



OPEN Evaluating quality of life improvements in endometriosis patients following laparoscopic surgery using EHP-30 scale

Yuyan Guo^{1,3,4}, Penghui Huang^{2,3}, Chaobin Liu², Zhenna Wang², Yi Wang², Wei Qi², Xi Xie², Zhenhong Wang^{2,4}, Jinna Zhang^{2,4} & Shunhe Lin^{2,4}✉

This study aims to evaluate whether laparoscopic surgery enhances health-related quality of life (HRQoL) in endometriosis patients, utilizing the Endometriosis Health Profile-30 (EHP-30) questionnaire. The study also explores the correlations between disease severity, preoperative scores, and the subsequent changes following surgical intervention. This is a prospective observational study. Seventy women undergoing laparoscopic surgery for endometriosis at Fujian Maternity and Child Health Hospital were prospectively recruited. Each participant was assessed using the EHP-30 questionnaire both 4 weeks prior to and 3 months post-surgery to obtain preoperative and postoperative subscale scores. The Wilcoxon signed-rank test was applied to determine the statistical significance of changes in these scores. Spearman's rank correlation coefficient was employed to explore the relationships between preoperative EHP-30 scores, serum CA125 levels, and intraoperative revised American Society for Reproductive Medicine (rASRM) scores. Statistically significant correlations were further examined using multivariate linear regression analysis to adjust for potential confounders. Laparoscopic surgery resulted in a significant reduction in EHP-30 subscale scores ($P \leq 0.002$), indicating a marked improvement in HRQoL among endometriosis patients. Spearman correlation analysis revealed positive correlations between preoperative serum CA125 levels ($P = 0.005$) and intraoperative rASRM scores with preoperative pain ($P = 0.035$) and sexual intercourse scores ($P = 0.046$). Additionally, multivariate linear regression analyses demonstrated that changes in pain scores (Δ Pain), control and powerlessness (Δ Control and Powerlessness), and work life (Δ Work Life) were significantly interrelated ($P < 0.01$). Emotional well-being (Δ Emotional Well-being), control and powerlessness (Δ Control and Powerlessness), and work life (Δ Work Life) also exhibited significant mutual influences ($P < 0.01$). Furthermore, changes in social support (Δ Social Support), self-image (Δ Self-image), and treatment perception (Δ Treatment) were positively correlated ($P < 0.01$), as were changes in sexual intercourse (Δ Sexual Intercourse) and concern about infertility (Δ Concern on Infertility) ($P < 0.01$). Laparoscopic surgery for endometriosis significantly improves HRQoL by alleviating pain and positively influencing daily functioning and emotional well-being. These findings highlight the critical role of laparoscopic surgery as an effective intervention for enhancing the quality of life in endometriosis patients.

Keywords Endometriosis, Laparoscopic surgery, Health-related quality of life (HRQoL), Endometriosis Health Profile-30 (EHP-30), Serum CA125, rASRM scores

Endometriosis is a chronic gynecological condition affecting approximately 5% to 10% of women of reproductive age and is a leading cause of infertility, affecting up to 50% of patients^{1–4}. It is characterized by the presence of endometrial-like tissue outside the uterine cavity, causing symptoms such as chronic pelvic pain, dysmenorrhea, and dyspareunia^{1,2}. The diagnosis is primarily confirmed through laparoscopy and histopathological examination,

¹Department of Physical Examination Center, Fujian Medical University Union Hospital, Fujian, China. ²Fujian Maternity and Child Health Hospital, College of Clinical Medicine for Obstetrics and Gynecology and Pediatrics, Fujian Medical University, Fuzhou 350001, Fujian, China. ³Yuyan Guo and Penghui Huang contributed equally to this work and share first authorship. ⁴Yuyan Guo, Zhenhong Wang, Jinna Zhang and Shunhe Lin contributed equally to this work. ✉email: lsh2816@sina.com

often supplemented by imaging modalities like ultrasound or MRI and biomarkers such as CA125^{5–8}. Beyond its physical symptoms, endometriosis has profound impacts on health-related quality of life (HRQoL), disrupting daily activities, impairing work efficiency, and affecting mental well-being^{9–12}.

Laparoscopic surgery is a cornerstone treatment for endometriosis, offering precise lesion removal and faster recovery compared to traditional surgical approaches. This minimally invasive technique not only alleviates pain but also improves fertility outcomes and addresses complications from advanced-stage disease^{15–18}. In addition to surgery, pharmacological treatments, including NSAIDs, oral contraceptives, GnRH agonists, and progestins like dienogest, play a critical role in managing symptoms and preventing disease recurrence^{19–21}. However, the recurrent nature of endometriosis—40% to 50% within 2–5 years—necessitates comprehensive treatment strategies that address both symptoms and HRQoL^{13,14}.

Assessing HRQoL in endometriosis patients requires specific tools to capture the unique impact of the disease. While general instruments like the SF-36 are widely used, they lack disease specificity and may overlook important dimensions^{22–25}. The Endometriosis Health Profile-30 (EHP-30), a validated, endometriosis-specific scale with 11 subscales, provides a comprehensive assessment of HRQoL and is widely applied in clinical research^{26–28}. Its sensitivity to changes in HRQoL makes it an ideal tool for evaluating therapeutic interventions.

In this study, we utilize the EHP-30 to evaluate the changes in HRQoL before and after laparoscopic surgery in patients with endometriosis. This study aims to assess the effectiveness of laparoscopic surgery as an intervention and explore correlations between disease severity, preoperative HRQoL scores, and postoperative outcomes, providing a comprehensive understanding of its impact on various dimensions of HRQoL.

Methods

Study design and participants This study was designed as a prospective observational study conducted at Fujian Maternity and Child Health Hospital. Seventy women with regular menstrual cycles who underwent laparoscopic procedures during the proliferative phase. These participants were treated at Fujian Maternity and Child Health Hospital between January and November 2020. A preliminary power analysis was conducted prior to participant recruitment to determine the required sample size. Based on expected effect sizes from similar studies, the power analysis indicated that 70 participants would provide 80% power to detect significant changes in HRQoL scores with a 95% confidence level. This sample size was chosen to balance statistical power with the available resources and time frame. Patients were not receiving hormonal or anti-inflammatory treatments in the 3 months prior to surgery to allow unbiased preoperative HRQoL assessment. Those requiring immediate medical treatment for severe symptoms were excluded to minimize confounding factors. Inclusion criteria included women with a confirmed diagnosis of endometriosis scheduled for laparoscopic surgery. The primary indications for laparoscopic surgery included chronic pelvic pain, infertility, and recurrence of endometriotic lesions that did not respond to medical treatment. These patients were scheduled for laparoscopic surgery to alleviate symptoms and improve fertility outcomes. Postoperative histopathological examination was required to confirm the diagnosis of endometriosis in all included participants. Endometriosis was confirmed in all participants through laparoscopic visualization and histopathological examination. Preoperative imaging, including transvaginal ultrasound and/or pelvic MRI, was performed to support clinical suspicion and facilitate surgical planning. Exclusion criteria included recent use of hormones or anti-inflammatory drugs within 3 months before surgery, confirmed gynecological malignancies, acute inflammation, pregnancy, or perimenopausal/postmenopausal status, or severe symptoms necessitating urgent treatment. Each participant was assessed using the Endometriosis Health Profile-30 (EHP-30) questionnaire 4 weeks before surgery and 3 months after surgery to obtain preoperative and postoperative subscale scores.

Study outcomes The primary outcome of this study was the change in HRQoL scores, measured by the Endometriosis Health Profile-30 (EHP-30), before and after laparoscopic surgery. Secondary outcomes included correlations between preoperative serum CA125 levels, intraoperative rASRM scores, and changes in HRQoL scores across various subscales. These outcomes were chosen to evaluate the effectiveness of laparoscopic surgery and to identify potential predictors of HRQoL improvement.

EHP-30 questionnaire The EHP-30 questionnaire was administered online through “Wenjuanxing”. “Wenjuanxing” is a widely used online survey platform in China that allows for easy distribution and completion of questionnaires. Four weeks before surgery, participants completed the questionnaire via a QR code. Three months postoperatively, participants were re-contacted via WeChat, a popular messaging and social media app in China, and instructed to complete the follow-up EHP-30 questionnaire using a new QR code, enabling the collection of post-surgery HRQoL data. The EHP-30 consists of a 30-item core survey and a 23-item module, covering 11 subscales: pain, control and powerlessness, emotional well-being, social support, self-image, work life, relationship with children, sexual intercourse, medical profession, treatment, and concern about infertility. Each response was scored from 0 (never) to 4 (always), with subscale scores calculated by summing raw scores, dividing by the maximum possible score, and multiplying by 100.

Surgical procedure and data collection Laparoscopic surgery for endometriosis was performed according to standard clinical protocols, with disease severity assessed using the revised American Society for Reproductive Medicine (rASRM) staging system (Stage I: 1–5 points, Stage II: 6–15 points, Stage III: 16–40 points, Stage IV: > 40 points). Postoperative pathology confirmed endometriosis in all cases. Additionally, retrospective clinical data, including age, BMI, gravida, parity, infertility status, pain symptoms, serum CA125 levels, rASRM staging, and pathological results, were collected from the Hospital Information System (HIS).

This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to ensure the quality and rigor of the study design and reporting. The completed STROBE checklist is provided as a supplementary file to demonstrate compliance with these standards.

Ethics approval The study was approved by the Research Ethics Committee of Fujian Maternity and Child Health Hospital (grant number: 2021-KRD022). Informed consent was obtained from all participants. The appropriate norms and regulations were adhered to during the execution of all methods and procedures.

Statistical analysis

Statistical analyses were conducted using SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as mean ± standard deviation or median with interquartile range, as appropriate. The Wilcoxon signed-rank test was employed to compare EHP-30 scores before and after surgery. Spearman correlation analysis was used to evaluate the relationships between preoperative serum CA125 levels and preoperative EHP-30 scores, intraoperative rASRM scores and preoperative EHP-30 scores, as well as changes in subscale scores following laparoscopic surgery. For variables that showed statistical significance, further multivariate linear regression analysis was conducted to elucidate the interrelationships. Statistical significance was defined as a *p*-value of less than 0.05.

Results

Baseline characteristics of study population

All 70 patients who were enrolled in this study and underwent laparoscopic surgery for endometriosis successfully completed the EHP-30 questionnaire. The mean age of the participants was 33.06 ± 6.63 years. Baseline demographic and clinical characteristics are detailed in Table 1. Of these patients, 50% had no history of pregnancy, 62.86% were nulliparous, and 42.86% had a history of infertility. Pain-related symptoms were prevalent, with 71.67% reporting lower abdominal pain during menstruation, 18.57% experiencing chronic pelvic pain, and 34.29% reporting dyspareunia. The mean preoperative serum CA125 level was 82.04 ± 66.92. The median EHP-30 total scores were 25.00 preoperatively and 10.15 postoperatively, indicating a significant reduction in symptom burden following surgery.

Variable	Samples(N = 70)
Age	33.06 ± 6.63
BMI	21.01 ± 2.44
Gravida	
0	35(50.00%)
≥ 1	35(50.00%)
Parity	
0	44(62.86%)
≥ 1	26(37.14%)
Infertility	
Primary infertility	24(34.29%)
Secondary infertility	6(8.57%)
Pain symptom	
Dysmenorrhoea	43(71.67%)
Chronic pelvic pain	13(18.57%)
Dyspareunia	24(34.29%)
CA125	82.04 ± 66.92
rASRM stage	
Stage I	5(7.14%)
Stage II	1(1.43%)
Stage III	19(27.14%)
Stage IV	45(64.29%)
Endometriotic phenotype	
Superficial peritoneal endometriosis (SUP)	52(74.29%)
Ovarian endometrioma (OMA)	61(87.14%)
Deeply infiltrating endometriosis (DIE)	8(11.43%)
Overall EHP-30 scores	
Preoperation	25.00(15.57, 36.91)
Postoperation	10.15(3.18, 20.75)

Table 1. Baseline characteristics of the patients with endometriosis. Data are expressed as mean ± standard deviation, number (percentage) of patients, median (quarter median, three-fourths median). \ BMI, body mass index; CA125, cancer antigen 125; rASRM stage, revised American Society for Reproductive Medicine; EHP-30 (Endometriosis Health Profile-30). Data are shown as median (quarter median- three-fourths median).

	Preoperative score	Postoperative Score	P value
Overall	25.00 (15.57, 36.91)	10.15 (3.18, 20.75)	< 0.0001
Pain	27.27 (9.09, 47.73)	0.00 (0.00, 14.78)	< 0.0001
Control and powerlessness	33.33 (8.33, 50.00)	8.33 (0.00, 25.00)	< 0.0001
Emotional well-being	29.17 (16.67, 41.88)	14.59 (0.00, 25.00)	< 0.0001
Social support	25.00 (6.25, 45.31)	0.00 (0.00, 25.00)	< 0.0001
Self-image	8.33 (0.00, 25.00)	0.00 (0.00, 16.67)	0.0037
Work life	15.00 (5.00, 30.00)	0.00 (0.00, 15.00)	< 0.001
Relationship with children	0.00 (0.00, 15.62)	0.00 (0.00, 0.00)	0.044
Sexual intercourse	20.00 (0.00, 30.00)	0.00 (0.00, 21.25)	0.0017
Medical profession	0.00 (0.00, 6.25)	0.00 (0.00, 0.00)	0.0168
Treatment	25.00 (0.00, 42.36)	8.33 (0.00, 33.33)	0.0232
Concern on infertility	37.50 (0.00, 78.13)	18.75 (0.00, 50.00)	0.1544

Table 2. Preoperative score and postoperative score of each EHP-30 subscale. Data are expressed as median (quarter median, three-fourths median).

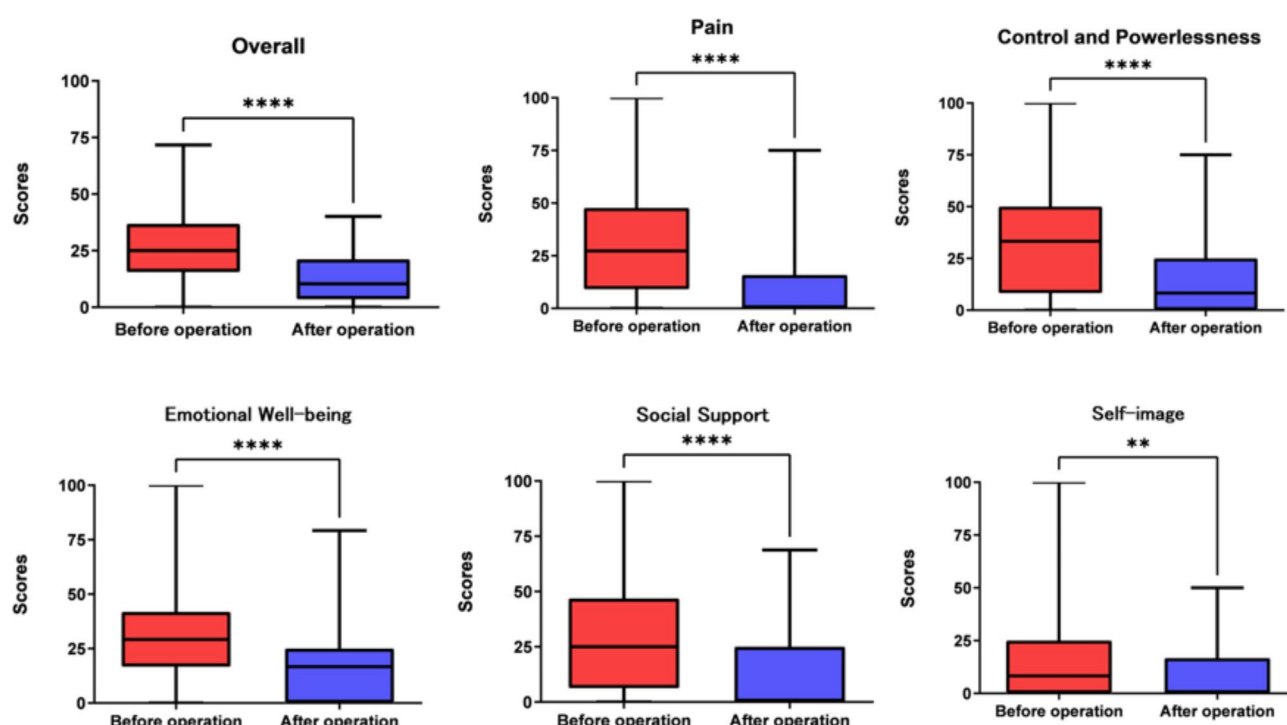


Fig. 1. Changes in HRQoL subscale scores before and after laparoscopic surgery. Note: **** $P < 0.0001$ indicates a statistically significant difference, ** $P < 0.01$ indicates a highly significant difference.

Changes in EHP-30 scores pre- and post-laparoscopic surgery

Statistical analysis revealed significant reductions in overall EHP-30 scores following surgery ($P < 0.001$) (Table 2). Notable decreases were observed across all EHP-30 core subscales, including pain, control and powerlessness, emotional well-being, social support, and self-image (all $P < 0.001$). Similarly, substantial reductions were seen in the EHP-30 module subscales, such as work life (all $P < 0.001$), relationship with children ($P = 0.002$), sexual intercourse (all $P < 0.001$), medical profession ($P = 0.001$), treatment (all $P < 0.001$), and concern about infertility (all $P < 0.001$). The box plot in Fig. 1 and Fig. 2 visually represents these changes, highlighting the marked improvement in HRQoL among patients with endometriosis.

Correlation between preoperative EHP-30 scores, serum CA125 levels, and rASRM scores

Table 3 demonstrates a statistically significant positive correlation between serum CA125 levels and preoperative EHP-30 pain subscale scores ($R = 0.334$, $P = 0.005$). However, the correlation between serum CA125 levels and the overall EHP-30 score, as well as other subscales, was not statistically significant. In contrast, Table 4 reveals that intraoperative rASRM scores were significantly positively correlated with preoperative EHP-30

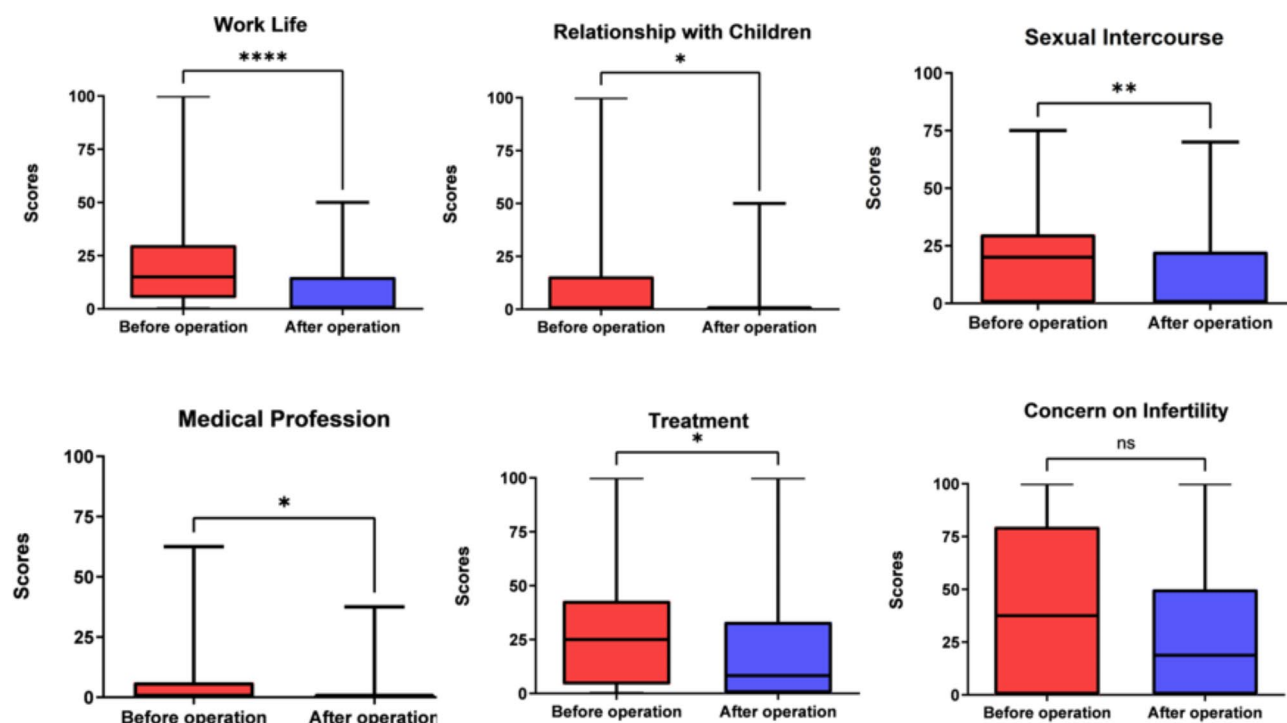


Fig. 2. Preoperative score and postoperative score of each EHP-30 module subscale. Note **** $P < 0.0001$ indicates a statistically significant difference, ** $P < 0.01$ indicate a highly significant difference. * $P < 0.05$ indicate a significant difference. Ns indicates a non-statistically significant difference.

Preoperative score of each subscale	R value	P value
Overall	0.080	0.509
Pain	0.334	0.005
Control and powerlessness	0.128	0.290
Emotional well-being	- 0.059	0.629
Social support	0.080	0.511
Self-image	- 0.047	0.698
Work life	0.113	0.350
Relationship with children	0.055	0.648
Sexual intercourse	- 0.085	0.483
Medical profession	- 0.230	0.056
Treatment	- 0.147	0.224
Concern on infertility	- 0.001	0.992

Table 3. The correlation between CA125 and preoperative score of EHP-30 subscale. Bold values indicate $p < 0.05$.

pain subscale scores ($R = 0.263$, $P = 0.035$) and sexual intercourse subscale scores ($R = 0.240$, $P = 0.046$). No statistically significant correlations were observed between rASRM scores and other EHP-30 subscales.

Correlation between preoperative and postoperative changes in EHP-30 subscale scores

Table 5 presents the Spearman correlations of changes (Δ) in subscale scores for the 70 patients who underwent laparoscopic surgery for endometriosis. Changes in pain scores (Δ Pain) exhibited significant positive correlations with changes in control and powerlessness, emotional well-being, and work life scores, with all correlations reaching statistical significance ($P < 0.01$). Similarly, changes in control and powerlessness were strongly correlated with changes in emotional well-being, social support, and work life scores, all showing statistically significant relationships ($P < 0.01$). Positive correlations were also observed between changes in emotional well-being and changes in social support, work life, and sexual intercourse scores, with each correlation being statistically significant ($P < 0.01$). Furthermore, changes in social support were significantly correlated with improvements in self-image, work life, and relationship with children scores ($P < 0.01$). Changes in self-image were significantly correlated with changes in medical profession scores ($P < 0.01$). Lastly, changes in work life

Preoperative score of each subscale	R value	P value
Overall	0.120	0.323
Pain	0.263	0.035
Control and powerlessness	0.094	0.440
Emotional well-being	0.006	0.963
Social support	0.024	0.843
Self-image	-0.020	0.868
Work life	0.126	0.297
Relationship with children	0.155	0.201
Sexual intercourse	0.240	0.046
Medical profession	-0.063	0.607
Treatment	0.088	0.469
Concern on infertility	-0.078	0.523

Table 4. The correlation between rASRM scores and preoperative score of each EHP-30 subscale. Bold values indicate $p < 0.05$.

	Δ Pain	Δ Control and powerlessness	Δ Emotional well-being	Δ Social support	Δ Self-image	Δ Work life	Δ Relationship with children	Δ Sexual intercourse	Δ Medical profession	Δ Treatment	Δ Concern on infertility
Δ Pain		0.507**	0.358**	0.246*	0.067	0.541**	0.287*	-0.062	-0.084	-0.153	-0.178
Δ Control and powerlessness	0.507**		0.656**	0.569**	0.234	0.564**	0.270*	0.271*	-0.041	0.092	0.149
Δ Emotional well-being	0.358**	0.656**		0.485**	0.197	0.573**	0.300*	0.331**	-0.046	0.256*	0.053
Δ Social support	0.246*	0.569**	0.485**		0.465**	0.372**	0.364**	0.078	0.118	0.288*	0.106
Δ Self-image	0.067	0.234	0.197	0.465**		0.208	0.250*	0.052	0.313**	0.177	0.178
Δ Work life	0.541**	0.564**	0.573**	0.372**	0.208		0.415**	0.151	0.056	0.040	0.216
Δ Relationship with children	0.287*	0.270*	0.300*	0.364**	0.250*	0.415**		0.061	-0.016	0.156	0.033
Δ Sexual intercourse	-0.062	0.271*	0.331**	0.078	0.052	0.151	0.061		0.030	0.232	0.460**
Δ Medical profession	-0.084	-0.041	-0.046	0.118	0.313**	0.056	-0.016	0.030		0.114	0.203
Δ Treatment	-0.153	0.092	0.256*	0.288*	0.177	0.040	0.156	0.232	0.141		0.185
Δ Concern on infertility	-0.178	0.149	0.053	0.106	0.178	0.216	0.033	0.460**	0.203	0.185	

Table 5. Correlation between preoperative and postoperative changes in the scores of each EHP-30 subscale. * $P < 0.05$ ** $P < 0.01$.

	Δ Pain	Δ Control and powerlessness	Δ Emotional well-being	Δ Social support	Δ Self-image	Δ Work life	Δ Relationship with children	Δ Sexual intercourse	Δ Medical profession	Δ Treatment	Δ Concern on infertility
Δ Pain		0.367**	-0.023	-0.065		0.272**	0.163				
Δ Control and powerlessness	0.470**		0.394**	0.215		0.039	-0.101	0.147			
Δ Emotional well-being	-0.115	0.530**		0.066		0.403**	0.111	0.053		-0.044	
Δ Social support	-0.201	0.185	0.064		0.318**	0.157	0.172			0.409*	
Δ Self-image				0.311**			0.257		0.231		
Δ Work life	0.421**	0.031	0.292**	0.157			0.290				
Δ Relationship with children	0.141	-0.069	0.064	0.130	0.268*	0.203*					
Δ Sexual intercourse		0.212	0.074								0.408**
Δ Medical profession					0.289						
Δ Treatment			0.047	0.227**							
Δ Concern on infertility			0.053					0.373**			

Table 6. Multivariate linear regression analysis of preoperative and postoperative changes in the scores of each EHP-30 subscale. * $P < 0.05$, ** $P < 0.01$.

were strongly correlated with changes in relationship with children scores ($P < 0.01$), and changes in sexual intercourse were significantly correlated with changes in concern about infertility scores ($P < 0.01$).

Multivariate linear regression analysis of preoperative and postoperative changes in EHP-30 subscale scores

Table 6 presents the results of the multivariate linear regression analysis, focusing on the statistically significant Spearman correlations between preoperative and postoperative changes in EHP-30 subscale scores. The analysis revealed that changes in pain scores (Δ Pain) were significantly associated with changes in control and powerlessness ($B = 0.470$, $P < 0.01$) and work life ($B = 0.421$, $P < 0.01$). Furthermore, changes in control and powerlessness (Δ Control and Powerlessness) showed significant associations with changes in pain ($B = 0.367$, $P < 0.01$) and emotional well-being ($B = 0.530$, $P < 0.01$).

Changes in emotional well-being (Δ Emotional Well-being) were significantly correlated with changes in control and powerlessness ($B = 0.394$, $P < 0.01$) and work life ($B = 0.292$, $P < 0.01$). Similarly, changes in social support (Δ Social Support) were significantly associated with changes in self-image ($B = 0.311$, $P < 0.01$) and treatment ($B = 0.277$, $P < 0.01$). Additionally, changes in self-image (Δ Self-image) were significantly correlated with changes in social support ($B = 0.318$, $P < 0.01$) and relationship with children ($B = 0.268$, $P < 0.05$).

Changes in work life (Δ Work Life) were significantly associated with changes in pain ($B = 0.272$, $P < 0.01$), emotional well-being ($B = 0.403$, $P < 0.01$), and relationship with children ($B = 0.203$, $P < 0.05$). Changes in sexual intercourse (Δ Sexual Intercourse) were significantly correlated with changes in concern about infertility ($B = 0.373$, $P < 0.01$). Similarly, changes in treatment (Δ Treatment) showed significant associations with changes in social support ($B = 0.409$, $P < 0.05$). Changes in concern about infertility (Δ Concern on Infertility) were significantly associated with changes in sexual intercourse ($B = 0.408$, $P < 0.01$). However, there were no statistically significant factors influencing changes in relationship with children (Δ Relationship with Children) and medical profession (Δ Medical Profession).

Discussion

Endometriosis is a chronic gynecological condition characterized by the presence of endometrial-like tissue outside the uterus, leading to debilitating symptoms such as chronic pelvic pain, dysmenorrhea, dyspareunia, and infertility¹. Affecting approximately 10% of women of reproductive age, this condition profoundly impacts quality of life (QoL), encompassing physical, emotional, and social domains¹². Given the widespread and multifaceted impact of endometriosis, effective treatment strategies are essential to alleviate symptoms and improve health-related quality of life (HRQoL).

Laparoscopic surgery is a pivotal tool in the management of endometriosis, offering not only minimally invasive access but also advanced visualization techniques that significantly enhance surgical precision. The use of indocyanine green (ICG) fluorescence imaging and 3D visualization systems allows for better magnification and delineation of pathological lesions, thereby optimizing surgical outcomes²⁹. These technologies provide an improved ability to differentiate between healthy and diseased tissues, enabling precise lesion excision while minimizing damage to surrounding structures.

White light imaging, while commonly used in laparoscopic surgery, has significant limitations in detecting occult endometriotic lesions. Small, deeply infiltrating, or poorly vascularized lesions may be overlooked under standard visualization, potentially leading to residual disease. These remnants can contribute to persistent symptoms, increased recurrence rates, and a diminished quality of life post-surgery. Advanced imaging techniques, such as ICG fluorescence imaging and 3D visualization systems, offer substantial advantages in overcoming these limitations. ICG fluorescence imaging enhances lesion detection by highlighting vascularized tissues, enabling more precise differentiation between healthy and diseased areas²⁹. Similarly, 3D visualization systems improve depth perception and accuracy during complex dissections, particularly in cases involving deep infiltrating endometriosis. These technologies not only aid in reducing occult remnant disease but also contribute to the preservation of critical structures, such as pelvic nerves, minimizing complications and enhancing overall surgical outcomes.

Moreover, laparoscopic surgery provides superior appraisal of pelvic anatomy, which is critical in preserving delicate nervous structures. The ability to carefully identify and protect these structures is particularly relevant in cases involving deep infiltrating endometriosis, where the risk of nerve damage is substantial³⁰. This underscores the dual benefit of laparoscopic surgery: enhancing surgical outcomes while safeguarding functional integrity. These advancements highlight the importance of integrating modern imaging techniques into laparoscopic procedures, paving the way for improved quality of life and reduced postoperative complications for patients with endometriosis. Advanced surgical techniques, such as fluorescence-guided imaging and 3D visualization, significantly enhance surgical precision and outcomes but may raise concerns about their economic and ecological sustainability. These technologies often require high-cost equipment and generate substantial disposable surgical waste, contributing to environmental challenges. Efforts to balance innovation with affordability and ecological responsibility, such as adopting reusable instruments and optimizing operating room energy use, are increasingly important in modern surgical practice³¹. These results align with previous findings, but importantly, this study offers a more nuanced understanding of how specific HRQoL domains interact and improve post-surgery.

Laparoscopic surgery, while highly effective in improving QoL for endometriosis patients, is not without risks. Potential anatomical and functional complications, such as pelvic adhesions, nerve damage, or altered function of pelvic organs, can occur. These complications may lead to chronic pelvic pain, reduced mobility, or disruptions in bowel and bladder function, which could negatively affect postoperative QoL³².

For example, unintended damage to the pelvic nerves during excision of deep infiltrating endometriosis could result in neuropathic pain or sexual dysfunction, undermining the improvements in pain relief and emotional well-being typically achieved through surgery. Similarly, the formation of postoperative adhesions could limit

mobility and exacerbate discomfort, partially offsetting the QoL benefits gained. These considerations highlight the need for meticulous surgical techniques and preoperative counseling to minimize complications and manage patient expectations.

The positive correlations between preoperative serum CA125 levels, intraoperative rASRM scores, and preoperative pain highlight the importance of these biomarkers in clinical assessment. Elevated CA125 levels and higher rASRM scores were associated with increased pain, reinforcing their use in stratifying patients for targeted surgical intervention. These findings are consistent with established literature that validates CA125 as a biomarker for disease severity^{33,34}. Additionally, the association between rASRM scores and pain underscores the utility of this staging system in clinical decision-making, further advocating for its integration into routine preoperative evaluations³⁵.

The multivariate regression analysis provided deeper insights into the interconnections between various HRQoL dimensions. Notably, improvements in pain were closely linked with better control and powerlessness, as well as enhanced work life, indicating that alleviating physical symptoms can directly influence patients' sense of autonomy and professional engagement. This underscores the necessity for a comprehensive treatment approach that addresses both physical and psychosocial aspects of endometriosis³⁶.

Furthermore, the relationship between emotional well-being and control underscores the importance of psychological interventions. Enhancing patients' sense of control and reducing feelings of powerlessness are crucial for improving emotional outcomes, suggesting that integrating mental health support into endometriosis care could yield significant benefits^{37,38}. The interconnected nature of HRQoL domains, such as the links between emotional well-being, work life, and control, emphasizes the need for a multidisciplinary approach to care that addresses these interdependencies holistically^{39,40}.

Social support emerged as a critical factor influencing self-image and treatment perception, suggesting that strengthening social networks can significantly improve HRQoL outcomes. The close correlation between self-image and supportive relationships further highlights the role of family and community in patient recovery. These findings suggest that future interventions should focus not only on the patient but also on their broader support systems, to foster a more holistic recovery^{41,42}.

The associations between work life and changes in pain, emotional well-being, and relationships with children illustrate the broad impact of endometriosis management. Effective pain relief and emotional support have far-reaching effects beyond symptom control, improving professional and personal life dimensions. This finding underscores the importance of comprehensive pain management strategies within endometriosis care^{43,44}. Moreover, the influence of infertility concerns on sexual health underscores the significant psychological burden these patients face. Addressing reproductive health concerns within the treatment framework is crucial for improving both sexual and emotional well-being^{45,46}.

One of the strengths of this study is the use of the EHP-30 questionnaire, a tool specifically designed for endometriosis patients, enabling a nuanced assessment of how surgery impacts HRQoL. However, this study's limitations include a relatively small sample size and short follow-up period, which may affect the generalizability of the findings. Larger, longitudinal studies are needed to confirm these results and explore the long-term effects of laparoscopic surgery. Additionally, comparative studies of different laparoscopic techniques could identify the most effective strategies for individualized patient care.

In conclusion, laparoscopic surgery significantly improves HRQoL in endometriosis patients by reducing pain and enhancing various aspects of daily life and emotional well-being. This highlights the critical role of surgical intervention as part of a comprehensive treatment plan that also addresses psychological and social dimensions. A multidisciplinary approach, integrating surgical, medical, and psychological support, is essential for optimizing patient outcomes. Future research should focus on refining these strategies and exploring the long-term benefits of such integrated care.

Data availability

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

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Author contributions

Yuyan Guo and Penghui Huang conceived the research. Penghui Huang conducted the data analysis and drafted the initial manuscript. Shunhe Lin contributed to the drafting and revision of the article. Chaobin Liu and Xi Xie collected the medical histories and surgical data. Zhenna Wang, Yi Wang, and Wei Qi were responsible for follow-up and collecting pregnancy-related information. Zhenhong Wang, Jinna Zhang and Shunhe Lin managed the organization and implementation of the project and provided final approval of the version to be published as the corresponding author. All authors reviewed and approved the final manuscript for submission.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics statement

The study protocol was approved by the Research Ethics Committee of Fujian Maternal and Child Health Hospital (Approval No. 2021KRD022). All participants provided written informed consent prior to inclusion in the study, agreeing to the use of their medical records for research purposes.

Additional information

Correspondence and requests for materials should be addressed to S.L.

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