian cadavers (107 men and 102 women, age range: 19-85 years), found the prevalence of RF to be 63.6% in men but only 2.9% in women. Additionally, in the examination of the skeletal collection compiled by William F. McCormick at the University of Tennessee (231 males and 113 females, age range: 10-92 years), the presence of RF in the left clavicle indicated male sex in 92.2% and female sex in 7.8%, while in the right clavicle, these rates were 81.7% for men and 18.3% for women.[4] In both studies, it is evident that RF was more common in men, consistent with our findings.

In our study, we found the occurrence of the condition bilaterally in 93 patients (56%), followed by right-sided in 42 patients (25%) and left-sided in 31 patients (19%). Similarly, in Prado et al.'s[3] study, the prevalence of bilateral RF in men was found to be 29%. In addition to that, it was shown that the prevalence of right and left sided RF was 18.7% and 15.9%, respectively.[3] Paraskevas et al.'s[10] study revealed that excavated type RF was more common on the right side than the left side in both male and female samples. In the same study, it has been stated that excavated type RF is more common on the right side in right-handed individuals and more common on the left side in left-handed individuals.[10] These findings indicate that the localization of excavated-type RF may vary in different populations and studies, but the tendency to occur bilaterally and be followed by occurrence on the right side is evident.

In our study, we also found that in cases of bilateral prevalence, excavated type RFs are usually asymmetric. A new and significant finding is that in cases with bilateral excavated type of RF, the comparison of right and left sizes showed no significant difference in the transverse, but the anteroposterior and craniocaudal sizes were significantly larger on the right side. This reveals asymmetry between the two sides. Also, the statistical analysis showed that larger RFs were significantly associated with bilateral localization, suggesting that fossa size may play a role in their distribution pattern. To the best of our knowledge, no such information is provided in the literature.

We are unable to make a definitive determination regarding the potential causes of excavated type RF, as we do not possess the necessary data on the occupations and sporting activities of the individual patients. However, in previous studies, the presence of RF in a two-year-old child (our earliest case with RF) renders physical overload insufficient to account for the RF.[9]

Our findings have potential clinical, forensic, and anthropological implications. Clinically, the excavated type RF may mimic pathological bone lesions on imaging, especially in pediatric patients, leading to diagnostic pitfalls if not properly recognized. In forensic and anthropological contexts, the presence and size of RF may aid in sex estimation and skeletal profiling. However, the generalizability of these findings may be limited due to ethnic, genetic, and developmental variability. Morphological variations in clavicles across populations should be considered when applying these results outside the Turkish pediatric cohort. Therefore, future multicenter studies involving diverse populations are warranted to validate and extend these observations.

Study Limitations

This study has several limitations. First, it is retrospective in nature. Although the overall CT dataset was large, the number of patients with excavated RF was limited. Additionally, a possible selection bias exists, as only pediatric patients who underwent chest CT examinations were included, which may not reflect the general population incidence of excavated RF. Another limitation is the absence of interobserver and intra observer agreement analysis for RF detection and measurement, which may affect the reproducibility and generalizability of our radiological assessments.

CONCLUSION

The findings of our study demonstrate that excavated type RF tends to be more common in the right clavicle, and the larger excavated type RF is significantly associated with bilateral occurrence, highlighting a potential influence of fossa size on distribution patterns. Our study proves, that the presence of an excavated type RF can be used as a qualitative criterion for the differentiation of sex in Turkish individuals. Furthermore, awareness of the excavated type RF in pediatric imaging is crucial, as it may mimic pathological conditions such as lytic lesions or chronic infection. Recognizing this anatomical variant can help radiologists avoid diagnostic pitfalls.

Ethics

Ethics Committee Approval: This retrospective study was conducted in accordance with the Declaration of Helsinki and approved by the Biomedical Research Ethics Committee of Koç University with a reference number of 2024.311.IRB2.140, date: 24.09.2024.

Informed Consent: The study had retrospective design, no additional procedures were performed. Informed consent forms are obtained from each patient and/or their parents before the radiological examination in our institution as a clinical routine.

Footnotes

Author Contributions

Concept Design – G.T.Y., E.Ö.; Data Collection or Processing – G.T.Y., H.Ö.A., E.Ö.; Analysis or Interpretation – G.T.Y.; Literature Review – G.T.Y., H.Ö.A.; Writing, Reviewing and Editing – G.T.Y., H.Ö.A., E.Ö.

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

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