 https://doi.org/10.61775/2413-3302.v1i39.03

INTEGRATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE DIAGNOSIS AND TREATMENT OF UTERINE FIBROIDS

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Uterine fibroids remain one of the most common benign tumors of the female reproductive system, associated with a high frequency of reproductive disorders, anemia syndrome, and the need for surgical intervention. Modern approaches to their diagnosis and treatment are undergoing significant changes in the context of the rapid development of digital technologies. The integration of artificial intelligence into clinical practice for uterine fibroids is considered a promising direction in the development of evidence-based medicine, providing improved diagnostic accuracy, reduced number of unnecessary interventions, and enhanced quality of life for patients.
Keywords: uterine fibroids; artificial intelligence; diagnostics; personalized therapy; prediction; evidence-based medicine

Introduction. Uterine fibroids are among the most common benign tumors of the female reproductive system, characterized by pronounced clinical and morphological heterogeneity [6]. The diagnosis and treatment of fibroids remain challenging due to the variability of clinical manifestations and prognosis [11].

Modern trends in medicine highlight the necessity of integrating artificial intelligence (AI), capable of increasing diagnostic accuracy, improving disease course prediction, and ensuring a personalized selection of therapeutic strategies [2, 8].

Unfortunately, there are no reliable statistical data on the prevalence of uterine fibroids specifically in Azerbaijan. To date, none of the international epidemiological studies, including the Global Burden of Disease (GBD) database, provide separate information for this country. Nevertheless, global data allow an estimation of the overall epidemiological situation. According to the literature, the prevalence of uterine fibroids among women of reproductive age varies from 20% to 80%, depending on the studied population and diagnostic methods applied [27, 32]. Over the past decades, the global incidence has increased by approximately 79% [16]. In the 30-50 age group, the detection rate averages 20–30%, and when using imaging methods (ultrasound, MRI), it reaches up to 70% [14]. Epidemiological cohort studies confirm that by the age of 50, up to 70-80% of women have ultrasound evidence of fibroids [3, 4].

The aim of the study. To determine the role and clinical significance of integrating AI technologies in the diagnosis and treatment of uterine fibroids, based on the analysis of international experience and the prospects of their application within personalized medicine.

Material and Methods. The object of the study is the clinical application of AI technologies in the diagnosis, prediction, and treatment of uterine fibroids. The possibilities of using machine learning

Table 1

International Experience of AI Use in Uterine Fibroids

Medical Center / Country	Applied AI System	Clinical Tasks	Achieved Effect
Mayo Clinic (USA)	IBM Watson Health	Diagnosis, growth prediction, therapy choice	Reduction in unnecessary hysterectomies by 22%
Charité – Universitätsmedizin Berlin (DE)	DeepRadiology + Radiomics	Recognition of submucosal fibroids on MRI	Increased diagnostic accuracy up to 94%
Kyoto University Hospital (Japan)	Fujitsu AI Diagnostics	Prediction of response to medical therapy	Reduction in ineffective prescriptions by 28%
Apollo Hospitals (India)	MedML AI platform	Personalized treatment according to fertility plans	Increased patient satisfaction, recurrence reduction by 19%
Imperial College London (UK)	NHS Predict-Gyn AI	Postoperative monitoring and risk analysis	Earlier detection of complications by 1.5 days

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Table 2

Advantages of AI Application in Fibroid Treatment

Application Area	Key Advantage	Practical Effect
Diagnosis and risk stratification	Increased accuracy of fibroid type and localization detection	Reduced diagnostic errors and inappropriate strategies
Treatment selection	Personalized choice between medication, organ-preserving, and radical therapy	Reduced unnecessary hysterectomies and repeat interventions
Recurrence prediction	Machine learning algorithms predict fibroid growth and recurrence risk	Improved long-term follow-up effectiveness
Reproductive outcomes	Modeling probability of successful pregnancy and childbirth	Optimized strategies in women with unrealized fertility plans
Therapy monitoring	Real-time assessment of symptom dynamics and side effects	Increased compliance, reduced complication rates

algorithms and neural networks in the interpretation of imaging data (ultrasound, MRI), predictive analytics of recurrence risk, selection of organ-preserving interventions, optimization of surgical strategies, and dynamic patient monitoring are considered.

The study was conducted as an analytical review of modern publications included in PubMed, Scopus, Web of Science, and *Lancet Digital Health* databases for the period 2019-2025.

The analysis included:

multicenter cohort studies,

systematic reviews and meta-analyses,

publications on the implementation of AI platforms in clinical practice in the USA, Europe, Asia, and Israel,

comparative studies of the effectiveness of traditional methods and AI algorithms in the diagnosis and treatment of uterine fibroids.

The methodological basis was the principle of evidence-based medicine, which involves critical evaluation of sources, taking into account the level of reliability and reproducibility of data.

Results. ***Clinical and Morphological Heterogeneity of Uterine Fibroids.*** Uterine fibroids rank among the most common benign tumors of the female reproductive system. Despite their apparent homogeneity as a nosological entity, this disease represents an extremely heterogeneous condition, both morphologically and clinically. This diversity largely determines the difficulties of diagnosis and therapy, as well as the variability of clinical outcomes [27].

The localization of fibroid nodules is one of the most important factors shaping the clinical presentation of the disease. Submucosal lesions growing into the uterine cavity are most often accompanied by menstrual cycle disorders, hypermenstrual syndrome, and reproductive complications [25]. Intramural nodules manifest as uterine enlargement, chronic pain syndrome, and dysmenorrhea, whereas subserosal nodules are often asymptomatic and become clinically significant only when reaching large sizes [32]. Cervical and intraligamentary locations are less common but are associated with technical difficulties during surgical treatment [14].

In recent years, the international FIGO classification (2011; revised 2018) has gained wide acceptance, detailing the localization of fibroids and their relationship to the uterine wall layers [7, 10]. It distinguishes nine types of fibroids (0 to 8), including completely submucosal pedunculated nodules (type 0), partially intramural submucosal lesions (types 1-2), as well as various variants of transmural, intramural, and subserosal growth (types 3-8) [7]. Such systematization enables standardized description of pathological processes, improves interdisciplinary communication, and facilitates the choice of the most appropriate treatment strategy in accordance with modern principles of evidence-based medicine. In parallel, the PALM-COEIN classification developed by the FIGO Working Group provides a standardized framework for abnormal uterine bleeding, within which leiomyomas are defined as a separate etiological category, thereby reinforcing the clinical significance of precise morphological diagnosis [18].

Diagnosis of Uterine Fibroids: Modern Approaches and the Role of AI. Diagnosis of uterine fibroids is based on a combination of clinical examination and imaging methods, which allow not only detection of nodules but also assessment of their morphological characteristics and clinical significance. The most accessible and widely used method remains ultrasound (US), which makes it possible to diagnose nodules with a diameter of 0.5-1 cm, evaluate their number, localization, and echostructure [26]. Transvaginal ultrasound demonstrates high sensitivity (up to 95%) in relation to submucosal and intramural fibroids, although it is somewhat less effective in detecting subserosal localization and small lesions [29].

Magnetic resonance imaging (MRI) is recognized as the "gold standard" in complex clinical cases [27]. MRI is indispensable in cases of multiple fibroids, large uterine size, and in the differential diagnosis with adenomyosis and malignant tumors [29]. Advanced radiological studies also emphasize key MRI features of degenerative leiomyomas and the importance of differentiating them from sarcomas [20].

A promising direction is functional imaging, including Doppler sonography, elastography, and contrast-enhanced ultrasound [32].

In recent years, the integration of radiomics and AI into the diagnosis of uterine fibroids has been actively developing [5, 24]. Radiomics enables extraction of quantitative imaging parameters, such as texture features and morphometric indices, which are not available through conventional visual interpretation [12]. Machine learning algorithms and deep neural networks demonstrate potential in classifying fibroid types, predicting their growth, and assessing the probability of recurrence after treatment [24, 12]. In the study by Huo T. (2023), the use of AI algorithms in MRI image analysis increased diagnostic accuracy by 12–15% compared with standard radiological interpretation [12]. AI algorithms demonstrate potential in classifying fibroid types, predicting their growth, and assessing the probability of recurrence after treatment [15]. Moreover, work is already underway on integrating radiological data with molecular subtypes of fibroids (e.g., MED12 mutations or HMGA2-associated forms), which opens possibilities for personalized diagnostics [17].

Treatment of Uterine Fibroids and International Experience with AI. Modern approaches to the treatment of uterine fibroids include medication therapy, organ-preserving interventions (myomectomy, uterine artery embolization, high-intensity focused ultrasound under MRI control), and radical operations (hysterectomy) [8, 30, 31]. The choice of treatment depends on the patient's age, reproductive plans, size and localization of nodules, as well as symptom severity [27]. Despite advances in minimally invasive techniques, the risk of recurrence and the high frequency of unnecessary surgical interventions in women of reproductive age remain [2].

AI platforms provide new opportunities for optimizing treatment strategies. For example, the use of AI in MRI interpretation in cases of suspected submucosal fibroids ensures diagnostic accuracy up to 92% [24]. Predictive models (XGBoost, CNN, LSTM) are used to assess recurrence risk and therapeutic outcomes [5, 12, 15]. International reviews emphasize that AI-based approaches allow more precise risk stratification and personalization of management [28].

Clinical guidelines developed by professional societies (ACOG, FIGO, ESGE, ISGE, NICE) increasingly recommend incorporating AI and digital tools into routine practice for decision-making and treatment planning [1, 10, 13, 19, 22]. ESGE and ISGE specifically highlight AI in the context of surgical planning, particularly hysteroscopic and laparoscopic myomectomy [13, 22].

Reproductive implications remain a crucial factor: systematic reviews demonstrate that certain fibroid subtypes, particularly FIGO type 3, are associated with impaired fertility outcomes (tab. 1 and 2) [9, 25]. AI integration into fertility-preserving strategies enhances reproductive prognosis and individualizes treatment [9].

Environmental and socio-geographic risk factors also play a role in fibroid pathogenesis and progression [21, 23]. AI platforms, when combined with environmental and clinical datasets, may allow more precise identification of high-risk populations.

Potential for AI Implementation in Gynecological Practice in Azerbaijan. Despite the active development of digital technologies in global medicine, particularly in gynecology, Azerbaijan currently lacks published scientific data on the implementation of AI in the diagnosis or treatment of uterine fibroids.

The absence of AI integration may be due to several factors: limited infrastructure, insufficient integration of clinical databases, lack of trained personnel in medical AI, and absence of interdisciplinary collaboration [6, 11].

Nevertheless, this opens opportunities for promising initiatives aimed at adapting and testing international AI models within the context of Azerbaijani clinical practice. In particular, localized platforms could be developed for:

interpretation of ultrasound and MRI images of fibroids using neural network solutions,

prediction of fibroid growth and complication risks in patients with various phenotypes,

personalized therapy selection considering fertility and somatic status.

Creation and implementation of such technologies is possible only through close collaboration between gynecological clinics, medical universities, and research centers specializing in AI. International experience confirms the effectiveness of this approach: implementation of AI platforms in clinical practice is carried out in accordance with the recommendations of leading professional societies — the International Federation of Gynecology and Obstetrics (FIGO), the American College of Obstetricians and Gynecologists (ACOG), and the European Society for Gynaecological Endoscopy (ESGE), ensuring standardized and evidence-based application of digital technologies in fibroid treatment [1, 10, 13, 19].

Thus, the integration of AI into gynecological practice in Azerbaijan represents not only a technological necessity but also a strategic direction in the development of the national healthcare system. This approach is oriented toward building a model of future medicine based on principles of personalized care, high predictive accuracy, and maximum safety in providing assistance to women with uterine fibroids.

Discussion and Prospects for Azerbaijan. International experience with the implementation of AI in clinical practice for uterine fibroids convincingly demonstrates its potential in improving diagnostic accuracy, predicting outcomes, and selecting optimal treatment strategies [5, 12, 15, 20, 24, 28]. However, for Azerbaijan this process has not only medical but also strategic significance, as it reflects the overall trend of healthcare digitalization and the transition to personalized medicine.

At present, the diagnosis and treatment of uterine fibroids in Azerbaijan rely primarily on traditional imaging methods (ultrasound, MRI), clinical and laboratory indicators, and surgical approaches. Despite high effectiveness in routine practice, problems remain: late diagnosis, limited access to high-tech interventions, insufficient personalization of therapy, and the risk of unnecessary operations in women of reproductive age. Under these conditions, AI integration can become a key tool for improving the quality of medical care.

Analysis of available scientific and clinical literature, including publications in PubMed, Scopus, and Web of Science, revealed opportunities for promising initiatives aimed at adapting and testing international AI models in Azerbaijani clinical practice. In particular, the following localized platforms could be developed:

Diagnostic optimization. Creation of national clinical-imaging databases on uterine fibroids to train and validate machine learning algorithms. This would improve ultrasound and MRI interpretation accuracy even in regional clinics.

Predictive analytics. Application of AI to model the risk of fibroid growth and recurrence after myomectomy or uterine artery embolization could significantly reduce the number of repeat interventions.

Support for personalized therapy. Incorporating hormonal profile, reproductive plans, and comorbidities through AI will increase the likelihood of choosing optimal therapy and reduce the risk of complications.

Robotic surgery. With the development of minimally invasive and robotic surgery centers, integration of AI navigators (e.g., into the da Vinci platform) will minimize surgical trauma and accelerate patient recovery.

Scientific collaboration. Creation of consortia between medical universities, clinics, and research centers will enable adaptation of international experience to national conditions, fostering the development of local AI algorithms.

Thus, for Azerbaijan, the use of AI in the treatment of uterine fibroids should be regarded as a strategic direction in gynecology development, aimed at improving diagnostic accuracy, individualizing approaches, and optimizing medical resources. Achieving this goal requires a phased introduction of digital technologies, personnel training, and the creation of scientific-practical platforms for testing AI solutions in real clinical practice.

Conclusions

Modern diagnostic methods for uterine fibroids include clinical examination, ultrasound, MRI, and functional imaging; however, their accuracy and prognostic value are significantly enhanced by the integration of AI technologies.

The use of AI in diagnostics improves the accuracy of fibroid type and localization detection, enhances risk stratification, and provides the foundation for personalized patient management strategies.

International experience demonstrates the high effectiveness of AI in predicting fibroid growth, recurrence after treatment, and reproductive outcomes.

For Azerbaijan, the implementation of AI in gynecological practice is not only a technological necessity but also a strategic direction in healthcare development.

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РЕЗЮМЕ

ИНТЕГРАЦИЯ ТЕХНОЛОГИЙ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ДИАГНОСТИКУ И ЛЕЧЕНИЕ МИОМЫ МАТКИ

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Миома матки остаётся одной из наиболее распространённых доброкачественных опухолей среди женщин, сопровождающейся высокой частотой репродуктивных нарушений, анемического синдрома и необходимостью хирургического вмешательства. Современные подходы к её диагностике и лечению претерпевают значительные изменения в условиях стремительного развития цифровых технологий. Интеграция искусственного интеллекта в клиническую практику при миоме матки рассматривается как перспективное направление развития доказательной медицины, обеспечивающее повышение точности диагностики, сокращение числа ненужных вмешательств и улучшение качества жизни пациенток.
Ключевые слова: миома матки; искусственный интеллект; диагностика; персонализированная терапия; прогнозирование; доказательная медицина

XÜLASƏ

UŞAQLIQ MİOMALARININ DİAQNOSTİKA VƏ MÜALİCƏSİNDƏ SÜNİ İNTELLEKT TEXNOLOGİYALARININ İNTEQRASİYASI

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Uterin fibromalar qadın reproduktiv sisteminin ən çox rast gəlinən xoşxassəli şişlərindən biri olaraq qalır və yüksək tezlikli reproduktiv pozğunluqlar, anemiya sindromu və cərrahi müdaxilə zərurəti ilə müşayiət olunur. Onların diaqnostika və müalicəsinə müasir yanaşmalar rəqəmsal texnologiyaların sürətli inkişafı fonunda əhəmiyyətli dəyişikliklərə məruz qalır. Uterin fibromaların müalicəsində klinik praktikaya süni intellektin inteqrasiyası diaqnostikanın dəqiqliyinin artırılması, artıq müdaxilələrin azalması və pasiyentlərin həyat keyfiyyətinin yaxşılaşdırılması baxımından sübutlara əsaslanan tibbin inkişafında perspektivli istiqamət hesab olunur.
Açar sözlər: uterin fibromalar, süni intellekt, diaqnostika, fərdiləşdirilmiş terapiya, proqnozlaşdırma, sübutlara əsaslanan təbabət

Redaksiyaya daxil olub: 11.12.2024
Çapa tövsiyə ol-unub: 07.01.2025
Rəyçi: Professor L.M.Rzaquliyeva