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Original Research

Is robot-assisted laparoscopic myomectomy superior to laparoscopic myomectomy?

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Abstract

Background: To determine whether RLM (Robot-assisted Laparoscopic Myomectomy) or LM (Laparoscopic Myomectomy) provides better surgical and post-operative outcomes for patients willing to have minimally invasive myomectomy. **Methods**: In this retrospective cohort (Class II-2) analysis, all patients who underwent RLM and LM by a single expertise surgical team from January 1st, 2018 to March 31st, 2020 were identified. The patients' characteristics, operative data, and post-operative outcomes were collected and statistically analyzed. **Results**: A total of 118 patients with an indication of myomectomy were included, 39 of whom underwent RLM, while 79 underwent LM. There were no significant differences among the groups in demographic characteristics ($p > 0.05$). RLM was associated with lower estimated blood loss (55.00 ± 39.11 mL vs. 110.80 ± 74.72 mL, respectively, $p < 0.001$) and larger myoma size (6.92 ± 1.88 cm vs. 6.00 ± 2.07 cm, $p < 0.001$) compared with LM. No significant differences were noted between the groups for other parameters ($p > 0.05$). **Conclusions**: Although RLM was associated with significantly less blood loss, this difference did not entail clinical implications. In general, both methods demonstrated similar clinical outcomes. For cost effectiveness, LM appears to outperform RLM, particularly in experienced hands.

Keywords: Minimally invasive surgery; Laparoscopic myomectomy; Robot-assisted myomectomy; Intra-operative; Post-operative; Outcomes

1. Introduction

Myomas are benign tumoral neoplasms of the uterus [1]. The prevalence rate of myomas is nearly 75%, and an estimated 25% of myomas cause symptoms such as heavy and prolonged uterine bleeding resulting in anemia, pelvic pain, infertility, and urinary symptoms [2]. When these symptoms adversely affect patients' daily activities and quality of life, treatment options become vitally important. Some women who seek future fertility elect for myomectomy despite the risk of disease recurrence [3]. Currently, either minimally invasive surgeries (MIS) or laparotomy is the alternative treatment to myomectomy. Several studies have compared MISs with conventional procedures. Minimally invasive myomectomy has been reported to cause less blood loss and to require a shorter hospital stay and recovery period than laparotomic myomectomy; moreover, the recurrence and reoperation rates are similar to those in laparotomy [4–7]. Nevertheless, the frequency of laparotomic myomectomy as a treatment choice is still high [8]. The difficulty of suturing when fibroids are located at deep and difficult anatomical positions, such as intra-ligamentous and cervical fibroids, combined with surgeons' inadequate experience and training, may account for the underutilization of laparoscopic myomectomy (LM). Robot-assisted LM (RLM) may provide an advantage for reaching myomas with difficult anatomical positions, and multilayer closure of the myoma bed using articulated instruments can be more comfortable. Both procedures have advantages and disadvantages, and comparison of the two procedures is controversial [9,10]. The retrieval of all myomectomy materials is realized with morcellation technics. The power morcellator is the most effective device for morcellation but can spread the leiomyosarcoma. The FDA (U.S. Food and Drug Administration) suggests greater care before using power morcellation for the dissemination of occult leiomyosarcoma [11,12]. In 2020, the FDA recommended performing laparoscopic morcellation for myomectomy or hysterectomy only with a tissue containment system.

In this study, our aim was to determine whether RLM or LM provides better surgical and postoperative outcomes for patients willing to undergo minimally invasive myomectomy.

2. Materials and methods

This retrospective cohort study (Class II-2) was approved by our institutional review board. Informed consent from the patients was not required because of the retrospective chart review design of the study. All patients who underwent RLM and LM by a single expert surgeon team between January 1, 2018, and March 31, 2020, were identified. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Acıbadem University (approval number: 2021-10/02).

A total of 118 patients with an indication for myomectomy were included, of whom 39 underwent RLM and 79 underwent LM. All patients were operated upon in Acıbadem Taksim Hospital (Istanbul). All myomas were intramural and subserous (FIGO classification system grade 2–7), and the surgeries were performed for pelvic pain adversely affecting quality of life and daily activities, abnormal uterine bleeding, compression-related symptoms causing urinary frequency, urinary incontinence, hydronephrosis, or constipation. Myoma sizes and localizations were examined with ultrasonography for all patients. MRI was performed for some patients who were not clearly diagnosed. MIS was decided, and the choice between laparoscopic and robotic approaches was left solely to the patient's discretion.

Before surgery, the following patient characteristics were recorded: age, gravidity, history of prior pelvic or abdominal surgery, intercurrent diseases and indications for myomectomy, myoma size, number of myomas, and hemoglobin level.

2.1 Myomectomy techniques

All myomectomies were classified using the PALM-COEIN (polyp; adenomyosis; leiomyoma; malignancy and hyperplasia; coagulopathy; ovulatory dysfunction; endometrial; iatrogenic; and not yet classified) subclassification system for leiomyomas and defined as classes 2–7.

The following steps were used in both robotic and laparoscopic cases: The patient was placed in a Trendelenburg position, with arms tucked at the sides. A VCare (standard; ConMed Corporation, Utica, NY, USA) or Rumi Koh-Efficient system uterine manipulator (4.0 cm; Cooper Surgical, Trumbull, CT, USA) was used. Pneumoperitoneum was obtained with the Verres needle technique, usually from the umbilicus (if not possible from the Palmer's point), for insufflation, followed by placement of a 12-mm bladeless trocar introduced from the umbilicus under direct visualization.

- For RLM: The Da Vinci-Si robotic system was used (Intuitive Surgical, Inc, Sunnyvale, CA, USA). With an umbilical incision, a 12-mm camera port, two 8-mm side ports, and a 10-mm assistant port were inserted, and docking was achieved. A pair of monopolar curved scissors was held in the right arm, and a bipolar forceps was held in the left arm. The monopolar curved scissors were used for the myoma incision, and a tenaculum forceps in the other arm was used for the countertraction. The uterine wall was sutured completely layer by layer using 2-0 V-Loc barbed sutures (Covidien, North Haven, CT, USA). The fascia and subcutaneous layer were closed using 1-0 Vicryl (Ethicon Inc, Cincinnati, OH, USA), and the skin was closed using 3-0 Vicryl (Ethicon Inc). The robotic system was then undocked.

- For LM: LM was performed with similar insufflation and surgical techniques as previously described. In this approach, the only differences in the trocar placement were the two 5-mm bladeless trocars used instead of two robotic trocars. The Thunderbeat bipolar energy system (Olympus Medical Systems Corp, Tokyo, Japan) was preferred for myoma incision. The fascia and subcutaneous layer were closed using 1-0 Vicryl (Ethicon Inc., Johnson and Johnson, New Brunswick, NJ, USA), and the skin incision was closed using 3-0 Vicryl (Ethicon Inc., Johnson and Johnson, New Brunswick, NJ, USA).

Intracapsular myomectomies were performed in order to preserve the pseudo-capsules. Vasopressin injection (20 IU/100 mL saline) was applied to subcapsular area in randomly selected patients. All pathological specimens were removed by morcellation using an endoscopic morcellator in a safely protected endoscopic bag (Versator® MorSafe, Veol Medical Technologies, Maharastra, India) for both robotic and laparoscopic cases.

2.2 Collected intraoperative and perioperative characteristics

The following intraoperative and perioperative characteristics of the cases were monitored: concomitant procedures performed with myomectomy, operating room time, intraoperative complications, estimated blood loss (EBL), vasopressin injection, transfusion requirements, conversion to laparotomy, length of hospital stay, postoperative complications, requirement of reoperation, and final pathological results. The intraoperative complications evaluated were as follows: intraoperative hemorrhage exceeding 500 mL; bladder injury, including full perforation; ureteral injury; intestinal injury, including thermal defect or full perforation; and severe ventilation problems.

Postoperative complications were evaluated, such as postoperative fever (defined by a body temperature of at least 38 °C on two consecutive occasions at least 6 h apart, excluding the first 24 h); urinary tract infections (UTI), including pyelonephritis or persistent UTI; pelvic hematoma or abscess; port site herniation; severe or persistent ophthalmologic problems; severe or persistent gastrointestinal problems; incisional problems; persistent wound opening; cardiovascular and pulmonary problems; and intraoperative positional nerve injuries.

2.3 Statistical analyses

Data were analyzed using the Statistical Package for the Social Sciences v21.0 for Windows (SPSS, Inc. Chicago, IL, UAS). The normality of the data distribution was tested with the Kolmogorov-Smirnov test. The patients' characteristics and intraoperative and perioperative outcomes were compared between the groups. The first step in the data analysis was the examination of each variable for outliers and missing values. Normally distributed metric variables were expressed as mean, standard deviations, and minimum and maximum values and examined for each of the continuous variables. Normally distributed metric variables were tested with a *t* test. Chi-square statistics were used to test the homogeneity of the categorical variables. The Fisher exact test was used to analyze the categorical variables with low expected counts in the frequency tables ($<$5 in $>$20% of the cells). The Kendall correlation coefficient was used to test the linear relationship between myoma size, number of myomas with bleeding, operation time, and length of hospital stay. In all instances, a p value < 0.05 was considered to indicate statistical significance.

3. Results

A total of 118 women with an indication for myomectomy, either robot assisted or laparoscopic (RLM, n = 39; LM, n = 79), were included in the study. The mean body mass index (BMI) values in the RLM and LM groups were 25.90 $\pm$ 3.12 kg/m^2 and 24.58 $\pm$ 1.27 kg/m^2, respectively. The BMI in the RLM group was higher than that in the laparoscopic group (p = 0.01). Among the characteristics of the remaining patients, age, gravidity, parity, race, smoking habit, intercurrent disease, and previous myomectomy history were similar between the groups ($p > 0.05$; Table 1).

No significant differences were found between the groups in terms of indications for myomectomy and final pathological results ($p > 0.05$; Table 1). The main indication for myomectomy was abnormal uterine bleeding in both groups (56.4% for RLM and 59.4% for LM, p = 0.22). The indications for myomectomy are presented in Table 1 in detail.

The quantity and localization of the myomas are defined by ultrasonography and MRI (Tables 2,3 (Ref. [13])).

The mean myoma size was larger in the RLM group than in the LM group (6.92 $\pm$ 1.88 cm vs. 6.00 $\pm$ 2.07 cm, respectively; p = 0.01; Fig. 1).

The mean operating room time for RLM and LM were 142.10 $\pm$ 38.27 min and 151.80 $\pm$ 32.17 min, respectively, which are not significantly different between the groups (p = 0.17; Table 4). Patients in the RLM group had less EBL than those in the LM group (55.00 $\pm$ 39.11 mL vs. 110.80 $\pm$ 74.72 mL, respectively; $p < 0.001$; Fig. 2).

No major complications were detected. One complication in the RLM group was an intestinal herniation at the port site and was treated with laparoscopy. Three complications occurred in the LM group, namely intestinal serosal

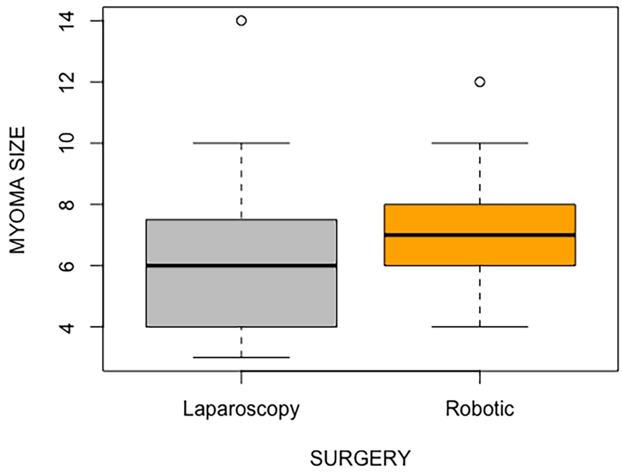

Fig. 1. Box plot of the myoma sizes in the two surgical groups.

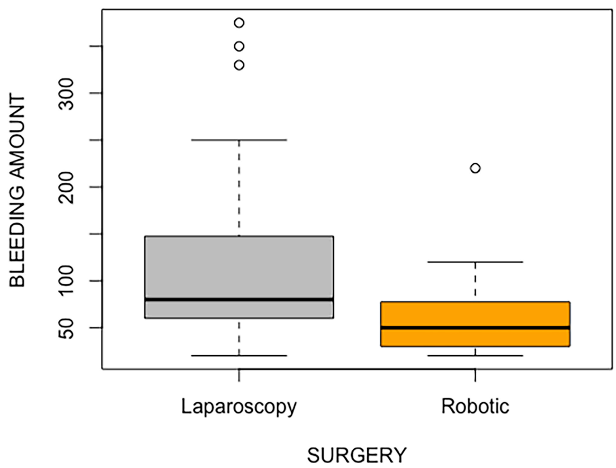

Fig. 2. Box plot of the bleeding amounts in the 2 surgical groups.

injury (repaired during the operation), ileus (treated medically), and vulvar hematoma (resolved spontaneously). The mean length of hospital stay was similar in each group (p = 0.63; Table 4).

The differences between vasopressin for laparoscopic myomectomy patients are statistically significant with p-values of 0.00, but the differences between vasopressin for robotic myomectomy patients are not statistically significant, with p-values of 0.11 as seen in Table 5.

Depending on the use of different uterine manipulator devices, there is no significant evidence to indicate statistical differences between these three groups (p = 0.44 for robotic myomectomy patients and p = 0.97 for laparoscopic myomectomy patients) (Table 6).

The correlation coefficients between operation time and bleeding amount (r = 0.47), operation time and hospitalization time (r = 0.43), and bleeding amount and hospitalization time (r = 0.43) were statistically significant (Fig. 3) when compared in each group. The RLM group showed

Table 1. The characteristics of the patients.

	RLM (n = 39)	LM (n = 79)	p values
Age (years)	39.74 ± 7.39	38.39 ± 6.15	0.33*
Gravidity (n)	1.26 ± 0.91	1.01 ± 0.77	0.16*
BMI⋆ (kg/m^2)	25.90 ± 3.12	24.58 ± 1.27	0.01*
Previous abdominopelvic surgery			
n (%)			
Cesarean	19 (0.49)	34 (0.43)	0.67**
None	20 (0.51)	45 (0.57)	
Symptom			
n (%)			0.22***
Pain	16 (0.41)	24 (0.30)	
Asymptomatic	1 (0.03)	8 (0.10)	
Bleeding	22 (0.56)	47 (0.60)	
Prev. myomectomy			
n (%)			1***
No	35 (0.90)	72 (0.91)	
Yes	4 (0.10)	7 (0.09)	

⋆Body Mass Index.

* *T*-test.

** Chi-squared test.

*** Fisher's Exact Test for Count Data was used since one of the groups had less than five observations on the contingency table.

Table 2. Distribution of single and multiple myomas.

Number of patients	Single myoma	2–4 myomas	5 and more myomas
Laparoscopic (n = 79)	33 (27.9%)	27 (22.9%)	19 (16.1%)
Robotic (n = 39)	14 (11.9%)	19 (16.1%)	6 (5%)
Total (n = 118)	47 (39.8)	46 (39%)	25 (21.1%)

Table 3. Distribution of myomas according to FIGO myoma classification system [13].

Number of myomas	Intramural myomas	Subserous myomas
	FIGO 2–5	FIGO 6–7
Laparoscopic (n = 234)	143 (41.8%)	91 (26.6%)
Robotic (n = 108)	68 (19.9%)	40 (11.7%)
Total (n = 342)	211 (61.7%)	131 (38.3%)

different relationships, having statistically significant correlation coefficients between operation time and bleeding amount (r = 0.54), operation time and hospitalization time (r = 0.60), and bleeding amount and hospitalization time (r = 0.56), and a small but statistically significant positive correlation between myoma size and operation time (r = 0.26) and myoma size and bleeding amount (r = 0.31), as shown in Figs. 4,5.

After checking linear models between these variables for the robotic myomectomy group, we observed statistically significant positive correlation (p = 0.03) between myoma size and operation time, with a small positive correlation coefficient (r = 0.26) which can be seen on the left in Fig. 5. We further observed statistically significant correlation (p = 0.12) between myoma size and bleeding amount with a small positive correlation coefficient (r = 0.31) as seen on the right (Fig. 5).

4. Discussion

Minimally invasive myomectomy reportedly causes less blood loss and requires a shorter hospital stay and recovery period than laparotomic myomectomy; moreover, the recurrence and reoperation rates are similar to those in laparotomy [4–7]. Our results demonstrated significantly less blood loss (55.00 mL vs. 110.80 mL), higher BMI (25.90 kg/m^2 vs. 24.58 kg/m^2), and larger myoma size (6.92 cm vs. 6.00 cm) in the RLM group than in the LM group. Although these differences were significant, the changes seemed not to cause any major clinical implications. The hospital stay duration, amount of blood loss, operation time, and myoma size positively correlated with each other in each group. No major surgical complications were found in each group.

In a review reported in 2016, 15 studies that compared LM with robotic myomectomy were reviewed, and a total of 2027 patients were examined. No statistically significant differences in amount of blood loss, transfusion amount, operation time, or hospital stay were found [10]. Similar findings were reported in another review that included five studies that examined a total of 602 patients [14]. In another review that included 10 studies comparing 510 robotic myomectomy cases with 490 LM cases, similar results were obtained for amount of postoperative bleeding,

Table 4. Characteristics of the two surgery groups.

	RLM (n = 39)	LM (n = 79)	*p*-value*
Number of myoma Mean ± SD	2.77 ± 1.97	2.97 ± 2.29	0.61
Myoma size (cm) Mean ± SD	6.92 ± 1.88	6.00 ± 2.07	0.01
Estimated blood loss (mL) Mean ± SD	55.00 ± 39.11	110.80 ± 74.72	<0.01
Operation time (min) Mean ± SD	142.10 ± 38.27	151.80 ± 32.17	0.17
Hospitalization time (day) Mean ± SD	1.59 ± 1.07	1.68 ± 0.81	0.63

* *T*-test.

Table 5. Blood Loss with/without vasopressin injection.

Surgery (n)	Vasopressin	Mean (sd) of Bleeding amounts -mL	*p*-value
Laparoscopic (34)	None	154.26 (88.80)	0.01*
Laparoscopic (45)	Applied	77.88 (37.62)	
Robotic (11)	None	69.09 (30.81)	0.11
Robotic (28)	Applied	49.46 (41.10)	
Total	None	133.4	$p < 0.05$*
	Applied	66.98	

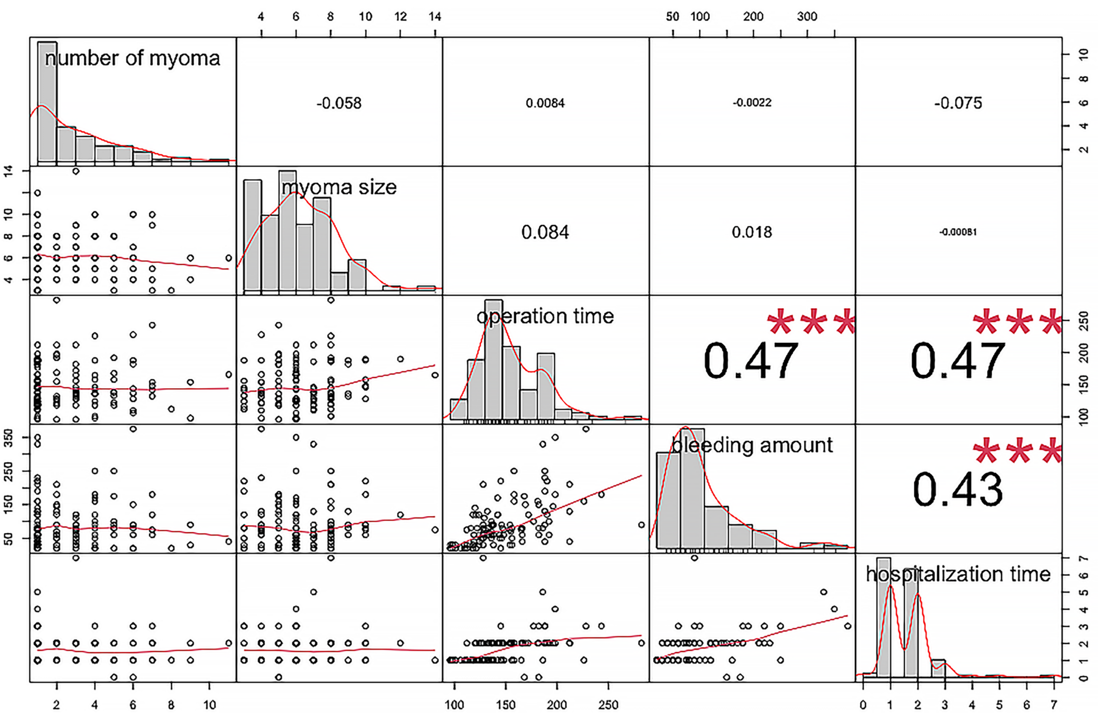

Fig. 3. Correlation chart including the number of myomas, myoma size, operation time, bleeding amount, and hospitalization time (Kendall correlation coefficient).

hospital stay, transfusion amount, operation time, largest myoma size, and long-term outcomes, such as postoperative fertility and reoperation requirement [7]. Our findings were in line with the results of these studies. As emphasized above, no significant difference in short-term follow-up period was found between the RLM and LM groups. Some studies claimed that robotic myomectomy increased the total operation time and cost as compared with LM [15–17].

Table 6. Comparison of uterine manipulator - blood loss – operation time.

Uterine manipulator	n (%)	Bleeding amount (mL) mean (Sd)	*p*-value*	Operation time (min.) mean (Sd)	*p*-value*
None	6 (5%)	60.00 (64.19)		143.67 (33.45)	
Rumi	42 (36%)	87.38 (60.40)	0.1874	147.38 (33.32)	0.97
V-Care	70 (59%)	98.07 (75.66)		149.73 (35.61)	

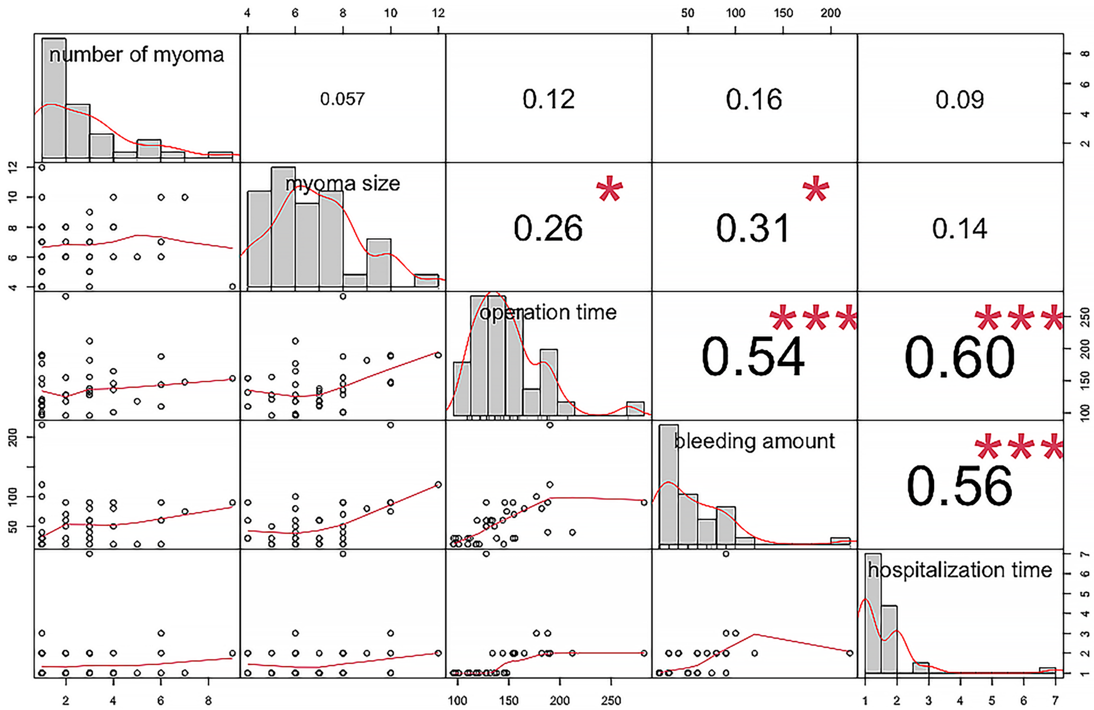

Fig. 4. Correlation chart including the number of myomas, myoma size, operation time, bleeding amount, and hospitalization time for the robot-assisted laparoscopic myomectomy group (Kendall correlation coefficient).

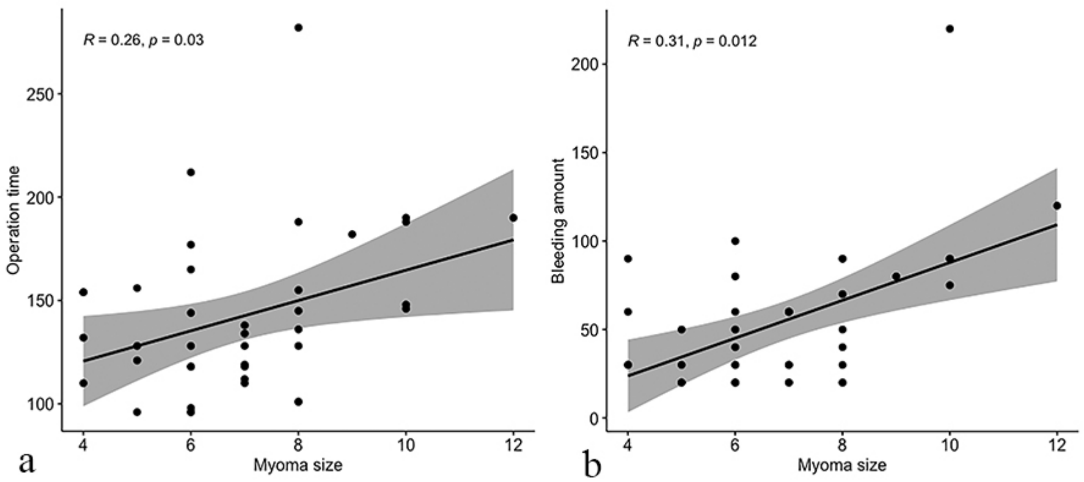

Fig. 5. Scatter plots for comparison between myoma sizes and operation times (left), and between myoma sizes and bleeding amounts (right), with a regression line in the robotic myomectomy group.

On the other hand, when the number of myomas is higher, robotic myomectomy can provide a shorter operation time than LM [18,19]. In our study, the operation time and bleeding amount increased similarly in both groups. The suturing experience of the surgeon appears to be the major factor affecting total operation time.

Vasopressin injection is a way to reduce blood loss during minimally invasive myomectomies. In a retrospective comprising 150 patients undergoing laparoscopic myomectomy, 50 were treated without the use of any vasoconstrictive agent (group 1), and 100 were treated with intraoperative intramyometrial injection of dilute vasopressin (20 IU/100 mL normal saline). EBL was significantly lower in the vasopressin group [20]. A total of 152 women were randomized; 76 patients in each group (i) received 200 mL of diluted vasopressin solution (20 U in 400 mL normal saline), and (ii) received 30 mL of concentrated vasopressin solution (20 U in 60 mL normal saline). Intraoperative blood loss was not significantly different. However, the higher volume usage of vasopressin did not reduce blood loss [21]. In our study, too, the patients' blood loss was remarkably minimal in vasopressin-injected patients (133.4 mL vs. 66.4 mL).

Shorter hospital stay and less blood loss are the strengths of minimally invasive surgeries. Controversial results were reported for blood loss in each procedure [7,10,14,15]. In our research, less blood loss was found in the robot-assisted group; despite the statistical significance of the difference in mean blood loss of nearly 50 mL, there were no clinical implications for these cases. Long operation time and high operation cost are the weakest points of robotic surgery. Our data represent similar results for operation time between the groups. Even docking seems to be a limitation in terms of operation time. Our data exclude docking and undocking times, which is a limitation of our study. When we added the docking and undocking times, laparoscopy became superior to RLM. All excised myomas were intramural, but the locations of the myomas were not noted, which is another limitation of our study. The number of myomas and myoma size may affect the surgeon's choice, and robotic surgery may be preferred for cases of large myomas in difficult locations. Our results demonstrated that the myoma sizes were larger in the robotic group. On the other hand, the data available in the current literature showed similarities between the two procedures in terms of mean blood loss, operation time, hospital stay, and short-term complications in cases of large myomas and even high number of myomas [7,10,14,18,19]. As in previous reports, significant correlations were found between myoma size and number of myomas, operation time, bleeding amount, and length of hospital stay in each group [7,10,14–16]. In our study, the operation duration and the blood loss in the RLM and LM groups represent crucial points of minimally invasive myomectomies. The relationship between operation time and blood loss was found in a statistically positive correlation in RLM.

Robotic surgery involves a short learning curve and three-dimensional view, permitting easier suturing and knot-tying [9]. This innovation may help surgeons overcome the difficulties arising from laparoscopy itself. However, the high cost, lack of haptic feedback, and decreased perception of tissue characteristics are the drawbacks of this innovative method [15]. The surgical comfort in robotic surgery is an undeniable fact. However, in expert hands, laparoscopy can provide similar outcomes at lower cost. In the present study, the operation time, even without docking and undocking, is similar between the procedures in each group. In experienced hands, suturing and knotting for repairing the uterus do not appear to be unduly time consuming. Moreover, tactile feedback during suturing is another important advantage for suture safety.

The major strength of this research is that it provides data from an experienced single surgical team for both RLM and LM in a single institution. This study provides comparative information with a sufficient number of cases by considering previous research studies that compared RLM and LM. The major limitations of this study are the retrospective design and the fact that it provides data mostly on short-term outcomes of the surgeries and limited data on long-term follow-up such as fertility, pregnancy, and recurrence rates. The limited data about cost is another limitation. Data concerning the docking-undocking times in robotic approaches are also lacking. Other limitations were previously described.

5. Conclusions

Minimally invasive surgeries have been widely preferred recently, especially in treatments using benign gynecologic procedures. In experienced hands, even for myomas in difficult anatomical locations and in high number, both procedures have similar medical outcomes. By considering cost issues in the sphere of experienced hands, LM seems to be superior to robotic myomectomy. Due to the economic crisis stemming from the COVID-19 pandemic, especially for developing countries, this research provides cost-effective treatment modalities for myomas with minimally invasive interventions. To obtain precise information and the exact interpretation about this subject, prospective, well-designed, large-scale randomized controlled studies are necessary.

Author contributions

FA, ÖLT and İD designed this research study. FA, ÖLT, BS, FGY, AG and İD performed the research. FA, İD and BS realized the above indicated operations. FGY evaluated the statistics. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Acıbadem University (approval number: 2021-10/02).

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Conflict of interest

The authors declare no conflict of interest.

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