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Deep Infiltrating Endometriosis Influence of Endometriosis and Progestin Therapy on the Course of COVID Infection: A Prospective Study at a University Endometriosis Center in Germany

Morva Tahmasbi Rad MD*, Lisa Marie Wilhelm MD, Denis Brachmann MD, Sven Becker MD, PhD, Sophie Simon MD¹

Department of Obstetrics and Gynecology, University of Frankfurt, Frankfurt am Main, Germany

*Correspondence to: Morva Tahmasbi Rad, Theodor-Stern-Kai 7, Haus 15, 60590 Frankfurt am Main, Department of obstetrics and gynecology, University of Frankfurt, Frankfurt, Germany, Tel: 0049-6301-5115, Fax:0049-6301-6317, Email: Morva.TahmasbiRad@unimedizin-ffm.de

Abstract: Objective: Endometriosis is a chronic immune-related inflammatory disease. As progestin therapy modulates estrogen and progesterone pathways it may also influence antiviral immune response. This study aimed to evaluate the impact of deep infiltrating endometriosis (DIE) and progestin therapy on the clinical course of SARS-CoV-2 infection. **Methods:** This prospective, single-center cohort study included 30 women with confirmed deep infiltrating endometriosis (DIE). Clinical data and standardized questionnaires were used to assess SARS-CoV-2 infection status, symptom severity, duration of PCR positivity, vaccination status, and endometriosis symptoms. Patients were stratified according to progestin therapy use versus no hormonal treatment. **Results:** Seventeen women (56.7%) were receiving progestin therapy, while 13 (43.3%) did not. The mean age was 34.0 ± 7.2 years, with no significant baseline differences between the groups. All patients contracted SARS-CoV-2. The mean time to PCR negativity was significantly longer in the progestin group (10.76 ± 4.1 vs. 8.00 ± 2.2 days; $p = 0.026$). Moderate COVID-19 symptoms were more frequent among progestin users (47.1% vs. 7.7%; $p = 0.042$), whereas mild disease predominated in non-users (92.3%). No hospitalizations or thromboembolic events were observed. Endometriosis-related symptoms remained stable following both SARS-CoV-2 infection and vaccination. **Conclusion:** In women with DIE, progestin therapy was associated with prolonged viral clearance and a higher frequency of moderate COVID-19 symptoms. Although causality cannot be established in this small cohort, the findings suggest a potential interaction between hormonal therapy and the immune response to SARS-CoV-2. As current evidence in this area remains scarce, these preliminary observations provide a basis for future larger, adequately powered prospective studies aimed at elucidating the immunological mechanisms underlying these associations and determining their clinical relevance.

Keywords: Deep Infiltrating Endometriosis (DIE); COVID; Progestin



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1. Introduction

Endometriosis is a common chronic inflammatory disease affecting 5–10% of women of reproductive age (1, 2). The most prevalent symptoms include dysmenorrhea, chronic pelvic pain and dyspareunia. Given its chronic nature, endometriosis requires a life-long management plan. Tailored treatment based on symptom burden and disease phenotype is essential, and long-term adherence to medical therapy plays a critical role in minimizing disease progression and avoiding unnecessary surgical interventions.

Endometriosis is associated with multiple immune system dysfunctions that contribute to the persistence and progression of ectopic endometrial tissue. Affected individuals demonstrate alterations in both innate and adaptive immune responses, including impaired macrophage-mediated clearance of ectopic cells, reduced natural killer (NK) cell cytotoxicity, and increased production of pro-inflammatory cytokines such as IL-6, TNF- α and IL-1 β (3, 4). These immune alterations promote a chronic inflammatory environment that supports angiogenesis, neurogenesis, and tissue remodeling. Furthermore, endometriosis is frequently characterized by a shift towards a Th2-dominant immune profile, which may facilitate immune tolerance of ectopic tissue and hinder effective immune surveillance (5). This immune imbalance contributed to lesion survival and may also underlie the increased prevalence of systemic immune activation and comorbid autoimmune disorders.

Estradiol plays a central role in the pathogenesis of endometriosis, promoting inflammation and cellular proliferation and lesion survival (6). Partial suppression of estradiol to a range of 30–60 pg/ml has been proposed as an optimal compromise between efficacy, tolerance and safety in this disease. Progestins are the most important medications used to achieve this hormonal modulation (7) and are effective in achieving pain control in two-thirds of women (8). Progestins exert their effects primarily through decidualization and subsequent atrophy of endometriotic lesions, inhibition of ovulation and reduction of estrogen levels locally and systemically. Commonly used progestins include dienogest, norethisterone acetate and medroxyprogesterone acetate, which vary in potency,

side-effect profiles and routes of administration. Dienogest, in particular, has been shown to be highly effective in reducing pelvic pain and lesion size, and has a favorable safety profile, making it a widely recommended first-line treatment (9).

COVID-19 is a viral infectious disease that was first described in 2019 and spread rapidly around the world. It presents with a wide spectrum of clinical severity, ranging from asymptomatic or mild respiratory symptoms to severe pneumonia, acute respiratory distress syndrome (ARDS), multi-organ failure, and death. Most individuals experience mild to moderate symptoms, including fever, cough, loss of taste and smell, gastrointestinal symptoms and fatigue. However, a subset of patients—particularly older adults and those with comorbidities such as cardiovascular disease, diabetes, or obesity—are at higher risk of developing severe or critical illness (10, 11). The progression to severe disease is often associated with a dysregulated immune response, characterized by excessive inflammation and a cytokine release syndrome leading to tissue damage and organ dysfunction. Elevated biomarker levels such as C-reactive protein, D-dimer, and interleukin-6 levels have been linked to worse outcomes and are used to help stratify disease severity in clinical practice (10, 11).

Regarding COVID-19, estrogen has been identified as a sex-based factor regarding differences in disease severity and outcomes between men and women. Epidemiological data consistently shows that females, particularly those of reproductive age, tend to experience less severe symptoms of COVID-19 and show lower mortality rates than males (12, 13). This disparity is thought to be partially driven by estrogen-mediated modulation of the immune response. Estrogen enhances antiviral defenses by promoting type I interferon production and reducing pro-inflammatory cytokine release (12, 14, 15). This may help to prevent dysregulated immune activation that is characteristic of severe cases of the disease.

This study aims to investigate the relationship between endometriosis and the clinical course of SARS-CoV-2 infection. Additionally, it explores the potential impact of estrogen suppression as a part of endometriosis therapy, on the immune response to SARS-CoV-2. This monocentric study focuses on a cohort of women with histologically and radiologically

confirmed deep infiltrating endometriosis (DIE) who had undergone at least one surgical intervention prior to 2024.

2. Material and Methods

2.1. Ethical approval and informed consent for study

This study was approved by the Ethics Committee of the University Hospital Frankfurt, Germany (approval Nr. 2023-1478). Written informed consent was obtained from all patients during follow-up interviews. This study was registered in the German Trials Register as a prospective clinical study (DRKS - Deutsches Register Klinischer Studien, 15.01.2024, DRKS-ID der Studie: DRKS00033366. prospective study. <https://drks.de/search/de/trial/DRKS00033366/details>).

2.2. Subject selection and variables

All patients referred to the Endometriosis Center at the University Hospital Frankfurt (Germany) since its first certification in 2018 have been enrolled in prospective follow-up program. For this present analysis, we evaluated women with confirmed complex deep infiltrating endometriosis (DIE) who had been referred to our center for a planned complex surgical

intervention prior to the first COVID-19 related lockdown at our institution (April 1, 2020). The diagnosis of DIE was established via MRI imaging or during endometriosis-related surgery performed before or after the onset of the COVID-19-pandemic.

Inclusion criteria comprised women aged ≥ 18 years in 2020 and < 50 years by the end of 2024, in accordance with the age range defined by the Stiftung Endometriose Forschung, Germany (www.endometriose-sef.de). Exclusion criteria were significant comorbidities, particularly immunosuppressive conditions or immune-related diseases. Women actively attempting conception, undergoing fertility treatments, or having recently completed fertility interventions were excluded. (Figure 1) Deep infiltrating endometriosis diagnosis was confirmed by surgery and MRI scans. All included patients had complex DIE and had initially been scheduled for surgical treatment at our center. Due to pandemic-related triage measures at the University Hospital Frankfurt and national guidelines, surgical procedures for this patient cohort were postponed until after June 1, 2021.

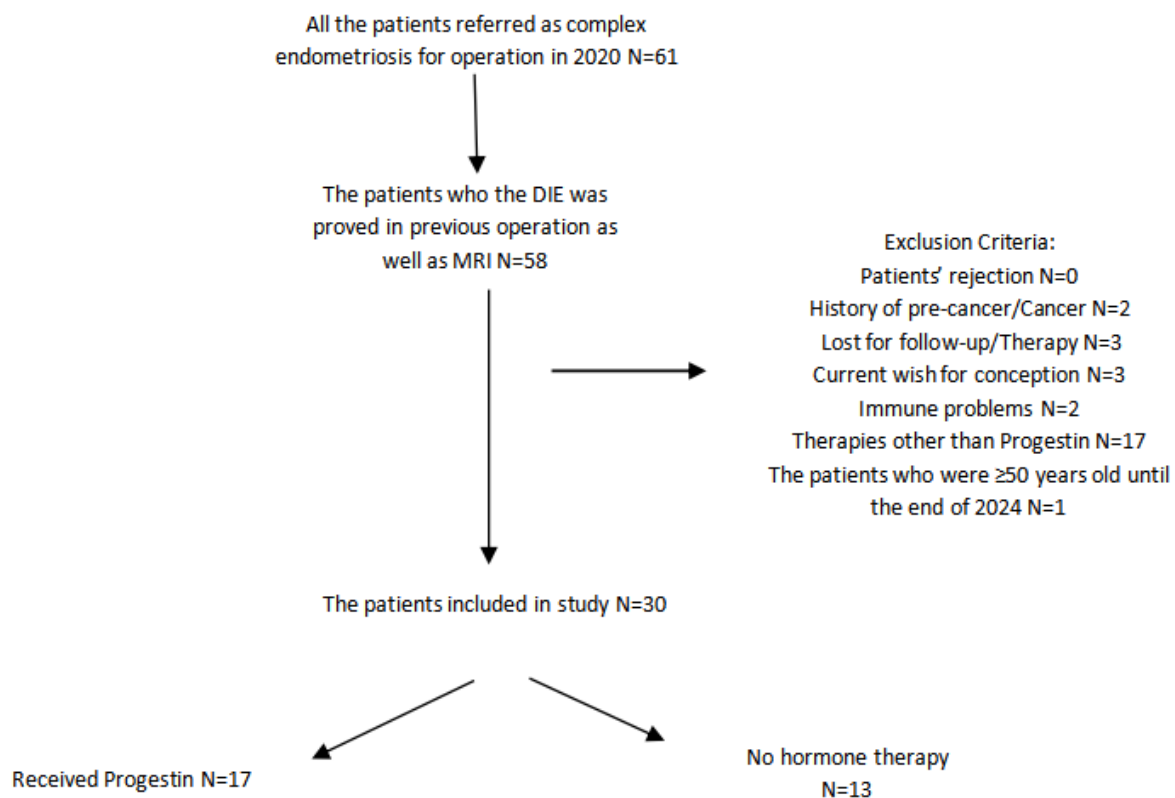


Figure 1. Flowchart of study population.

Clinical data were extracted from the patients' medical records. A standardized questionnaire was designed for this study (amendment 1) Patients were followed up prospectively between April 2020 and November 2024, with a mean follow-up time of 70 months. Follow up assessments were conducted through regular visits as well as standardized questionnaires designed to evaluate COVID infection and its clinical course.

Variables relating to endometriosis: The following variables were assessed: age (years), BMI (kg/m^2) before and after pandemic, menstrual cycle duration, age at onset of first endometriosis symptoms, age at diagnosis, diagnostic delay (in years), and endometriosis-related symptoms such as abdominal pain, dysmenorrhea, dyspareunia, and dyschezia. Disease severity was classified using both the #ENZIAN system and the revised American Society for Reproductive Medicine (rASRM) classification, following recommendations from the Stiftung Endometriose Forschung (www.endometriose-sef.de). Surgical and perioperative parameters were also analyzed.

Variables relating to COVID: COVID-19-related variables included the presence and type of symptoms, the interval between the onset of endometriosis symptoms and SARS-CoV-2 infection, disease severity, duration until polymerase chain reaction (PCR) negativity, and SARS-CoV-2 vaccination status. COVID-19 severity was classified according to internationally accepted criteria, based on the categorization proposed by Feng et al. (2020). Mild disease was defined as cases not requiring hospitalization and managed at home with supportive care (e.g., rest, hydration, antipyretics). Moderate disease included patients requiring medical evaluation by a general practitioner or telemedicine consultation with closer clinical monitoring. Severe disease was defined as cases requiring hospitalization or admission to an intensive care unit (16).

In all patients, nasopharyngeal or oropharyngeal swabs were obtained for real-time reverse transcription polymerase chain reaction (RT-PCR) testing immediately upon the onset of any symptoms. RT-PCR was selected due to its high analytical sensitivity and established role in early detection of SARS-CoV-2, as widely implemented in Germany during the pandemic (17).

Following a positive PCR result, patients were closely monitored. Repeat PCR testing was performed within 24 to 48 hours after resolution of symptoms. In asymptomatic cases who remained PCR-positive, PCR was repeated after one week; this occurred in one patient per group.

Group comparisons of normally distributed continuous variables were conducted using independent samples t-tests, while non-parametric variables were analyzed with the Mann–Whitney U test. Categorical variables were compared using the Pearson chi-square test or Fisher's exact test, depending on the expected cell counts. Correlations between continuous variables were assessed using Pearson correlation coefficients.

All statistical analyses were performed using IBM SPSS Statistics, version 28 (IBM Corp., Armonk, NY, USA). A two-tailed p -value < 0.05 was considered statistically significant.

3. Results

30 women with confirmed deep infiltrating endometriosis (DIE) were included in the study. Of these, 17 patients (56.7%) were receiving progestin therapy, whereas 13 (43.3%) were not undergoing any form of hormonal treatment.

The mean age of the cohort in 2020 was 34.0 ± 7.2 years (range: 20–45), with no statistically significant difference between the progestin group (33 ± 7.4 years) and the non-treatment group (35.3 ± 6.8 years; $p = 0.39$). Pre-pandemic BMI values were comparable between the two groups ($24.9 \pm 4 \text{ kg}/\text{m}^2$ vs. $26.7 \pm 4.9 \text{ kg}/\text{m}^2$; $p = 0.32$). No significant differences were observed between the groups regarding: age at menarche, menstrual cycle length, parity status, or smoking behavior. Twelve patients (40%) reported at least one pregnancy, with a live birth rate of 91.7%. Menstrual bleeding intensity was reported as strong or very strong by 83% of the overall cohort, with a higher proportion in the non-hormonal group compared to the progestin group (92.3% vs. 76.5%), however this difference did not reach statistical significance.

All patients in the study were classified as stage III or IV according to the revised American Society for Reproductive Medicine (rASRM) classification. Based on the #ENZIAN classification, all participants had deep infiltrating endometriosis involving at least one of the compartments (A, B, or C) either in isolation

or in combination. In addition, 60% of the patients demonstrated peritoneal involvement measuring ≥ 3 cm. No significant differences in endometriosis staging

or anatomical distribution were observed between the progestin and non-treatment groups. A comprehensive summary is provided in **Table 1**.

Table 1. Patients characteristics regarding the endometriosis

Variable		All patients with DIE	Patients with Progestin	Patients without Therapy	P-Value
Age (years old)		34 $\pm$ 7.2	33 $\pm$ 7.4	35.31 $\pm$ 6.8	0.39
BMI before pandemic		25.7 $\pm$ 4.5	24.9 $\pm$ 4	26.7 $\pm$ 4.9	0.32
BMI after pandemic		26.5 $\pm$ 5.3	25.7 $\pm$ 5	27.5 $\pm$ 5.7	0.61
Menarche		12.4 $\pm$ 1.3	12.1 $\pm$ 1.3	12.9 $\pm$ 1.3	0.08
Menstrual cycles (days)		28.4 $\pm$ 3.6	28.9 $\pm$ 4.4	27.5 $\pm$ 1.4	0.34
Age by the first symptoms		25.3 $\pm$ 10.8	24.47 $\pm$ 12.1	26.31 $\pm$ 9.4	0.61
Age by the first diagnosis		32.2 $\pm$ 7.8	31.76 $\pm$ 7.5	32.8 $\pm$ 8.5	0.75
Delay in Diagnosis (yrs)		6.9 $\pm$ 7.4	7.3 $\pm$ 7.6	6.5 $\pm$ 7.4	0.31
Number of Endometriosis operations before pandemic		1.33 $\pm$.9	1.35 $\pm$ 0.9	1.31 $\pm$ 1.0	0.92
Symptoms	Chronic abdominal pain	28(93.3%)	15 (88.2%)	13 (100%)	0.21
	Dysmenohea/ Bleeding	24(80%)	14 (82.4%)	10 (76.9%)	0.73
	Dysparunia	17 (56.7%)	10 (58.8%)	7 (53.8%)	0.71
	Dysparunia	17 (56.7%)	10 (58.8%)	7 (53.8%)	0.72
	Dyschezia	12 (40%)	6 (35.3%)	6 (46.2%)	0.53
rASRM	III	16 (53.3%)	8 (47.1%)	8 (61.5%)	0.56
	IV	14 (46.7%)	9 (52.9%)	5 (38.5%)	
#ENZIAN	P2 and P3	18 (60%)	15 (88.2%)	13 (100%)	0.54
	A/B/C	30 (100%)	17 (100%)	13 (100%)	

All patients experienced at least one laboratory-confirmed SARS-CoV-2 infection during the pandemic period and prior to the widespread availability of COVID-19 vaccination in Germany (spring–summer 2021). Among the cohort, nausea and vomiting were the most frequently reported symptoms. In terms of disease severity, moderate COVID-19 cases were significantly more common in the progestin therapy group compared to the non-treatment group (47.1% vs. 7.7%, $p = 0.042$). Conversely, mild cases

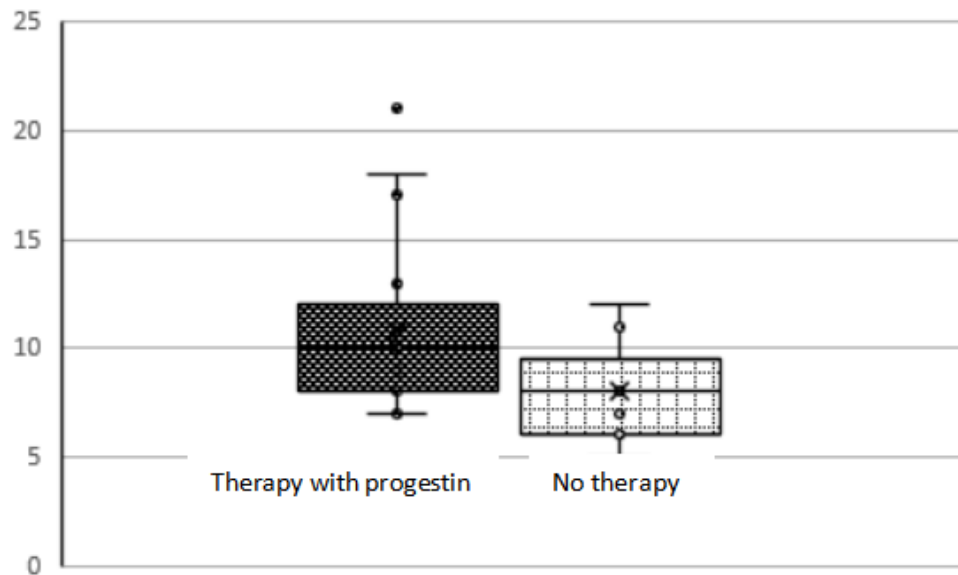
predominated in the group without hormonal therapy (92.3%) relative to the progestin group (52.9%). No statistically significant differences were observed between the groups regarding the frequency of other typical symptoms of SARS-CoV-2 infection, such as fever, cough, anosmia, or fatigue (**Table 2**). The mean duration to PCR negativity was significantly longer in patients undergoing progestin therapy compared to those without hormonal treatment (10.76 $\pm$ 4.1 days vs. 8.00 $\pm$ 2.2 days; $p = 0.026$) (**Figure 2**).

Table 2. COVID related variable in different groups

Variable		All patients with DIE	Patients with Progestin	Patients without Therapy	P-Value
First endometriosis symptoms until COVID infection (yrs)		9.9 $\pm$ 8.6	9.5 $\pm$ 7.8	10.5 $\pm$ 9.8	0.71
					0.042
COVID Severity	mild	21 (70%)	9 (52.9%)	12 (92.3%)	
	moderate	9 (30%)	8 (47.1%)	1 (7.7%)	
COVID Symptoms	Fever	26 (86.7%)	14 (82.4%)	12 (92.3%)	0.42
	Nausea/ Vomiting	16 (53.3%)	9 (52.2%)	7 (53.8%)	0.93
	Loss of taste/smell	13 (43.3%)	6 (35.3%)	7 (53.8%)	0.34
	Cough/shortness of breath	11 (36.7%)	8 (47.1%)	3 (23.1%)	0.12

Continuation Table:

Variable	All patients with DIE	Patients with Progestin	Patients without Therapy	P-Value
Fatigue/ body pain	11 (36.7%)	8 (47.1%)	3 (23.1%)	0.14
Diarrhea	6 (20%)	4 (23.5%)	2 (15.4%)	0.50

**Figure 2.** Time to reliving the symptoms and PCR Conversion

All participants received at least one dose of a COVID-19 vaccine following their infection, with vaccinations administered no earlier than 12 weeks post-infection. No significant differences were observed between the progestin and non-treatment groups in terms of the number of vaccine doses received (3 ± 0.8 vs. 3 ± 1 ; $p = 1.0$). Although 30% of patients ($n = 9$) expressed concerns about potential effects of vaccination on endometriosis symptoms, only one individual—not receiving hormonal therapy at the time—reported transient increases in pelvic pain and menstrual bleeding post-vaccination. Overall, no significant changes in endometriosis-related symptoms were observed after SARS-CoV-2 infection or vaccination. Importantly, no thromboembolic events occurred in the study population.

4. Discussion

Endometriosis predominantly affects women of reproductive age, who due to the disease's chronic course, unclear pathogenesis, and diagnostic delays, represent a particularly vulnerable patient population to additional stressors such as SARS-CoV-2 infection.

Despite the high prevalence of endometriosis, there

is no established non-invasive diagnostic tool with adequate sensitivity and specificity. As a result, most studies rely primarily on symptom-based diagnosis rather than histopathological or surgical confirmation. This limitation is particularly critical in complex cases such as deep infiltrating endometriosis, where imaging modalities sometimes fail to detect the full extent of the disease. Diagnostic uncertainty therefore continues to compromise both research quality and clinical decision-making (18). In contrast, the presented study exclusively included patients with surgically and histopathologically confirmed DIE in different anatomical compartments, with documentation of peritoneal involvement and thereby strengthening diagnostic accuracy and cohort homogeneity.

The cohort comprised relatively young patients, with a mean age of 34 years. A modest increase in body mass index (BMI) of 0.8 kg/m^2 was observed during the COVID-19 pandemic, with no difference between patients receiving progestin therapy and those not undergoing hormonal treatment. (similar in 2 groups). Symptom onset typically occurred at a mean age of 25 years, while diagnosis of endometriosis was delayed by an average of at least 6.9 years,

consistent with international data. Understanding the factors contributing to these delays is crucial for the development and implementation of effective global strategies aimed at reducing the time to diagnosis (19).

All patients in the cohort experienced SARS-CoV-2 infection during the pandemic. While most of the patients (70%) had a mild disease course, 30% developed moderate symptoms. Notably, disease severity differed significantly between treatment groups: among patients receiving progestin therapy, 52.9% experienced mild disease and 47.1% moderate disease, whereas in the non-treatment group, 92.3% had mild disease and only 7.7% moderate disease. This contrasts with epidemiological evidence from Germany and the United States indicating that more than 80% of SARS-CoV-2 infections in adults younger than 50 years are mild, underscoring a potentially distinct risk profile in women with DIE receiving hormonal therapy (20).

Fever, cough, and fatigue were the most reported symptoms in COVID-19 patients in early pandemic meta-analyses, with approximate prevalence of 78%, 57%, and 31%, respectively. Gastrointestinal manifestations were documented less frequently overall, with prevalence estimates significantly lower than respiratory symptoms in large observational studies (21). In contrast our cohort of patients with deep infiltrating endometriosis (DIE) presented with gastrointestinal symptoms in over 50% of cases. This suggests a distinct symptom pattern in this patient population, potentially influenced by the underlying disease pathology. In this context, we assessed the duration between the initial manifestation of endometriosis-related symptoms and the incidence of COVID-19 infection. The data indicates that this patient cohort had been affected by symptoms of the chronic disease for an average of over nine years prior to their COVID-19 diagnosis, underscoring the prolonged disease burden in this population.

As demonstrated in Table 1, 60% of patients presented with peritoneal endometriotic lesions exceeding 3 cm in size and all patients demonstrated involvement of compartments A, B, and/or C according to the #ENZIAN classification. These findings may potentially contribute to a better understanding of the complexity of endometriosis and its interaction with other disease processes.

To assess the interaction between COVID-19

infection and the immune response in this patient population, we evaluated both symptom resolution and PCR test conversion. In previous studies in younger populations have been reported an average PCR conversion time of approximately 9 days (22) varying to 20 days post-symptom onset, depending on the viral variant and individual factors (e.g., immunity status). Our findings demonstrate that patients with deep infiltrating endometriosis (DIE) exhibit a relative prolonged time to PCR conversion, averaging 9.6 days to symptom relief and PCR negativity, with a significantly longer duration observed in those undergoing progestin therapy. This extended period may reflect an altered immune response in this subgroup, potentially influenced by chronic inflammation and hormonal modulation inherent to DIE and its treatment. These findings suggest a possible interaction between exogenous hormones, endometriosis, and the host immune response to SARS-CoV-2 infection and highlight the need for tailored clinical management strategies in patients with complex gynecological conditions. Further research is warranted to elucidate the mechanisms underlying these differences and to optimize COVID-19 management in this susceptible patient population.

Although 30% of patients ($n = 9$) expressed concerns regarding potential effects of COVID-19 vaccination on their endometriosis-related symptoms, only one patient – who was not receiving hormonal therapy at the time – reported a transient increase in pelvic pain and menstrual bleeding following vaccination. While direct data on vaccination effects in endometriosis remain limited existing evidence suggests that COVID-19 vaccines do not result in clinically meaningful worsening of endometriosis symptoms. Mild and transient menstrual changes, including increase in dysmenorrhea have been observed in some cases (23).

The relationship between sex hormones, hormonal therapy, and COVID-19 outcomes remain controversial. While a pilot trial in hospitalized men indicated that progesterone supplementation might improve clinical status (24), subsequent trials found no clear clinical benefit of combined estradiol and progesterone, despite modest reductions in inflammatory biomarkers (25). Large-scale observational studies of hormonal contraceptive users also reported little to no effect on

hospitalization or mortality, and in some cases even a reduced risk of severe outcomes among younger women (26, 27). In contrast, our results point towards more moderate acute disease in progestin users, likely reflecting differences in study populations, hormone regimens, and underlying conditions.

Both COVID-19 and estrogen-containing therapies have been associated with increased venous thromboembolism (VTE) risk. Some observational data suggest an additive effect (19), but systematic reviews rate the certainty of evidence as low. No thromboembolic events occurred in our cohort.

Most previous research on endometriosis during the COVID-19 has focused on healthcare disruption, mental health, and symptom burden (28). Only limited data address acute SARS-CoV-2 outcomes in this patient population. Emerging evidence suggest that women with endometriosis may be at higher risk for long-term effects of the virus, consistent with the chronic immune dysregulation associated with the disease (29). Our findings of delayed viral clearance in progestin users add to this picture and underline the need for further mechanistic and clinical studies.

This study has several limitations, primarily the relatively small sample size which limits the statistical power and precludes comprehensive multivariable adjustment for potential confounders. However, its strengths include a well-defined and clinically confirmed subgroup of patients with deep infiltrating endometriosis (DIE), rigorously screened for other medical conditions that could influence immune response. To reduce heterogeneity, patients receiving other forms of endometriosis therapy were excluded; only those treated with dienogest, a widely used progestin, were included. Despite the limitations, the study provides novel insights into an underrepresented patient population in COVID-19 research and may contribute to a better understanding of the interaction between chronic inflammatory gynecological diseases and viral infections.

To confirm and expand upon these findings, further well-designed, larger-scale studies are needed. These should include diverse endometriosis phenotypes, various treatment modalities, and broader immunological assessments to better understand the complex interaction between endometriosis, hormonal therapy, and viral infections such as COVID-19.

This prospective study provides novel insights into the interaction between deep infiltrating endometriosis (DIE), progestin therapy, and the clinical course of SARS-CoV-2 infection in a well-characterized cohort of reproductive-aged women. Despite the limited sample size, the findings suggest a potential association between progestin use and prolonged viral clearance, as well as increased frequency of moderate COVID-19 symptoms. The high prevalence of gastrointestinal symptoms and the long-standing disease burden further underscore the distinct clinical profile of this patient population. Although, COVID-19 vaccination was well tolerated, patient-reported concerns emphasize the need for targeted communication.

Collectively, these findings point to a complex interplay between chronic inflammation, hormonal modulation, and immune response in women with DIE. Larger, adequately powered studies are warranted to validate these observations, elucidate the underlying biological mechanisms, and inform individualized care strategies for patients with endometriosis during infectious disease outbreaks. Future research should also evaluate emerging therapeutic approaches in comparison with established hormonal treatments, with the aim of optimizing long-term symptom control while minimizing immune modulation and systemic adverse effects. As current evidence in this area remains scarce, these exploratory observations provide a basis for future larger, adequately powered prospective studies aimed at elucidating the immunological mechanisms underlying these associations and determining their clinical relevance.

Abbreviations

deep infiltrating endometriosis	DIE
natural killer cell	NK
magnetic resonance imaging	MRI
revised American Society for Reproductive Medicine	rASRM
polymerase chain reaction	PCR
real-time reverse transcription polymerase chain reaction	RT-PCR
body mass index	BMI
venous thromboembolism	VTE

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of

the University Hospital Frankfurt, Germany (approval Nr. 2023-1478). Written informed consent was obtained from all patients during follow-up interviews. This study was registered in the German Trials Register as a prospective clinical study (DRKS - Deutsches Register Klinischer Studien, 15.01.2024, DRKS-ID der Studie: DRKS00033366. prospective study. <https://drks.de/search/de/trial/DRKS00033366/details>).

This study adhered to the Declaration of Helsinki.

Consent for Publication

Not applicable

Data Availability Statement

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests

Funding Information

This study did not receive any funding or grants.

Author Contributions

Morva Tahmasbi Rad, Denis Bachmann and Sven Becker contributed to study planning, including study design and data interpretation. Denis Brachmann handled data collection and analysis. Morva Tahmasbi Rad and Lisa Marie Wilhelm drafted and edited the manuscript, respectively. Sophie Simon was responsible for data verification and editing. All authors approved the final version of the manuscript.

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