Section: Radiodiagnosis

Original Research Article

MAGNETIC RESONANCE IMAGING: A KEY TOOL IN MULLERIAN DUCT ANOMALIES

Soujanya B[1],Venkatarathnam V[2], Sanjeev Kumar M[3], Ramesh Kumar R[4]

[1]Post Graduate, Department of Radiodiagnosis, PES Institute of Medical Sciences and Research, Kuppam, Chitoor district, Andhra Pradesh, India.
[2]Professor, Department of Radiodiagnosis, PES Institute of Medical Sciences and Research, Kuppam, Chitoor district, Andhra Pradesh, India
[3]Associate Professor, Department of Radiodiagnosis, PES Institute of Medical Sciences and Research, Kuppam, Chitoor district, Andhra Pradesh, India
[4]Professor and HOD, Department of Radiodiagnosis, PES Institute of Medical Sciences and Research, Kuppam, Chitoor district, Andhra Pradesh, India.

Received : 04/01/2025
Received in revised form : 20/02/2025
Accepted : 08/03/2025

Keywords:
Mullerian, uterus, bicornuate, didelphys, septate.

Corresponding Author:
Dr. Soujanya B,
Email: samskruthi.sri999@gmail.com

DOI: 10.47009/jamp.2025.7.2.57

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (2); 284-288

Abstract

Background: Mullerian duct anomalies are the result of failure of formation, fusion or resorption of the Mullerian ducts and are relatively common, with a prevalence of 5.5–7.0% in the general population. Accurate diagnosis of the various sub-types of these anomalies is of great importance as they are frequently associated with a broad variety of clinical symptoms. Magnetic resonance imaging (MRI) is a useful tool for complete characterization of the anomaly. Our aim is to study the diagnostic efficiency of MRI in classification of sub-types of mullerian duct anomalies .We studied 25 cases of diverse sub-types of mullerian duct anomalies and the corresponding MRI findings. **Materials and Methods:** In this retrospective study, patients (n = 25) with clinical suspicion and diagnosed (ultrasound / HSG) of mullerian duct anomalies were referred to department of radiology and examined with MRI. Axial, sagittal, coronal T2 and axial T1 -weighted images were acquired. MRI based diagnosis was made and patients were grouped according to the ASRM classification system. **Result:** Most common anomaly in total study sample is hypo-plastic uterus(32%). MRI revealed six patients with mullerian agenesis(24%), eight patients were diagnosed with hypoplastic uterus(32%), one patient with didelphys uterus (4%), two patients with bicornuate uterus (8%) and seven patients with septate uterus(28%) and one patient with arcuate uterus (4%). **Conclusion:** MRI pelvis emerged as a highly efficient diagnostic tool for Müllerian duct anomalies, with the ability to accurately identify morphological characteristics crucial for diagnosis and treatment planning. These findings suggest that MRI can serve as a cornerstone in diagnosing mullerian duct anomalies, aiding in better patient management and outcomes.

INTRODUCTION

Mullerian duct anomalies (MDAs) are a diverse group of rare congenital conditions resulting from abnormal development or nonfusion of the Mullerian ducts during fetal development, which give rise to the female reproductive tract. Concomitant urinary malformations, particularly renal agenesis, are often present in these conditions.[1] Variable prevalence estimates are available in the literature. As per the meta-analysis done by Chan et al, a prevalence of 5.5% in the general population was reported, detecting a higher prevalence amongst infertile women (8.0%) and even higher in patients with miscarriages (ranging 13.3–24.5%).[2]

Fetal intrauterine growth retardation, fetal malposition, multiple spontaneous abortions in the first trimester, infertility, premature labor and retained placenta are all known to be more common in patients with MDA.[3] The role of imaging is to detect and classify these Mullerian duct anomalies so that appropriate treatment is undertaken.

Before the era of MRI, transvaginal ultrasound, HSG, laparoscopy and laparotomy constituted the first line modalities in evaluating Mullerian duct anomalies. However, HSG is always associated with exposure of the patient to contrast material and radiation and most importantly, it is not much useful for accurate differentiation of the diverse uterine subtypes.[4] Laparoscopy as well as laparotomy are invasive procedures that carry a definite risk and thus should be considered as second-line strategies.

The assessment of Mullerian duct anomalieshas gained attention in recent years due to MR imaging. The ability of magnetic resonance imaging to precisely describe and illustrate the anatomical

ISSN (O): 2687-5365; ISSN (P): 2753-6556

relationship of the female reproductive organs to surrounding structures has made it a potent imaging technique that complements and, in many situations, competes with alternate imaging modalities. Here, we report MRI results from patients with various uterine subtypes of Mullerian duct anomalies.

Embrology: Embryologically, at six weeks of gestation, two pairs of mesonephric (wolffian) and paramesonephric (mullerian or female genital) ducts are present. Since the female fetus lacks the mullerian inhibitory factor, the mullerian ducts will expand in both directions while the mesonephric ducts will simultaneously regress.[5] This is accompanied by midline migration and fusion of these ducts with ultimate resorption of the intervening septum, resulting in the development of the uterus, cervix, fallopian tubes and proximal 2/3 of the vagina. Interruption of any of these processes will result in a certain mullerian anomaly according to the stage of development.[5]

Development of the Müllerian ducts progresses through three key stages: organogenesis, fusion, and septal resorption.

1. Organogenesis: Both Müllerian ducts form, and any failure at this stage can lead to uterine agenesis, hypoplasia, or a unicornuate uterus.
2. Fusion: The two ducts fuse to form the uterus. Failure in fusion can result in a bicornuate or didelphys uterus.
3. Septal Resorption: The septum between the fused ducts is resorbed, and failure to resorb leads to a septate or arcuate uterus.

Whereas mesothelial, mesenchymal, and primordial germ cells give rise to the ovaries, which are distinguishable by the tenth week of gestation. The gubernaculum, which later forms the utero-ovarian ligament and round ligament, guides the ovaries as they descend caudally from the urogenital ridge next to the developing kidneys to the pelvis during Müllerian duct fusion.[6] In patients with müllerian hypoplasia, the function of the ovaries is usually normal, which reflects their separate embryologic origins. The ovaries may be located superior to their expected location owing to failure of descent.[7]

Classification system: Although there are several classification systems for Mullerian duct anomalies, the American Fertility Society (AFS) classification (later named the American Society for Reproductive Medicine; ASRM) is the most popular used classification due to its simplicity. It is a revision of the classification system first created by Buttram and Gibbons in 1979.[8] However, this classification system has its limitations pertaining to its inability to classify complex anomalies involving different portions of the mullerian duct and the obstructive cervical and vaginal anomalies. A more recent classification system was introduced by the working group of the European Society of Human Reproduction and Embryology (ESHRE) and the European Society for Gynecological Endoscopy (ESGE), although it is not widely accepted and was criticized for its over-diagnosis of septate uterus, which may result in unnecessary treatment. Very recently, by the end of the year 2021, the ASRM presented their new classification (ASRM mullerian anomalies classification 2021) which is a modification and expansion of the original AFS classification system. Unlike the AFS classification, anomaly categories are no longer numbered but instead are identified by descriptive terminology:[9]

- Müllerian agenesis
- Cervical agenesis
- Unicornuate uterus
- Uterus didelphys
- Bicornuate uterus
- Septate uterus
- Longitudinal vaginal septum
- Transverse vaginal septum
- Complex anomalies

MATERIALS AND METHODS

This is a retrospective study based on the data of 25 patients clinical or imaging findings (hysterosalpingography or ultrasound) that were indicative of MDAs and underwent investigation with MRI study. The mean age recorded was 22 years (age range 11–54years). They had variable clinical indications including amenorrhea, infertility, cyclic abdominal pain, and one case of post-partum bleeding. MRI was performed on a 1.5-T GE Signa MR scanner. Informed consent was obtained from all patients. No contrast material was used. T1- and T2-weighted images were acquired in Sagittal, transaxial and coronal planes. T1-weighted images were obtained with a TR of 900 ms and a TE of 20 ms. T2-weighted images were acquired with a TR of 5000 ms and a TE of 130 ms. Section thickness of 3 mm.

Additional coronal T2-weighted images with a large field of view was done for some patients to visualize the kidneys. Other imaging modalities such as ultrasound and CT were available for a subset of patients, that helped in the diagnosis of other associated anomalies like renal abnormalities and gonadal dysgenesis.

Detailed imaging findings were recorded for each patient. Differentiation between septate and bicornuate uterus was done as follows:

It is identified as septate uterus - 1)If an external fundal indentation of < 1 cm on the coronal uterine plane (This is determined by drawing a line between the tops of both uterine horns and measuring the distance perpendicularly from this line to the lowest point of the indentation).2) If the internal fundal indentation towards the endometrium is >1 cm (measured by drawing a line between the two tubal ostia and measuring the distance from this line to the top of the myometrial or fibrous septum towards the endometrial cavity). 3) The leading edge of the septum is at an angle (indentation angle) of < 90°.

On the other hand, to diagnose a bicornuate/didelphys abnormality, the external fundal contourindentation to be by > 1 cm.[9]

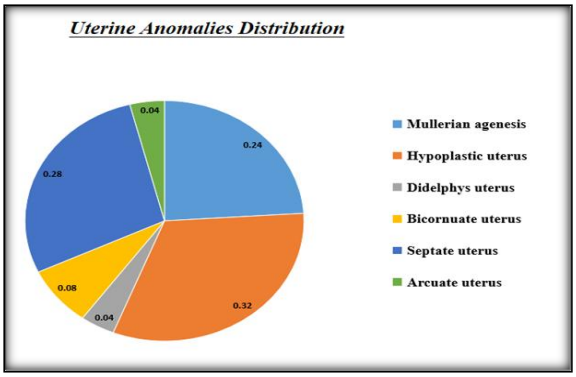
ISSN (O): 2687-5365; ISSN (P): 2753-6556

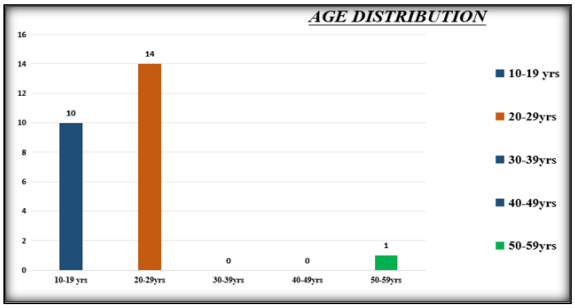
Other ways of calculation are available in the literature, which are particularly useful in equivocal cases, they are 4) If the intercornual distance is <4 cm, it is usually septate and intercornual distance of >4 cm seen more commonly in a bicornuate uterus. 5) if the intercornual angle is <75°, it is suggestive of a septate uterus and intercornual angle >105°, more suggestive of a bicornuate uterus.[10] 6) The septate uterus was further stratified into partial septate uterus, if the septum does not reach the external cervical os and complete septate uterus if it reaches the external os resulting in two separate cervical canals.[11,12]

The evaluation of hypoplastic/infantile uterus done on the small size of the uterus, which showed either a uterine body: cervix ratio of 1:1 or 1:2 or the thinned endometrial stripe with poor zonal anatomy. The resulting anomalies were then stratified according to the most widely used classification system of the AFS (used since 1988) and new classification (ASRM mullerian anomalies classification 2021.Associated anomalies particularly of the urinary system, special findings regarding the ovaries, and other pelvic pathologies were also taken note of.

RESULTS

Variable congenital mullerian anomalies were found at different frequencies in a total study group of 25 pateints. Most common MDA in total study sample is hypoplastic uterus(32%). MRI revealed six patients with mullerian agenesis (24%), eight patients were diagnosed with hypoplastic uterus (32%), one with didelphys uterus (4%), two with bicornuate uterus (8%) and seven with septate uterus(28%) and one with arcuate uterus (4%).





Six cases (24%), were diagnosed as complete mullerian agenesis ie, Mayer–Rokitansky–Kuster–Hauser syndrome (age range of 15– 29years), in which 3 are typical and 3 are atypical type with renal agenesis and ectopic location of kidneys [Figure 1].

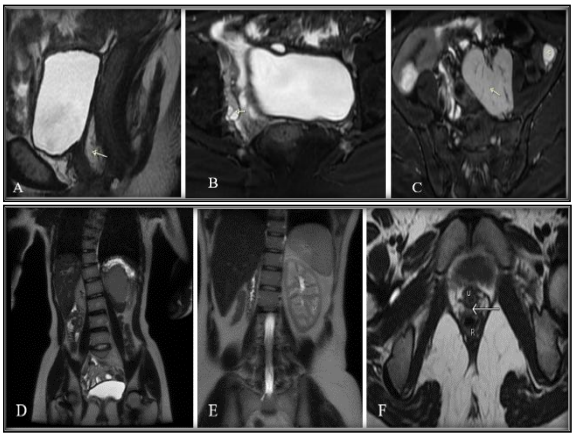


Figure 1: (A–D) MRKHS with ectopic left kidney and abnormal position of both ovaries in a 16 yr old patient with primary amenorrhea. Sag T2-weighted MR image (A) shows fat in the expected location of the lower vagina (arrow). Axial T2-weighted FS MR image (B) shows abnormal positioning of the right ovary in the right pelvic cavity. Axial T2- weighted FS MR image(C)shows ectopic left kidney (arrow) and left ovary in iliac fossa (arrow head). Coronal T2-weighted MR image (D) with large FOV shows dextroscoliosis of thoracic spine. Coronal T2-weighted MR image (E) shows right renal agenesis and left kidney is normal(LK) in a 19 year old patient with MRKH. Axial T2-weighted MR image (F) shows absent vagina(arrow)between urethra (U) and rectum(R).

Uterus didelphys was diagnosed in 1 patient (4%) with wide separation of fundus and body of two uterine cavities with intercornual distance of 8.5 cm and a partial septum extending till upper cervical canal [Figure 2].

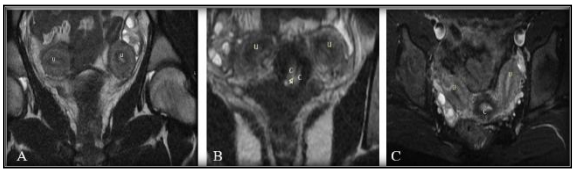


Figure 2: MR images with MDAs of absent or incomplete fusion. (A) Coronal T2-weighted MR image of a uterus didelphys in a 21-year-old woman shows two separate unicornuate uterine cavities (U) separated widely and a thin T2 hypointense partial septum (arrow) (B) separating upper cervical canal (c).Coronal MR image (C) shows single cervical canal (c) in lower portion.

Seven patients (28%) had a septate uterus (11–29 years), Out of 7, four had partial septate uterus and three had complete septate uterus. Two patients had complete septate uterus with longitudinal vaginal septum. One of the patient with partial septate uterus had post partum status with retained placenta in the right endometral cavity at fundal level [Figure 3].

ISSN (O): 2687-5365; ISSN (P): 2753-6556

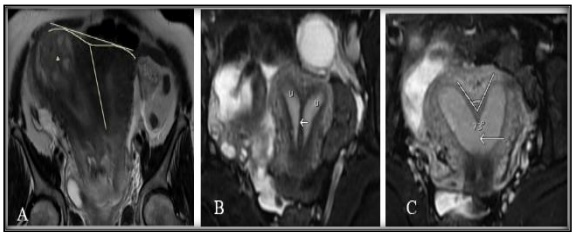


Figure 3: Coronal T2-weighted MR image (A)of a septate uterus in a 29-year-old woman shows minimal external indentation (curved line), septal length of 7cm(oblique line)and retained palcenta(arrow head) in right cavity. Axial T2-weighted MR image (B)of a complete septate uterus with normal external uterine contour and fibrous septum dividing uterus into two cavities. Axial T2-weighted MR image (C)of a partial septate uterus with flat external uterine contour, internal indentation of greater than 1.5 cm, an angle of indentation of less than 90.

Two cases (8%) were found to have bicornuate uterus (23–54 years). One patient had bicornuate bicollis anomaly with Intrauterine pregnancy in left horn and one patient had bicornuate unicollis anomaly with large left lateral wall adenomyosis and right lateral intramural fbroid. [Figure 4].

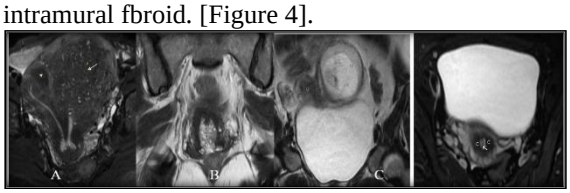


Figure 4: Coronal T2-weighted MR image (A&B)of a Bicornuate unicollis uterus in a 54-year-old woman showing external indentation of >1cm, T2 hypointense leiomyoma in right horn and adenomyosis in left horn. (B) demonstrates communication of two cavities above the cervix.Coronal T2-weighted MR image (C &D)of a Bicornuate bicollis uterus with external uterine contour indentation, intrauterine gestation sac in left horn and septum (arrow)dividing cervix into two.

Eight cases (32%), were diagnosed with hypoplastic/infantile uterus, with the age range of 14–27 years, one patient had hypoplastic vagina [Figure 5].

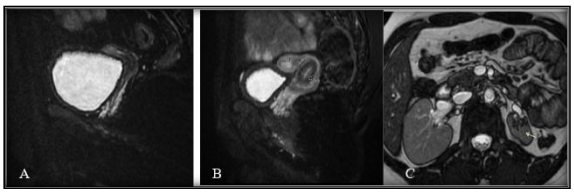


Figure 5: Sagittal T2 and T2 FS-weighted MR images (A&B) shows hypoplastic uterus and infantile uterus (B). Axial FIESTA image (C) shows small left kidney(arrow).

One patient (4%) had arcuate uterus with normal external contour of uterine fundus and mild indentation of myometrium < 1cm into endometrial cavity [Figure 6].

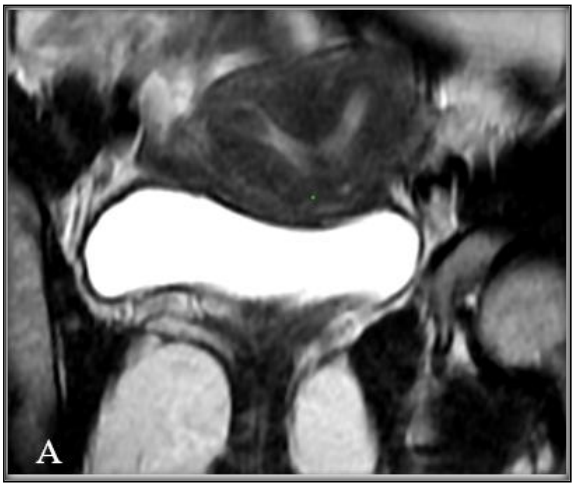
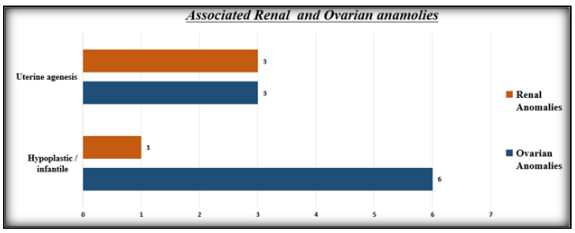


Figure 6: Coronal T2 weighted MR image (A) shows Arcuate uterus.

Ovarian and Renal Abnormalities: Ovarian abnormalities were found in association with hypoplastic/infantile uterus (6 out of 8 cases). 5 patients had ovarian agenesis - no ovaries were identified in the pelvis or lower abdominal region, one of these had sweyers syndrome with 46xy karyotype and one with small ovaries for age. One patient had right ovarian simple cyst. One patient had small left kidney.

Limited ovarian abnormalities were detected among the other mullerian anomalies.

One patient had bilateral ectopic ovaries in iliac fossa in Mayer–Rokitansky syndrome and 2 patients with Mayer–Rokitansky syndrome had right renal agenesis, of these one had right ovarian cyst. Ectopic ovaries were seen in the left iliac fossa and right pelvic cavity in one more case of Mayer–Rokitansky syndrome. Ectopic left kidney in one case of MRKH. Two patients with septate uterus had left ovarian hemorrhagic cyst and large Mucinous cystadenoma of right ovary.



DISCUSSION

MRI has emerged as the universally accepted standard in the imaging evaluation of Mullerian duct anamolies. Accuracies of up to 100% in the evaluation of Mullerian duct anamolies have been reported. MRI provides excellent delineation of both internal and external uterine anatomy.[12] T2-weighted images provide excellent detail regarding uterine zonal anatomy and are considered the mainstay of pelvic imaging. The endometrium is hyperintense on T2-weighted images. The junctional

ISSN (O): 2687-5365; ISSN (P): 2753-6556

zone surrounds the endometrium, and is readily identified as a hypointense band measuring up to 8 to 10 mm in thickness. The uterine myometrium is of intermediate signal intensity on T2-weighted images. The uterus is uniformly hypointense on T1- weighted images, which are of limited value in the evaluation of uterine anatomy T1-weighted sequences are used to identify blood products; this can be very helpful when an obstructed MDA results in hematometrocolpos. One of the most valuable features of MR in the evaluation of pelvic anatomy is the multiplanar imaging capability, which allows the contour of the uterine fundus to be visualized that is essential for the evaluation of Mullerian duct anomalies.

Not only MRI was able to correctly characterize the external uterine contour, but also it revealed the tissue composition of the septum muscular or fibrous septum. This particular finding is of great clinical importance as tissue composition significantly impacts on the surgical approach: hysteroscopic metroplasty with resection of the septum suffices in septate uterus, whereas a well-vascularized myometrial septum in bicornuate uterus requires a transabdominal approach in order to prevent life-threatening bleeding. These results are in concordance with Carrington et al,[13] and Mintz et al,[14] who could show that MRI is an excellent tool for depiction of septum tissue composition. Furthermore, tissue composition of the septum may play a major role for a patient's ability to maintain pregnancy, as the attempted placental implantation into the fibrous part of the septum will ultimately lead to an increased risk of abortion.[14]

MRI does accurate characterization of the different subtypes of Mullerian duct anamolies could be often impossible using other diagnostic methods. Physical examination is of very limited value in diagnosis of MDAs.[15] HSG has been the first line of defense in diagnosis of anomalies of the female reproductive system for many years, but its diagnostic value is severely impaired by its lack to display the external uterine contour (which is particularly important for differentiation of septate and bicornuate uterus).[15] It requires exposure to radiation and contrast material and does not deliver any information about tissue composition, which is crucial in the differentiation of septate and bicornuate uterus.[14,15] In particular, with regard to differentiation of septate and bicornuate uterus, accuracy of HSG is 55%. When combined with ultrasound, accuracy increases. Transvaginal ultrasound (TVS) in particular has been shown to be a valuable tool in diagnosis of uterine anomalies, but in case of vaginal obstruction, like by septa, cannot easily be applied. However, TVS has been proposed as initial diagnostic modality in patients with suspicion of Mullerian duct anomalies, predominantly because of lower costs compared to MRI. Accuracy for diagnosis of uterine anomalies has been shown to be 100% for MRI and 92% for TVS.[15] In the diagnosis of those uterine anomalies, both MRI and TVS demonstrated and excellent sensitivity and specificity of 100%.[15] However, in the diagnosis of septate uterus, MRI demonstrated a higher specificity as compared to TVS (100% vs. 80%), whereas sensitivity was 100% for both methods.[15]

CONCLUSION

In conclusion, MRI is quite helpful in the differentiation of uterine anomalies. With its ability to provide information about the external and internal uterine anatomy and tissue composition, it represents a powerful tool in diagnosis and classification of patients with MDAs, and thereby creates a strong basis for choosing on further treatment options.

REFERENCES

1. Vitale F, Dolmans MM, Houeis L. Magnetic resonance imaging for proper diagnosis and management of Müllerian duct anomalies. Journal of Endometriosis and Uterine Disorders. 2024 Jun 1;6:100060.
2. Al Najar MS, Al Ryalat NT, Sadaqah JS, Husami RY, Alzoubi KH. MRI evaluation of mullerian duct anomalies: practical classification by the new ASRM system. Journal of Multidisciplinary Healthcare. 2022 Jan 1:2579-89.
3. Chandler T, Machan LS, Cooperberg PL, Harris AC, Chang SD. Müllerian duct anomalies: from diagnosis to intervention. The British journal of radiology. 2009 Dec 1;82(984):1034-42.
4. Vosshenrich R, Funke M, Baum F, Grabbe E, Marten K, Obenauer S. MRI in the evaluation of müllerian duct anomalies.
5. Marcal L, Nothaft MA, Coelho F, Volpato R, Iyer R. Mullerian duct anomalies: MR imaging. Abdominal imaging. 2011 Dec;36:756-64.
6. Rivas AG, Epelman M, Ellsworth PI, Podberesky DJ, Gould SW. Magnetic resonance imaging of Müllerian anomalies in girls: concepts and controversies. Pediatric Radiology. 2022 Feb;52(2):200-16.
7. Sugi MD, Penna R, Jha P, Põder L, Behr SC, Courtier J, Mok-Lin E, Rabban JT, Choi HH. Müllerian duct anomalies: role in fertility and pregnancy. Radiographics. 2021 Oct;41(6):1857-75.
8. Buttram Jr VC, Gibbons WE. Müllerian anomalies: a proposed classification (an analysis of 144 cases). Fertility and sterility. 1979 Jul 1;32(1):40-6.
9. Pfeifer SM, Attaran M, Goldstein J, Lindheim SR, Petrozza JC, Rackow BW, Siegelman E, Troiano R, Winter T, Zuckerman A, Ramaiah SD. ASRM müllerian anomalies classification 2021. Fertility and sterility. 2021 Nov 1;116(5):1238-52.
10. Marcal L, Nothaft MA, Coelho F, Volpato R, Iyer R. Mullerian duct anomalies: MR imaging. Abdominal imaging. 2011 Dec;36:756-64.
11. Practice Committee of the American Society for Reproductive Medicine. Uterine septum: a guideline. Fertility and sterility. 2016 Sep 1;106(3):530-40.
12. Olpin JD, Moeni A, Willmore RJ, Heilbrun ME. MR imaging of Müllerian fusion anomalies. Magnetic Resonance Imaging Clinics. 2017 Aug 1;25(3):563-75.
13. Carrington BM, Hricak H, Nuruddin RN, Secaf E, Laros Jr RK, Hill EC. Müllerian duct anomalies: MR imaging evaluation. Radiology. 1990 Sep;176(3):715-20.
14. Mintz MC, Thickman DI, Gussman D, Kressel HY. MR evaluation of uterine anomalies. American Journal of Roentgenology. 1987 Feb 1;148(2):287-90.
15. Js P. Diagnosis of uterine anomalies: relative accuracy of MR imaging, endovaginal sonography, and hysterosalpingography. Radiology. 1992;183:795-800.

ISSN (O): 2687-5365; ISSN (P): 2753-6556