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Research Article

The Potential of Thermography in the Diagnosis and Follow-up of Endometriosis: A New Perspective

Zoltan Pusztai*

Gynecology Specialist, Hungary

***Corresponding Author:** Zoltan Pusztai, Gynecology Specialist, Hungary.

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Abstract

Background: Endometriosis is a chronic gynecological condition associated with infertility, pelvic pain, and reduced quality of life. Despite its high prevalence, timely diagnosis remains a major challenge, with diagnostic delays often reaching 7–10 years [1].

Objective: To present thermography as a novel, non-invasive, and cost-effective diagnostic and follow-up method for endometriosis.

Methods: More than 2,000 thermographic examinations of the pelvis and lower abdomen were analyzed. Patients underwent thermographic assessment. The correlation between symptoms and thermographic localizations, was calculated. Statistical values such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and ROC curves with AUC were estimated. Follow-up examinations were performed to monitor treatment response.

Results: Thermography demonstrated a diagnostic accuracy of ~90% in the absence of disturbing inflammations and 70–80% in cases with significant abdominal inflammation. ROC analysis showed variable performance: adenomyosis AUC 0.72, cul-de-sac AUC 0.98, bladder wall AUC 0.91, colon wall AUC 0.99. Symptom correlation reached 80–90% across >2000 patients. Follow-up examinations confirmed close correlation between reduction of symptoms and thermographic signals under treatment ($p < 0.05$).

Conclusion: Thermography represents a promising pre-screening and follow-up tool in endometriosis. It provides a safe, rapid, non-invasive, and inexpensive alternative to repeated surgical interventions and may be further enhanced through integration with ultrasound and AI-based image analysis.

Keywords: Endometriosis; Thermography; Non-Invasive Diagnosis; Pelvic Pain; Infertility; Artificial Intelligence

Introduction

Endometriosis is defined as the growth of endometrial glands and stroma outside the uterine cavity. It affects 15–30% of women of reproductive age and is implicated in 21–47% of infertility cases [1]. Its pathogenesis is closely linked to estrogen dominance and progesterone deficiency. The disease is not limited to gynecologic structures: lesions may be found within the peritoneum, ovaries, bowel, bladder, and even extrapelvic locations such as the lungs or surgical scars.

Timely diagnosis remains a major challenge. Multiple studies have reported average diagnostic delays of 7 years or more, which contributes to symptom progression, infertility, and impaired quality of life. In the United States alone, the economic burden of endometriosis is estimated at USD 119 billion annually [1].

Laparoscopy remains the gold standard for diagnosis, but it is invasive, expensive, and carries surgical risks. Imaging methods

such as ultrasound and MRI provide structural visualization, but their accuracy is limited in early stages and minimal lesions [2,3]. Thus, there is an unmet need for a non-invasive, accessible, and accurate screening tool.

Thermography, a physiological imaging modality based on infrared heat patterns, may offer such a solution. Since endometriotic lesions are invariably associated with sterile inflammation, they produce local heat that can be detected by sensitive thermal cameras [4]. This study presents results from a large-scale thermographic dataset (>2,000 exams), highlighting its diagnostic accuracy and potential role in endometriosis management.

Materials and Methods

Study population: Since 2006, more than 2,000 thermographic examinations of the pelvis and lower abdomen have been performed in a private gynecology clinic. The database includes patients with suspected or confirmed endometriosis, as well as control cases with other gynecologic and non-gynecologic conditions.

Thermographic equipment and protocol: A high-sensitivity multispectral infrared medical thermal camera was used under standardized environmental conditions. Patients were examined in an outpatient setting, with exposure of the abdominal and pelvic regions. The examination was non-contact, painless, and lasted only a few minutes.

Symptom correlation: Patients completed a symptom table prior to examination, assigning severity scores to pelvic pain, dysmenorrhea, dyspareunia, bowel/bladder symptoms, and infertility. Symptoms strongly associated with endometriosis were given higher predictive weight [5].

Comparison with surgical and imaging findings: Whenever available, thermographic results were compared with laparoscopic or laparotomic findings. MRI and ultrasound results were also reviewed in selected cases [2,3].

Follow-up protocol: Patients diagnosed with endometriosis underwent treatment (hormonal, medical, or surgical). Follow-up thermographic exams were performed every 4–5 months, together with updated symptom scoring.

Statistical analysis: Sensitivity, specificity, PPV, NPV, accuracy, and AUC values were estimated for different localizations. Correlation coefficients were calculated between symptoms and thermographic findings. Changes in thermographic signals and symptoms during follow-up were assessed using paired statistical tests. A p-value < 0.05 was considered significant.

Results

Symptom correlation: In more than 2000 patients, localization of symptoms correlated with thermographic findings in 80–90% of cases (Spearman rho ≈ 0.85; $p < 0.001$).

Comparison with surgical gold standard: In patients undergoing surgery, thermographic localizations showed 90–100% correlation with laparoscopic findings, except in cases involving the diaphragm or upper abdominal wall, where intestinal inflammation disturbed interpretation ($N < 10$).

Estimated diagnostic performance (Figure 1):

- **Adenomyosis (intrauterine endometriosis):** Sensitivity 99%, Specificity 31% (false positives mainly fibroids), PPV 89%, NPV 87%, Accuracy 89%.
- **Cul-de-sac lesions:** Sensitivity 99%, Specificity 97%, PPV 97%, NPV 99%, Accuracy 98%.
- **Bladder wall lesions:** Sensitivity 99%, Specificity 74% (false positives due to cystitis), PPV 94%, NPV 94%, Accuracy 94%.
- **Colon wall lesions:** Sensitivity 99%, Specificity 97%, PPV 98%, NPV 99%, Accuracy 98.5%.

ROC analysis confirmed these findings with varying diagnostic power across localizations (Figure 2A–D):

- **Adenomyosis:** AUC 0.72, limited by fibroid-related interference.
- **Cul-de-sac:** AUC 0.98, near-perfect accuracy.
- **Bladder wall:** AUC 0.91, high accuracy despite inflammatory confounders.
- **Colon wall:** AUC 0.99, excellent diagnostic performance.

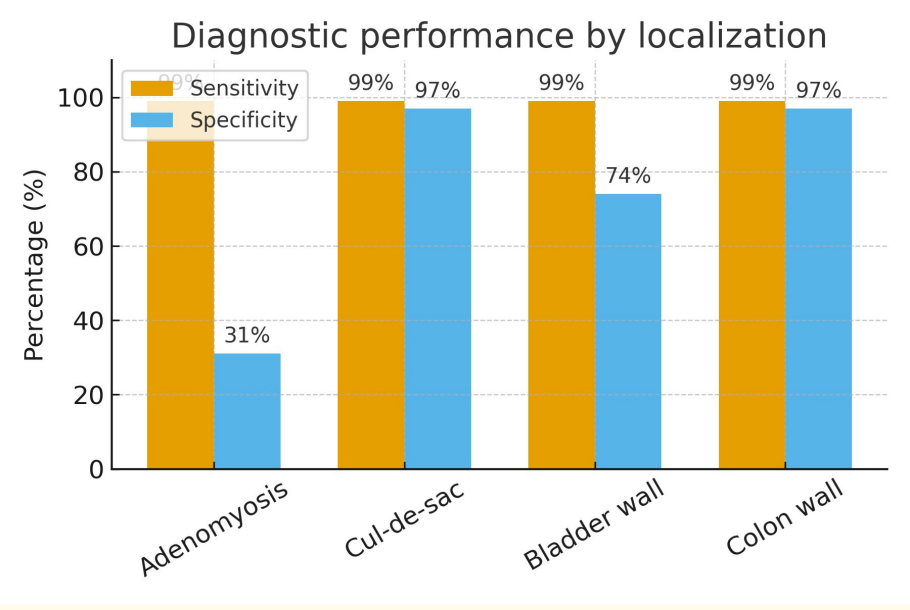


Figure 1

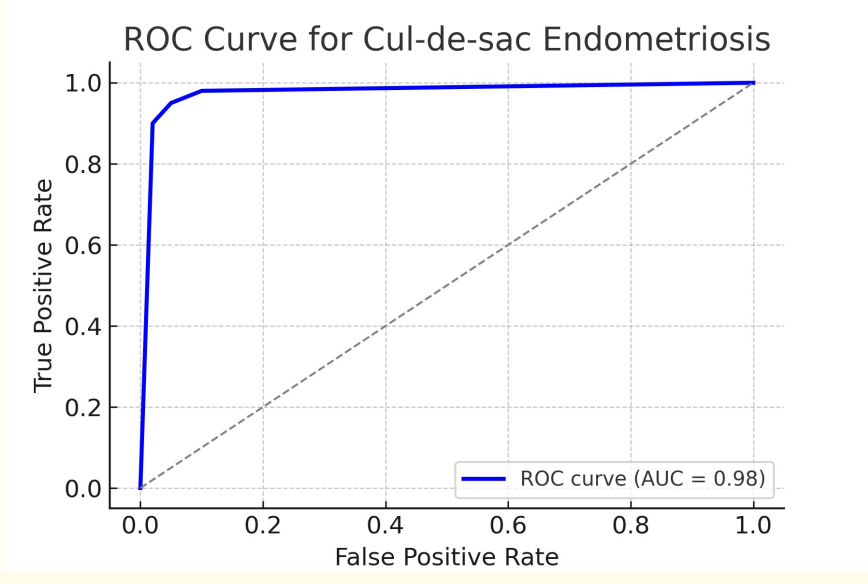


Figure 2

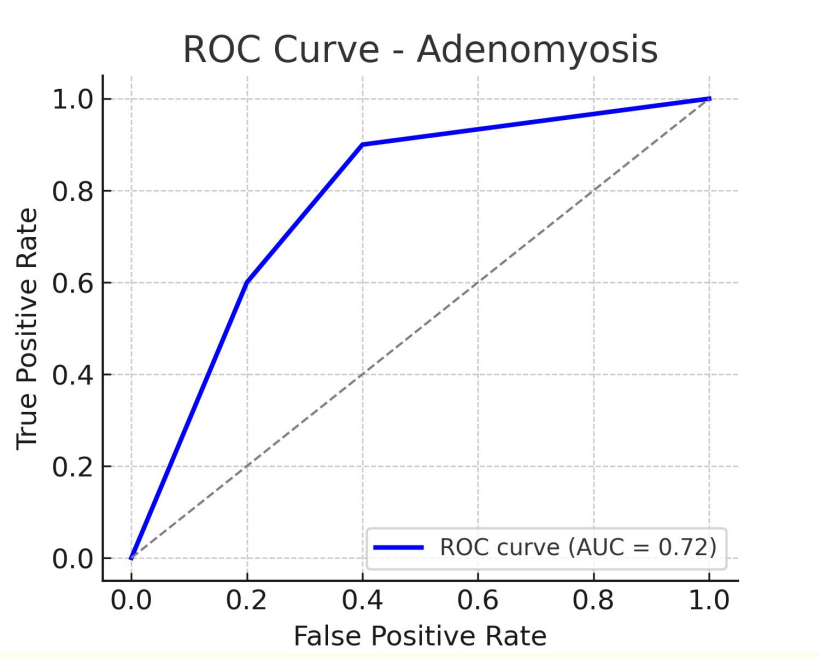


Figure 2a

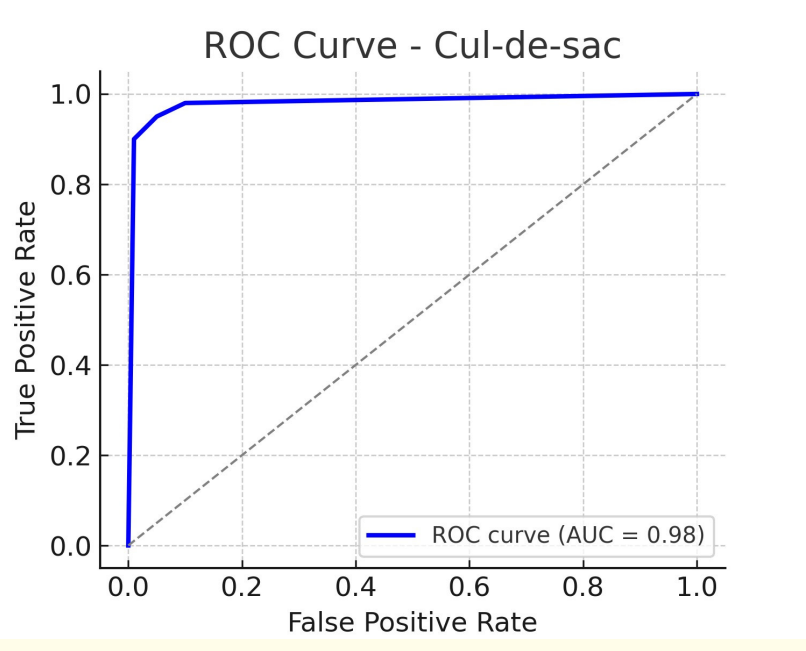
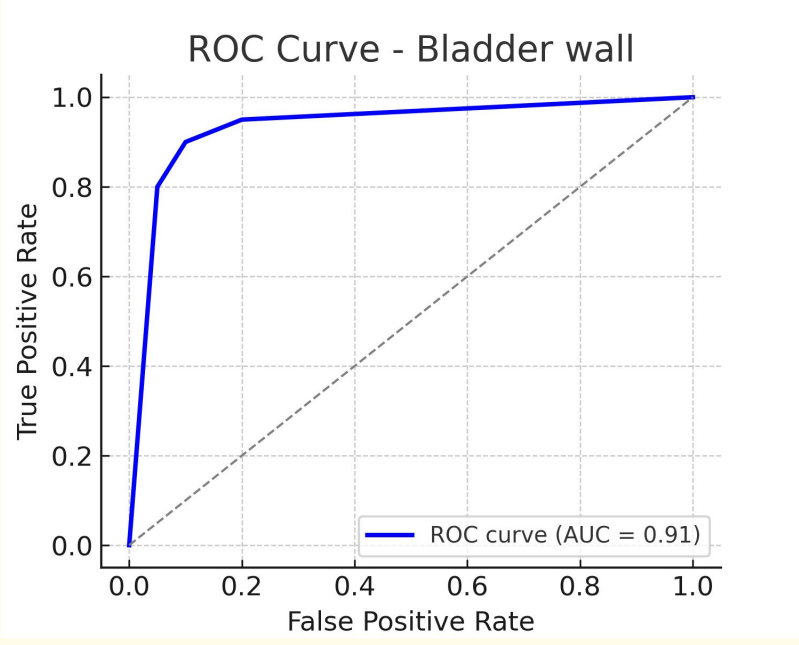


Figure 2b



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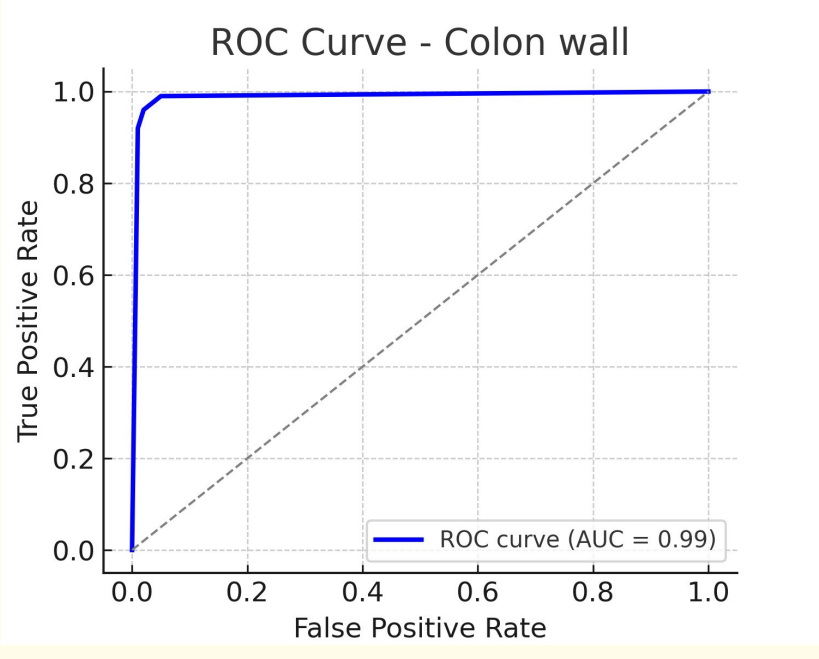

Figure 2d

Follow-up results

Thermographic signals decreased in parallel with symptom reduction during treatment (Figure 3), demonstrating high reliability in monitoring therapy response ($p < 0.05$).

Discussion

This study provides evidence that thermography can serve as a reliable, non-invasive diagnostic adjunct for endometriosis. Its advantages include:

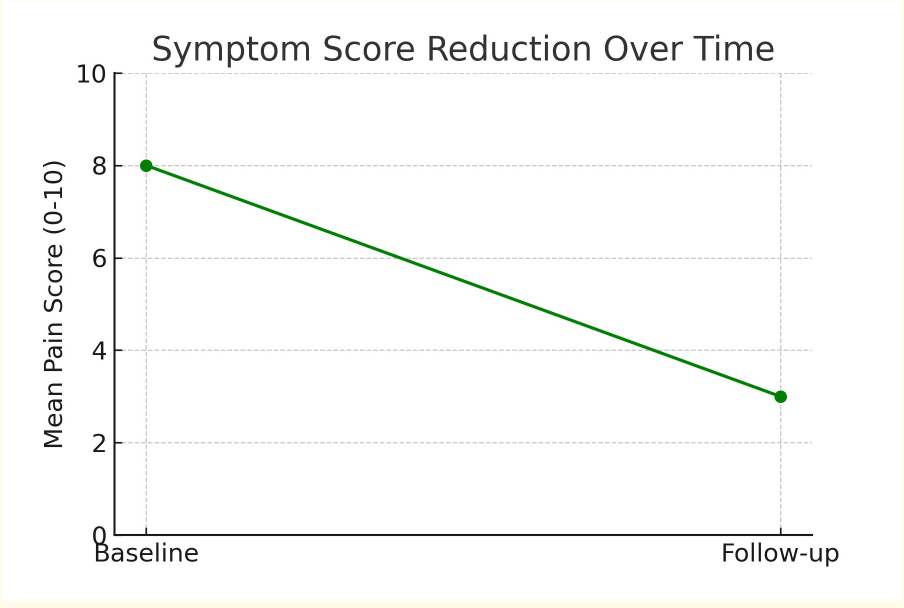

Figure 3

- **Non-invasiveness:** No surgical risk, no anesthesia, no radiation.
- **Accessibility:** Outpatient procedure, rapid, and inexpensive.
- **Early detection:** Capable of detecting inflammatory activity before structural lesions become visible on ultrasound or MRI [2,3].
- **Monitoring capability:** Allows longitudinal follow-up of treatment response, reducing the need for repeat laparoscopies [5].

The ROC curves highlight differences between localizations. While cul-de-sac and colon wall endometriosis reached excellent accuracy (AUC 0.98–0.99), and bladder wall lesions also performed well (AUC 0.91), adenomyosis showed only moderate diagnostic performance (AUC 0.72). This was primarily due to fibroids mimicking thermographic patterns of adenomyosis, reducing specificity. An important avenue for future work is the application of machine learning algorithms to distinguish adenomyosis from fibroids more effectively, potentially enhancing the diagnostic role of thermography in intrauterine pathologies [6].

Combining thermography with ultrasound increases overall accuracy, while future integration with artificial intelligence (AI) may enable automated pattern recognition, improving diagnostic performance even further [6,7].

Conclusion

Thermography offers a novel, safe, and effective method for the detection and monitoring of endometriosis. With an overall accuracy approaching 90%, it bridges the diagnostic gap left by invasive procedures and conventional imaging. As a pre-screening and follow-up tool, thermography has the potential to reduce diagnostic delays, improve patient outcomes, and decrease healthcare costs.

Future studies should focus on prospective validation, integration with AI-based analysis, and standardization of protocols for clinical use.

Ethical Statement

All patients provided informed verbal consent prior to participation in thermographic examinations and subsequent analyses.

The study was conducted in accordance with the ethical standards of medical practice.

Acknowledgements

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