REVIEW ARTICLE

Comparative analysis of robotic-assisted laparoscopic myomectomy versus traditional abdominal and laparoscopic myomectomy: A meta-analysis and systematic review

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Abstract

Uterine fibroids are the most common benign tumors affecting women of reproductive age, often requiring surgical intervention. This meta-analysis and systematic review compared the effectiveness, safety, and cost of three surgical approaches: robotic-assisted laparoscopic myomectomy (RLM), traditional abdominal myomectomy (AM), and laparoscopic myomectomy (LM). Following PRISMA guidelines, we systematically searched PubMed, EMBASE, and Google Scholar databases for studies published through January 2024, with no restrictions on publication date. Fifteen studies were included in the qualitative synthesis, and nine studies in the meta-analysis, comprising 2,559 patients. Our findings revealed that AM had significantly shorter operative time compared to RLM (mean difference: 82.54 minutes; 95% CI: -122.14, -42.93; $P < 0.00001$; $I^2 = 94\%$). However, RLM was associated with significantly shorter hospital stays than AM (mean difference: 1.54 days; 95% CI: 1.31 to 1.77; $P \leq 0.00001$; $I^2=58\%$). No significant differences were found in operative time (mean difference: 36.47 minutes; 95% CI: -11.58, 84.51; $P = 0.14$) or blood loss between RLM and LM. Intraoperative bleeding (EBL >1000 mL) was most common in AM (7.0%) compared to RLM (1.3%) and LM (2.6%). Postoperative transfusion rates were highest in AM (20%), followed by LM (5.8%) and RLM (3.8%). The study demonstrated substantial heterogeneity ($I^2 > 75\%$ for most outcomes), attributed to differences in patient characteristics and study designs. In conclusion, RLM provides favorable outcomes with shorter hospital stays and fewer complications compared to AM, while showing comparable results to LM, though at potentially higher cost. *(Afr J Reprod Health 2025; 29 [12]: 230-246)*

Keywords: Laparoscopes; Meta-analysis; Myomectomy; Robotic-assisted; Uterine fibroids

Résumé

Les fibromes utérins sont les tumeurs bénignes les plus fréquentes chez les femmes en âge de procréer et nécessitent souvent une intervention chirurgicale. Cette méta-analyse et revue systématique compare l'efficacité, la sécurité et le coût de trois approches chirurgicales : la myomectomie laparoscopique robot-assistée (MLR), la myomectomie abdominale traditionnelle (MAT) et la myomectomie laparoscopique (ML). Conformément aux recommandations PRISMA, nous avons effectué une recherche systématique dans les bases de données PubMed, EMBASE et Google Scholar pour les études publiées jusqu'en janvier 2024, sans restriction de date de publication. Quinze études ont été incluses dans la synthèse qualitative et neuf dans la méta-analyse, portant sur 2 559 patientes. Nos résultats ont révélé que la MAT présentait une durée opératoire significativement plus courte que la MLR (différence moyenne : 82,54 minutes ; IC à 95 % : -122,14, -42,93 ; $p < 0{,}00001$; $I^2 = 94$ %). Cependant, la RLM était associée à des durées d'hospitalisation significativement plus courtes que l'AM (différence moyenne : 1,54 jour ; IC à 95 % : 1,31 à 1,77 ; $p \leq 0{,}00001$; $I^2 = 58$ %). Aucune différence significative n'a été observée concernant la durée opératoire (différence moyenne : 36,47 minutes ; IC à 95 % : -11,58 à 84,51 ; $p = 0{,}14$) ni les pertes sanguines entre la RLM et la LM. Les saignements peropératoires (pertes sanguines estimées > 1 000 mL) étaient plus fréquents dans le groupe AM (7,0 %) que dans les groupes RLM (1,3 %) et LM (2,6 %). Les taux de transfusion postopératoire étaient les plus élevés dans le groupe AM (20 %), suivis des groupes LM (5,8 %) et RLM (3,8 %). L'étude a mis en évidence une hétérogénéité importante ($I^2 > 75$ % pour la plupart des critères d'évaluation), attribuable aux différences de caractéristiques des patients et de méthodologie. En conclusion, la technique RLM offre des résultats favorables, avec une durée d'hospitalisation plus courte et moins de complications, comparativement à la technique AM, tout en présentant des résultats comparables à ceux de la technique LM, malgré un coût potentiellement plus élevé. *(Afr J Reprod Health 2025; 29 [12]: 230-246).*

Mots-clés: Laparoscopes ; Méta-analyse ; Myomectomie ; Chirurgie robotique ; Fibromes utérins

Introduction

The most frequently occurring benign tumors in women in their reproductive years are leiomyomas, also known as uterine fibroids.[1] Leiomyomas are benign, monoclonal smooth muscle tumors of the myometrium.[2] According to imaging modalities, about 70% of White women and 80% of African-American women will get uterine myomas by the time they are in their late 40s.[3] In addition, Uterine myomas have been linked to considerable symptoms and morbidity, including infertility, pelvic pain, irregular uterine bleeding, and problems with the bowels or urinary system.[2]

However, when leiomyomata are symptomatic, surgery is required.[4] Even though hysterectomy is an effective therapy for leiomyomas, many women seek alternatives to preserve their uterus or maintain their potential fertility. A conservative surgical option for women with symptomatic uterine fibroid is a myomectomy. Hence, laparotomy has traditionally been the preferred surgical method for removing uterine leiomyoma because the purpose of a myomectomy surgery is to reconstruct the uterine wall and remove the leiomyomata that are visible and reachable; however, patients and doctors are starting to favor less invasive surgical methods.[5,4] *Conventional* laparoscopic myomectomy (CLM), robotic-assisted laparoscopic myomectomy (RLM), and abdominal myomectomy (AM) are the three most popular surgical techniques for myomectomy. Shorter lengths of stay (LOS), fewer complications, better cosmesis, and less blood loss have all been linked to CLM in contrast to AM; nonetheless, longer procedure times are present. Additionally, RLM has benefits similar to those of CLM, but it also requires more operating time and money to operate.[6] Furthermore, the site, quantity, and size of the fibroids as well as the surgical team's knowledge and expertise, will determine which surgical approach is the best.[1]

Based on these considerations, the present study aims to compare the effectiveness, safety, and cost of three surgical approaches for treating uterine fibroids: robotic-assisted laparoscopic myomectomy (RLM), traditional abdominal myomectomy (AM), and laparoscopic myomectomy (LM). Through our evaluation of these three methods, we intend to offer a thorough breakdown of each one's benefits and drawbacks regarding surgical results. This research also aims to evaluate the impact of uterine fibroid surgery on significant patient-centered outcomes, including overall quality of life, pregnancy, and fertility. Our purpose is to analyze the current literature on these subjects to offer insightful analysis that can guide clinical judgment and enhance patient care.

Despite the increasing adoption of RLM in clinical practice, significant gaps remain in the existing literature. While several studies have compared these surgical approaches, there is considerable heterogeneity in reported outcomes, limited data on long-term fertility outcomes, and insufficient evidence regarding cost-effectiveness across different healthcare settings. Furthermore, most available studies are retrospective in nature, and there is a lack of high-quality randomized controlled trials comparing all three approaches simultaneously. These gaps underscore the need for comprehensive systematic reviews and meta-analyses to synthesize the available evidence and provide clearer guidance for clinical decision-making.

Methods

Registration

This comprehensive evaluation adhered to the criteria specified by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[7] and utilized Cochrane review methodologies. The study protocol was proactively recorded in the National Institute of Health Research's Prospective Register of Systematic Reviews, PROSPERO,[8] (CRD42024503832).

Search strategies

A literature search from database inception through January 2024MeSH) terms, free text, and Boolean logic operators, following discussions with the senior authors. The selected keywords included: "(Robotic-Assisted Laparoscopic Myomectomy AND Abdominal Myomectomy AND Laparoscopic Myomectomy) OR (Surgical Outcomes of Myomectomy AND RLM vs AM vs LM AND Operative Outcomes in Myomectomy)".

Furthermore, a meticulous screening of the references within the included articles was performed to ensure their relevancy to the research topic.

Screening and selection of studies

After the database search, study data were collected and organized in an Excel worksheet. The screening of titles and abstracts to identify relevant articles was performed using the Rayyan software.[9] by one independent researcher (MZ). In cases of any inconsistencies, the paper underwent a comprehensive full-text assessment. Subsequently, the full texts of the shortlisted studies were subjected to an eligibility screening by the Same Author. Any discrepancies were resolved through collaborative discussions, and the final decision on inclusion or exclusion was made after consultation by four independent researchers (RH, MS, RZ, and MZ).

A standardized extraction template was employed to extract relevant data from the full-text articles. The extracted data encompassed key aspects such as study design, sample size, patient characteristics, intervention details, and reported outcomes. Any arising disparities were addressed through consensus among the researchers or referred to the lead researcher (MZ) for resolution.
The following data were extracted from each study: first author; year of publication; study design; sample size; BMI; other Demographic Information; Number of Leiomyomata; Tumor Size; Total Operative time; Amount of Blood Loss; Hospital Length of Stay; Location of Myoma in the Uterus; surgical Outcome; reported complication.

The primary outcome of this systematic review was to compare the effectiveness, safety, and cost of robotic-assisted laparoscopic myomectomy (RLM), traditional abdominal myomectomy (AM), and laparoscopic myomectomy (LM) for treating uterine fibroids. Through a rigorous examination of the selected studies, we assessed the effectiveness of surgical interventions for treating uterine fibroids, focusing on myomectomy. As a secondary outcome, we aimed to assess the impact of uterine fibroid surgery on fertility, pregnancy, and quality of life outcomes.

Study design and criteria

This systematic review design focused on all primary human studies assessing the Surgical approaches for treating uterine fibroids. The inclusion and exclusion criteria were as follows.
We included these studies involving women of reproductive age undergoing myomectomy, as well as studies comparing robot-assisted laparoscopic myomectomy (RLM) with abdominal myomectomy (AM) and/or laparoscopic myomectomy (LM). We also included studies that reported on specified outcomes such as estimated blood loss (EBL), length of hospital stays (LOHS), and complications. Additionally, we only included studies that were published in the English Language with no restrictions on publication date to ensure comprehensive data collection for our analysis.

Exclusion criteria were implemented to ensure the reliability and validity of our findings. Studies that did not compare robotic-assisted laparoscopic hysterectomy with either abdominal or laparoscopic hysterectomy were excluded. Additionally, case reports, editorials, letters, and conference abstracts without detailed data were not included in this analysis. Studies that did not report on the specified outcomes, were written in a language other than English, or had incomplete data or unclear methodologies were also excluded from our study sample. By implementing these exclusion criteria, we aimed to focus on high-quality, relevant studies that could provide valuable insights into the comparative effectiveness of different myomectomy techniques.

Risk of bias and quality assessment

The quality assessment of the included studies was performed using the Methodological Index for Non-Randomized Studies (MINORS).[10] The MINORS is a validated tool for assessing the methodological quality of non-randomized studies, including cohort, case-control, and comparative observational studies. It consists of 12 items for non-comparative studies and 8 items for comparative studies, each scored on a 0-2 scale, with a maximum score of 16 for non-comparative studies and 24 for comparative studies. Two authors independently (MZ, RZ) assessed the quality of the included studies using the MINORS tool, with disagreements resolved through discussion or consultation with a third author.

Data synthesis

As the included studies exhibited substantial clinical homogeneity in their design, interventions, and outcome measures, conducting a quantitative meta-analysis was feasible. Therefore, the findings were synthesized to provide a quantitative analysis of the data. The synthesis allowed for a comprehensive and descriptive exploration of the diverse Surgical approaches for Myomectomy in uterine fibroid patients. Each study's individual characteristics, findings, and limitations were carefully considered, and the results were presented in a coherent and interpretive manner.

Analysis

Researchers performed the meta-analysis using Review Manager (RevMan) software (version 5.4, The Cochrane Collaboration, 2020). We calculated the risk ratio (RR) with 95% confidence intervals (CI) for dichotomous outcomes using the Mantel-Haenszel method. We used the mean difference (MD) with 95% CI for continuous outcomes. The heterogeneity was assessed among the included studies using the I^2 statistic and Chi-square test. We considered an I^2 value greater than 50% indicative of substantial heterogeneity. In substantial heterogeneity, we applied a random-effects model for the meta-analysis; otherwise, we used a fixed-effects model. For all statistical analyses, we considered a P-value less than 0.05 as statistically significant.

Results

Study selection

The literature search was conducted using three electronic databases: PubMed, EMBASE, and Google Scholar. The initial search yielded a total of 393 studies (PubMed: 102, EMBASE: 91, Google Scholar: 200). After removing three duplicates, 192 studies were screened for eligibility. Two independent reviewers assessed the titles and abstracts of the remaining 192 studies against the predefined inclusion and exclusion criteria. Any reviewer disagreements were resolved through discussion or consulting a third reviewer. After this initial screening, 146 studies were excluded, leaving 46 studies for full-text review. The two reviewers independently evaluated the full-text articles of the remaining 46 studies. Studies that did not meet the inclusion criteria were excluded, with reasons for exclusion recorded. Any reviewer discrepancies were resolved through consensus or by involving a third reviewer. Finally, 15 studies were included in the qualitative synthesis [1-15], and nine studies were included in the meta-analysis. The study selection process was documented using a PRISMA flow diagram, which illustrates the number of studies identified, screened, eligible, and included in the systematic review and meta-analysis. (Figure 1)

Characteristics of the included studies

The systematic review included 15 studies comparing robotic-assisted laparoscopic myomectomy to traditional abdominal and laparoscopic myomectomy. The publication years they were ranged from 2009 to 2022. The included studies consisted of 13 retrospective studies (86.7%), one case-control study (6.7%), and one comparative cohort study (6.7%). The studies were conducted in various countries, with ten studies (66.7%) from the United States, two studies (13.3%) from Turkey, one study (6.7%) from China, one study (6.7%) from Mexico, and one study (6.7%) from the Middle East (Table 1).

Patient's characteristics

The study included 2,559 patients across three different surgical approaches to myomectomy. Specifically, the distribution of patients was as follows: 1334 patients underwent AM, 531 patients underwent RALM, and 627 patients underwent LM. Across all three groups, the overall weighted mean age was 35.37 years with a pooled standard deviation of 5.34 years (33.5 – 43 years). Overall, the weighted mean BMI was 24.12 kg/m², with a pooled standard deviation of 3.69 kg/m² and a range of 20.39 to 31.0 kg/m². Overall, the weighted mean for the number of leiomyomas was 6.87, with a

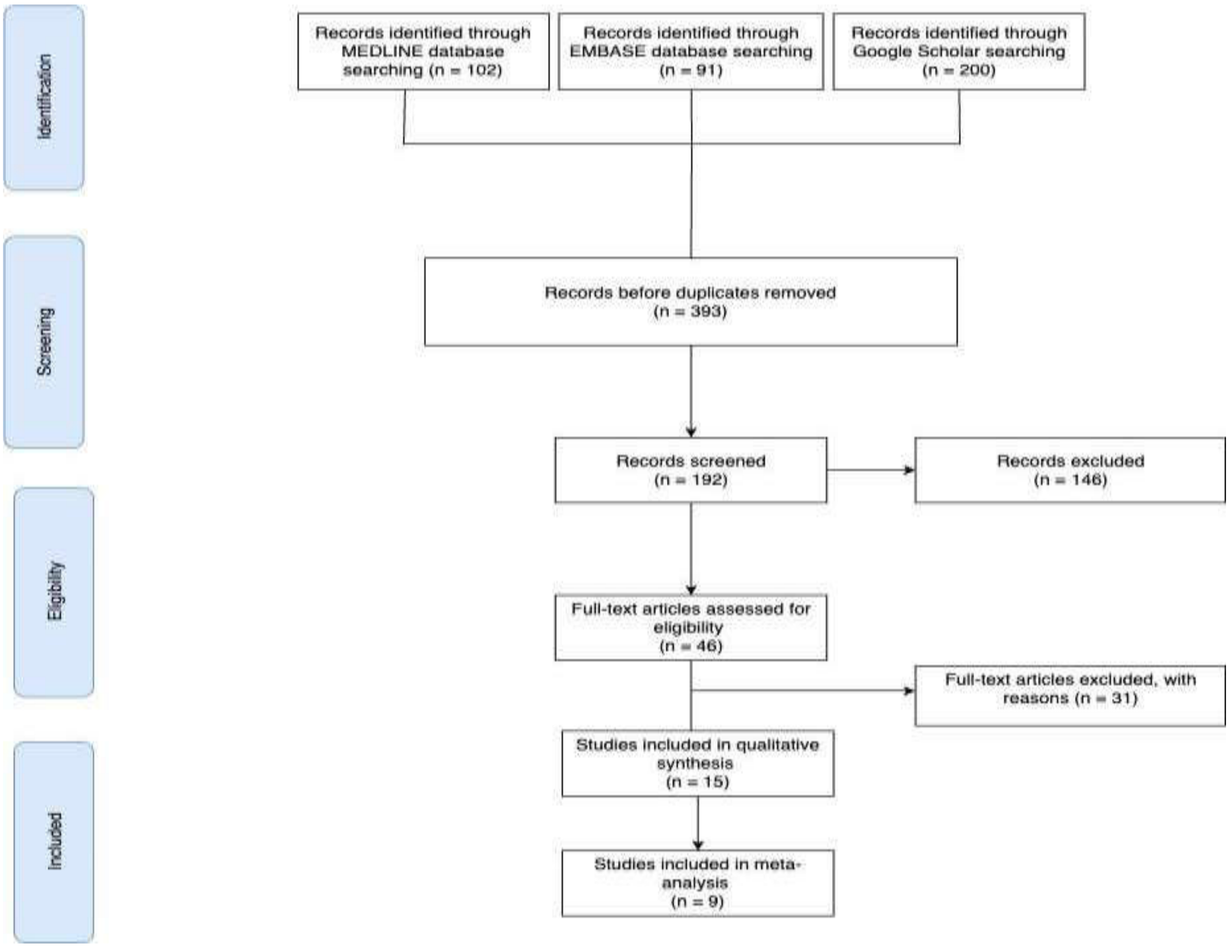

Figure 1: PRISMA flow diagram of the study selection process

pooled standard deviation of 3.10 and a range of 1.68 to 9.1. The AM group had a weighted mean tumor size of 101.74 mm, with a pooled standard deviation of 143.37 mm and a range of 53 to 321.16 mm. The weighted mean tumor size in the Robotic-Assisted Laparoscopic Myomectomy group was 92.76 mm, with a pooled standard deviation of 122.16 mm and a range of 6.8 to 331.54 mm. The Laparoscopic Myomectomy group had a weighted mean tumor size of 65.80 mm, a pooled standard deviation of 40.67 mm, and a range of 6.5 to 81.3 mm. Overall, the weighted mean tumor size was 88.40 mm, with a pooled standard deviation of 36.30 mm and a range of 6.5 to 331.54 mm.

Outcomes

The AM group had a significantly shorter operative time than robotic-assisted laparoscopic myomectomy (mean difference: 82.54 minutes; 95% CI: -122.14, -42.93; $P < 0.00001$; $I^2 = 94\%$). There was no significant difference in operative time between robotic-assisted and traditional laparoscopic myomectomy, although the laparoscopic approach trended towards being shorter (mean difference: 36.47 minutes; 95% CI: -11.58, 84.51; $P = 0.14$; $I^2 = 97\%$). Robotic-assisted laparoscopic myomectomy was associated with less blood loss compared to AM, but this difference was not statistically significant (mean difference: 93.63 mL; 95% CI: -16.41, 203.66; $P = 0.10$; $I^2 = 98\%$). Similarly, there was no significant difference in blood loss between robotic-assisted and traditional laparoscopic myomectomy (mean difference: 46.07 mL; 95% CI: -94.48 to 2.34; $P=0.06$; $I^2=78\%$). Robotic-assisted laparoscopic myomectomy was associated with significantly shorter hospital stays than traditional laparoscopic myomectomy (mean

Table 1: Basic demographics of included studies

Study	Year	Country	Study Design	Total N	Abdominal Myomectomy	Robotic Myomectomy	Laparoscopic Myomectomy	Age (Years)*	BMI (kg/m2)*	Number of Myomas*
Godoy Morales [1]	2022	Mexico	Retrospective	48	N=24	-	N=24	35.2 ± 4.2	24.6 ± 3.3	2.6 ± 1.7
Luo [2]	2020	China	Retrospective	58	-	N=15, 36.8 ± 6.8	N=43, 35.4 ± 5.8	-	26.3 ± 5.3 (RA), 27.4 ± 6.6 (LAP)	3.7 ± 2.2 (RA), 2.9 ± 1.2 (LAP)
MacKoul [3]	2019	United States	Retrospective	1150	N=686, 37.4 ± 5.6	N=156, 36.5 ± 5.7	N=308, 37.3 ± 5.7	-	29.1 ± 6.7 (AM), 28.6 ± 7.7 (RA), 28.0 ± 6.5 (LAP)	9.0 (AM), 8.8 (RA), 17.9 (LAP)
Griffin [4]	2013	United States	Retrospective	39	N=23, 35.2 ± 5.0	N=16, 33.8 ± 5.0	-	-	27.3 ± 7.5 (AM), 23.6 ± 3.8 (RA)	-
Nash [5]	2012	United States	Retrospective	133	N=106, 35.8 ± 5.5	N=27, 38.3 ± 6.3	-	-	26.5 ± 6.2 (AM), 25.0 ± 4.8 (RA)	-
Sangha [6]	2010	United States	Retrospective	-	-	-, 36.2 ± 5.5	-, 36.4 ± 6.8	-	-	Largest diameter 7.4 (RA), 8.1 (LAP)
Govern [7]	2013	United States	Retrospective	-	-	-	-	-	-	-
Asher-Walsh [8]	2010	United States	Case-Control	-	-	-	-	36.5 ± 7.2	21.7 ± 3.7	1.7 ± 0.8
Flyckt [9]	2016	United States	Retrospective	134	N=81, 34.1 ± 4.5	N=25, 34.0 ± 3.8	N=28, 33.5 ± 4.4	-	-	-
Bedient [10]	2009	United States	Retrospective	81	-	N=41, 43.0 ± 12.0	N=40, 40.9 ± 6.6	-	24.7 ± 5.0 (RA), 25.3 ± 5.4 (LAP)	6.5 ± 6.4 (RA), 2.7 ± 1.9 (LAP)
Nezhat [11]	2009	United States	Retrospective	50	-	N=15, 39.0	N=35, 41.0	-	23.0 (RA), 24.0 (LAP)	3.0 (RA), 4.0 (LAP)
Barakat [12]	2011	United States	Retrospective	575	N=393	N=89	N=93	-	-	-
Hanafi [13]	2013	Middle East	Retrospective	122	N=45, 37.0 ± 5.6	N=77, 38.0 ± 6.6	-	-	31.0 ± 7.2 (AM), 28.1 ± 6.0 (RA)	4.2 ± 3.4 (AM), 3.1 ± 1.4 (RA)

Takmaz [14]	2018	Turkey	Retrospective	64	-	N=31, 38.0 ± 5.0	N=33, 35.0 ± 5.0	-	23.0 ± 4.0 (RA), 24.0 ± 4.0 (LAP)	6.8 ± 1.1 (RA), 6.5 ± 1.4 (LAP)
Göcmen [15]	2013	Turkey	Comparative Cohort	38	-	N=15, 34.2 ± 5.7	N=23, 35.7 ± 6.1	-	25.5 ± 3.3 (RA), 27.6 ± 6.1 (LAP)	2.7 ± 3.1 (RA), 2.1 ± 1.9 (LAP)

*Data presented as Mean ± SD where available

AM = Abdominal Myomectomy, RA = Robotic-Assisted Myomectomy, LAP = Laparoscopic Myomectomy difference: 0.04 days; 95% CI: -0.21 to 0.30; P<0.74; I^2=77%).

However, there was no significant difference in hospital stay between robotic-assisted laparoscopic and AM (mean difference: 1.54 days; 95% CI: 1.31 to 1.77; P=<0.00001; I^2=58%). Symptom Severity Scores Preoperative and postoperative symptom severity scores were reported for AM and robotic-assisted laparoscopic myomectomy (RLM). AM had a preoperative mean score of 44.76 (SD = 4.18, median = 46.88) and a postoperative mean score of 24.90 (SD = 2.87, median = 25.00). RLM had a preoperative mean score of 46.59 (SD = 4.32, median = 43.75) and a postoperative mean of 23.87 (SD = 2.23, median = 25.00). Both groups showed a reduction in symptom severity from preoperative to postoperative periods. Preoperative and postoperative sexual function scores were reported for AM and RLM. AM had a preoperative mean score of 62.90 (SD = 5.54, median = 62.50) and a postoperative mean score of 75.40 (SD = 3.45, median = 75.00). RLM had a preoperative mean score of 64.02 (SD = 5.67, median = 62.50) and a postoperative mean of 79.17 (SD = 4.37, median = 100.00).

The location of myomas within the uterus varied across the three surgical groups: AM, RLM, and LM. Due to inconsistencies in data reporting and missing data, a comprehensive comparison of myoma locations among the groups was impossible. However, the available data provided insights into the distribution patterns. In the AM group, posterior (22.65-52.9%) and fundal (24.94-42.3%) myomas were the most common locations reported. Anterior myomas ranged from 16.54% to 51.2%, while submucosal (2.4-13.74%), subserosal (26.46-31.7%), and intramural (60.9-79.13%) myomas were also observed. For the RLM group, fundal (21.35-59.2%) and posterior (21.35-55%) myomas were the predominant locations. Anterior myomas ranged from 9.2% to 52%, while submucosal (6.2-23.6%), subserosal (33.3-35.96%), and intramural (56.2-78.65%) myomas were also reported. In the LM group, fundal (30.11-48.2%), posterior (29.03-47.9%), and anterior (15.05-32.2%) myomas were the most common locations. Intramural (59.14%), subserosal (27.96%), and submucosal (9.68%) myomas were also observed.

Complications

Intraoperative bleeding, defined as an estimated blood loss (EBL) of more than 1000 mL, was the most common intraoperative complication across all surgical groups, with rates of 7.0% for AM, 1.3% for RLM, and 2.6% for LM. Blood transfusion was also reported intraoperatively, with rates of 3.1% for AM, 0.6% for RLM, and 1.6% for LM. Bowel injury occurred in 1.3% of AM cases and 1.0% of RLM cases. Endometrial defect (0.3%) and uterine serosal injury (0.1%) were observed in the AM group. Postoperative transfusion was the most prevalent complication postoperatively, reported in 20% of AM cases, 3.8% of RLM cases, and 5.8% of LM cases. Other postoperative complications included ileus (4.2% for AM, 1.3% for RLM, 0.7% for LM), fever (1.2% for AM, 0.6% for RLM, 0.7% for LM), emergency department visit for abdominal pain (0.3% for AM, 0.6% for RLM, 1.3% for LM), and shortness of breath/chest pain (0.6% for AM). Hemorrhage requiring reoperation was reported in 0.9% of AM cases, 1.3% of RLM cases, and 0.3% of LM cases. Incisional bleeding occurred in 0.3% of AM cases, 1.3% of RLM cases, and 0.3% of LM cases. Incisional hematoma (0.3%) and hypoxia (0.1%) were observed in the AM group, while infection was reported in 0.4% of AM cases. Only in one study attempted pregnancy rates were examined in patients who underwent different surgical approaches for myomectomy: AM, RLM, and laparoscopic myomectomy (LM). In the AM group, data were available for 81 patients, of which 42 (51.9%) attempted pregnancy after the procedure, while 39 (48.1%) did not attempt pregnancy. For the RLM group, out of 25 patients, 15 (60%) attempted pregnancy, and 10 (40%) did not. In the LM group, 10 out of 28 patients (35.7%) attempted pregnancy, while 18 patients (64.3%) did not attempt pregnancy.

The rates of achieved spontaneous pregnancy were analyzed for patients who attempted pregnancy after undergoing myomectomy via different surgical approaches which was assessed in only one study: AM, RLM, and LM. In the AM group, out of 39 patients who

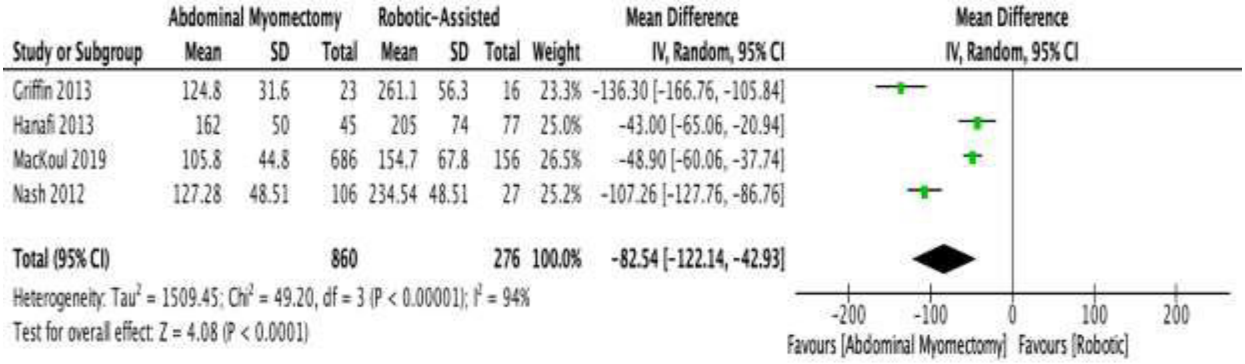

Figure 2: A. Forest plot comparing the operative time (in minutes) between abdominal myomectomy and robotic-assisted myomectomy, showing the mean difference and 95% confidence intervals for each included study and the overall pooled effect.

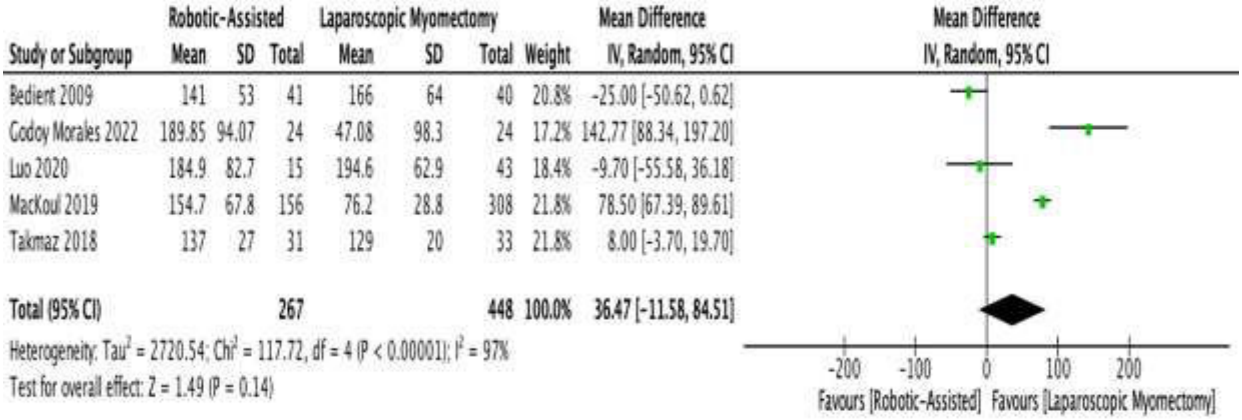

Figure 2: B. Forest plot comparing the operative time (in minutes) between robotic-assisted myomectomy and laparoscopic myomectomy, showing the mean difference and 95% confidence intervals for each included study and the overall pooled effect.

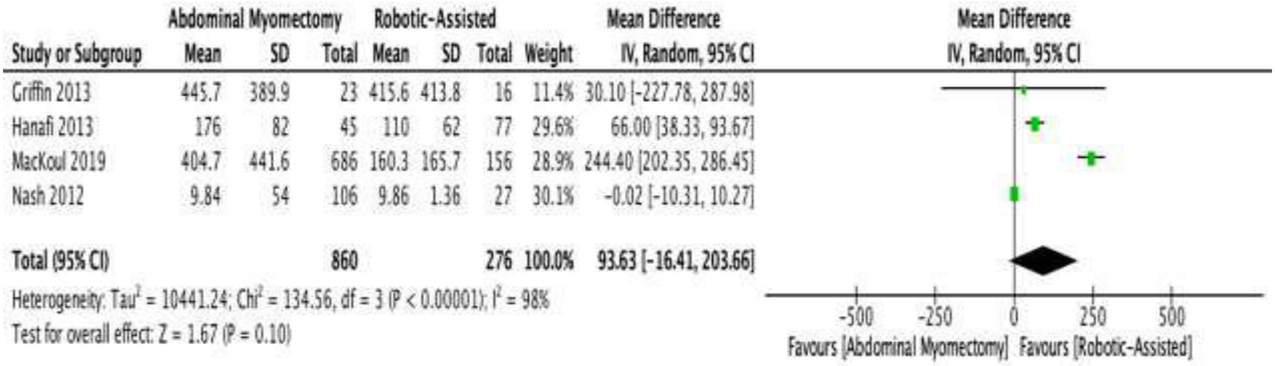

Figure 3: A. Forest plot comparing the blood loss (in milliliters) between abdominal myomectomy and robotic-assisted myomectomy, showing the mean difference and 95% confidence intervals for each included study and the overall pooled effect.

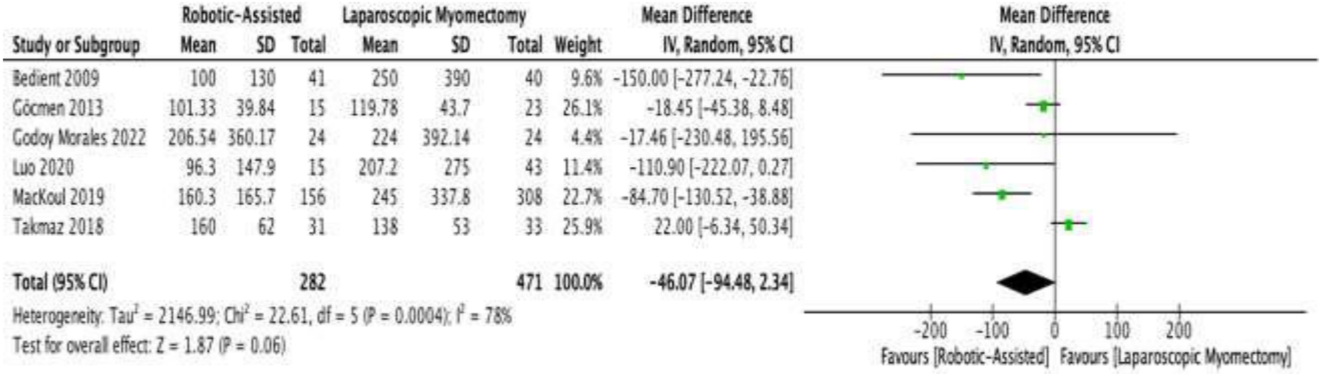

Figure 3: B. Forest plot comparing the blood loss (in milliliters) between robotic-assisted myomectomy and laparoscopic myomectomy, showing the mean difference and 95% confidence intervals for each included study and the overall pooled effect.

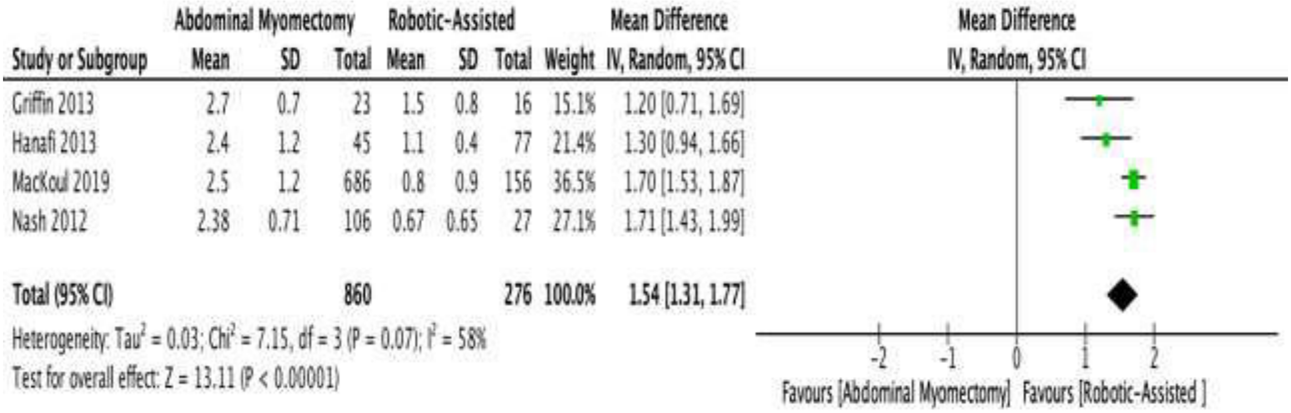

Figure 4: A. Forest plot comparing the hospital length of stay (in days) between abdominal myomectomy and robotic-assisted myomectomy, showing the mean difference and 95% confidence intervals for each included study and the overall pooled effect.

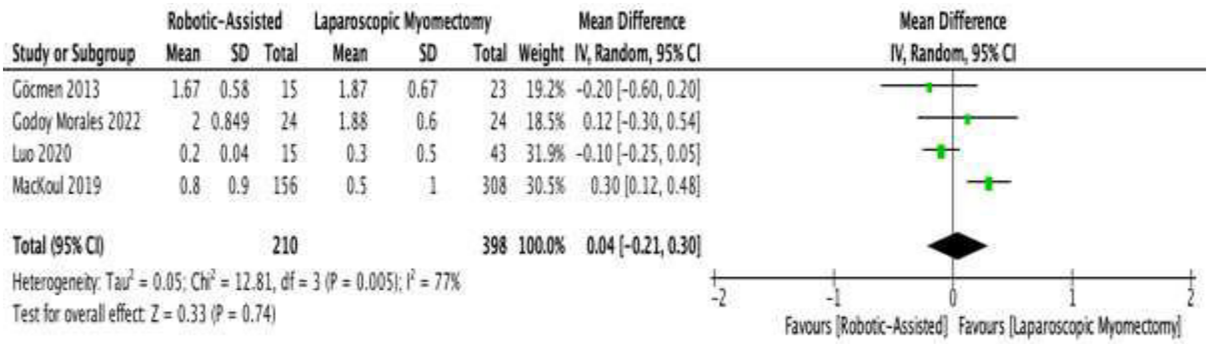

Figure 4: B. Forest plot comparing the hospital length of stay (in days) between robotic-assisted myomectomy and laparoscopic myomectomy, showing the mean difference and 95% confidence intervals for each included study and the overall pooled effect

attempted pregnancy, 26 (66.7%) achieved spontaneous pregnancy, while 13 (33.3%) did not. For the RLM group, out of 10 patients who attempted pregnancy, 5 (50%) achieved spontaneous pregnancy, and 5 (50%) did not. In the LM group, 9 out of 18 patients (50%) who

Table 2: MINORS assessment tool for non-randomized comparative studies (n = 15)

Item	**Godoy Morales 2022 (1)**	**Luo 2020 (35)**	**MacKoul 2019 (6)**	**Griffin 2013 (2)**	**Nash 2012 (5)**	**Sangha 2010 (3)**	**Gobren 2013 (23)**	**Asher-Walsh 2010 (36)**	**Flyckt, 2016 (33)**	**Bedient, 2009 (20)**	**Nezhat. 2009 (17)**	**Barakat, 2011 (22)**	**Hanafi, 2013 (4)**	**Takmaz, 2018 (32)**	**Göçmen, 2013 (25)**
An adequate control group	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**0**	**0**	**2**	**0**	**0**	**0**	**0**
Prospective calculation of the study size	**1**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**0**	**2**	**0**	**0**	**0**	**2**	**0**
Endpoints appropriate to the aim of the study	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**1**	**2**	**1**
Follow-up period appropriate to the aim of the study	**2**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**1**	**0**	**0**	**1**
Loss to follow-up less than 5%	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**1**
Prospective collection of data	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
A clearly stated aim	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Adequate statistical analyses	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Baseline equivalence of groups	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Contemporary groups	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**0**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Inclusion of consecutive patients	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Unbiased assessment of the study endpoint	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**
Total Score=24	**18**	**17**	**19**	**20**	**17**	**17**	**17**	**15**	**15**	**16**	**14**	**14**	**11**	**15**	**16**

attempted pregnancy achieved spontaneous pregnancy, while the other nine patients (50%) did not. Overall, across all three surgical groups, 40 patients achieved spontaneous pregnancy after myomectomy, while 27 patients did not achieve spontaneous pregnancy despite attempting pregnancy following the procedure.

Fertility Assistance /treatment after fibroid Surgery (Data from a single study), one study reported on the use of fertility assistance /treatment after undergoing fibroid surgery via different surgical approaches. AM, RLM, and LM. In the AM group, eight patients (21.1%) reported using fertility assistance/treatments after surgery, while 28 patients (73.7%) did not use and were not planning any treatments. Additionally, two patients (5.3%) did not use treatments but were planning to do so. For the RLM group, three patients (30%) used fertility assistance/treatments, six patients (60%) did not use and were not planning any treatments, and one patient (10%) did not use treatments but was planning to do so in the future. In the LM group, six patients (33.3%) used fertility assistance/treatments, ten patients (55.6%) did not use and were not planning any treatments, and two patients (11.1%) did not use treatments but were planning to do so in the future. The cost of myomectomy varied based on the surgical approach and uterine size. AM, costs ranged from $26,865 for the smallest uterine to $34,892 for the largest uterine. For RLM, costs ranged from $43,693 for the smallest uterine to $52,478 for the largest uterine. LM had a reported cost of $56,000. Additional costs of $26,720 for AM, $47,478 for RLM, and $34,500 across all approaches were also reported.

Risk of bias and quality assessment

MINORS: The MINORS tool was used to assess the quality of the non-randomized studies included in this review. The total score ranged from 11 to 20, with a mean score of 16.06. The items with the lowest scores were Loss to follow-up less than 5% (score of 0 in Most studies), the unbiased assessment of the study endpoint (score of 0 in Most studies), and the Endpoints appropriate to the aim of the study (score of 1 or 2 in most studies). The items with the highest scores were the clearly stated aim of the study (score of 2 in all studies), the Inclusion of consecutive patients (score of 2 in all studies), and the Adequate statistical analyses (score of 2 in all studies) (Table 2)

Discussion

For a long time, conventional laparoscopy and laparotomy have long been the gold standards of care in gynecologic surgery, until 2000 when Falcone T., Goldberg, J. M., Margossian, H. and Stevens, L. were the first to perform robot-assisted microsurgical tubal anastomosis, marking the initial record of robot-assisted surgeries in gynecologic literature.[26] In 2004, Advincula *et al*. reported their first use in myomectomy.[27] Since then, RLM has spread to many facilities due to its promising outcomes and advantages over AM, including less EBL, decreased LOHS, and more. Consequently, evaluating its validity as a standard of care became essential. Our study aimed to assess current literature on the topic and compare it to previous systematic reviews. Overall, similar to the reviews by Tsakos *et al*. and others.[28-31] RLM demonstrated better outcomes and fewer complications than AM, with not much significant differences between RLM and LM.

It is worth noting that the heterogeneity in our study was often very high (more than 75%), which was also true for other studies.[28-31] This could be due to differences in patient characteristics or study designs, but it also means the findings were diverse. All studies applied a random-effects model or other measures to address this.

The high heterogeneity observed in our meta-analysis has important clinical and methodological implications. This variability suggests that the effectiveness of different surgical approaches may be substantially influenced by surgeon experience, institutional protocols, patient selection criteria, and fibroid characteristics. The heterogeneity particularly affects the generalizability of our findings and highlights the need for caution when applying these results to individual clinical scenarios. Clinicians should consider these factors when selecting the most appropriate surgical approach for each patient. Furthermore, the heterogeneity underscores the importance of developing standardized reporting protocols and conducting multi-center studies with consistent methodologies to reduce variability in future research. The random-effects model employed in our analysis accounts for this heterogeneity, but standardization of surgical techniques and outcome measurements would enhance the reliability of comparative effectiveness studies.

The weighted mean tumor sizes in the AM and RLM groups were similar, while the LM group had smaller mean tumor sizes, which differs from Tsakos *et al.*[28], who found LM was often used for larger tumors. This discrepancy could be attributed to individual patient differences or the surgeons' experience.

Similar to Tsakos *et al.*[28] the AM group's operative time was significantly shorter than RLM, but contrary to their findings, we found no significant difference between RLM and LM.[28] Contrary to expectations, our study found no significant difference in overall blood loss between AM and RLM, which is opposite to the findings of Tsakos et al. and others.[28-31] This could be due to the very high heterogeneity in our EBL results. As for the difference between RLM and LM, no significant difference was found, which aligns with Tsakos *et al.*'s study.[28] As expected, the LOHS was significantly shorter with RLM than AM, and there was no significant difference between RLM and LM, matching previous literature.[28]

Unfortunately, the UFS-QoL score, which includes the Symptom Severity Score, concern, etc., was only used in one study, *32* pre- and post-operatively, preventing further analysis. However, that study found a significant reduction in the score with both RLM and LM, with no significant difference between them. Sexual function also showed significant improvement after both RLM and LM, with no significant difference between them in the same study.

Regarding intraoperative or postoperative complications, AM was more likely to be associated with complications, which was also true for other studies.[28-31] Intraoperatively, bleeding was the most common complication and was double to quadruple the likelihood with AM compared to RLM or LM. Consequently, the need for a blood transfusion was highest among the AM group, followed by LM, then RLM. Other rare complications like bowel injury were also associated with AM. Postoperatively, blood transfusion was the most common complication with all surgical approaches, especially AM, with one-fifth of the patients requiring it. Ileus and fever were more likely complications of AM, while shortness of breath, chest pain, infection, incisional hematoma, and hypoxia were less common. Emergency department visits for abdominal pain were more likely with LM, while hemorrhage requiring reoperation and incisional bleeding were more likely with RLM.

Fertility outcomes were only reported in one study.[33] showing that around half or more of all patients who attempted pregnancy following AM, RLM, and LM achieved spontaneous pregnancy. These results and others 28 highlight myomectomy's role as a potential treatment for eligible infertile patients. About 20-30% of patients reported using fertility treatments. One study included (34) mentioned cost differences, noting that RLM and LM were higher in cost than AM this is perhaps due to the instruments used and requiring higher surgical expertise. This was also observed in Pundir et al.'s study.[30]

It is important to mention that no RCTs were included in our search, nor did we include abstracts, unpublished articles, case reports, editorials, or letters. We also only included text found in English, and the heterogeneity of the included studies was high, indicating variability in the results. This could be attributed to many reasons, one being possible differences in surgeons' expertise, highlighting the importance of starting the training of new surgeons on robotic surgery earlier to have a better experience.

Most studies found were retrospective, and no RCTs examined the differences between surgical approaches. Our recommendation for future studies is to explore these differences through RCTs to better understand them. Future research should also focus on including scores like the UFS-QoL to explore patient illness experiences and the effect of different surgical approaches on them. As well as assess fertility outcomes and patients' need for fertility assistance, and other long-term outcomes like tumor recurrence. We also recommend including more patient characteristics when comparing surgical outcomes or possibly developing a standardized tool to evaluate which surgical approach to choose will better help clinicians decide the best approach for each patient.

Recommendations

Future research should focus on high-quality, large-scale randomized controlled trials to provide more definitive evidence on the comparative effectiveness of these surgical approaches. It's also important to explore how patient-specific factors might influence outcomes, to better tailor surgical decisions. Moreover, investigations into the cost-effectiveness and long-term reproductive outcomes of these procedures are needed to inform clinical practice more comprehensively

Conclusion

Indicating that RLM generally provides better outcomes and fewer complications than AM. However, no significant differences were found between RLM and LM. Specifically, RLM was associated with shorter hospital stays and potentially less blood loss, though AM was noted to be a quicker procedure. Intraoperative bleeding emerged as the most common complication, with higher rates observed in the AM group. Additionally, postoperative transfusions were more frequently required in the AM group compared to those who underwent RLM or LM. These findings have important clinical implications for both patients and healthcare providers. For patients desiring fertility preservation and faster recovery, RLM offers significant advantages with reduced hospital stays and lower complication rates compared to traditional AM. The shorter hospitalization associated with RLM translates to reduced healthcare costs, faster return to normal activities, and improved quality of life for patients. However, clinicians must carefully weigh these benefits against the longer operative times and higher procedural costs of RLM. The choice of surgical approach should be individualized based on patient-specific factors including fibroid characteristics (size, number, location), patient comorbidities, fertility desires, surgeon expertise, and institutional resources. The comparable outcomes between RLM and LM suggest that either minimally invasive approach is acceptable when surgically feasible, with the decision guided by surgeon experience and patient preferences.

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Competing interest

I confirm that I have no conflicts of interest related to the publication of this study.

Availability of data and materials

All data and materials related to this study were available upon request from the corresponding author.

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