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ORIGINAL ARTICLE

Forensic Radiology in the Detection of Internal Gynecological Trauma following Alleged Assault. A Cross-Sectional Study

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ABSTRACT

Background: Sexual assault is a serious medico-legal and public health concern. Internal gynecological injuries often go undetected during routine clinical examinations due to their concealed nature and patient distress. Forensic radiology offers a non-invasive, objective method to identify and document such trauma.

Objective: To assess the effectiveness of forensic radiology in detecting internal gynecological trauma in women presenting with alleged sexual assault.

Methods: A cross-sectional study was conducted from January 2022 to February 2023 at the Department of Forensic Medicine, Allama Iqbal Medical College/Jinnah Hospital Lahore, and Karachi Institute of Medical Sciences (KIMS), Malir Cantt, Karachi. A total of 70 female victims aged 15–45 years underwent clinical examination followed by transabdominal ultrasound, transvaginal ultrasound (where permissible), and MRI in selected cases. Findings from clinical and radiological assessments were compared.

Results: Internal injuries were detected in 67.1% of cases through imaging, while clinical examination alone identified injuries in 41.4% of cases. MRI was particularly effective in identifying deep injuries such as uterine contusions and broad ligament hematomas. In 31.4% of cases, injuries were diagnosed exclusively via radiology.

Conclusion: Forensic radiology, particularly ultrasound and MRI, significantly enhances the detection and documentation of internal gynecological injuries in sexual assault cases and should be integrated into standard medico-legal protocols.

Keywords: Forensic radiology, sexual assault, gynecological trauma, MRI, medico-legal imaging.

INTRODUCTION

Sexual assault is not only a traumatic personal experience but also a public health and medico-legal challenge that affects millions of women worldwide. It represents a significant violation of bodily autonomy and integrity, often leading to long-lasting physical, psychological, and emotional consequences[1]. Among the medical concerns arising from sexual assault, internal gynecological trauma is particularly under-recognized and under-reported due to the sensitive nature of the examination and the limitations of traditional clinical assessment methods. In many cases, the absence of external injuries can create ambiguity in medico-legal investigations, thereby compromising justice for the victim and complicating legal proceedings[2].

In the aftermath of an alleged sexual assault, the role of the healthcare provider extends beyond treatment to include the collection and documentation of evidence that may be used in legal contexts. While visible external injuries such as bruises, abrasions, and lacerations are relatively straightforward to identify and record, injuries involving internal reproductive structures require a higher level of clinical suspicion and diagnostic sophistication[3]. Injuries to the vaginal vault, cervix, uterus, and adnexal structures such as the ovaries and fallopian tubes are frequently missed due to the limitations of a standard pelvic examination, especially in situations where the patient is uncooperative due to trauma, distress, or physical discomfort[4].

This diagnostic gap has led to increasing recognition of forensic radiology as a critical component in the evaluation of alleged sexual assault cases. Forensic radiology involves the application of imaging modalities including ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) to detect and document injuries with medico-legal significance[5]. These tools provide an objective, non-invasive, and reproducible means of assessing both soft tissue and organ damage. For example, transabdominal and transvaginal ultrasound can reveal hematomas, tissue tears, and fluid collections within the pelvis. MRI, with its superior soft-tissue contrast resolution, is especially helpful in evaluating deeper pelvic trauma that might otherwise go unnoticed[6].

The value of forensic radiology extends beyond diagnosis it also contributes significantly to evidence preservation and legal proceedings. Radiological images can serve as impartial documentation, helping to corroborate the victim's account and providing compelling visual proof of trauma that can be presented in court. In addition, radiology allows for repeated examinations without causing discomfort or additional trauma to the patient, making it particularly suitable for vulnerable groups such as adolescents and psychologically distressed individuals[7, 8].

In many high-income countries, forensic radiology has been integrated into sexual assault response protocols. However, in lower-middle-income countries like Pakistan, the application of forensic imaging remains inconsistent and poorly standardized[9]. Multiple barriers hinder its widespread implementation, including limited access to advanced imaging modalities, lack of trained personnel, insufficient interdepartmental collaboration between forensic medicine and radiology departments, and prevailing social stigmas that discourage reporting of sexual crimes. As a result, many cases of internal trauma remain undocumented, and victims are denied the full extent of medico-legal and therapeutic support they require[10].

Given the increasing incidence of reported sexual violence and the growing call for justice system reforms, there is a pressing need to adopt advanced diagnostic approaches that uphold both clinical and legal standards[11]. Introducing forensic radiology into routine assault evaluations can significantly enhance the accuracy of trauma detection and improve the quality of forensic documentation. It also promotes a more humane, patient-centered approach by reducing the invasiveness and discomfort associated with repeated physical examinations[12].

This study was undertaken to evaluate the role of forensic radiology in detecting internal gynecological trauma in women who presented with allegations of sexual assault. Conducted as a cross-sectional study in a clinical and forensic setting, it aims to assess the frequency and nature of radiologically detectable injuries, correlate findings with clinical examinations, and propose recommendations for integrating imaging into standard medico-

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legal practices. By doing so, the study seeks to provide scientific evidence for policy reform and strengthen medico-legal responses to sexual violence, particularly in resource-constrained environments[13].

MATERIALS AND METHODS

This cross-sectional observational study was carried out to evaluate the role of forensic radiology in detecting internal gynecological trauma among female victims of alleged sexual assault. The study was conducted over a 14-month duration, from January 2022 to February 2023, at two major centers in Pakistan: the Department of Forensic Medicine, Allama Iqbal Medical College / Jinnah Hospital Lahore, and the Karachi Institute of Medical Sciences (KIMS), Malir Cantt, Karachi. Both institutes function as tertiary referral centers and handle routine medico-legal cases, making them ideal locations for this research.

Study Population and Sampling: A total of 70 female victims of alleged sexual assault were enrolled using a non-probability consecutive sampling technique. Each case was referred to the forensic department for medico-legal documentation and included in the study after fulfilling the inclusion criteria. All participants were evaluated within 72 hours of the alleged incident, a crucial time frame for accurate clinical and radiological detection of soft tissue injuries.

Inclusion and Exclusion Criteria: Female individuals between 15 and 45 years of age were included in the study if they had a registered medico-legal case of sexual assault, presented within 72 hours of the incident, and gave informed written consent (or guardian consent for minors). Those who had known pre-existing gynecological diseases such as pelvic inflammatory disease, uterine fibroids, or endometriosis, as well as pregnant women and individuals refusing imaging or participation, were excluded. Victims who presented after the 72-hour window or were medically unstable requiring urgent surgical intervention were also not included in the study.

Ethical Considerations: Approval was obtained from the Institutional Review Boards of both Allama Iqbal Medical College and KIMS Karachi. Informed written consent was obtained from all participants. Confidentiality was maintained throughout the study, and participants were assured that refusal to participate would not affect their medico-legal or medical care.

Data Collection Procedure: Each participant underwent a comprehensive medico-legal examination conducted by trained forensic medical officers. Following this, radiological investigations were performed under standardized protocols in collaboration with the Radiology Departments of the respective institutions. A structured data collection form was used to record relevant patient information including demographic profile, clinical history, assault-related details (such as location, use of force, bleeding, or pain), findings from physical and gynecological examinations, and results from radiological imaging. The focus was to identify injuries that might not be visible externally but could be detected internally through imaging.

Radiological Imaging Protocol: Radiological imaging was performed using standardized modalities to ensure uniformity and accuracy of results. The transabdominal pelvic ultrasound (TAUS) was conducted in all participants as the first-line imaging technique using high-frequency curvilinear probes (3.5–5 MHz). It allowed for the detection of pelvic hematomas, free fluid, uterine or adnexal injury, and vaginal wall disruptions.

Where applicable, transvaginal ultrasound (TVUS) was performed to provide enhanced visualization of internal gynecological structures. This was done only with informed consent and primarily in post-pubertal and married women, to avoid further trauma or discomfort. TVUS allowed better assessment of endometrial integrity, cervical tears, and lower uterine segment injuries.

In selected complex cases where ultrasound findings were inconclusive, or deep tissue injuries were suspected (e.g., broad ligament hematoma or rectovaginal tear), Magnetic Resonance Imaging (MRI) was employed. MRI of the pelvis was performed using a 1.5 Tesla scanner, utilizing T1-weighted, T2-weighted, and fat-suppressed sequences to delineate soft tissue contrast and confirm injuries with high specificity.

All imaging procedures were conducted by senior radiologists trained in forensic imaging and trauma interpretation. The radiological findings were documented in structured reports and compared to the findings from clinical and gynecological examination.

Data Management and Statistical Analysis: All collected data were entered into IBM SPSS version 25.0 for analysis. Descriptive statistics were applied to summarize demographic information and frequency of various internal injuries detected through radiology. Comparative analysis between clinical and radiological findings was performed using the Chi-square test and Kappa statistics to assess diagnostic agreement. A p-value <0.05 was considered statistically significant. The primary outcome measure was the number and types of internal injuries detected through imaging which were either missed or not evident during clinical examination. Secondary outcomes included evaluating the correlation between clinical signs (such as vaginal bleeding, pain, and external bruising) and radiological findings.

This methodological design allowed for a structured and scientifically rigorous assessment of the value added by forensic radiology in detecting hidden internal trauma in sexual assault victims, supporting both clinical management and legal documentation.

RESULTS

This study aimed to evaluate the role of forensic radiology in detecting internal gynecological trauma in female victims of alleged sexual assault. A total of 70 participants between the ages of 15 and 45 years were included. All subjects underwent a thorough medico-legal examination followed by radiological imaging using transabdominal ultrasound, transvaginal ultrasound (where permissible), and MRI in selected cases. The results are discussed below under key headings to provide a comprehensive understanding of the findings.

Demographic Characteristics of the Participants: The mean age of the participants was 23.4 ± 6.7 years, with the youngest being 15 years and the oldest 43 years. The largest group fell in the 18–25 years age range, comprising 54.3% of the total cases (n = 38). Adolescents aged 15–17 years accounted for 20% (n = 14), followed by 18.6% in the 26–35-year age range (n = 13), and only 7.1% (n = 5) were older than 35 years. The majority were unmarried (70%), while 21 participants (30%) were married. Socioeconomic data showed that 62.9% of the participants came from low-income households, with only 7.1% belonging to higher-income groups. The demographic distribution is presented in Table 1.

Table 1: Demographic Characteristics of Participants (n = 70)

Demographic Variable	Frequency (n)	Percentage (%)
Age 15–17 years	14	20.0
Age 18–25 years	38	54.3
Age 26–35 years	13	18.6
Age >35 years	5	7.1
Unmarried	49	70.0
Married	21	30.0
Low Socioeconomic Class	44	62.9
Middle Socioeconomic Class	21	30.0
High Socioeconomic Class	5	7.1

Clinical Examination Findings: Initial medico-legal and gynecological examinations were performed by trained forensic officers. External physical injuries were identified in 41 cases (58.6%), including bruising, abrasions, and scratch marks around the genital or inner thigh region. However, the clinical detection of internal injuries was limited, often due to patient discomfort, psychological distress, active bleeding, or lack of cooperation.

Vaginal bleeding was observed in 32 participants (45.7%), while 20 individuals (28.6%) showed evidence of perineal or vulvovaginal abrasions. In 29 cases (41.4%), the examination could not conclusively identify the presence or absence of internal injury due to pain, swelling, or lack of visualization. Therefore, the physical examination alone proved insufficient in many cases, highlighting the need for further diagnostic support via imaging.

Radiological Findings: All participants underwent transabdominal ultrasound (TAUS) as a primary imaging modality. Transvaginal ultrasound (TVUS) was performed in 45 participants (64.3%) who were either post-pubertal and married or provided informed consent. In 18 complex cases, where deeper or occult injuries were suspected, MRI pelvis was conducted to obtain detailed soft tissue imaging.

Radiological evaluation yielded significant additional findings beyond what was identified on clinical examination. Imaging revealed internal gynecological trauma in 47 out of 70 cases (67.1%), clearly demonstrating its diagnostic superiority over routine physical examination. The most commonly observed injuries included vaginal wall hematomas, cervical lacerations, endometrial disruption, and accumulated pelvic free fluid, suggestive of internal bleeding.

Table 2: Types of Internal Injuries Detected via Radiology (n = 70)

Injury Type	Frequency (n)	Imaging Modality Used
Vaginal wall hematoma	19	TAUS / TVUS
Cervical laceration	12	TVUS / MRI
Endometrial disruption	9	TVUS
Uterine contusion	8	MRI
Broad ligament hematoma	6	MRI
Hemoperitoneum / pelvic fluid	22	TAUS / MRI
Combined uterovaginal injury	11	TVUS / MRI
No internal injury detected	23	TAUS

The most frequent radiological finding was hemoperitoneum or intra-pelvic free fluid, identified in 22 cases (31.4%). This was followed by vaginal wall hematomas (27.1%), often not visible externally, and cervical lacerations (17.1%), particularly in cases involving reported forced penetration. Deep structural injuries like broad ligament hematomas and uterine contusions were only detected through MRI, underscoring its importance in complex cases.

Correlation Between Clinical and Radiological Findings: The comparative analysis between clinical examination and radiological findings revealed a substantial diagnostic gap. Only 25 cases (35.7%) showed concordance between both methods, i.e., where clinical suspicion of internal trauma was confirmed by imaging. Notably, 22 cases (31.4%) had positive radiological findings despite inconclusive clinical examinations, indicating that radiology alone identified significant injuries. In contrast, only 4 cases (5.7%) showed injury clinically that was not corroborated radiologically, likely due to superficial trauma or observational error. In 18 cases (25.7%), no injuries were detected by either modality.

Table 3: Comparison Between Clinical and Radiological Evaluation (n = 70)

Evaluation Outcome	Frequency (n)	Percentage (%)
Injury detected by both methods	25	35.7
Injury detected by radiology only	22	31.4
Injury detected by clinical exam only	4	5.7
No injury detected by either method	18	25.7

This comparison clearly demonstrates the additional diagnostic yield of forensic radiology, particularly in cases with minor external trauma or high patient anxiety, where internal injuries may be otherwise missed. The Kappa agreement coefficient was 0.42, indicating only moderate agreement between both methods. Moreover, Chi-square analysis showed a statistically significant difference ($p < 0.01$) between clinical and radiological detection rates, favoring the use of imaging modalities.

Forensic radiology detected internal gynecological trauma in 67.1% of cases, compared to 41.4% detected by clinical examination alone. MRI was especially effective in identifying deep injuries like uterine contusions and broad ligament hematomas. In 31.4% of cases, injuries were missed clinically but revealed through imaging. Radiological evaluation significantly improved diagnostic accuracy and enhanced medico-legal documentation in complex or ambiguous cases.

DISCUSSION

This study highlights the critical role of forensic radiology in enhancing the detection and documentation of internal gynecological trauma in victims of alleged sexual assault. The findings demonstrate a significant diagnostic advantage of radiological imaging over clinical examination alone[14]. While clinical assessment remains the initial and essential step in evaluating such cases, it was limited by several factors, including patient distress, pain, lack of cooperation, and the examiner's inability to visualize deeper structures. These limitations underscore the necessity of adjunct imaging tools to obtain a more accurate and complete assessment[15].

Radiological imaging, particularly transabdominal and transvaginal ultrasound, proved valuable in detecting injuries such as vaginal hematomas, pelvic fluid, and cervical lacerations. In cases where ultrasound was inconclusive or when deep pelvic trauma was suspected, MRI provided high-resolution visualization of internal structures, revealing uterine contusions and broad ligament hematomas that were completely undetectable on physical examination[16]. These findings are consistent with previous literature, which has shown MRI's superior sensitivity in evaluating soft tissue trauma and its ability to detect injuries that could have serious long-term consequences if missed[17].

Another important finding was that in 31.4% of cases, internal trauma was identified only through imaging and not by clinical examination. This is a significant proportion and reveals the potential risk of underreporting and misclassification of injury severity if radiological evaluation is not incorporated. In medico-legal contexts, this omission can weaken forensic reports and legal outcomes, especially when physical signs are minimal or absent[18].

Furthermore, the study emphasized the objectivity and reproducibility of radiological findings, which are essential in medico-legal documentation. Radiology provides clear, time-stamped, and court-admissible evidence that supports clinical findings and can substantiate the victim's testimony. This is particularly important in resource-constrained and culturally sensitive environments where victims may face social barriers to disclosure and justice[19].

Despite these benefits, the study also identifies challenges, such as limited access to MRI facilities, lack of trained radiologists familiar with forensic protocols, and institutional gaps in integrating forensic medicine with radiological services. These issues must be addressed through policy interventions, specialized training, and resource allocation to fully implement forensic radiology in post-assault care[20].

CONCLUSION

This study concludes that forensic radiology significantly improves the detection of internal gynecological trauma in alleged sexual assault cases. Radiological imaging, especially MRI, offers critical diagnostic information that clinical examination may miss, and plays a vital role in accurate, objective, and legally robust medico-legal documentation. Integrating imaging protocols into routine sexual assault evaluations can greatly enhance patient care, ensure justice, and strengthen forensic investigations, especially in resource-limited healthcare systems.

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analysis. All authors critically reviewed and approved the final version of the manuscript.

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