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Decoding Müllerian Duct Anomalies with MRI: Implementing the New ASRM Classification System

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Abstract:

- ***Objective:***
  To explore and categorize various Müllerian duct anomalies using magnetic resonance imaging (MRI) and evaluate these findings within the frameworks of the updated American Society for Reproductive Medicine (ASRM) system.

- ***Methods:***
  A retrospective analysis of pelvic MRI scans with Müllerian anomalies between July 2023 and December 2024.

- ***Subjects:***
  This study reviewed the pelvic MRI scans and medical records of 19 female patients diagnosed with congenital Müllerian anomalies between July 2023 and December 2024. The patients' ages ranged from 2 to 63 years, with a mean age of 22 years.

- ***Results:***
  A wide spectrum of Müllerian anomalies was observed in the study population, with the distribution of 3 patients (15.7%) Müllerian hypoplasia/ agenesis (type I), 5 patients (26.3%) bicornuate anomaly (type IV), 7 patients (36.8%) septate uterus (type V) and 3 patients (15.7%) arcuate uterus (type VI). No patients were identified to have didelphus, unicornuate or DES drug related anomalies Figure 1,2)

- ***Conclusion:***
  MRI proved to be an invaluable tool for accurately identifying and characterizing Müllerian anomalies, regardless of their complexity. The ASRM system, with its simplified and visually descriptive approach, was particularly advantageous in the radiological setting, providing clarity and streamlining the classification process.

Keywords: *Müllerian Duct Anomalies, ASRM Classification System, American Society for Reproductive Medicine (ASRM) System, MRI in Müllerian, Imaging in Müllerian.*

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I. INTRODUCTION

Müllerian duct anomalies (MDAs) are common congenital abnormalities that can significantly impact women's reproductive health. While prevalence rates vary across studies, a meta-analysis by Chan et al. reports a prevalence of 5.5% in the general population, with greater prevalence in women with recurrent miscarriages (13.3–24.5%) [5].

Embryologically, the development of the female reproductive tract begins around the sixth week of gestation with the presence of two paired ducts: the mesonephric (Wolffian) ducts and the paramesonephric (Müllerian) ducts. In females, the absence of Müllerian inhibiting factor leads to the bidirectional growth of the Müllerian ducts and regression of the Wolffian ducts. This process involves midline migration and fusion of the Müllerian ducts, followed by resorption of the intervening septum, ultimately forming the

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uterus and the proximal two-thirds of the vagina. Any disruption at different stages of this developmental process results in specific types of Müllerian anomalies [4].

Magnetic resonance imaging (MRI) is a pivotal tool for accurately identifying MDAs due to its superior soft-tissue contrast, multi-planar capabilities, and non-invasive nature. MRI provides clear visualization of the uterine anatomy, including zonal differentiation and external fundal contours, which are crucial for distinguishing between major anomaly types such as septate and bicornuate or didelphys uteri [4].

Multiple classification systems for MDAs exist, with the American Fertility Society (AFS) system (later adopted as the American Society for Reproductive Medicine [ASRM] system) being the most widely utilized due to its simplicity.

More recently, in 2021, the ASRM introduced an updated classification system—ASRM Müllerian Anomalies Classification 2021—which is an expansion and refinement of the original AFS framework, aiming to address its shortcomings.

This study aims to present the spectrum of Müllerian anomalies observed in our cohort based on MRI evaluations. These anomalies were categorized using the ASRM 2021 systems.

II. MATERIALS AND METHOD

This study, approved by the institutional review board of KAHER academy of higher education and research, Belagavi, involved a retrospective analysis of pelvic MRI scans and clinical records of 19 females with Müllerian anomalies between July 2023 and December 2024. The average age was 26 years (range: 8–34 years), with clinical indications including amenorrhea, infertility, cyclic abdominal pain and urogenital anomalies. MRI scans were conducted using a 3.0 Tesla Siemens MRI Machine (Magnetom Spectra), employing T2-weighted, T2 weighted fat supressed and T1-weighted sequences with detailed protocols to evaluate uterine anomalies.

Imaging findings were analyzed by an experienced radiologist, blinded to patient data. Septate and bicornuate anomalies were differentiated based on specific criteria, including external fundal cleft measurements and intercornual angles [3]. Other anomalies, such as hypoplastic uterus, were assessed by uterine dimensions and poor zonal anatomy. The anomalies were classified using the new ASRM system

III. RESULTS

Various mullerian anomalies were identified with differing frequencies. Among these, subseptate uterus is the most common anomaly, while other types like mixed and arcuate are less frequently observed [Figure 1,2].

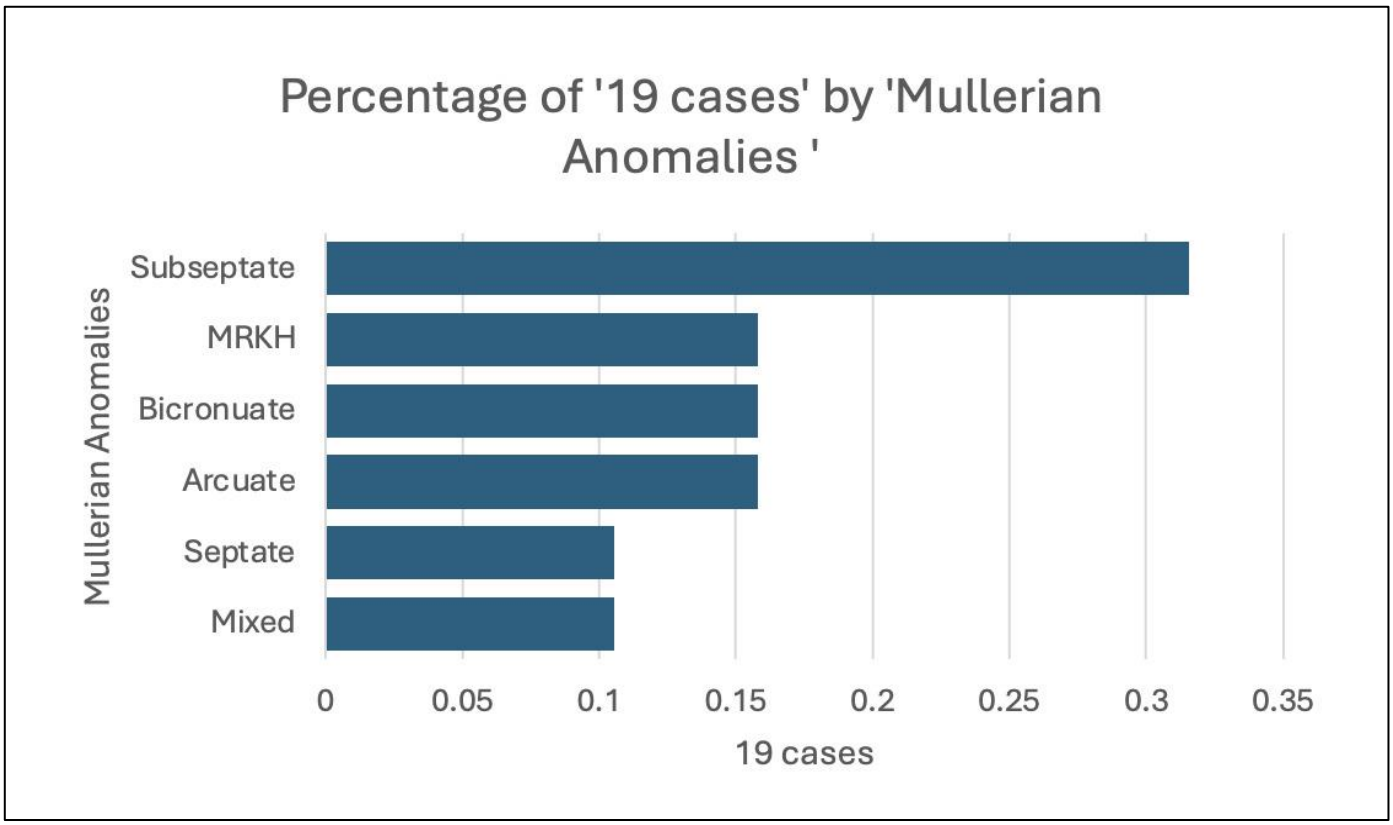

Fig 1: Bar Diagram Showing Percentage Distribution of Cases Among Mullerian Anomalies Subtypes

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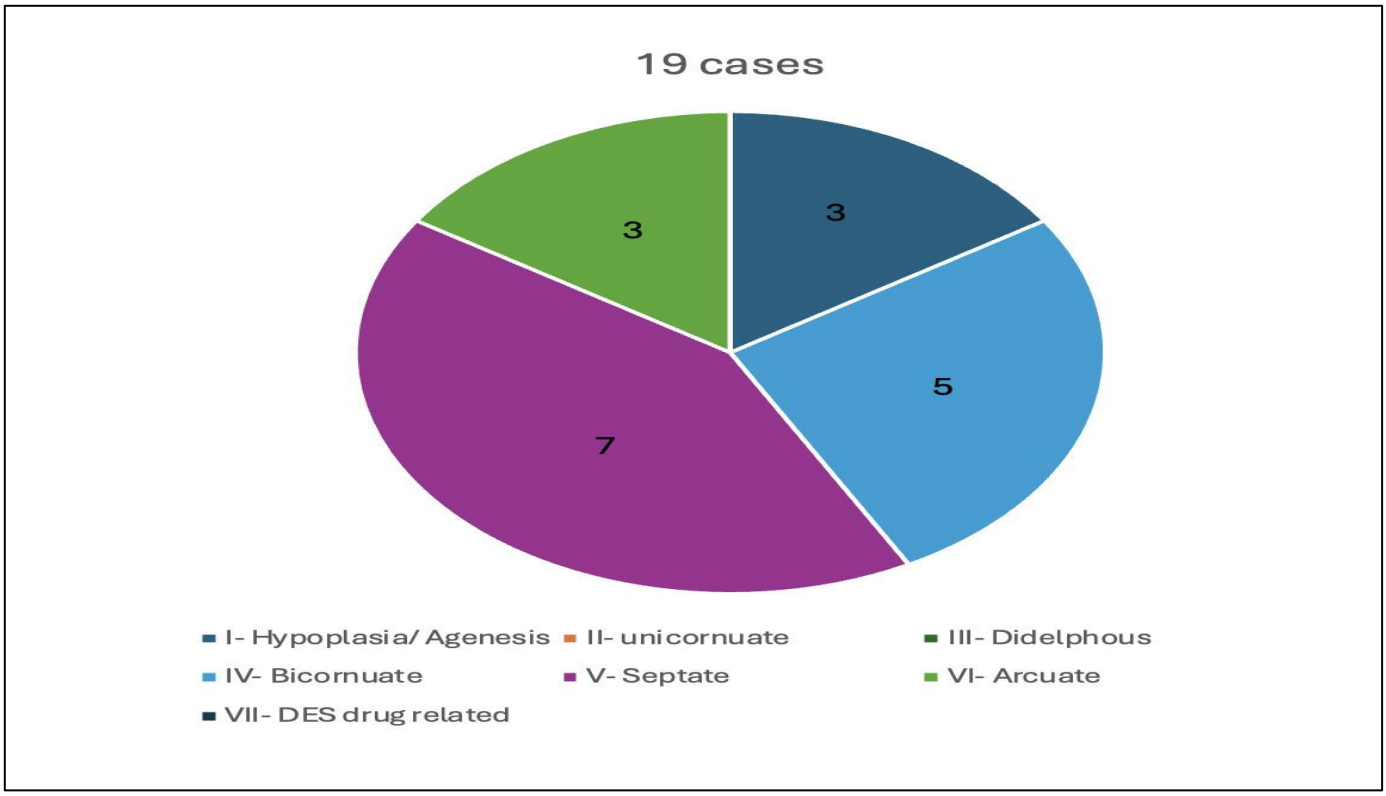

Fig 2: Pie Chart Showing Distribution of Cases Across Seven Types of Mullerian Anomalies

Mullerian agenesis was observed in 3 cases (15.7%) with ages ranging from 8 to 18 years. Among these, two showed agenesis of uterus, cervix and upper 2/3rd of vagina with intact ovaries corresponding to atypical form of Mayer-Rokitansky-Küster-Hauser (MRKH) syndrome [Figure 5a, 5b, 5c]. The remaining one case showed complete agenesis of uterus, cervix and upper 2/3rd of vagina and absent ovaries on both sides corresponding to typical form of MRKH syndrome [Figure 2].

Five cases (26.3%) involved a bicornuate uterus (ages 22- 34 years). one had bicornuate bicollis uterus with septate vagina and septal/ intramural fibroid [Figure 3], and one had bicornuate uterus with hematometra.

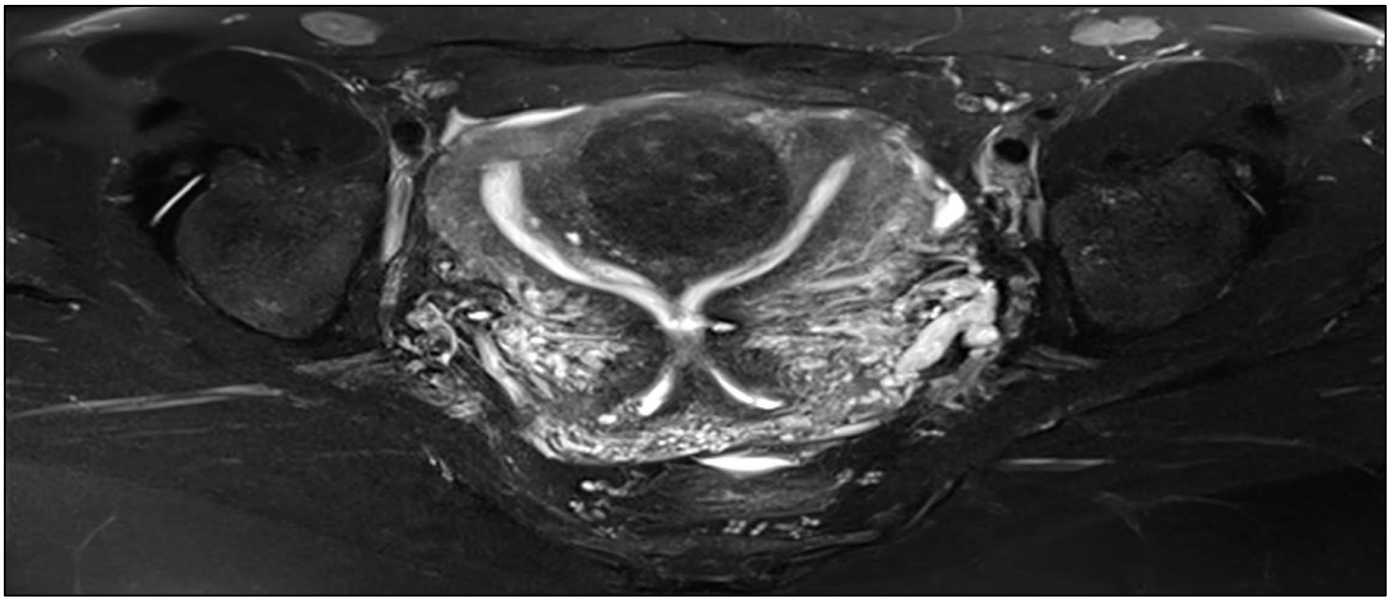

Fig 3: T2WI MRI Pelvis of 37 Year Old Female Showing Two Endometrial Cavities with Normal Fundal Contour. Endometrial Cavities are Fusing at Lower Uterine Segment and Duplication of Cervix and Vagina are Seen.

Note: fibroid with cystic degenerative changes is seen involving fundus in between two endometrial cavities (inter-cornual distance is not applicable in this case).

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Seven patients (36.8%) had a septate uterus (ages 24- 32 years). Among them, five had a partially septate uterus. One of the patient with subseptate uterus had gestational sac predominantly in the right cornua of the uterus [figure 4a, 4b]. The remaining two patients exhibited a complete septate uterus. One patient with septate uterus had multiple intramural fibroids [figure 5a, 5b].

Three patients (15.7%) had a arcuate uterus, aged 25- 32 years [figure 6].

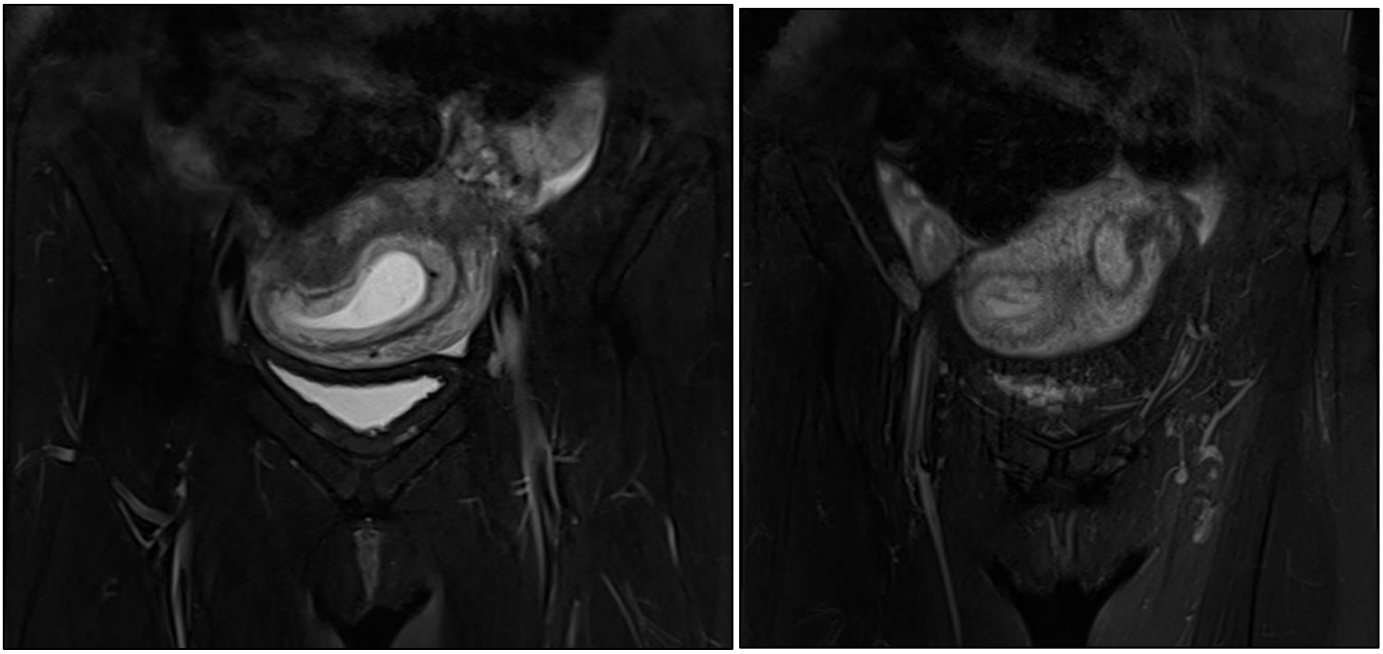

Fig 4(a,b): T2FS MRI Pelvis of 22 Year Old Female Showing Smooth Indentation on Fundus of Uterus (Depth 1.4 cm) Suggestive of Sub-Septate Uterus (4a). Gestational Sac with Placental Thickness Seen More towards the Right Side (4b).

IV. DISCUSSION

Magnetic Resonance Imaging (MRI) is a critical tool for evaluating congenital Müllerian anomalies due to its high sensitivity and specificity, which range from 28.6% to 100% and 66% to 100%, respectively. MRI excels in identifying uterine anatomy, distinguishing septate from bicornuate uteri [4].

Müllerian anomalies stem from failures in duct formation, fusion, or resorption and are categorized using various systems. The American Society for Reproductive Medicine (ASRM) system (1988) simplifies classification using anatomical drawings, correlating with clinical outcomes and treatment strategies [1]. However, it has limitations, including insufficient representation of complex or obstructive anomalies.

In 2021, ASRM updated its system, adding three new categories and improving clarity with detailed terms and educational tools though it still lacks coverage for non-Müllerian anomalies [1].

Common anomalies include septate uterus (19%), Müllerian agenesis (19%), bicornuate uterus (12.5%), uterus didelphys (8%), unicornuate uterus (11%), and vaginal anomalies (6%). The hypoplastic/infantile uterus (25%) highlights the need for hormonal assays and karyotyping for comprehensive diagnosis and management [1].

Presented here is a brief discussion of the types of anomalies shown in the article.

ASRM I - Hypoplasia/Agenesis (MRKH Syndrome): MRI demonstrates the absence or hypoplasia of the uterus and the upper two-thirds of the vagina, with normal development of the ovaries and fallopian tubes (typical form-Type A) [Figure 5a, 5b, 5c]. In contrast, when associated abnormalities of the ovaries and fallopian tubes, often renal anomalies (atypical form- Type B) [Figure 6] [2].

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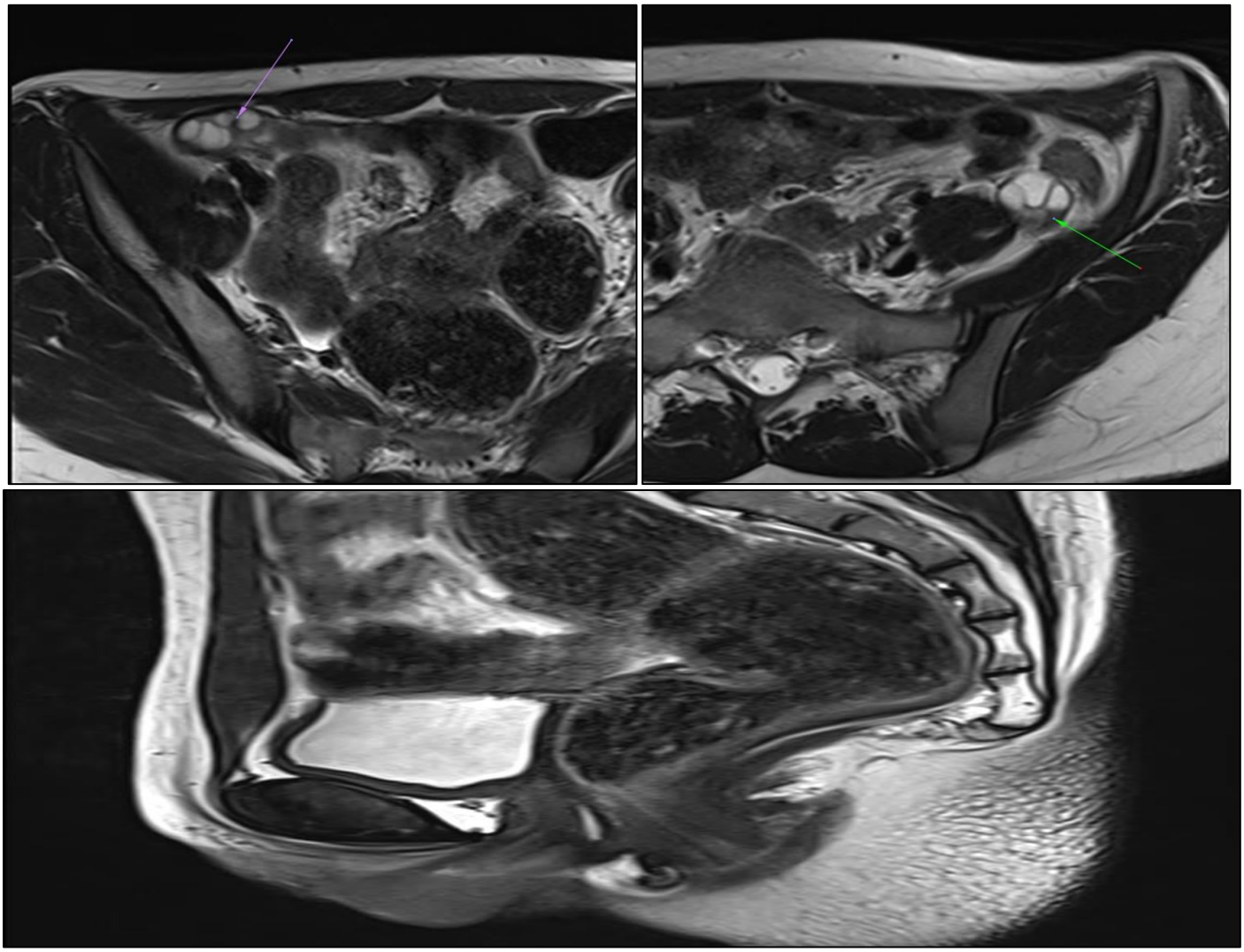

Fig 5(a,b,c): T2FS MRI Pelvis of a 16 Year Old Female Showing Presence of T2 Hyperintense Follicle Containing Right Ovary (1a) and Left Ovary (1b) and Absence of Uterus, Cervix and Upper 1/3rd of Vagina (1c) Consistent with MRKH Typical form (type A).

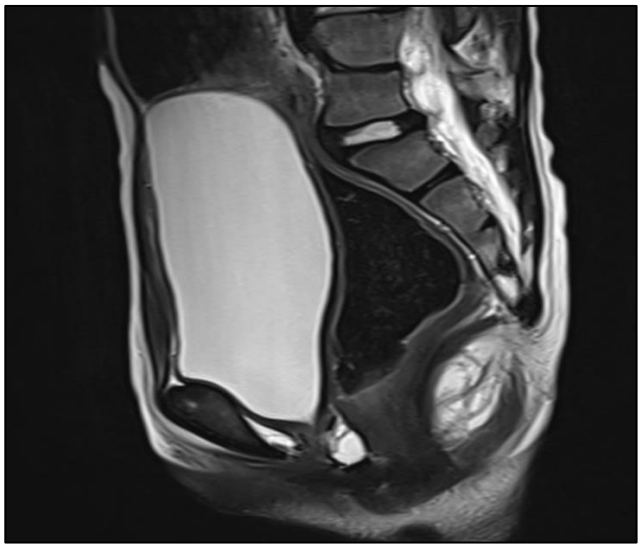

Fig 6: T2FS MRI Pelvis of 8 Year Old Female Showing Absence of Uterus, Cervix and Vagina along with Absence of Both Ovaries (Not Shown in the Image) Consistent with MRKH Atypical form (Type B).

ASRM II - Unicornuate Uterus: As this anomaly is readily diagnosed through hysterosalpingography with ultrasound correlation, cases were not referred for pelvic MRI in this study.

ASRM III - Didelphus Uterus: MRI reveals two completely separate uterine cavities, each with its own endometrial lining and distinct endocervical canals. The external uterine contour is typically flat or convex, with no significant bridging myometrial tissue between the cavities [2].

ASRM IV - Bicornuate Uterus: This anomaly is characterized by two endometrial cavities separated by a myometrial tissue bridge. Key features include a wide intercornual angle (>105°) and a fundal indentation >10 mm [Figure 7]. Unlike a septate uterus, the external uterine contour is concave or notched. Differentiation from a didelphus uterus is based on the presence of a shared cervix and partial myometrial bridging [2].

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ASRM V - Septate Uterus: MRI demonstrates two endometrial cavities divided by a fibrous or fibromuscular septum. A narrow intercornual angle (<75°) and a flat or convex external uterine contour distinguish it from a bicornuate uterus [Figure 7a] [2].

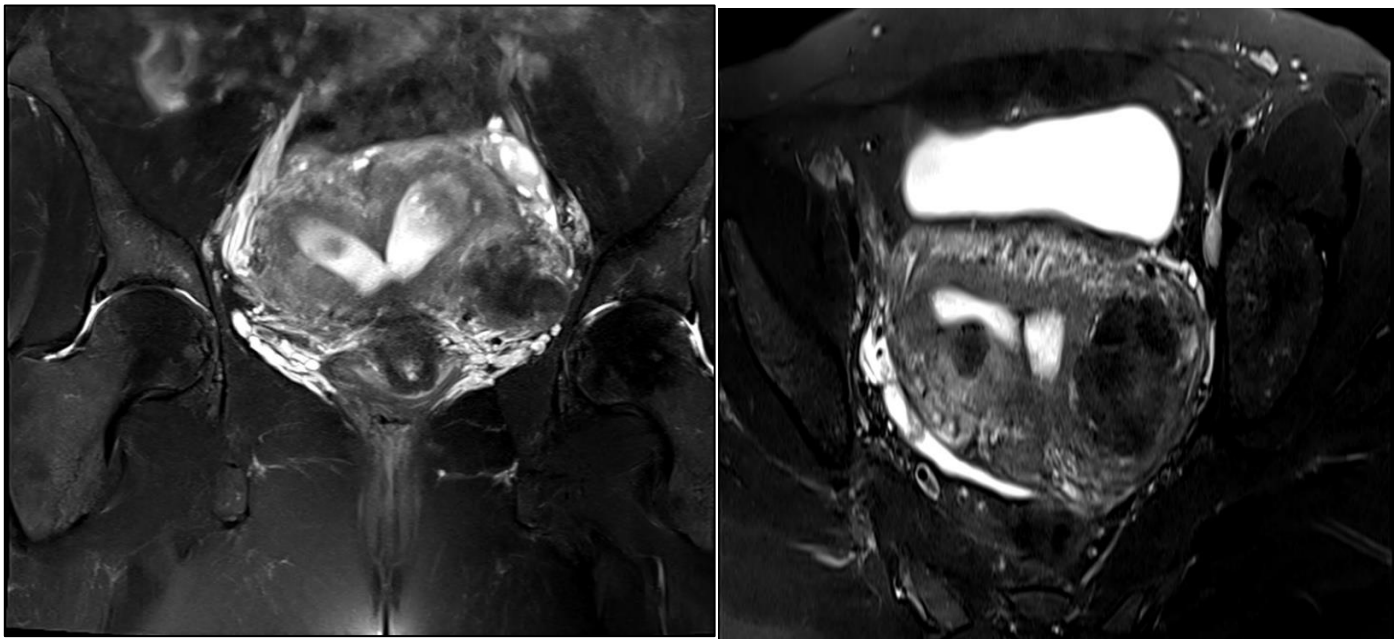

Fig 7(a,b): T2WI MRI Pelvis of a 42 Year Old Female Showing Smooth Indentation of Fundal Endometrium in Midline (depth 2.6 cm) with Acute Angle of Indentation (56°) Suggestive of Septate Uterus (5a). Axial Image Showing Two Endometrial Cavities with Intramural Fibroid (5b).

ASRM VI - Arcuate Uterus: MRI findings include a mild concavity of the endometrium with a broad, smooth fundal contour and an intercornual angle >75°. Uniform myometrial thickness at the midline differentiates it from a septate uterus [Figure 8] [2].

ASRM VII - DES-Related Anomalies: Due to the prohibition of diethylstilbestrol (DES) use, anomalies related to this drug are no longer observed [2].

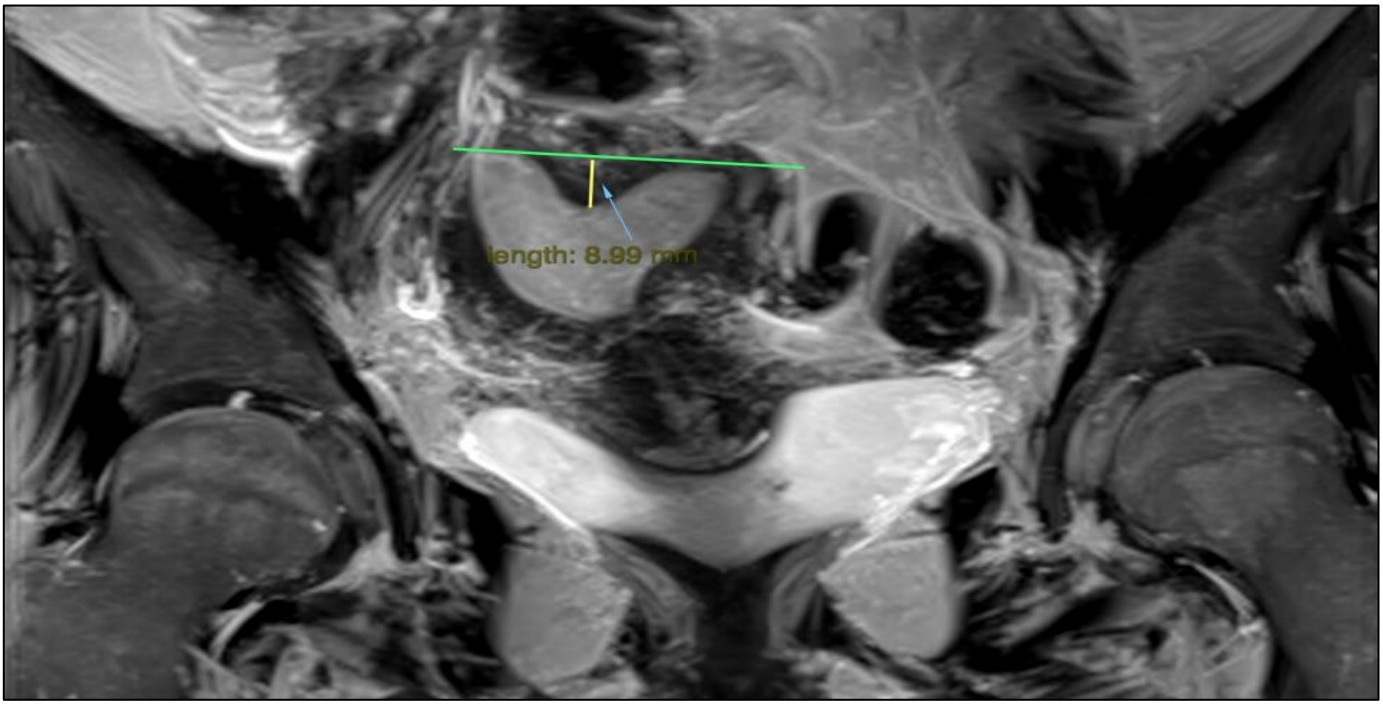

Fig 8: T2WI MRI Pelvis of 15 Year Old Female Showing Smooth Indentation of Fundal Endometrium in Midline (depth 0.89 cm) and Obtuse Angle of Indentation (110°) with Resultant Two Endometrial Cavities Suggestive of Arcuate Uterus

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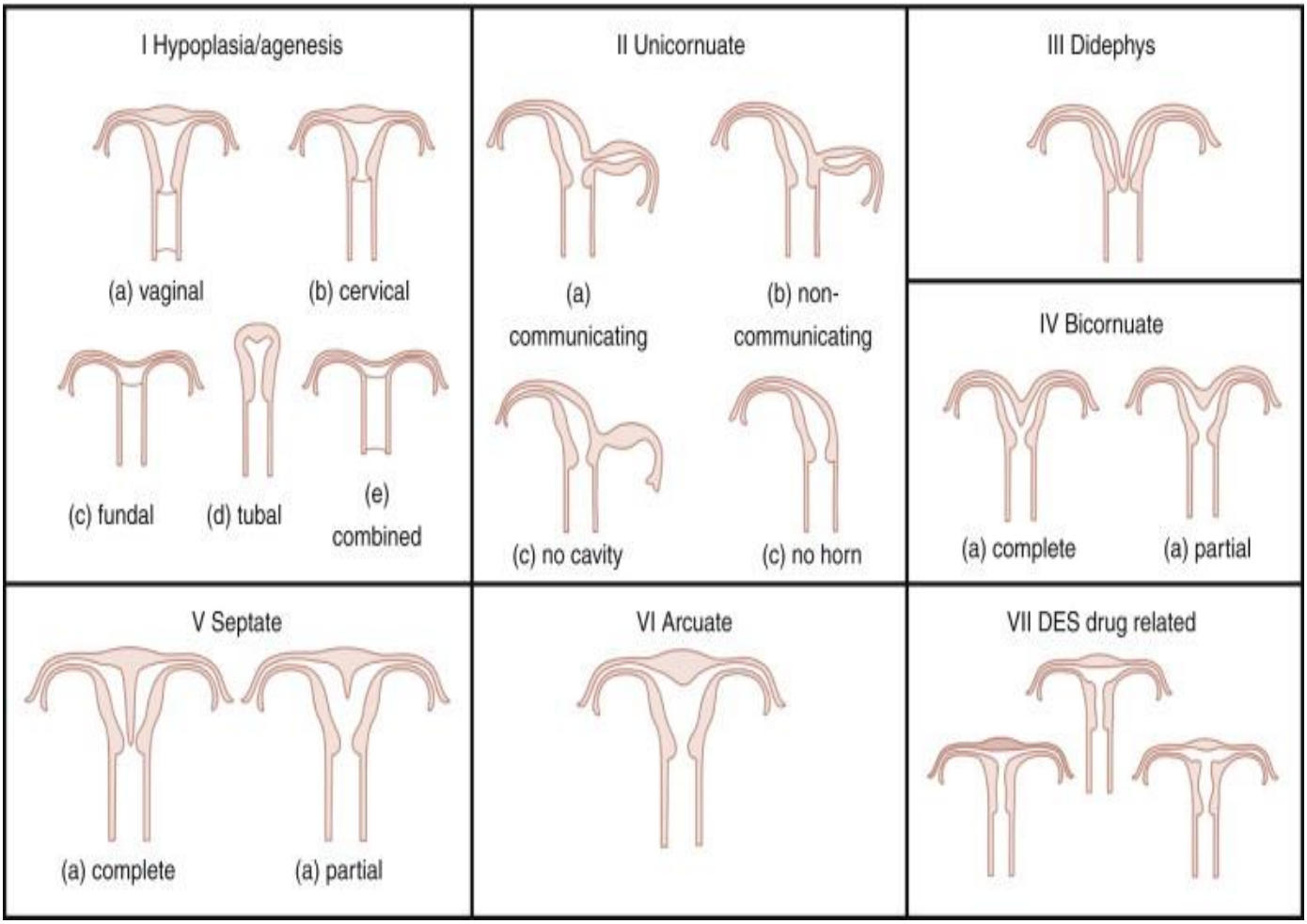

Fig 9: Classification of Müllerian Uterine Abnormalities, was Proposed by Buttram and Gibbons in 1979 (Later Modified by ASRM in 1988) [6].

There are few limitations to the study. One issue lies in its retrospective design, which relied on previously diagnosed patients and could lead to selection bias. This may affect prevalence rates, making comparisons with prospective studies unreliable. Another limitation is the small sample size, resulting in a limited number of cases for each abnormality and few of the abnormalities were not covered all together.

V. CONCLUSION

Müllerian anomalies, often complex and sometimes linked to urinary or other non-urinary malformations, can be effectively identified using MRI. By utilizing clear drawings instead of symbols, it provides an intuitive overview of anomalies, making it particularly useful in radiology. This design enables seamless comparison between MRI findings and classification diagrams, reducing effort and improving efficiency during reporting.

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