Original Article

DOI: 10.7860/IJARS/2026/85073.3079

Radiology Section

Establishing MRI-based Normative Acromiohumeral Distance and its Demographic Associations: A Cross-sectional Study from Puducherry, India

R PRASANNA[1], R MITHUNRAJ[2], PALLE MANJUNATHA REDDY[3]

ABSTRACT

Introduction: Acromiohumeral Distance (AHD) is a crucial imaging parameter that reflects the width of the subacromial space. Narrowing of the AHD is associated with shoulder impingement and rotator cuff pathology. Magnetic Resonance Imaging (MRI) offers multiplanar imaging with high soft tissue resolution, but normative MRI-based AHD data in asymptomatic shoulders are limited.

Aim: To determine MRI-based AHD in patients with normal supraspinatus and infraspinatus tendons, and to compare values across gender and side in Puducherry, India.

Materials and Methods: This hospital-based cross-sectional study was conducted at the Department of Radiodiagnosis, Sri Venkateshwaraa Medical College Hospital and Research Centre, Puducherry, India, from February 2020 and March 2024, comprising 64 retrospective and 30 prospective cases, totalling 94 participants. The MRI shoulder scans of 94 participants aged 18-60 years with no shoulder pathology were analysed. AHD was measured in coronal and sagittal planes as: (a) humeral cortex to acromion; and (b) humeral cartilage to acromion. Mean values and standard deviations were calculated. An Independent t-test was used to assess differences by gender and side. A p-value <0.05 was considered significant.

Results: Participants included 55 males (58.5%) and 39 females (41.5%); 45 left shoulders and 49 right shoulders were assessed. Mean AHD (cortex) in the coronal plane was 7.71±1.18 mm, and sagittal was 8.45±1.47 mm. Mean AHD (cartilage) in the coronal plane was 7.60±1.45 mm and in the sagittal plane was 8.05±1.39 mm. No statistically significant differences were found between genders or sides (p-value >0.05).

Conclusion: The MRI-based normative AHD values are provided for intact supraspinatus and infraspinatus tendons. These reference values can aid in accurate assessment of subacromial pathologies and planning of surgical or conservative management.

Keywords: Magnetic resonance imaging, Reference values, Rotator cuff injuries, Shoulder joint anatomy

INTRODUCTION

Shoulder pain continues to be one of the most frequently reported musculoskeletal conditions worldwide, with an annual prevalence of 16-26% and rotator cuff pathology being its leading cause [1]. Among the imaging parameters used to evaluate shoulder mechanics, the AHD serves as a crucial radiological marker, reflecting the integrity of the subacromial space and the status of the rotator cuff [2-4]. A reduction in AHD is strongly correlated with superior migration of the humeral head. It is frequently associated with subacromial impingement syndrome, partial- or full-thickness rotator cuff tears, and disturbed shoulder biomechanics [3-5].

While standard radiography remains a readily available and cost-effective diagnostic tool, recent evidence demonstrates that MRI provides superior precision and reproducibility in quantifying AHD [6,7]. MRI's multiplanar capability and high soft-tissue contrast enable detailed visualisation of both osseous and tendinous landmarks, even in the early stages of rotator cuff disease [6-8]. Several studies have further examined demographic and anatomical determinants of AHD [8-11]. In particular, a 2024 cohort study by Albar HF et al., demonstrated a moderate correlation between shoulder pain severity and reduced AHD with type III (hooked) acromion morphology, predisposing individuals to narrower subacromial spaces and heightened pain intensity [8]. Additionally, the combined use of AHD and critical shoulder angle has been shown to improve the diagnostic accuracy for rotator cuff tear prediction [2]. Few MRI studies validated by arthroscopy have also confirmed that smaller coronal and sagittal acromiohumeral intervals correlated closely with the severity of cuff tears [12,13].

Given the importance of these parameters, establishing MRI-based normative AHD values in asymptomatic shoulders with intact rotator cuff tendons is essential. Establishing such reference standards may improve the evaluation of shoulders with intact rotator cuff tendons. Such reference standards may facilitate early detection of subacromial pathology, enhance diagnostic precision, and improve pre-operative planning and post-operative outcome prediction in patients with rotator cuff disease. Therefore, the objective of the study was to determine normative MRI-derived AHD values and assess their variation with gender and side dominance and contribute to the development of reference benchmarks for clinical and research applications.

Previous MRI studies, including Saupe N et al., McCreesh KM et al., and De Oliveira Franca F et al., have evaluated AHD and its association with rotator cuff status; however, normative MRI-derived AHD values in asymptomatic adults remain limited [14-16]. Data on normal AHD in the Indian population has also been limited. Therefore, the present study aimed to establish reliable MRI-based normative AHD values and examine their demographic variations and provide reference benchmarks for clinical and research use.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted at the Department of Radiodiagnosis, Sri Venkateshwaraa Medical College Hospital and Research Centre in Puducherry, India from

February 2020 and March 2024 comprising 64 retrospective and 30 prospective cases, totalling 94 participants. Institutional Ethics Committee approval was obtained prior to study initiation (IEC approval No. 16/SVMCH/IEC-Cert/October 2022) and informed written consent was obtained from all prospective participants.

Sample size calculation: Sample size estimation was performed using the OpenRpi sample size calculator (version 3.01) based on previous studies by Saupe N et al., and De Oliveira Franca F et al., [14,16]. The minimum required sample size was calculated to be 84. To enhance statistical power and account for measurement variability, a total of N=94 participants were included in the study [14,16]. Non random convenient sampling was used.

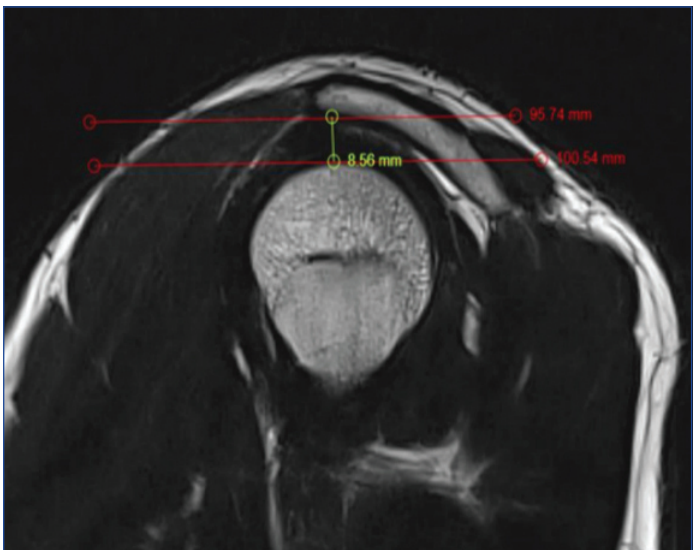
Inclusion criteria: Patients undergoing shoulder MRI with clinically normal supraspinatus and infraspinatus tendons were included.

Exclusion criteria: It included a history of shoulder trauma or surgery, rotator cuff pathology, acromioclavicular joint pathology, subacromial or subdeltoid bursal oedema, shoulder dislocation, paediatric patients and contraindications to MRI (e.g., pacemakers or metal implants).

Study Procedure

Imaging was performed with a SIEMENS 1.5 Tesla MRI scanner. Patients were positioned supine with the affected arm comfortably placed at their side or in slight abduction. Standard MRI sequences used included T1-weighted, T2-weighted, Proton Density (PD) -weighted, and fat-suppressed sequences to optimise soft-tissue contrast. Imaging was acquired in coronal, sagittal, oblique and axial images.

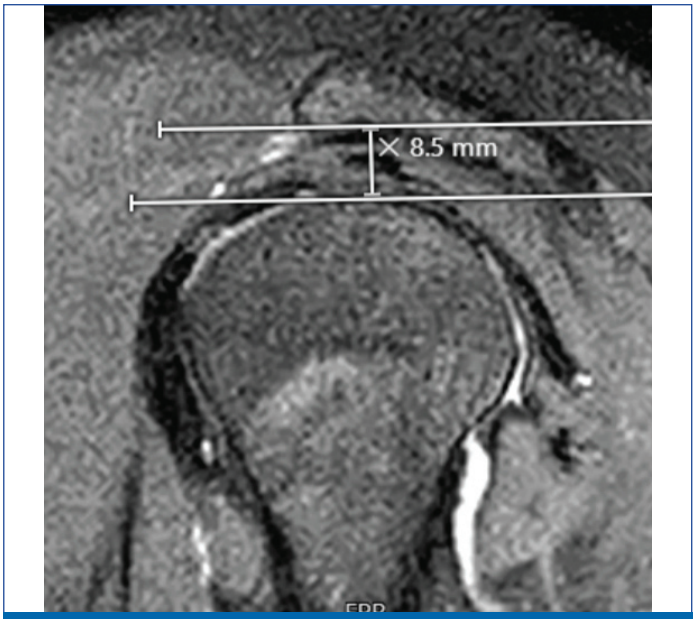
The AHD was defined as the shortest distance between the undersurface of the acromion and the humeral head. Two measurements were taken: the distance from the humeral cortex to the acromion and the distance from the humeral cartilage to the acromion. Measurements were taken on coronal and sagittal oblique MRI images [Table/Fig-1-4] [16,17]. Patient demographics (age, gender, side of evaluation) were recorded.



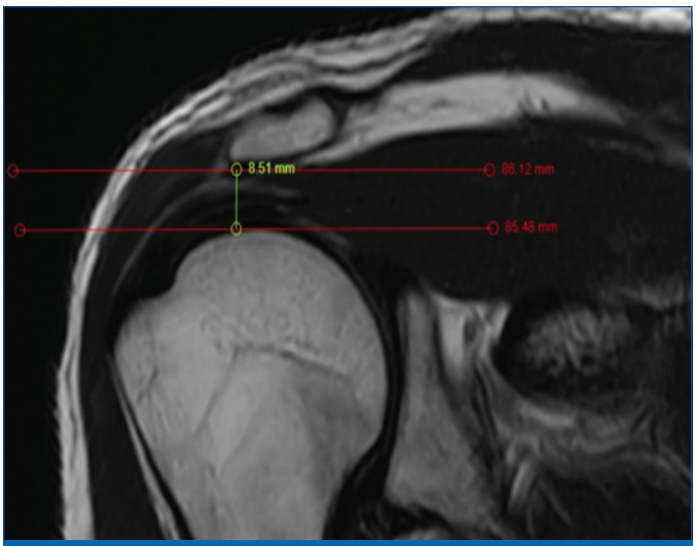
[Table/Fig-1]: T2-weighted sagittal image of left shoulder showing humeral cortex to acromion distance of 8.56 mm (green line).

STATISTICAL ANALYSIS

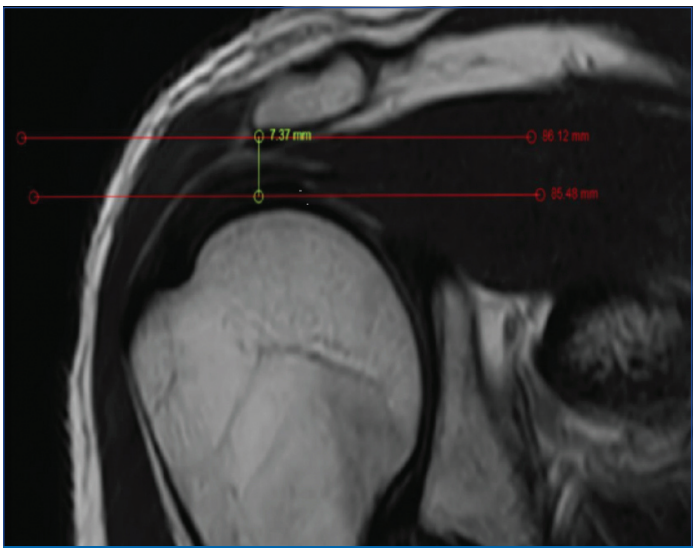
Data entry was done using MS Excel 2019, and statistical analysis was performed with IBM Statistical Package for Social Sciences (SPSS) version 26.0. Descriptive statistics summarised AHD values with means, medians, ranges and standard deviations. An Independent sample t-tests compared AHD with sex and side of evaluation. Pearson's correlation coefficient evaluated relationships between AHD and continuous variables such as age. Statistical significance was set at p-value<0.05.



[Table/Fig-2]: Proton Density (PD) fat suppressed sagittal image of the right shoulder showing humeral cartilage to acromion distance of 8.5 mm (vertical white line).



[Table/Fig-3]: T2-weighted coronal image of right shoulder showing the humeral cortex to acromion distance of 8.51 mm (green line).



[Table/Fig-4]: T2-weighted coronal image of right shoulder showing humeral cartilage to acromion distance of 7.37 mm (green line).

RESULTS

A total of 94 participants with normal supraspinatus and infraspinatus tendons were included in this study. The age, gender and side distribution along with AHD measurements are summarised below.

The participants range from 18-60 years of age, with the majority, 41 (43.6%) participants, in the 31-45 year group. Males comprised 55 (58.5 %) of the sample and the right shoulder was slightly more frequently evaluated 49 (52.1%) [Table/Fig-5].

Variables	Category	n (%)
Age (in years)	18-30	31 (33.0)
	31-45	41 (43.6)
	46-60	22 (23.4)
Gender	Male	55 (58.5)
	Female	39 (41.5)
Side evaluated	Right	49 (52.1)
	Left	45 (47.9)

[Table/Fig-5]: Demographic distribution of study participants (N=94).

The mean AHD values measured on MRI are presented in [Table/Fig-2]. Measurements were taken in both coronal and sagittal planes, considering both humeral cortex and cartilage reference points. No statistically significant differences were found between sex and side across all measurements (p-value>0.05) [Table/Fig-6].

Plane and measurement	Mean±SD (mm)	Male (Mean±SD mm)	Female (Mean±SD mm)	Right (Mean±SD mm)	Left (Mean±SD mm)	p-value (gender)	p-value (side)
Coronal							
Humeral cortex-acromion	7.71±1.18	7.87±1.15	7.48±1.20	7.77±1.13	7.63±1.24	0.116	0.564
Humeral cartilage-acromion	7.60±1.45	7.62±1.46	7.56±1.46	7.64±1.49	7.52±1.42	0.836	0.733
Sagittal							
Humeral cortex-acromion	8.45±1.48	8.63±1.49	8.20±1.44	8.57±1.53	8.33±1.41	0.170	0.472
Humeral cartilage-acromion	8.05±1.39	8.01±1.54	8.12±1.17	8.16±1.45	7.91±1.32	0.168	0.399

[Table/Fig-6]: Mean AHD measurements and correlation with gender/side.

Pearson's correlation analysis was performed to assess the relationship between age and AHD in each measurement plane. A significant positive correlation was observed between age and cartilage-based AHD in both coronal (r-value=0.313, p-value=0.002) and sagittal (r-value=0.234, p-value=0.023) planes, indicating a gradual increase in the distance with age [Table/Fig-7].

Measurements	Correlation coefficient (r)	p-value
Humeral cortex-acromion (coronal)	0.123	0.248
Humeral cartilage-acromion (coronal)	0.313	0.002
Humeral cortex-acromion (sagittal)	0.152	0.147
Humeral cartilage-acromion (sagittal)	0.234	0.023

[Table/Fig-7]: Correlation between acromiohumeral distance and age.

DISCUSSION

The present study sought to determine normative values of AHD using MRI among patients with intact supraspinatus and infraspinatus tendons. The results revealed mean values ranging from 7.6 to 8.45 mm, consistent with previously published MRI-based studies by Hufeland M et al., and Saupe N at al., who reported mean values between 7.5 mm and 9.2 mm in asymptomatic shoulders [14,18]. These findings reinforce the diagnostic value of MRI as a reliable modality for evaluating the subacromial space and shoulder biomechanics.

Compared to the radiograph-based measurements of Suape N et al., MRI provides more accurate soft-tissue delineation and multiplanar assessment of the AHD [14]. The present findings align with McCreesh KM et al., who emphasised the higher precision of MRI and Computed Tomography (CT) over conventional radiographs due to their ability to account for individual variations in tendon thickness and acromial morphology [15]. Similar to De Oliveira França F et al., AHD values were relatively stable across age and gender in this study, suggesting that physiological variations rather than demographic factors predominantly influence AHD [16].

Kaushal L et al., using ultrasonography, reported mean AHD values around 7 mm in healthy individuals, further supporting the MRI-based normative values in the present study. While ultrasonography offers dynamic evaluation, MRI provides superior spatial resolution and is less operator-dependent, making it the preferred method for research and clinical correlation [19].

A weak positive correlation was observed between age and AHD in the sagittal plane, differing from the weak negative correlation reported by Mirzayan R et al., who noted decreased AHD with age and rotator cuff degeneration [3]. This discrepancy could be attributed to the inclusion of asymptomatic individuals and MRI-based supine measurements, which neutralise the effect of gravity on humeral head descent, as noted by Yoshida Y et al., [20].

Anatomical and biochemical variations- including scapular rotation, acromion morphology, and humeral head positioning- play key roles in determining AHD. Studies by Baumer TG et al., and Giphart JE et al., highlighted that arm abduction and load application significantly alter the AHD, suggesting that patient positioning must be standardised to ensure reproducibility [21,22].

Establishing MRI-based normative AHD values is crucial for distinguishing between physiological and pathological narrowing, particularly in subacromial impingement syndrome and rotator cuff tears. A reduction of AHD below 6 mm has been consistently linked to full-thickness supraspinatus tears and superior humeral head migration [3,14]. By providing MRI-based reference ranges in asymptomatic subjects, this study supports early and accurate detection of subacromial pathology. Furthermore, MRI-based AHD assessment can aid in pre-operative planning for rotator cuff repair. Kholinne E et al., conducted a study on 112 patients and found that regional AHD measured on MRI after repair was significantly associated with rotator cuff integrity and therefore is relevant to surgical planning and prognosis [23]. The supine positioning inherent to MRI may underestimate AHD compared to upright radiographs, as noted by Fehringer FV et al., [24].

Limitation(s)

While the findings add valuable normative data, certain limitations persist. MRI performed in the supine position may underestimate the acromiohumeral distance relative to upright radiographs. Future research incorporating upright or dynamic MRI could provide more physiologically relevant measurements. Multicentre studies with larger cohorts and inclusion of pathological shoulders could further refine threshold values distinguishing normal from pathological AHD.

CONCLUSION(S)

The present MRI-based study provided normative data for the AHD in asymptomatic shoulders. The AHD ranged from 7.6-8.5 mm, with slightly higher values in sagittal sections. No significant differences were noted by gender or side, while cartilage-based AHD correlated positively with age. These findings are in agreement with recent MRI literature and emphasise the importance of modality-specific reference values for accurate clinical interpretation of shoulder MRI.

REFERENCES

[1] Luime J, Koes B, Hendriksen I, Burdorf A, Verhagen A, Miedema H, et al. Prevalence and incidence of shoulder pain in the general population: A systematic review. Scand J Rheumatol. 2004;33(2):73-81.

[2] Hamie QM, Huber FA, Grunder V, Finkenstaedt T, Marcon M, Ulbrich E, et al. Added value of combined acromiohumeral distance and critical shoulder angle measurements on conventional radiographs for the prediction of rotator cuff pathology. Eur J of Radiol Open. 2022;9:100416.

[3] Mirzayan R, Donohoe S, Batech M, Suh BD, Acevedo DC, Singh A. Is there a difference in the acromiohumeral distances measured on radiographic and magnetic resonance images of the same shoulder with a massive rotator cuff tear? J Shoulder Elbow Surg. 2020;29(6):1145-51.

[4] Mayerhoefer ME, Breitenseher MJ, Wurnig C, Roposch A. Shoulder impingement: Relationship of clinical symptoms and imaging criteria. Clin J Sport Med. 2009;19(2):83-89. Doi: 10.1097/JSM.0b013e318198e2e3. PMID: 19451760.

[5] Werner CML, Conrad SJ, Meyer DC, Keller A, Hodler J, Gerber C. Intermethod agreement and interobserver correlation of radiologic acromiohumeral distance measurements. J Shoulder Elbow Surg. 2008;17(2):237-40.

[6] Dede BT. Intra- and inter-rater reliability of magnetic resonance imaging measurements of supraspinatus muscle thickness, acromiohumeral distance, and coracohumeral distance in patients with shoulder pain. Skeletal Radiol. 2024;53:123-129.

[7] Graichen H, Bonél H, Stammberger T, Englmeier KH, Reiser M, Eckstein F. Sex-specific differences of subacromial space width during abduction, with and without muscular activity, and correlation with anthropometric variables. J Shoulder Elbow Surg. 2001;10(2):129-35.

[8] Albar HF, Rendy G, Nanto ID. Correlation between shoulder pain severity, acromion morphology, and acromiohumeral distance using MRI: A study at Haji Adam Malik Hospital Medan in 2022. JOINTS. 2024;13(2):69-74.

[9] Kajita Y, Harada Y, Takahashi R, Sagami R, Iwahori Y. A comprehensive analysis of the acromial morphology and etiological factors of partial rotator cuff tears. JSES Int. 2025;9(1):86-90.

[10] Kaur R, Dahuja A, Garg S, Bansal K, Garg RS, Singh P. Correlation of acromial morphology in association with rotator cuff tear: A retrospective study. Pol J Radiol. 2019;84:e459-e463.

[11] Chaimongkhol T, Benjachaya S, Mahakkanukrauh P. Acromial morphology and morphometry associated with subacromial impingement syndrome. Anat Cell Biol. 2020;53(4):435-43.

[12] Ilyas G, Ipci FB, Egeli E, Kalenderer O. Association between rotator cuff tears and shoulder mri parameters: importance of arthroscopic validation in coronal acromiohumeral interval measurement. Orthop J Sports Med. 2025;13(1):23259671241309695.

[13] Altuntas Y, Ipek E, Balkanlı B, Alibakan G, Akbas H, Eren OT. Association between acromial morphology and tear severity in arthroscopically confirmed rotator cuff tears. BMC Musculoskelet Disord. 2025;26(1):909.

[14] Saupe N, Pfirrmann CWA, Schmid MR, Jost B, Werner CML, Zanetti M. Association between rotator cuff abnormalities and reduced acromiohumeral distance. AJR Am J Roentgenol. 2006;187(2):376-82.

[15] McCreesh KM, Anjum S, Crotty JM, Lewis JS. Ultrasound measures of supraspinatus tendon thickness and acromiohumeral distance in rotator cuff tendinopathy are reliable. J Clin Ultrasound. 2016;44(3):159-66.

[16] De Oliveira França F, Godinho AC, Ribeiro EJS, Falster L, Búrigo LEG, Nunes RB. Evaluation of the acromiohumeral distance by means of magnetic resonance imaging. Rev Bras Ortop (English Edition). 2016;51(2):169-74.

[17] Sürücü S, Aydın M, Çapkın S, Karahasanoglu R, Yalçın M, Atlıhan D. Evaluation of bilateral acromiohumeral distance on magnetic resonance imaging and radiography in patients with unilateral rotator cuff tears. Arch Orthop Trauma Surg. 2022;142(1):175-80.

[18] Hufeland M, Brusis C, Kubo H, Grassmann J, Latz D, Patzer T. The acromiohumeral distance in the MRI should not be used as a decision criterion to assess subacromial space width in shoulders with an intact rotator cuff. Knee Surg Sports Traumatol Arthrosc. 2021;29(7):2085-89.

[19] Kaushal L, Singh S, Maravi P. Assessment of acromiohumeral interval in A-P radiograph as an indicator of rotator cuff injury and its comparison with high-frequency USG in Bhopal, Central India. Int J Sci Stud. 2020;8(5):98-109.

[20] Yoshida Y, Matsumura N, Yamada Y, Yamada M, Yokoyama Y, Matsumoto M, et al. Evaluation of three-dimensional acromiohumeral distance in the standing position and comparison with its conventional measuring methods. J Orthop Surg Res. 2020;15(1):436.

[21] Giphart JE, van der Meijden OAJ, Millett PJ. The effects of arm elevation on the 3-dimensional acromiohumeral distance: A biplane fluoroscopy study with normative data. J Shoulder Elbow Surg. 2012;21(11):1593-600.

[22] Baumer TG, Dischler J, Mende V, Zauel R, van Holsbeeck M, Siegal DS, et al. Effects of asymptomatic rotator cuff pathology on in vivo shoulder motion and clinical outcomes. J Shoulder Elbow Surg. 2017;26(6):1064-72.

[23] Kholinne E, Kwak JM, Sun Y, Kim H, Park D, Koh KH, et al. The relationship between rotator cuff integrity and acromiohumeral distance following open and arthroscopic rotator cuff repair. SICOT J. 2021;7:23.

[24] Fehringer EV, Rosipal CE, Rhodes DA, Lauder AJ, Puumala SE, Feschuk CA, et al. The radiographic acromiohumeral interval is affected by arm and radiographic beam position. Skeletal Radiol. 2008;37(6):535-39.

PARTICULARS OF CONTRIBUTORS:

1. Junior Resident, Department of Radiodiagnosis, Sri Venkateshwaraa Medical College Hospital and Research Centre, Puducherry, India.
2. Assistant Professor, Department of Radiodiagnosis, Sri Venkateshwaraa Medical College Hospital and Research Centre, Puducherry, India.
3. Senior Resident, Department of Radiodiagnosis, Pondicherry Institute of Medical Sciences, Puducherry, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
R Mithunraj,
AniNavi Illam, 1st Main Road, Siva Nagar, Puducherry-605001, India.
E-mail: dr.muthu1211@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Nov 02, 2025
- Manual Googling: Nov 28, 2025
- iThenticate Software: Dec 06, 2025 (9%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Oct 25, 2025**
Date of Peer Review: **Nov 15, 2025**
Date of Acceptance: **Dec 08, 2025**
Date of Publishing: **Jan 01, 2026**