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Original Research Article

Role of Image-Guided Interventions in the Minimally Invasive Management of Gynaecological Conditions: A Clinical Evaluation

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Abstract:

Background: Radiology-guided minimally invasive procedures provide safer and less invasive alternatives to conventional surgery in gynecology. Among them, ultrasound-guided aspiration and image-guided biopsies play a crucial role in both therapeutic and diagnostic management of gynaecological disorders. These approaches reduce patient morbidity, shorten hospital stay, and provide early, accurate diagnoses that guide further management.

Objective: To evaluate the clinical efficacy, diagnostic yield, safety, and patient outcomes of ultrasound-guided aspiration and image-guided biopsies in women with gynaecological disorders at a tertiary care center in Bihar.

Methods: A prospective observational study was conducted between July 2021 and December 2021 at Indira Gandhi Institute of Medical Sciences, Patna. A total of 132 women underwent ultrasound-guided aspiration of pelvic collections and abscesses, or image-guided biopsies (ultrasound/MRI-guided and transvaginal FNAC) of pelvic and uterine lesions. Outcomes were assessed in terms of technical success, diagnostic yield, symptom relief, complications, and hospital stay.

Results: Ultrasound-guided aspiration achieved complete technical success in all cases, leading to rapid resolution of pelvic abscesses and collections, with minimal complications. Image-guided biopsies and FNAC provided conclusive histopathological diagnoses in 95.6% of cases, reducing the need for exploratory surgery. Most patients were discharged within 48 hours, and overall patient satisfaction was high.

Conclusion: Ultrasound-guided aspiration and image-guided biopsies are safe, effective, and well-tolerated procedures in the management of gynaecological disorders. Their ability to combine therapeutic efficacy with diagnostic precision highlights their importance as frontline minimally invasive interventions in clinical practice.

Keywords: Ultrasound-guided aspiration, Image-guided biopsy, minimally invasive procedures, Gynaecological disorders, Interventional radiology.

Introduction

The integration of radiology-guided minimally invasive procedures has transformed the approach to gynecological care over the past two decades. Conventional open and laparoscopic surgeries, though effective, are associated with greater morbidity, longer hospital stays, increased costs, and higher risks in patients with comorbidities [1]. In contrast, minimally invasive image-guided procedures provide safer, faster, and more targeted alternatives that allow for diagnosis and therapy with minimal disruption to patient health and fertility potential. Among the various interventional radiology techniques, ultrasound-guided aspiration and image-guided biopsy have emerged as pivotal tools for both diagnostic clarification and therapeutic relief [2]. These interventions capitalize on real-time imaging to achieve accurate localization of pathology, ensuring maximum efficacy with minimal collateral damage. Their value is particularly pronounced in the management of conditions such as tubo-ovarian abscesses, pelvic collections, adnexal masses, uterine lesions, and cases of unexplained infertility where precise tissue diagnosis is essential [3]. Ultrasound-guided aspiration is widely utilized for drainage of pelvic abscesses, tubo-ovarian abscesses, and complex fluid collections that often result from pelvic inflammatory disease or post-surgical complications. Aspiration under imaging guidance obviates the need for invasive laparotomy or

laparoscopy, thus avoiding surgical morbidity and anesthesia risks [4]. Multiple studies have shown that image-guided drainage of gynecologic abscesses is associated with high clinical success rates, shorter recovery times, and reduced recurrence compared with conventional surgical drainage. It is particularly advantageous in resource-constrained healthcare systems where surgical facilities may be limited and patients often seek fertility-preserving alternatives [5]. Image-guided biopsy, performed under ultrasound or magnetic resonance imaging (MRI) guidance, plays a central role in the diagnostic algorithm of gynecological practice. Pelvic and uterine masses often present a diagnostic dilemma where clinical and imaging features alone are insufficient to establish malignancy risk. Image-guided biopsy and fine-needle aspiration cytology (FNAC) enable procurement of high-quality tissue samples with minimal invasiveness, yielding diagnostic accuracy rates exceeding 90%. This facilitates timely decision-making for management, reduces the need for exploratory laparotomy, and allows appropriate triaging of patients to surgery, chemotherapy, or conservative follow-up [6]. In low- and middle-income settings, image-guided biopsy assumes added importance by reducing the burden of unnecessary surgical interventions and optimizing healthcare resource utilization. Another key advantage of these procedures is their safety profile. Complications are rare and typically limited to mild discomfort, low-grade fever, or self-limiting bleeding [7]. With most patients being discharged within 24 to 48 hours, these techniques significantly contribute to faster turnover of hospital beds, improved patient satisfaction, and lower treatment costs. This is especially relevant in high-volume public hospitals in India, where reducing inpatient burden is an ongoing challenge [8].

Despite their demonstrated utility, ultrasound-guided aspiration and image-guided biopsy remain underutilized in routine gynecological practice, particularly outside tertiary care centers. Limited awareness, lack of trained interventional radiologists, and unequal distribution of imaging resources restrict their wider adoption. Addressing these gaps through training, resource allocation, and integration into standardized gynecological care pathways is critical for maximizing patient benefit [9].

Therefore, it is of interest to evaluate the clinical efficacy, safety, and procedural outcomes of ultrasound-guided aspiration and image-guided biopsies in women presenting with gynecological disorders at a tertiary care center, to establish their role as frontline minimally invasive interventions in everyday practice.

Materials and Methods

Study Design and Setting: This prospective observational study was conducted at the Department of Radiology, Indira Gandhi Institute of Medical Sciences (IGIMS), Patna, Bihar, in collaboration with the Department of Obstetrics and Gynecology. The study was carried out over a six-month period from July 2021 to December 2021.

Study Population and Sample Size: A total of 132 women with clinically and radiologically diagnosed gynecological disorders were enrolled. All patients were referred for radiology-guided minimally invasive interventions, specifically ultrasound-guided aspiration or image-guided biopsy.

Inclusion Criteria

- Women aged 18 to 60 years
- Diagnosed with gynecological conditions requiring aspiration (e.g., tubo-ovarian abscesses, pelvic collections) or biopsy (e.g., adnexal masses, uterine lesions, endometrial thickening, indeterminate pelvic lesions)
- Clinically stable and suitable for minimally invasive intervention
- Provided written informed consent

Exclusion Criteria

- Patients with uncorrected coagulopathy or bleeding diathesis
- Hemodynamically unstable patients
- Pregnancy (unless aspiration was specifically indicated for pelvic sepsis)
- Patients refusing consent or lost to follow-up

Procedures Performed

1. **Ultrasound-guided aspiration and drainage**
    - Performed for tubo-ovarian abscesses, pelvic collections, and complex cystic adnexal lesions.
    - Transabdominal or transvaginal approaches were selected depending on lesion accessibility.
    - Under aseptic precautions and local anesthesia, aspiration was performed using an 18–20 G needle or pigtail catheter under real-time ultrasound guidance.
    - Samples were sent for cytology, microbiology, and culture sensitivity testing when indicated.
2. **Image-guided biopsy / FNAC**
    - Performed for adnexal masses, uterine lesions, or endometrial abnormalities requiring histopathological confirmation.
    - Guidance modalities included ultrasound for accessible lesions and MRI-guided biopsy for deep-seated or indeterminate pelvic lesions.

- Core needle biopsy or FNAC was performed under strict aseptic technique.
- Samples were fixed and processed for cytopathological or histopathological analysis.

Outcome Measures

Each procedure was assessed on the basis of:

- Technical success (completion of the intended aspiration or biopsy)
- Diagnostic yield (percentage of samples providing conclusive cytology/histology)
- Symptom relief (resolution of pelvic pain, fever, or sepsis after aspiration)
- Complications (classified as minor or major, intra- or post-procedural)
- Hospital stay duration
- Impact on further management (e.g., avoidance of surgery, initiation of specific therapy based on biopsy results)

Data Collection: Demographic details, clinical presentation, imaging findings, type of intervention, outcomes, and complications were recorded in a structured proforma. Follow-up assessments were conducted at 1 week, 1 month, and 3 months post-procedure to evaluate resolution of symptoms, recurrence, and subsequent clinical management decisions.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 22.0.

- **Categorical variables** were expressed as frequency and percentage.
- **Continuous variables** were presented as mean ± standard deviation (SD).
- Associations between clinical variables and outcomes were assessed using Chi-square test or Fisher's exact test.
- A p-value <0.05 was considered statistically significant.

Results

A total of 132 patients underwent radiology-guided minimally invasive procedures for various gynaecological disorders during the study period. The mean age of the participants was 35.7 ± 8.4 years, with the majority falling in the 31–40 years age group. The most common presenting complaints were pelvic pain (46.2%), abnormal uterine bleeding (30.3%), and adnexal mass-related symptoms (18.9%).

Out of all procedures, ultrasound-guided aspirations and image-guided biopsies were the most frequently performed. The technical success rate across these interventions was 96.9%, and clinical symptom resolution was reported in 88.6% of cases during follow-up. Minor complications occurred in 5.3% of cases, primarily in the form of transient post-procedural pain or low-grade fever. None of the patients experienced major complications or required surgical conversion.

Radiology-guided interventions significantly reduced hospital stay duration, with most patients discharged within 24 to 48 hours. Image-guided biopsies yielded diagnostic tissue in 95.2% of cases, avoiding unnecessary exploratory surgeries and ensuring appropriate management decisions.

Table 1: Age-wise distribution of study participants

Age Group (Years)	Number of Patients	Percentage (%)
18–25	18	13.6%
26–30	22	16.7%
31–40	49	37.1%
41–50	31	23.5%
>50	12	9.1%
Total	**132**	**100%**

Table 2: Distribution of presenting symptoms

Presenting Symptom	Number of Patients	Percentage (%)
Pelvic Pain	61	46.2%
Abnormal Uterine Bleeding	40	30.3%
Adnexal Mass Symptoms	25	18.9%
Fever/Sepsis	6	4.6%
Total	**132**	**100%**

Table 3: Types of radiology-guided procedures performed

Procedure Type	Number of Cases	Percentage (%)
USG-guided aspiration of pelvic collection	49	37.1%
USG/MRI-guided biopsy	58	43.9%
Transvaginal FNAC	25	18.9%
Total	**132**	**100%**

Table 4: Indications for radiology-guided interventions

Diagnosis	Number of Patients	Percentage (%)
Tubo-ovarian abscess/collection	49	37.1%
Adnexal mass/uncertain lesion	43	32.6%
Endometrial thickening/uterine lesion	24	18.2%
Indeterminate pelvic lesion (FNAC)	16	12.1%
Total	**132**	**100%**

Table 5: Technical success rate by procedure type

Procedure	Success Rate (%)
USG-guided aspiration	100%
USG/MRI-guided biopsy	96.6%
Transvaginal FNAC	92.0%
Overall Mean	**96.9%**

Table 6: Post-procedural complications

Complication Type	Number of Cases	Percentage (%)
None	125	94.7%
Mild pain/discomfort	4	3.0%
Fever (<38.5°C)	3	2.3%
Major complications	0	0%

Table 7: Duration of hospital stay

Hospital Stay Duration	Number of Patients	Percentage (%)
<24 hours	59	44.7%
24–48 hours	52	39.4%
>48 hours	21	15.9%

Table 8: Diagnostic yield from image-guided biopsy

Biopsy Outcome	Number of Cases	Percentage (%)
Diagnostic yield	79	95.2%
Inconclusive specimen	4	4.8%

Table 1 presents the age distribution of patients undergoing radiology-guided aspiration and biopsy. A majority belonged to the 31–40 years age group, reflecting a peak in reproductive health concerns. Table 2 outlines the presenting symptoms of the patients. Pelvic pain and abnormal uterine bleeding were the most common complaints leading to referral. Table 3 categorizes the types of radiology-guided procedures performed. Image-guided biopsy was most frequently used, followed by ultrasound-guided aspiration. Table 4 highlights the underlying gynaecological diagnoses for which interventions were conducted. Tubo-ovarian abscesses and adnexal masses were the leading indications. Table 5 demonstrates the technical success rates for each intervention. All procedures had high success rates, particularly aspiration and biopsy. Table 6 summarizes post-procedural complications. The majority of patients experienced no adverse events, and minor complications were self-limiting. Table 7 shows the hospital stay duration for patients undergoing radiology-guided procedures. Most were discharged within 24 to 48 hours, highlighting the minimally invasive nature. Table 8 assesses the diagnostic yield of image-guided biopsies and FNAC. The vast majority provided conclusive tissue diagnoses, reducing the need for surgical exploration.

Discussion

This prospective study demonstrates that ultrasound-guided aspiration and image-guided biopsy function as complementary, frontline, minimally invasive tools for the evaluation and management of common gynaecological conditions in a tertiary-care setting [10]. Three findings stand out. First, technical performance was consistently high across procedures, with an overall success rate of 96.9% and 100% completion for aspirations. Second, safety was favorable, with only minor, self-limited adverse events (5.3%) and no major complications or surgical conversions. Third, the diagnostic utility of image-guided tissue sampling was excellent (95.2% conclusive yield), enabling confident downstream decision-making while reducing reliance on exploratory surgery. Together, these results support broader incorporation of these interventions into routine care pathways for women presenting with pelvic collections, adnexal masses, or uterine/endometrial abnormalities [11]. In therapeutic terms, ultrasound-guided aspiration offered rapid, targeted control of infection and sepsis in patients with tubo-ovarian abscesses and other pelvic collections. Real-time sonographic visualization allowed precise selection of transabdominal versus transvaginal routes,

minimization of adjacent organ injury, and optimal catheter positioning when drainage was indicated [12]. The practical benefits observed short post-procedure observation, early ambulation, and discharge predominantly within 24–48 hours are consistent with the physiological advantages of avoiding general anaesthesia and open or laparoscopic access. For patients desiring fertility preservation or those with medical comorbidities that heighten surgical risk, this modality provides a particularly attractive option [13]. From a systems perspective, rapid clinical defervescence, brief inpatient stays, and low complication rates translate into bed turnover advantages and likely cost savings, which are material in high-volume public hospitals. Diagnostic impact was driven by the performance of image-guided biopsy and FNAC for adnexal, uterine, and indeterminate pelvic lesions [14]. By securing high-quality, representative samples under imaging control, these methods reduced nondiagnostic explorations and allowed clinicians to stratify patients promptly to appropriate therapy ranging from conservative follow-up after benign diagnoses to oncologic referral and staging when malignancy was confirmed. The observed 95.2% conclusive yield is congruent with expectations when needle gauge, trajectory planning, and lesion viability (solid components, vascularity, necrosis avoidance) are optimized [15]. In practice, this yield enables: (i) earlier initiation of targeted medical or surgical treatment, (ii) reduction of diagnostic latency, and (iii) better counselling about prognosis and fertility implications. Importantly, this diagnostic performance was achieved with a favorable safety profile, again supporting routine use. Patient-centred outcomes in this cohort reinforce the clinical value of both procedures [16]. Presenting complaints were dominated by pelvic pain and abnormal uterine bleeding symptoms with substantial quality-of-life impact and, in some cases, urgent clinical implications (e.g., infection, anaemia). Aspiration addressed pain and sepsis drivers directly, while biopsy clarified the pathological basis of bleeding or mass effect, thereby guiding specific therapies rather than empiric management. The combination of rapid symptom relief, brief hospitalization, and minimally invasive diagnostic certainty is a compelling package for patients, clinicians, and administrators alike. Several pragmatic considerations emerge for implementation [17]. First, pre-procedure planning should integrate clinical status, laboratory parameters (including coagulation profile), and cross-sectional imaging to select the safest path and the most informative target. Second, strict asepsis, real-time imaging, and post-procedure monitoring protocols are central to sustaining low complication rates. Third, specimen handling—prompt fixation, appropriate media for microbiology when aspirating infected collections, and clear requisitions with clinical context enhances diagnostic yield and reduces repeat procedures. Fourth, establishing joint workflows with gynaecology, infectious diseases, and oncology services accelerates action on results and closes the loop on care [18]. The data also highlight where further optimization is feasible. Although overall performance was strong, FNAC success trailed core-needle biopsy, reflecting the inherent limitations of cytology in some gynaecologic lesions (e.g., architectural patterns needed for definitive classification). When feasible, prioritizing core sampling, or combining core with FNAC in complex lesions, may increase conclusive rates further [19]. Likewise, standardized criteria for catheter placement and dwell time in complex abscesses could reduce residual cavities and reinterventions. This real-world experience is particularly relevant to resource-constrained environments. Ultrasound systems are widely available, relatively inexpensive to operate, and suitable for bedside or day-care pathways [20]. Building capacity through targeted training of radiology and gynaecology teams, checklists for aspiration and biopsy, and audit of key performance indicators (technical success, conclusive yield, complications, and unplanned readmissions) can reliably embed these services beyond tertiary centres. Given the rapid recovery and high success rates observed, day-care models with structured follow-up calls at 24–72 hours may further reduce inpatient utilisation. The study has strengths that enhance its applicability [21]. It captures a consecutive, real-world cohort with common indications tubo-ovarian abscesses, adnexal masses, and endometrial/uterine abnormalities reflecting the clinical spectrum encountered in busy Indian centres [22]. Outcomes were tracked at defined intervals, and endpoints encompassed procedural metrics, safety, and patient-centred measures (symptom relief, length of stay). Nonetheless, limitations merit acknowledgment [23]. This was a single-centre experience over six months; as such, findings may reflect local referral patterns and operator expertise. Follow-up was relatively short, precluding robust assessment of long-term recurrence after drainage, need for re-aspiration, or durability of symptom control [24]. For biopsies, while conclusive yield was high, we did not capture downstream treatment response or long-term oncologic outcomes, which would strengthen the argument for impact on survival or recurrence. Finally, selection bias is possible: clinically unstable patients or those with unfavourable anatomy may have been triaged to surgery and thus are under-represented here [25].

Future work should focus on multicentre prospective registries with longer follow-up to quantify recurrence after aspiration, reintervention rates, and fertility outcomes; head-to-head evaluations of FNAC versus core biopsy in specific lesion subtypes; cost-effectiveness analyses

incorporating direct and indirect costs; and patient-reported outcome measures covering pain, return to activities, and satisfaction. Standardized operating procedures and competency benchmarks for operators would support reproducibility and scale-up across secondary-care hospitals.

This study confirms that ultrasound-guided aspiration and image-guided biopsy deliver high technical success, diagnostic certainty, and rapid recovery with minimal complications. For women presenting with pelvic collections, adnexal masses, or uterine/endometrial abnormalities, these minimally invasive interventions provide timely relief and definitive diagnosis, frequently obviating the need for surgical exploration. Embedding these pathways into routine gynaecologic care can improve patient outcomes and optimize utilisation of constrained inpatient resources.

Conclusion

Radiology-guided minimally invasive procedures, particularly ultrasound-guided aspiration and image-guided biopsy, have proven to be highly effective, safe, and well-tolerated in the management of a broad spectrum of gynaecological disorders. Ultrasound-guided aspiration provided rapid therapeutic relief in cases of tubo-ovarian abscesses and pelvic collections, while image-guided biopsies and FNAC yielded high diagnostic accuracy, thereby reducing unnecessary exploratory surgeries. Both interventions were associated with high technical success, minimal complications, and short hospital stays, underscoring their value in clinical practice. These findings highlight the importance of integrating ultrasound-guided aspiration and image-guided biopsy into standard gynaecologic care pathways, especially in resource-constrained settings, to improve patient outcomes and optimize healthcare delivery.

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