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RESEARCH

The effect of robot-assisted surgery on the gynecology patients' experience and quality of life after surgery

Nalineshwaary Ravichandren[1,2] · Nur Aina Nabilah binti Mohd Faris[1,2] · Tan Ee Ping[2] · Thangeswaran Ayakannu[1,2,3]

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Abstract

Robot-assisted gynecological surgery enhances precision, shortens recovery time, and reduces postoperative complications. However, its impact on patient-reported outcomes and their quality of life remains underexplored. This study evaluates the patient's quality of life following robot-assisted gynecological surgeries, focusing on physical function, pain, vitality, and sexual health. A prospective non-randomized study was conducted, assessing quality of life using validated tools before and at multiple intervals post-surgery using the RAND-36 survey, the Brief Pain Index and the Female Sexual Function Index. Subgroups included patients undergoing robot-assisted hysterectomy, myomectomy, cystectomy or both myomectomy and cystectomy. Significant improvements in quality of life were observed as early as 3 weeks post-surgery, with continued gains at 12 and 24 weeks, where maximum quality of life was achieved. Pain scores decreased from baseline to week 3 and remained consistently low thereafter. Vitality scores returned to baseline within 3 weeks, indicating a faster recovery compared to laparoscopic and traditional open surgeries. Sexual health outcomes initially declined post-surgery but gradually improved over six months. These findings suggest that robot-assisted gynecological surgery enhances long-term quality of life and offers a quicker recovery compared to conventional surgical approaches. However, the non-randomized study design limits the generalizability of the results, underscoring the need for randomized controlled trials to validate these outcomes and further refine patient care strategies.

Key message

Quality of life improved significantly within three weeks after robot-assisted surgery.
Energy recovery faster with robot-assisted surgery than laparoscopic and open.
Myomectomy and cystectomy patients recovered faster than hysterectomy patients.

Keywords Robotic surgery · Gynecology · Hysterectomy · Myomectomy · Patient-reported outcome measure · Quality of life (QoL)

Introduction

Robot-assisted laparoscopic surgery (RALS) has revolutionized the field of surgery, offering a minimally invasive approach that combines precision, flexibility, and enhanced visualization [1]. Use in general surgery, gynecology and urology, has demonstrated its potential to reduce postoperative pain, minimize scarring, and shorten recovery times, when compared to traditional open or laparoscopic methods [2].

Traditional gynecologic surgeries for the removing the cervix, uterus, fallopian tubes, and/or ovaries, whether for benign or malignant conditions, include open laparotomy,

✉ Thangesweran Ayakannu
thangeswerana@sunmed.com.my

1 Clinical Research Centre, Sunway Medical Centre, Bandar Sunway, Subang Jaya 47500, Selangor, Malaysia

2 Obstetrics & Gynecology Centre of Excellence, Sunway Medical Centre, Bandar Sunway, Subang Jaya 47500, Selangor, Malaysia

3 Department of Clinical Medicine and Surgery, Division of Obstetrics & Gynecology, Sunway University, No.5, Jalan Universiti, Bandar Sunway 47500, Selangor, Malaysia

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vaginal hysterectomy, or laparoscopic approaches. Since 2005 robotic-assisted total hysterectomy (RALH) has emerged as a transformative alternative, offering reduced blood loss, hospital stays, and postoperative complications particularly in patients with malignant diagnoses [3, 4].

RALS, is feasible in morbidly obese patients, where laparoscopy is often hindered poor visualization and intolerance to high intra-abdominal pressures [5, 6]. By contrast, RALS provides superior 3D visualization, greater instrument mobility, and tremor filtering, enabling precise, controlled surgeries, even in high-risk patients [5, 7] and offers clear clinical benefits, yet its impact on the gynecological patients' QoL- including physical, emotional, and social well-being, remains underexplored. Beyond outcomes, such as reduced blood loss and shorter hospital stays, further research is needed on postoperative experiences, especially on sexual function. Indeed, sexual health and satisfaction are key contributors to overall QoL [8].

This study examined Quality of Life (QoL) outcomes following RALS in gynecological patients. Patient-reported measures revealed effects on physical function, emotional resilience, general health, and sexual well-being. These findings contribute to a broader understanding of RALS's benefits and may support more informed, patient-centered clinical decision-making in optimized gynecologic care.

Materials and methods

Study population

Women scheduled for robot-assisted gynecological surgery at Sunway Medical Centre (SMC), Selangor, Malaysia between December 2022 and July 2023 were invited to participate in this prospective cohort study. Of 53 women, three declined, and three completed only the pre-surgery questionnaire. All underwent surgery.

Outcomes and data collection

The primary outcome was the assessment of QoL indices using the Short Form Survey SF36 instrument [9], incorporation of the RAND 36 Corporation adjustments [10]. Secondary outcomes included pain evaluation via the Brief Pain Inventory (BPI) [11] and reproductive health status measured by the Female Sexual Function Index (FSFI). Additionally, self-reported patient experiences were collected both pre- and post-operatively [12]. A tertiary outcome was derived by comparing primary and secondary measures across surgical groups – specifically, patients who underwent hysterectomy versus those who received alternative procedures such as myomectomy, cystectomy, or a combination of both. Preoperative patient demographic data and surgical indications, and postoperative activity levels, (expressed as a percentage of the pre-operative activity) level, were also documented.

Tools and single-item questions

QoL was evaluated using the standardized SF36 instrument, developed to describe, and rate respondents' health status [9]. This instrument, increasingly used in gynecologic research [13–15], was scored according to the RAND 36 Health Status guidelines [10]. The RAND36 comprises eight scales: Physical functioning; Role limitations due to physical health; Role limitations due to emotional problems; Emotional well-being; Energy/fatigue; Social functioning; and Pain [9, 15]. Each scale is assessed by single-item questions with up to six response levels or binary yes/no formats. Participants also rated their general health compared to the previous year, on a scale from 1 (much better) to 5 (much worse). Raw scores were converted to the standardized RAND Corporation [10] 0–100 scale, with higher values reflecting better QoL or functioning. For consistency, pain scores were inverted so that higher values indicated greater pain severity or duration. Missing data were excluded, and single-item measures were imputed where necessary. Pain-related findings were corroborated using the Brief Pain Inventory (BPI) [11]. A composite Total RAND36 score was calculated by summing all domain scores and used for subsequent cohort-level analyses.

The BPI questionnaire contains nine questions that combine to provide six indices: Pain other than everyday pain; Where is that pain; How severe is that pain; What treatments have you received for that pain; How much relief did that treatment produce; and in the past 24 h, has that pain interfered with your everyday life? Most questions use a visual analogue score from 0 to 100, where 100 equates to the worst pain imaginable or complete interference with one of seven everyday functions [16].

Sexual function was evaluated using the FSFI scoring instrument, a validated index consisting of 19 questions covering both physical and psychological aspects sexual health [12]. All women were sexually active. Higher scores in domains such as desire, arousal, lubrication, orgasm, and sexual satisfaction, indicated better sexual functioning. Conversely higher scores in pain-related domains indicated poorer sexual function. Each domains was subjected to a correction factor (0.6 for desire; 0.3 for arousal and lubrication; and 0.4 for orgasm, sexual satisfaction, and pain) as indicated [12], before summation. Validated questionnaires in local languages sourced from Musa et al. [17] and Sidi et al. [18].

Procedure and data collection

Fifty women participated and completed the RAND-36, BPI, and FSFI questionnaires preoperatively. Inclusion criteria encompassed women ≥ 18 years old diagnosed with benign or malignant conditions requiring robotic-assisted procedures at Sunway Medical Centre, including total/subtotal hysterectomy (± BSO), modified radical hysterectomy, hysterectomy/BSO/staging, robotic myomectomy, sentinel lymph node biopsy, robotic excision of deep-infiltrating endometriosis or adenomyoma, and robotic cystectomy. Exclusion criteria were recreational drug use, other gynecological cancers, immunosuppressive therapy, analgesic use exceeding three consecutive days pre-/post-surgery, ECOG performance status ≥ 3, or advanced-stage (III/IV) cancer. Baseline data were collected in person on the last weekday before surgery (W0). Follow-up assessments of QoL, BPI, and FSFI were conducted at weeks 1 (W1), 3 (W3), 12 (W12), and 24 (W24) postoperatively via telephone or online questionnaires.

Data analysis and statistical analyses and method

Double data entry was performed, and the two datasets were compared for discrepancies. Potential differences between included women and those not included/excluded were resolved. The data were subjected to normality tests (Shapiro-Wilk normality test and graphical evaluation). No continuous variables were normally distributed. Demographic data were normally distributed and presented as mean ± SD. All questionnaire data did not follow a Gaussian distribution, so reported as median (interquartile ranges). Differences in outcome measures were analyzed using non-parametric one-way ANOVA with Dunn's multiple comparison tests. Analysis of differences between patients who had a hysterectomy and those who did not, were by non-parametric two-way ANOVA with Tukey's multiple comparisons test. Two-sided p-values of < 0.05 was considered statistically significant. Data were analyzed using SPSS version 29·0 (Inc., Chicago, Il, USA) available from the following website (https://www.ibm.com/support/pages/downloading-ibm-spss-statistics-29).

Results

Demographics and clinical characteristics

The study consisted of 50 women (mean age of 43·1 ± 7·39 years; BMI 24·85 ± 4·89 kg/m^2). Of these, 20 underwent hysterectomy (TH) − 19 total and 1 subtotal (Fig. 1). Among TH cases, 10 included bilateral salpingo-oophorectomy (BSO), nine had bilateral salpingectomy (BS) with ovarian conservation, and one underwent BS with right oophorectomy. Additionally, eight TH patients also underwent bilateral pelvic lymph node dissection (BPLND). In the non-hysterectomy group, nine underwent myomectomy, six cystectomies, and 15 received both procedures.

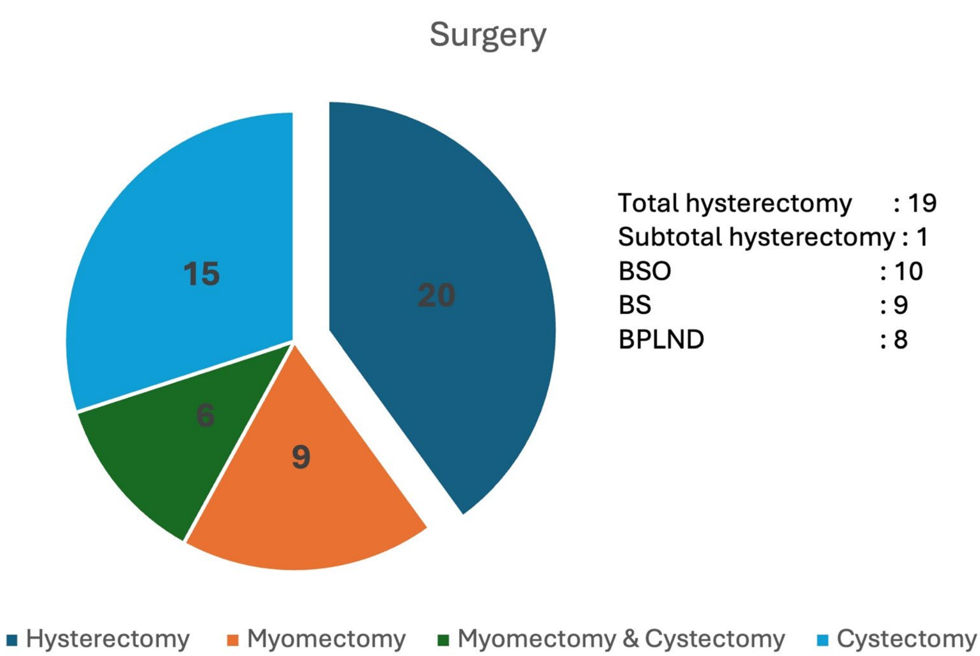

Fig. 1 Surgeries undergone by patients. A total of 50 women underwent robotic surgery for the indicated gynecological conditions. Twenty women had either a total or subtotal hysterectomy, and thirty either had a cystectomy, myomectomy, or a cystectomy and myomectomy. BSO: Bilateral Salpingo-Oophorectomy, BS: Bilateral Salpingectomy, BPLND: Bilateral Pelvic Lymph Node Dissection

Forty-four women were diagnosed with benign conditions (leiomyoma, endometriosis, adenomyoma, ovarian cysts, endometrial polyps, vaginal nodules, adhesions, and/or adenomyosis). Postoperative histopathological analysis indicated one participant, initially suspected of having uterine cancer, had a benign condition. Three women were diagnosed with premalignant conditions: two with cervical intraepithelial neoplasia (CIN) and one endometrial intraepithelial neoplasia (EIN). Additionally, two participants were diagnosed with endometrial cancer, classified as grade 1 and stage 1 A.

Quality of Life, Pain, and sexual function

The response to the second question of the RAND-36 survey, "Compared to one year ago, how would you rate your health in general now?", is shown in Fig. 2A. At W0, the median score was 50(IQR: 25–50). At W1 and W3 the median scores were also 50 in both cases, but the IQR at W1 was larger and at W3 was above the median resulting in a significant ($p<0·05$) increase in general health score at W3 when compared to baseline. Substantial and statistically significant improvements were observed a later time point, being significantly different at W12 and W24 ($p<0·0001$). By W12 and W24, participants consistently reported feeling markedly better compared to one year ago, (median 75(IQR:50–100) indicating the positive long-term impact of surgery on QoL. Total RAND-36 scores (Fig. 2B) indicated that before surgery, the total mean (±SD) score was 490·32±154·72, decreasing to 378·13±138·44 after surgery ($p<0·05$). The score increased at W3 to 441·59±152·36, at W12 (611·94±150·18; $p<0·001$) being maintained at W24 (611·95±151·91; $p<0·0001$).

Detailed analysis of individual RAND-36 scales revealed improvements in various QoL aspects. The physical functioning score (Fig. 3A) decreased after surgery, from 85(IQR:65·42–100) at baseline to 50(IQR:30–80; $p<0·001$) at W1. A significant increase ($p<0·001$) was observed from W1 to W3, to 65(IQR:42·5–85), with continued improvement at W12 (95(IQR:75–100; $p<0·0001$) reaching the highest value of 100 (IQR:85–100; $p<0·0001$) at W24.

The role limitations due to physical health score (Fig. 3B) decreased from 75(IQR:0–100) at baseline to 0 (IQR:0–25; $p<0·01$) at W1 and remained at 0(IQR:0–50) until W3. After W3, the score significantly increased to 100(IQR:100–100; $p<0·0001$) at W12 and remained at this level until W24 (100(IQR:75–100; $p<0·0001$).

Similarly, the role limitations due to emotional problems score (Fig. 3 C) decreased after surgery from 33.33(IQR:0–100) to 0(IQR:0–100;) at W1 but improved over time, reaching 33.33(IQR:0–100) at W3 and 100(IQR:75–100; $p<0·01$) at W12 and remaining at 100(IQR:100–100; $p<0·0001$) at W24.

The participants' energy levels (Fig. 3D) decreased slightly from baseline at 55(IQR:45–70) to 50(IQR:45–65) at W1. However, by W3, the score returned to baseline levels (55(IQR:45–66·26)) and continued to increase to 60(IQR:50–75; $p<0·05$) at W12 and 65(IQR:55–75; $p<0·01$) at W24.

Emotional well-being (Fig. 3E) decreased slightly from a baseline score of 66(IQR:52–76) to 60(IQR:48–72) at

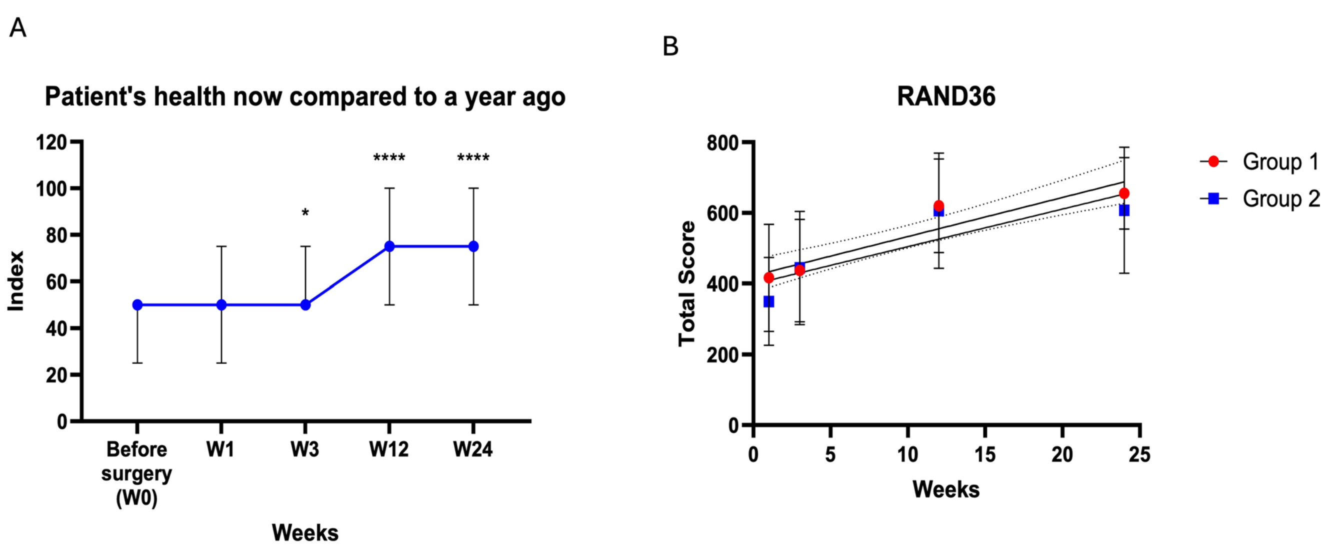

Fig. 2 **A**. The effect of robotic surgery on the patient's quality of life. The data show the patients' indexed responses to the question "How is your health compared to a year ago?" from the RAND36 questionnaire and are presented as the median (dot) ± IQR (bars); *p < 0·05;****p < 0·0001; Kruskal-Wallis one-way ANOVA with Dunn's multiple comparisons test. **B.** The total RAND36 score for subgroups. The two groups consisted of those undergoing ahysterectomy (Group 1) or those having other surgeries, such as myomectomy, cystectomy, or both myomectomy and cystectomy (Group 2).

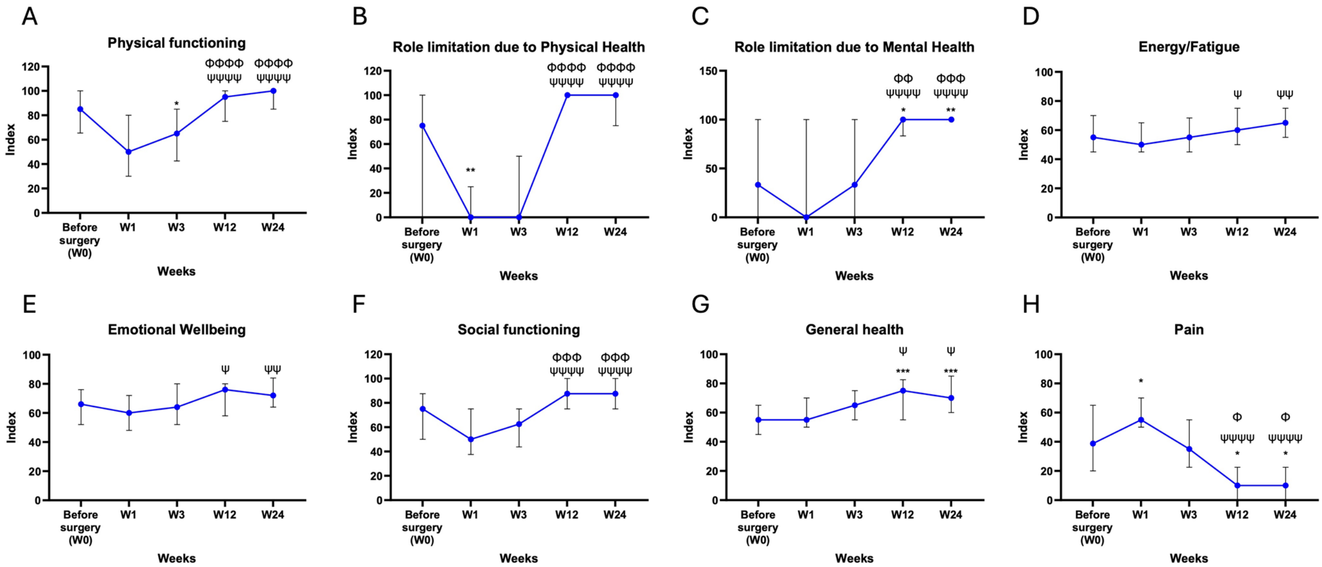

Fig. 3 The effect of robotic surgery on factors affecting the patient's quality of life.Panels **A** to **H** show the calculated indices for the indicated RAND36 Scales. The data are presented as the median (dot) ± IQR (horizontal bars); *p < 0·05; **p < 0·01; ***p < 0·001, compared to before surgery (W0); Ψp < 0·05; ΨΨp < 0·01; ΨΨΨp < 0·001; ΨΨΨΨp < 0·0001, compared to week 1 (W1); Φp < 0·05; ΦΦp < 0·01; ΦΦΦp < 0·001; ΦΦΦΦp < 0·0001, compared to week 3 (W3); Kruskal-Wallis one-way ANOVA with Dunn's multiple comparisons test

W1. The score increased to 64(IQR:52–79) at W3 and to 76(IQR:57–80; $p<0·01$) at W12, before decreasing to 72(IQR:63–84; $p<0·05$) at W24.

The social functioning score (Fig. 3 F) decreased from a baseline score of 75(IQR:50–87.5.5) to 50 (IQR:37·5–75) at W1, increased to 62·5(IQR:40·63–75) at W3, 87·5(IQR:75–100; $p<0·0001$) at W12, being maintained at 87·5(IQR:75–100; $p<0·0001$) at W24.

The participants' general health (Fig. 3G) was unchanged at W1 (55(IQR: 45–65)) when compared to baseline (55(IQR: 45–65)). However, it improved at W3 (65(IQR: 55–75)), reaching 75(IQR:55–80; $p<0·001$) at W12, before decreasing to 70(IQR:60–85; $p<0·001$) at W24.

Pain assessment

Pain levels were analyzed both through the RAND-36 and BPI questionnaires. From the RAND-36 (Fig. 3H), pain increased significantly from baseline to W1, from a score of 38.75(IQR:20–65) to 57·5(IQR:32·5–77·5; $p<0·01$). However, pain levels significantly decreased at W12 ($p<0·0001$) and remained low at W24 ($p<0·0001$), with scores of 10(IQR:0–22·5) at both time points.

Further analysis of pain using the BPI instrument revealed that median pain severity (Fig. 4A) was 1·88(IQR:0·75−3·19) before surgery, which increased slightly to 2(IQR:1–3·5) at W1. The pain severity scores significantly decreased to 1·0(IQR:0·25−2·38; $p<0·01$) at W3 and 0(IQR:0–2·5; $p<0·05$) at W12, where it remained (W24: (IQR:0–2·13; $p<0·05$).

The pain interference score (Fig. 4B) was 0.21(IQR:0–4) at baseline and increased to 2.29(IQR:0·57−4·43) at W1 but significantly decreased to 1(IQR:0·14−2·64) at W3 and to 0·57(IQR:0–1·93) at W12. It further improved to 0·07(IQR:0–1·89) at W24. Significant differences were found between W1 and W24 ($p<0·01$).

Sexual health (Female sexual function Index)

The sexual function of participants over time was assessed using FSFI, which includes six domains (Fig. 5). In addition to these six domains, the total FSFI scores at different time points post-surgery were calculated and analyzed. The mean FSFI score at W0 was 11·88±6·76, which declined to 9·47±5·48 at W1 and further decreased to 8·05±5·29 at W3. By W12, the score showed improvement, reaching 11·58±6·89, and further increased to 12·37±7·64 at W24.

Statistical analysis revealed significant differences in FSFI scores between W0 and W3 ($p<0·05$), indicating a notable decline in sexual function during the early post-surgical period. Similarly, significant differences were observed between W3 and W24 ($p<0·05$), reflecting recovery in sexual function over time.

In the desire domain (Fig. 3 A), the score remained stable over time, with a median value of 4·8 at W0, W1, W12, and W24. At W3, a slight increase in desire was noted, with a score of 5·4(4·2–6). None of differences were statistically significant.

Arousal scores decreased from a median of 2·4(IQR:0–3·30) at W0 to 0(IQR:0–3·38) at W1 and remained there at

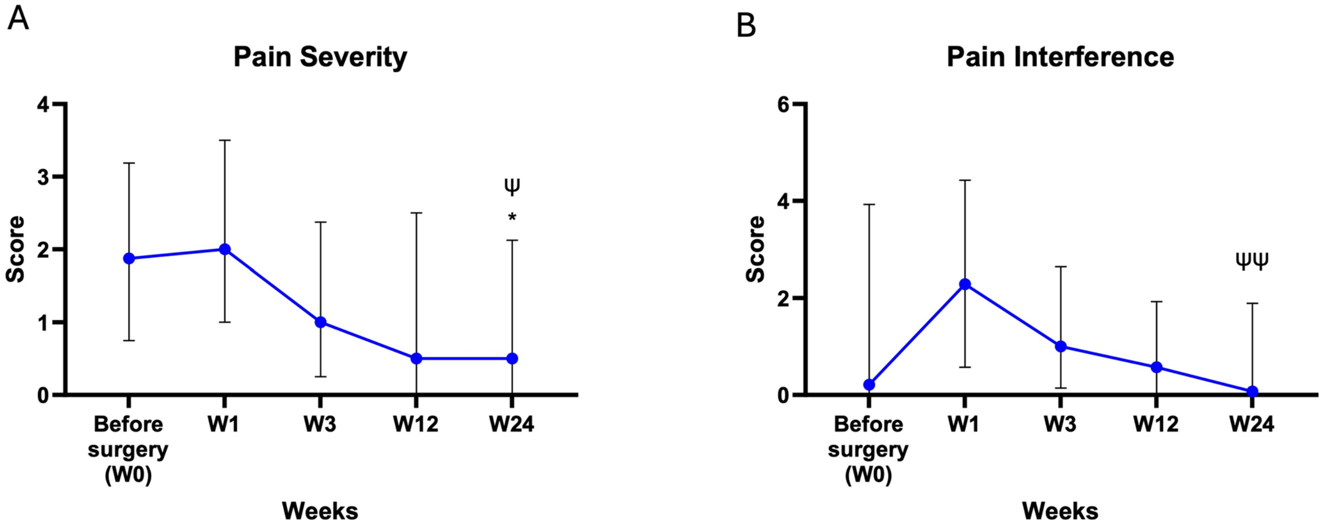

Fig. 4 The effect of robotic surgery on the patient's pain severity and interference.Panel **A** shows the calculated pain severity score as perceived by the patient. Panel **B** shows the degree of patient interference required to negate the pain experienced at the time. The data are presented as the median (dot) ± IQR (horizontal bars); *p < 0·05, compared to before surgery (W0); ΨΨp < 0·01; compared to week 1 (W1); Kruskal-Wallis one-way ANOVA with Dunn's multiple comparisons test

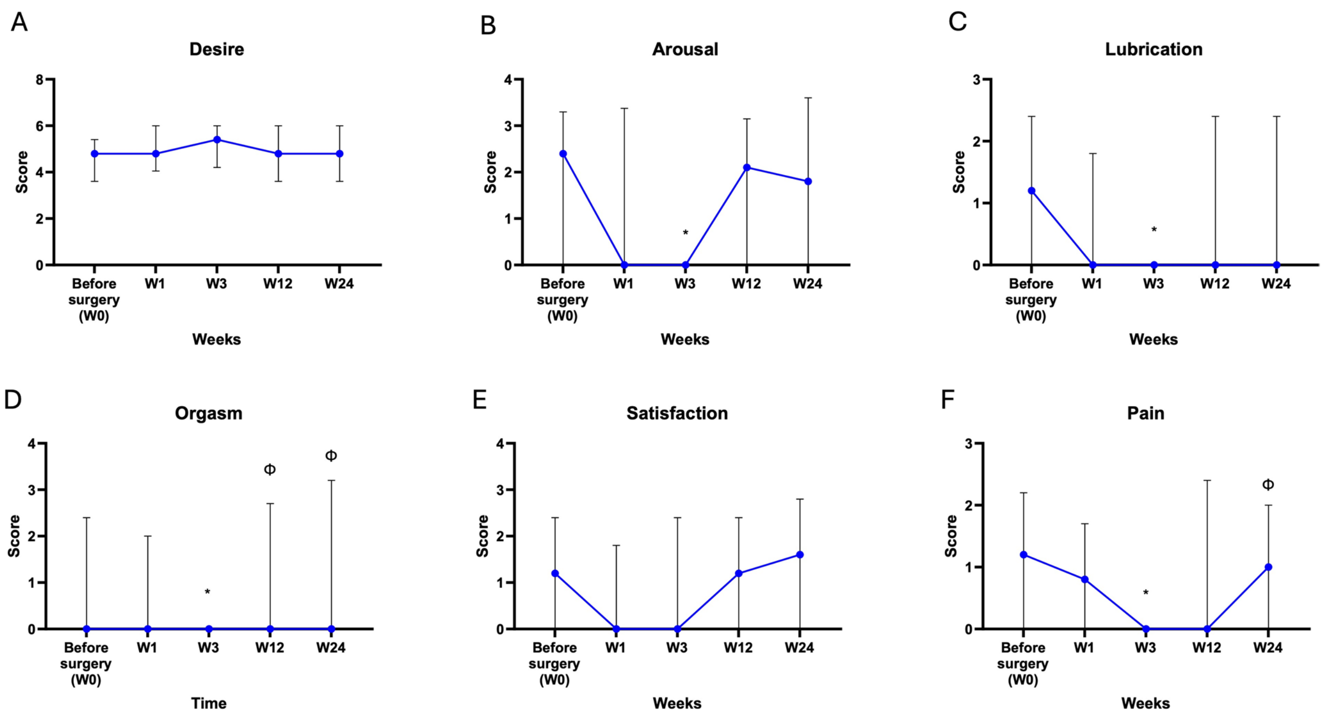

Fig. 5 The effect of robotic surgery on the patient's Female Sexual Function Index. Panels **A** to **F** show the calculated indices for the indicated FSFI domains. The data are presented as the median (dot) ± IQR (horizontal bars); *p < 0·05; **p < 0·01 compared to before surgery (W0); Φp < 0·05 compared to week 3 (W3); Kruskal-Wallis one-way ANOVA with Dunn's multiple comparisons test

W3. The score increased to 2·1(IQR:0–3·15) at W12 and decreased again to 1·8(IQR:0–3·6) at W24. Pairwise comparison revealed a significant difference between W0 and W3 ($p<0·05$).

The lubrication score decreased from 1·2(IQR:0–2·4) at W0 to 0 across all time points, with IQR values of 0–1·8 at W1, 0–0 at W3, 0–2·4 at W1 and W24. Pairwise analysis showed a significant change between W0 and W3 ($p<0·05$).

The orgasm domain remained at the lowest score of 0 throughout the study period, with IQR values of 0–2·4 at W0, 0–2.0 at W1, 0–0 at W3, 0–2·7 at W12, and 0–3·2 at W24. Pairwise comparisons revealed significant differences between W0 and W3 ($p<0·05$), W3 and W12 ($p<0·05$), and W3 and W24 ($p<0·05$).

For the satisfaction domain, the median score was 1·2(IQR: 0–2·4) at W0, which decreased to 0(IQR:0–1·8) at W1 and remained at 0(IQR: 0–2·4) at W3. At W12, the score increased to 1·2(IQR: 0–2·4) and to 1·6 at W24 (IQR: 0–2·8). However, none of these differences were statistically significant.

The pain score decreased from a baseline value of 1·2(IQR:0–2·2) to 0·8(IQR:0–1·7) at W1 and to 0(IQR:0–0; $p<0·05$) at W3. The score remained at 0(IQR:0–2·4) at W12 but increased to 1.0(IQR:0–2·0; $p<0·05$) at W24.

Subgroup analyses

A comparison of outcomes for women who underwent hysterectomy (Group 1) with those who underwent other surgical procedures, including myomectomy, cystectomy, or a combination of myomectomy and cystectomy (Group 2) are summarized in Supplemental Tables 1, 2 and 3.

Both groups reported comparable health status prior to surgery, with a median score of 50(IQR:25–50) for Group 1 and 50(IQR:25–45·25) for Group 2. However, participants in Group 2 demonstrated significantly greater and more consistent improvements in health by W12, achieving a median score of 75(IQR:50–100; $p<0·01$. In contrast, Group 1 required 24 weeks reach a similar improvement level. By W24, both groups achieved the same median score of 75(IQR:50–100), showing significant improvements compared to W0.

Group 1 experienced a decline in physical functioning immediately post-surgery, with a median score decreasing from 87·5(IQR:70–100) to 45(IQR:25–85) at W1. The score reached 50(IQR:25–65) by W3 and exceeded baseline by W12 (90(IQR:60–100)). For Group 2, the physical functioning score also decreased after surgery but recovered faster, achieving the baseline score of 80(IQR:63·75–100) by W3 and improving further to 95(IQR:76·25–100) at W12.

In the domain of role limitations due to physical health, Group 1's median score decreased from 100(IQR:0–100) at baseline to 0 at W1 (IQR:0–50) and W3 (IQR:0–25) and increased to 100 (IQR:100–100) by W12. Group 2 started with a lower baseline score of 75(IQR:0–100), which decreased further to 0(IQR:0–25) at W1. Unlike Group 1, Group 2 showed a gradual recovery from W3, from 0(IQR:0–25) to 25(IQR:0–93·75).

Before surgery, Group 2 had a slightly higher median pain score of 38·75(IQR:20–66·63) compared to G1's score of 37·5(IQR:13·13–64·38). At W1, pain scores increased in both groups, with Group 2 exhibiting a lower median pain score of 52.5(IQR:22·5–67·5) compared to 60(IQR:55–75) in Group 1. Both groups showed continuous improvement after W1. Group 2 reached a median pain score of 10(IQR: 0–22·5) by W12, whereas G1 achieved a similar score by W24(IQR: 0–7·5).

Group 1 reported better general health before surgery, with a median score of 62·5(IQR:51·25–77·5) compared to 50(IQR:40–65) in Group 2. For Group 1, general health scores decreased at W1 but improved consistently until W12. For Group 2, general health scores did not decrease post-surgery and continued to improve steadily. By W12 and W24, both groups achieved the same median score of 75(IQR:50–100). Further analyses indicated no statistically significant differences in FSFI.

Discussion

This study found significant time-dependent quality of life (QoL) improvements in RAL patients, with noticeable benefits appearing as early as three weeks after surgery (Fig. 2A), consistent with positive outcomes from minimally invasive surgeries and much earlier than previously reported [3, 13–15, 19–22].

While perceived health remained unchanged between baseline and 1–3 weeks post-surgery, substantial improvements emerged by 12 and 24 weeks, remaining stable during these later time points. This suggests that while immediate post-surgical recovery may not drastically change subjective health perceptions, significant long-term benefits become evident as recovery progresses. This aligns with the 2016 study by Herling et al. [3], who reported that QoL exceeded baseline by 6 weeks postoperative of RALS. The delayed improvements in this study reflect differences in patient populations as factors like co-morbidities can influence recovery despite RALS reduced surgical trauma compared to open approaches [23].

Our observations revealed a temporary decline in total RAND-36 scores immediately after surgery, reflecting the expected short-term impact of surgery on QoL. Recovery began by 3 weeks, with significant improvements noted at 12 and 24 weeks. These findings align with those of Kornblith et al. [24] that QoL and body image returning to baseline by three weeks and exceeding baseline levels at six weeks [24].

Similarly, our observations mirror the QoL improvement patterns observed by Kluivers et al. (2011) with scores plateauing at later stages[14], indicating sustained QoL in both robotic and laparoscopic procedures. Interestingly, we also found parallel QoL trends across patient cohorts, consistent with the 2007 study by Kluivers et al. [13] as both hysterectomy and other procedure groups (e.g., myomectomy, cystectomy) exhibited similar trends, and comparable scores by

12 weeks, suggesting consistently high QoL improvements regardless of the surgical procedure or speed of recovery.

The stable improvements observed at later time points (W12 and W24) suggest that RALS offers outcomes comparable to, if not superior to, traditional laparoscopy, while mitigating the prolonged recovery often perceived from open surgery. These findings show the importance of providing patients with evidence-based information on recovery patterns and the long-term benefits of RALS.

The vitality scale, which measures fatigue and energy depletion, is particularly relevant given the prevalence of chronic and debilitating fatigue, over pain following hysterectomy [25], as it can significantly impair QoL. Various global and specific self-assessment tools have been developed to evaluate fatigue and QoL in postoperative gynecologic surgery patients [25]. Kluivers et al. [13] reported that vitality scores returned to baseline at approximately 4 weeks after laparoscopic hysterectomy (LH), and around 8 weeks for abdominal hysterectomy (AH). In our study, energy/fatigue (vitality) scores recovered more quickly, reaching baseline by 3 weeks post-surgery (Fig. 3D), suggesting a faster recovery of energy levels in our cohort when compared to both LH and AH procedures [13].

For patients undergoing hysterectomy (Group 1), vitality scores remained stable at 55 from W0 to W1, followed by a slight, non-significant increase to 65 at W3, W12, and W24 (Table 1). Despite the lack of statistical significance, these scores exceeded those reported for AH and LH in previous studies [13], suggesting that robot-assisted laparoscopic hysterectomy (RALH) may offer better vitality during recovery.

Improvement in daily physical functioning is a key outcome of surgical interventions [26]. Both the study by Yurtkal and Canday 15] and ours demonstrate enhancements in physical functioning; though with different follow-up periods. While their study assed outcomes at a single time point (6 months post-surgery), our study tracked over multiple time points, providing a more detailed view of the early recovery process. Despite difference in timelines and recovery patterns, both studies consistently revealed physical functioning improvements regardless of the surgical technique employed, emphasizing the importance of regular follow-ups for better patient and clinician insights.

Pain, being a critical factor influencing physical function, was analyzed in this study using the RAND-36 and BPI pain tools. Both revealed significant pain reduction over time, underscoring the essential role of pain management in promoting postoperative recovery. As expected, pain levels were initially high during the acute postoperative phase. However, a significant reduction in pain intensity and amount of pain interference was observed, with stabilization at low levels by week 12 that continued through to week 24. This pattern highlights how surgical techniques, such as RALS, which minimize port site trauma, can promote smoother recovery. The constant pain decrease aligns with improved physical function, supporting the role of effective pain management in enhancing rehabilitation, mobility, and overall QoL.

Clinically, the integration of advanced surgical techniques and comprehensive pain management is crucial for optimizing recovery. By reducing both pain severity and its interference on daily activities, patients more easily resume normal physical functioning, reinforcing the interconnectedness of surgical innovation, effective pain control, and postoperative rehabilitation [27].

Recent comparative analyses have evaluated other minimally invasive approaches such as vaginal natural orifice transluminal endoscopic surgery (vNOTES) and conventional laparoscopy. Bulutlar et al. demonstrated that vNOTES hysterectomy offers comparable intraoperative outcomes and faster postoperative recovery compared with laparoscopic hysterectomy, with lower postoperative pain and shorter hospital stays [34]. Similarly, optimization of vNOTES techniques, such as the GelPoint and glove port methods, has improved ergonomics and reduced perioperative complications [35]. When viewed in this context, the early and sustained QoL recovery observed in our robotic cohort suggests that RALS delivers patient-centered benefits similar to, or potentially complementary with, these evolving minimally invasive methods. However, direct comparative trials are required to confirm relative advantages among RALS, vNOTES, and laparoscopic approaches.

Our study demonstrated an initial decline in FSFI scores after RALH, followed by recovery within 6 months. Similarly, a study published in the *Journal of Personalized Medicine* [15] reported significant FSFI improvements six months following various surgical techniques, including total abdominal hysterectomy (TAH), laparoscopic hysterectomy (TLH), vaginal hysterectomy (VH), and a modified vaginal technique, VH Mujas. However, their study lacked interim recovery data, stressing the unique contribution of our study in providing a more detailed, time-based assessment of sexual function.

The World Health Organization (WHO) defines sexual health as a state of physical, emotional, mental, and social health related to sexuality [28]. The paper 'Scoring and Interpretation of the FSFI: What Can Be Learned From 20 Years of Use? ' [29], emphasizes, that although the FSFI has been widely accepted, further validation studies are necessary, particularly linguistic and cultural adaptations, to improve the tool's applicability across diverse populations. This is especially relevant in cultures where discussing sexual health is less common or taboo [29], such as in many Asian communities, where conservative attitudes and religious beliefs often influence such conversations [30]. As a result, conducting research on sexuality in Malaysia presents significant challenges, both culturally and methodologically.

The FSFI Desire domain, which assesses motivation for sexual activity [31], is the only one of six domains usable independently [29]. In our study, Desire scores showed slight, non-significant fluctuations over 24 weeks, indicating stable sexual desire. This stability may reflect cultural factors, where external influences on sexual motivation are less pronounced or shaped by cultural sensitivities affecting the expression and measurement of sexual desire.

The FSFI Arousal domain represents cognitive arousal, capturing a woman's mental experience of sexual stimulation [29]. In our study, Arousal mirrored emotional wellbeing - initially declining post-surgery, then gradually improving. This suggests emotional resilience during recovery may influence both sexual motivation and mental arousal.

The psychological adjustments often following surgery, such as stress, anxiety, or changes in self-perception, emphasize the importance of addressing emotional well-being in postoperative care. Supporting emotional health may aid recovery in cognitive arousal and overall sexual function, highlighting the interconnected relationship between psychological and sexual health in robotic surgery outcomes.

The FSFI Lubrication domain, which reflects genital arousal [29], showed a significant decrease post-surgery, with scores remaining low throughout the study. This early decline may stem from surgical trauma or psychological factors. Although some improvement was observed later, the persistent reduction suggests the need for targeted interventions, such as lubricants or moisturizers, to support sexual function during recovery.

The FSFI Satisfaction domain that reflects sexual wellbeing [32], declined after surgery and stayed low in early recovery, with minor later improvements. These changes were not statistically significant, indicating surgery had limited impact on sexual satisfaction.

Our findings of transient postoperative declines in FSFI scores followed by recovery at six months align with previous reports. Uluutku Bulutlar et al. [33] showed that surgical technique, particularly the method of vaginal cuff closure, can significantly influence postoperative sexual comfort and arousal. The anchorflow suture technique was associated with reduced vaginal apex tension and improved FSFI scores compared to continuous suturing [33]. In our cohort, gradual improvement in FSFI domains, especially in pain and orgasm, may reflect similar mechanisms—reduced pelvic floor tension and improved tissue healing associated with the precision of robotic suturing. This supports the notion that surgical refinement and meticulous cuff reconstruction contribute substantially to postoperative sexual health recovery.

In 2021, Chen et al. investigated acute postoperative pain following laparoscopic-assisted vaginal hysterectomy (LAVH), laparoscopic myomectomy (LM), and laparoscopic adnexectomy (LA) [34] and found higher pain severity and incidence in the LAVH group compared to the LM and LA groups, highlighting the importance of considering surgery type when planning postoperative pain management strategies.

Beyond comparing RALH with other hysterectomy types, our subgroup analyses evaluated how different surgical procedures on affect recovery and QoL. We compared hysterectomy (Group 1) with other procedures such as myomectomy, cystectomy, or a combination of these (Group 2). These comparisons highlight variations in recovery patterns, offering insights to enhance post-surgical care.

Our results revealed distinct recovery patterns, with Group 2 improving faster in several domains than Group 1. The pain domain reflects this, aligning with Chen et al.'s [34] report of higher postoperative pain reported in hysterectomy patients. Group 2's greater preoperative pain may explain their postoperative relief, contributing to reduced pain perception and better overall health, physical functioning, and QoL.

While our results demonstrate marked postoperative QoL improvements following RALS, the absence of a control or comparator group limits the ability to draw causal or quantitative comparisons with other surgical modalities [35, 36]. Therefore, these findings should be interpreted as temporal improvements within this specific cohort rather than as evidence of superiority over laparoscopic or open approaches.

This study has several limitations. First, the non-randomized design introduces potential selection bias and limits causal inference. Patients undergoing robotic surgery may differ in baseline characteristics, motivation, or access to care compared with those receiving laparoscopic or open procedures. Second, the absence of a contemporaneous control group restricts our ability to attribute observed QoL improvements solely to the robotic technique. Third, while validated patient-reported outcome measures were employed, self-reported data may be influenced by recall bias and sociocultural factors, especially regarding sexual health. These limitations underscore the need for future randomized controlled trials incorporating comparator arms and longer follow-up periods.

Conclusion

In conclusion, our study demonstrates significant QoL benefits of RALS in gynecology, with improvements in physical function, pain reduction, and vitality evident as early as three weeks postoperatively. A key strength of this study was the frequent assessment timeline, providing detailed insights of recovery patterns, with subgroup analyses (RALH, myomectomy, cystectomy) confirming consistent outcomes across procedures, supporting generalizability. Limitations include the non-randomized design and lack of a comparator group, furthermore, this study does not needing a comparator group: such as the patients at time 0 acted as their own baseline comparator for the questionnaire. Future randomized trials with larger, more diverse cohorts are needed to validate and refine these findings. Although RALS appears to offer sustained QoL benefits, randomized comparative studies are required to confirm whether these improvements exceed those seen with other minimally invasive or open surgical techniques.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no conflict of interest related to this study.

Ethics approval Written informed consent was obtained from each patient, and ethical approval was granted by the Sunway Medical Centre Independent Research Ethics Committee (SREC)(018/2022/IND/ER).

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