



Laparoscopic Myomectomy

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Surg J 2020;6(suppl S1):S35–S43.

Abstract

Laparoscopic myomectomy is minimally invasive treatment for patients suffering from fibroids, especially those wishing to maintain their fertility sparing potential. While this surgery requires intensive training in surgical skills such as intracorporeal suturing and specimen extraction, patients can also expect less adhesion and a quick return to normal activity. This surgery can be broken into three stages, each presenting its own specific and unique challenges—enucleation, reapproximation of the myoma bed, and specimen extraction. To prepare for the broad spectrum of cases where the size and number of fibroids can differ greatly, we have mastered several techniques for each stage of the procedure. To keep the surgery safe, we train for unexpected scenarios by practicing minimally invasive repair and reconstruction techniques. By following basic tenets and understanding the laparoscopic anatomy, we define the targets and boundaries of our dissection to ensure completeness. In this paper, techniques for the enucleation, reapproximation, and extraction will be presented in detail.

Keywords

- laparoscopy
- myomectomy
- less adhesion
- intracorporeal suturing
- specimen extraction
- fibroids

Recently, minimally invasive surgery is becoming a more popular intervention and the number of myomectomy surgeries using laparoscopy are increasing. There are two types of such surgeries. One is laparoscopic myomectomy (LM), the other is laparoscopically-assisted myomectomy (LAM). LM is defined as the enucleation and preparation of the myoma bed and extraction, all being performed totally laparoscopically. With LAM, a small incision, around 3 to 6 cm, is made in the lower abdomen and the suturing of the myoma bed and extraction are performed via this opening. In LAM, an abdominal incision retractor or LapDisc Mini is used. In LM, intracorporeal suturing is necessary, resulting in an increase in the difficulty of this surgery. In recent years, many laparoscopists are training to master intracorporeal suturing techniques thus increasing the number of LM surgeries. In this paper, we report on our LM procedures.

prerequisite as we can gain vital information such as the number, size, and characteristics of the target fibroids. As for the number fibroids, some small fibroids cannot be detected so the number determined from the MRI works only as a reference value.

Informed Consent

- The general risks and complications associated with laparoscopic surgery must be explained to patients before surgery. In addition, we must explain specific issues pertaining to surgery the patient will undertake, LM. For example, all cases who undergo myomectomy are required to have a cesarean section at the time of giving birth after undergoing this surgery. Another important issue is the case of unexpected malignancy. There is a possibility of the scattering of tumor cells resulting in poor survival outcome.

Preoperative Evaluation and Imaging

The general work-up consists of a chest XP, echocardiography, biochemical examination of blood and in addition to these tests, a pelvic magnetic resonance imaging (MRI) is a

Although the incidence is low, there is also the risk of rupture of the uterus during pregnancy. If there are a large number of fibroids or if the fibroids are in the areas that are difficult to



access, there is a possibility of not being able to perform hemostasis and subsequent need for hysterectomy.

- We use diluted vasopressin for bleeding control. This is delivered via local injection, directly into the uterus. This is an off-label use and therefore must be disclosed to the patient. Should the patient experience a rare severe complication such as heart failure, cardiac arrest, or shock, there is no compensation scheme in place to financially protect these patients. For this reason, patients must be fully aware of the risks and consent to the use of diluted vasopressin.

Surgical Steps

Setting

We place the patient in the lithotomy position with a 10-degree Trendelenburg tilt and a uterine manipulator was inserted to control the position of the uterus.

Placement and Configuration of Trocars

We place a 12-mm or 5-mm trocar at the bottom of the umbilicus as a camera port. Three 5-mm manipulation ports are placed in the lower abdomen—a midline port is placed halfway between the umbilicus and the upper edge of the symphysis, and the lateral ports are placed 4- or 5-cm median and 4 to 5-cm cephalad to the iliac crest, bilaterally.

As for the first trocar placement, the bottom of the umbilicus is grasped with two Kocher's forceps and pulled upward. We place a 5 or 10-mm incision between the

forceps, deeply, until the rectus fascia is reached. The peritoneum is incised by Mayo scissors and then the trocar is inserted.

As for manipulation ports I insert strong forceps from the lateral port and lift the abdominal wall up so as to be able to puncture the midline with the trocar without injuring the enlarged uterus (►Fig. 1a–c).

Prophylactic Hemostasis

If we cut the myometrium without preparation, there will be bleeding. To control the amount of bleeding, we use a local injection of a hemostatic agent. Diluted vasopressin is commonly used in these scenarios, even though this is an off-label use. It is a contraindication for patients with congestive heart failure, bronchial asthma, pregnancy-induced hypertension syndrome, migraine and epilepsy. We use 1 ampule (20 international units) of pitressin diluted with 70 mL of normal saline. This is infused into the myometrium over the targeted fibroid using an 18-g PTC needle or a suction needle (Hakkou co.). To avoid intravascular injection, we have to confirm no backflow in the syringe after injection. For the most effective hemostasis, we have to inject this fluid into the appropriate layer, indicated by the area of injection turning white and that white area expanding as more fluid is injected (►Figs. 2a and 3d1, 2). Once the fluid is infused, the incision and suture need to be performed quickly and smoothly as this preparatory treatment is most effective for just 20 minutes postinjection.

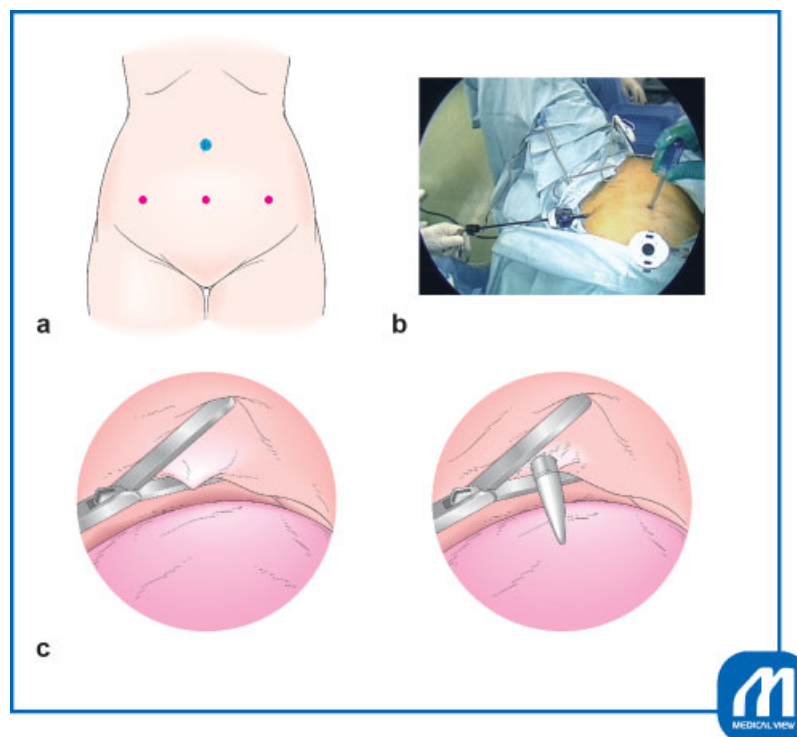


Fig. 1 Configurations of trocars. (a) Modified diamond configuration. (b) How to place trocars for huge fibroids. (c) How to place the midline port. Insert strong forceps from the lateral port and lift the abdominal wall up so as to be able to puncture the midline with the trocar without injuring the enlarged uterus. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid-focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

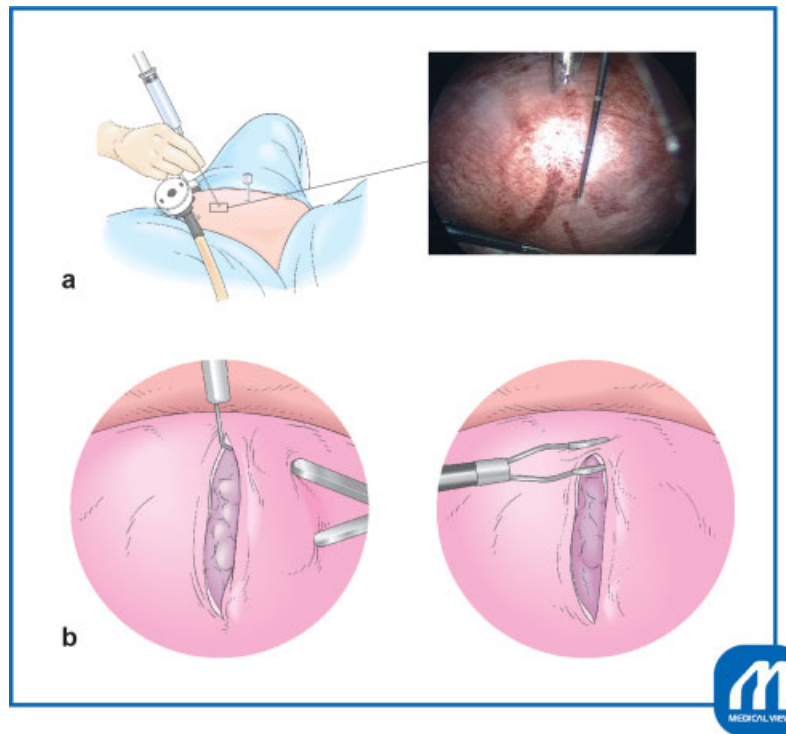


Fig. 2 Enucleation (1). (a) Injection of diluted vasopressin using PTC needle. (b) Incision of myometrium. We use a monopolar hook. If active bleeding occurs, we control bleeding using bipolar forceps. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.) PTC, percutaneous transhepatic cholangiography.

Myometrial Incision Method

Now we move to the incision of the myometrium. As for the direction of the incision, both longitudinal and transverse incisions are applicable. The needle driver is placed into the median port. Our method of choice is the longitudinal incision as it is easier to manipulate the needle driver than with the transverse incision. We can apply the incision at any point and the suturing can be applied in the same way at every point. If we use a parallel port configuration, the transverse incision is the preferred technique as suturing can be performed easily.

To incise the myometrium, we use a harmonic scalpel or monopolar cautery (pure cutting mode: 70 Watt; ▶ **Fig. 2b**). To minimize thermal spread to the myometrium, it is important to cut quickly. In the case of subserosal myomas, we remove the ship-shaped segment of the myometrium to reduce the amount of excess skin. As for the depth of the incision, it is important to find the appropriate plane. It is better to cut into the fibroid and then find the dissectible plane, rather than make a cut that is too shallow (▶ **Fig. 3a**).

Note: With regard to the electric knife, we do not use coagulation mode because there is a risk of unexpected organ heat injury via shunt burns.

Enucleation

First we grasp the fibroid with claw forceps and pull the fibroid while pushing away the myometrium using an aspiration nozzle or forceps. The assistant places countertraction on the myometrium. To dissect the fibroid smoothly, traction

of the myometrium by the assistant is extremely important (▶ **Fig. 3a–c**). During the enucleation, if we encounter hard, fibrous tissue, we would cut the tissue with a monopolar knife or scissors and then continue with blunt dissection. This combination of sharp and blunt dissection is repeated until the fibroid can be removed. We use Probe Plus II (Ethicon endosurgery) for the blunt dissector. This device allows monopolar incision, aspiration of smoke and blood as well as blunt dissection capabilities, all without having to change devices. This makes for seamless stepwise dissection. One negative point of the device is it has the tendency to bend when too much pressure is applied. For this reason, we use the Probe Plus II at the circumference of the fibroid, using blunt dissection to peel away the myometrium. We grasp close to the dissecting point and push back the myometrium with the Probe Plus II on a tangent so as to peel away the myometrium and expose the fibroid.

When we need stronger dissection power, we use a needle driver as it is stronger, allowing more pressure to be applied to the instrument. As for the direction of the dissection, we dissect evenly in each direction, careful not to work too much on one side of the dissection (▶ **Fig. 3b**). After enucleation, there are some fibrous tissues and we remove some of them, using the Probe Plus II to draw the tissue up, then dissecting it with monopolar.

Suturing Methods

Trimming of excess myometrium is required in case of subserosal fibroid (▶ **Fig. 4a1, 2**).

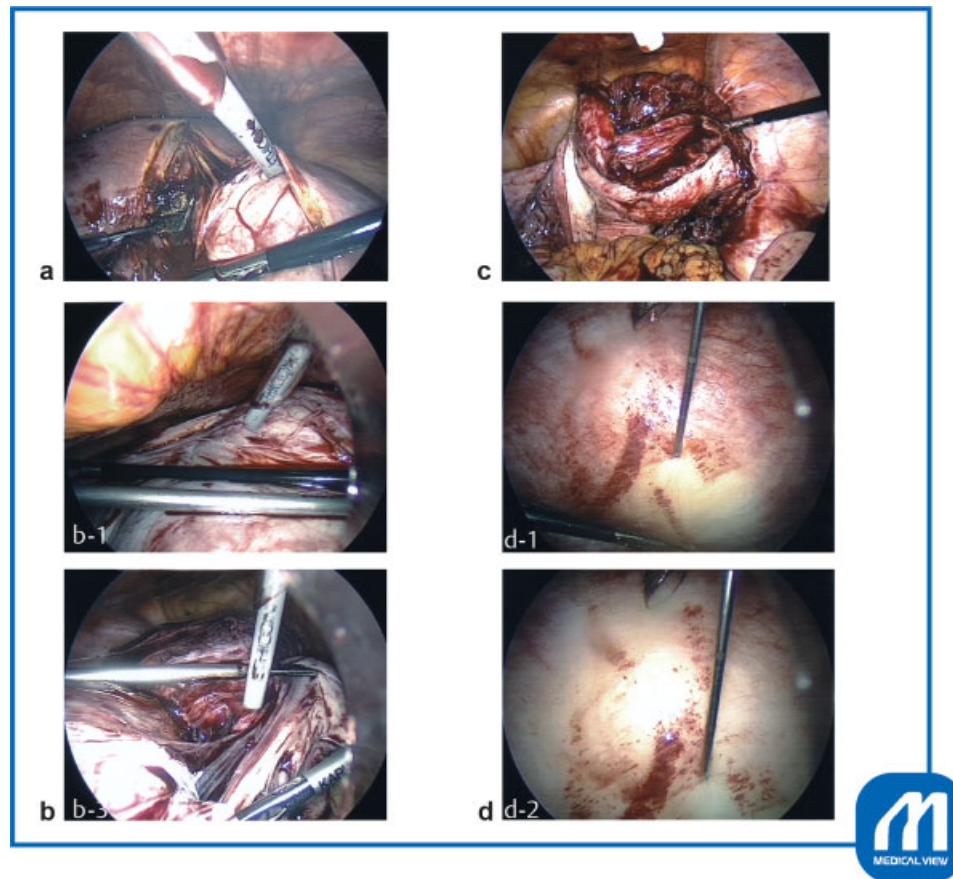


Fig. 3 Enucleation (2). (a) Finding an appropriate dissectible plane. (b) (1,2) 360-degree myometrial dissection—the fibroid is dissected from the myometrium evenly and stepwise in all directions. Countertraction is of paramount importance. (c) Postenucleation status. (d) (1,2) Aftereffects of the injection of diluted vasopressin—the surface becomes white due to localized ischemia. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

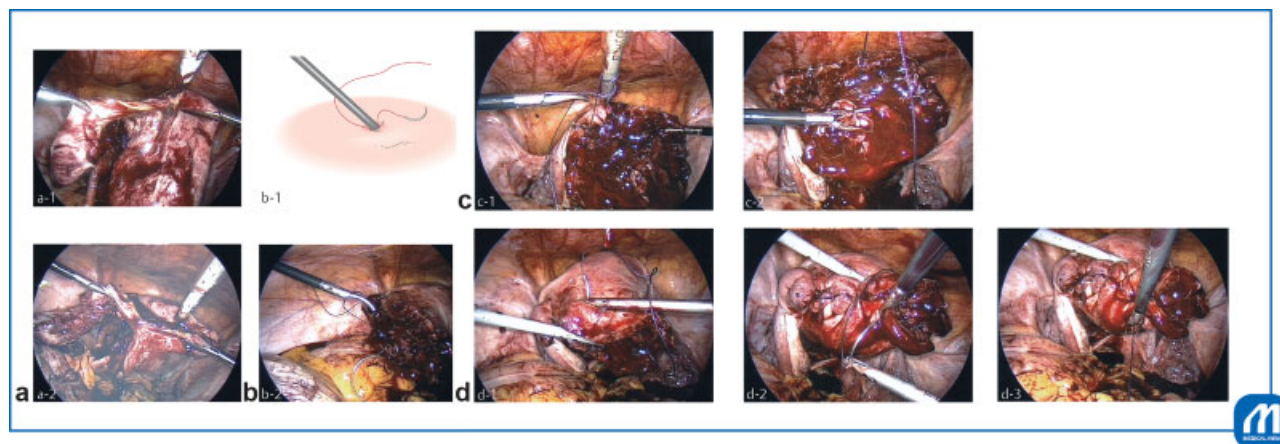


Fig. 4 Reapproximation of the myometrium. (a) (1,2) Trimming of excess myometrium in case of subserosal fibroid. (b) How to introduce the suture into the intraperitoneal cavity: (1) external view; (2) internal view. (c) (1) Starting the continuous suture; (2) It is important to maintain tension by keeping the suture tight. (d) Seromuscular suturing. (1,2) The edge of the wound needs to be inverted. (3) Tension on the suture needs to be maintained at all times. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

We generally use synthetic suture 1.0 (Vicryl CT1). We apply interrupted or continuous suture to reapproximate after the myoma is removed. Suture length is 30 cm for continuous suture. If the suture shorter than 30 cm is used, several sutures

would be required into the abdominal cavity. Anything longer than 30 cm is difficult to manage and manipulate.

The suture is introduced into the intraperitoneal cavity via the port site (→Fig. 4b1, 2).

When the defect is deep, we suture in several layers. While suturing, we make sure that the needle is introduced into the tissue at 90 degrees. We also ensure that each suture goes deep enough into the tissue to hold and prevent injury to the organ. The deeper the myoma bed, the more difficult the suturing repair becomes. In the case of a very deep defect, the assistant tracks the edge of the defect with suture. This is to ensure that there is no dead space after the wound is closed as this can result in hematoma. These deep defects often require suturing in four or five layers (►Fig. 4c1, 2).

For superficial reapproximation, we use baseball suture or seromuscular reapproximation (►Fig. 4d1, 2, 3). I prefer seromuscular reapproximation as, by this method, the edge of the wound becomes inverted, prohibiting subserosal bleeding and lowering the risk of adhesion of the bowel to the wound. Another advantage of large bite seromuscular suturing is that the suture compresses the uterus tightly and by this we can lower the risk of hematoma and postoperative bleeding.

Needle Driving

The most important point is to pass the need through the tissue perpendicularly. This makes it possible to involve full layers of the tissue. This facilitates good perfusion as not involving the full thickness of the tissue reduces blood perfusion, a disadvantage for wound healing and adds the possibility that shallow driving could lead to tissue laceration and bleeding.

When the Endometrium is Perforated

In the case that the endometrium is perforated, we close the opening of the uterine cavity using 4.0 monofilament suture in a continuous fashion to prevent interuterine adhesion. When this is difficult to perform, we place a Surgicel into the uterine cavity and then reapproximate the myometrium.

The Location of the Fibroid

There are three types of fibroids depending on the location—subserosal, intramural, and submucosal. When we perform the myometrial incision and enucleation for large subserosal myomas, due to an excess of tissue, we need to trim the tissue by making a “hip-shaped” incision. After dissecting the fibroid, the myometrium has the tendency to shrink down; so not overestimating the amount of tissue to be trimmed is one important point to keep in mind when making the initial “ship-shaped” incision.

As for the pedunculated subserosal fibroid, there are often blood vessels at the stalk which need suture ligation to prevent excessive bleeding.

Submucosal fibroid removal always carries a high risk of perforating the endometrium. Because of this, we need to control the power of retraction. We must dissect the fibroid from the endometrium using scissor in a meticulous manner to prevent injury. Although it is important not to create dead space when suturing the myometrium, it is also important to be aware of the balloon manipulator inside the uterus as puncturing the balloon or including the balloon in a suture bite is a real possibility in this scenario. Accurate suturing is vital for avoiding these potential complications.

Suture Ligation Methods

To reapproximate the myoma bed, we need intracorporeal ligation techniques. Due to the amount of tension on the sutures in these circumstances, to prevent loosening we use a slip knot or a surgeon's knot and sometimes a modified surgeon's knot—our triple throw surgeon's knot.

The Number and the Size of Fibroids

Number

A large number of fibroids are not always a barrier. One of our cases managed a successful pregnancy after more than 30 fibroids were removed. However, there are limitations when it comes to fibroid removal. As the number of fibroids increases, the chance of blood loss and surgical time also naturally increase. As wounds finally become scar tissue, there is a risk of uterine rupture during pregnancy after fibroid removal, and the number of fibroids determine the risk of rupture due to the increased number of fibroids equating to the amount of scar tissue. There are limitations in what can be addressed in terms of removing multiple or very large fibroids and these risks need to be considered thoroughly with every case.

Size

If the diameter is over 7 cm, there is a sudden increase in the difficulty in LM, and the difficulty increases exponentially. It takes longer to enucleate larger fibroids. The blood loss also increases and reapproximation and extraction get increasingly difficult with the increase in the size of the fibroid. If the diameter of the fibroid exceeds 13 cm, enucleation becomes almost impossible as the fibroid is pushed against the abdominal wall with dissection from the uterus. As a result, we have defined our limit as 12 cm. Although we set our size limit at 12 cm, this is not to say that we can remove any fibroid under this limit. There are several factors that determine whether a fibroid is operable via LM. They include the shape of the fibroid, the number of fibroids, the location of the fibroid, as well as the experience of the surgeon.

Extraction of the Specimens

In our institute, we use vaginal retrieval since we began LM in 1998. While we have always used scissors morcellation at our institute, the use of electric morcellators was once popular for extraction. On April 17, 2014, the Federal Drug Administration (FDA) in the United States reported a warning regarding the use of electric morcellators in laparoscopic hysterectomy and myomectomy for patients with fibroids. Unexpected malignancy, especially uterine sarcoma may have been caused by the dissemination of tumor cells during morcellation for the removal of fibroids. At that time, the FDA removed its recommendation for the use of electric morcellators in such surgery. According to the FDA, the incidence of sarcoma after fibroid removal operations is reported at 0.28%. Due to this warning from the FDA, the use of electric morcellation devices has suddenly decreased. Recently, “in-bag” morcellation and vaginal extraction after creating an opening in the posterior vaginal fornix is a popular trend in this surgery.

Vaginal Extraction

First, we pass suture through the biggest fibroid. In the case of multiple fibroids, we place suture through each of the fibroids, from the biggest to the smallest. Once the fibroids are strung together like beads, the uterine manipulator is removed and replaced with the Vagi-Pipe. We create the exit in the posterior vaginal fornix with a transverse incision, 1 to 2 cm below the cervix (►Fig. 5a, b1, 2, 3) and then we introduce the suture stringing the fibroids together into the Vagi-Pipe via the vaginal opening using a needle driver (►Fig. 6a, b). This suture is pulled from the vagina and the fibroids are extracted. The surgeon moves to the vaginal area for the retrieval.

Small fibroids only require gentle pulling of the suture for extraction. However, in the case of larger fibroids, we need to reshape the fibroids by cutting using strong scissors to enable exit. To prevent pelvic organ injury, like injury to the bladder or the rectum, maintenance of the operative field is of paramount importance. We maintain the extraction space using a bent ribbon retractor (width 2.5 cm). The bent ribbon retractor pushes the vaginal incision dorsally, while a rectangle retractor expands the opening ventrally. We grasp the fibroids using tenaculum and cut the fibroids and reshape them in the space between the two retractors (►Fig. 6c1, 2, 3).

- Morcellation using a long scalpel via the center umbilical port (in the case of very large fibroids).

Sometimes the fibroid is too large to descend into the small pelvic area. In that case, we remove the trocar from the center abdominal port site and insert a long scalpel (19 cm) into the abdominal cavity via this port for morcellating the

fibroid (►Fig. 7a). We remodel the fibroid without cutting it into pieces to enable it to descend (►Fig. 7b1, 2). The fibroid is sliced in parallel cuts, eventually, to take on an accordion shape and then the fibroid is introduced into the small pelvis. We grasp the fibroids via the vagina and morcellate using long scissors. If the scalpel is directed to the adjacent organs, it can cause serious organ injuries. Therefore, we do not begin slicing until the scalpel is completely introduced into the body and is under complete control. The scalpel has the potential to drop into the abdominal cavity and cause organ injury so constraint grasping of the scalpel is extremely important. The direction of cutting needs to be upward, cutting toward the space between the fibroid and the abdominal wall. If the fibroid is cut into pieces, extraction of the fibroid becomes difficult. This is the reason we chose to remodel the fibroid—to ensure its complete removal.

First, the leading surgeon's assistant pulls the fibroid bilaterally using claw forceps. Then the center of the fibroid is cut and parallel slices are made into the fibroid without cutting through it completely. We then place the fibroid upside down and do the same kind of parallel-intermittent cutting on the other side without cutting the fibroid into pieces. We place a stitch in the fibroid to create an anchor point. The tail of this suture is fed into the vagina and pulled to extract the fibroid through the vagina.

When the fibroid is degenerated we use an extraction bag. We carry the fibroid into this bag and close the bag's purse-string suture. This is introduced into the vagina and pulled to extract the fibroid.

The exit at the posterior vaginal fornix is closed in two layers using continuous 2.0 or 1.0 synthetic suture (►Fig. 8a, b).

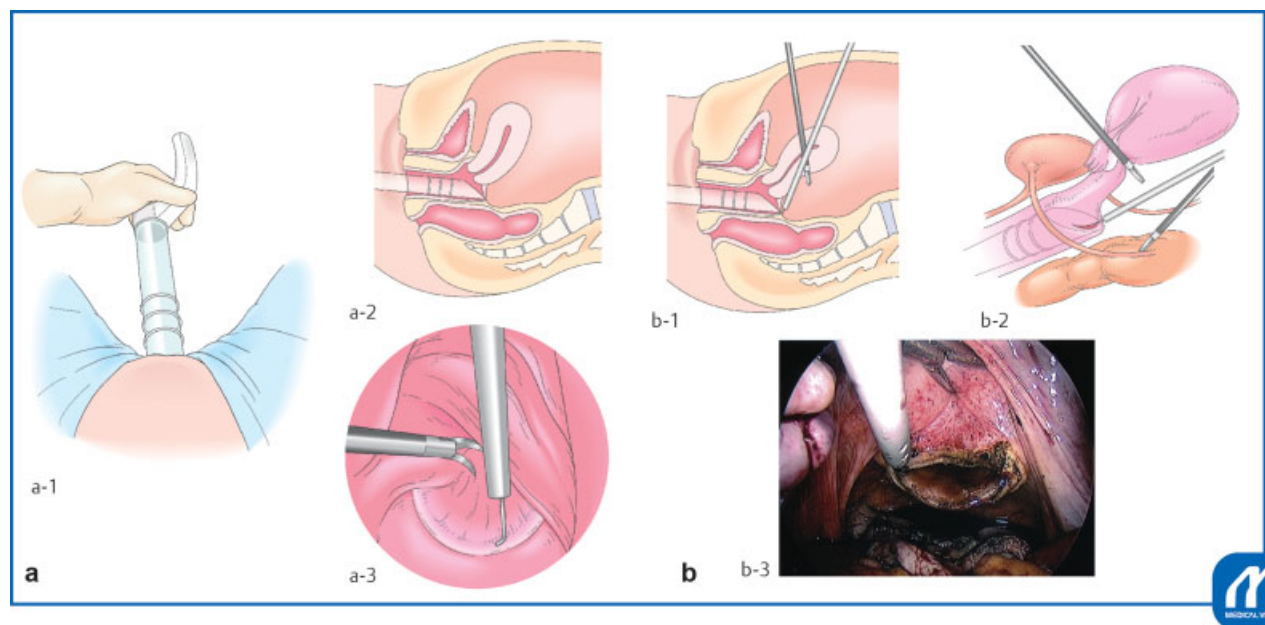


Fig. 5 Extraction of the fibroids (1). (a) Placement of the vaginal pipe. The vaginal pipe is inserted and the posterior vaginal fornix is pushed to elucidate the appropriate incision line. (b) (1,2) How to maintain the operative field during the incision of the posterior vaginal fornix. The surgeon pushed the uterine cervix anteriorly while the assistant pushed the rectum posteriorly. (3) The surgical view of opening the posterior vaginal fornix using a monopolar hook. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

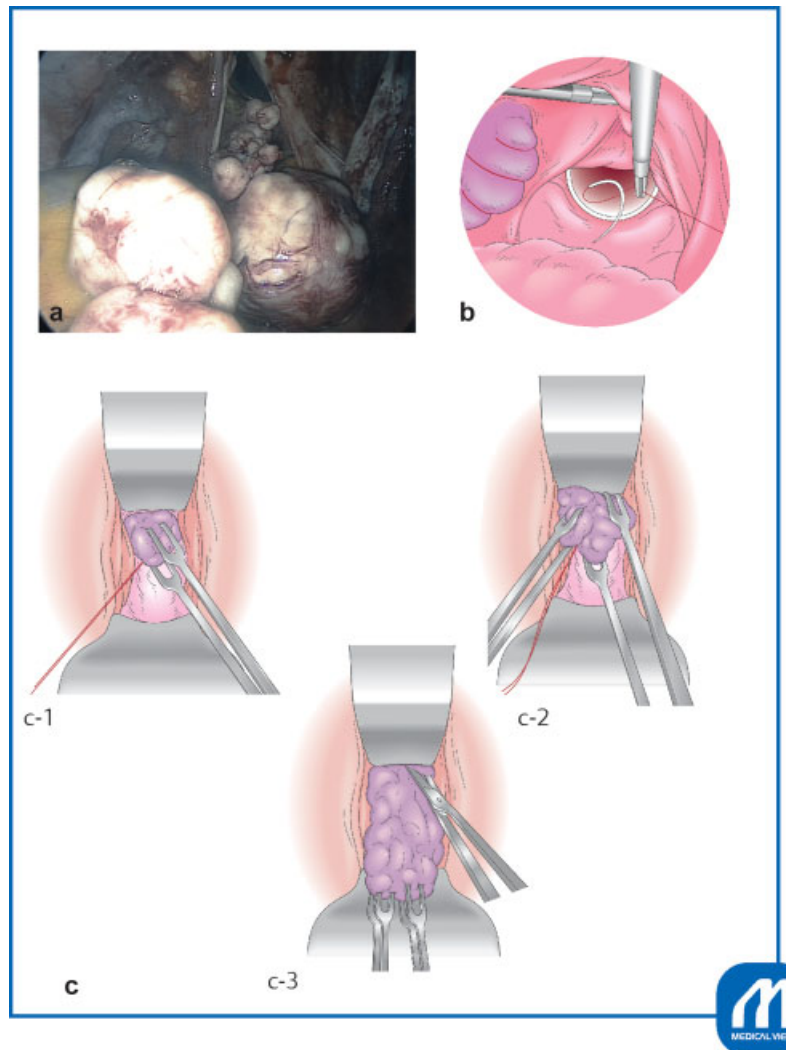


Fig. 6 Extraction of fibroids (2). (a) In the case of multiple fibroids, we use suture to connect the fibroids like beads on a string. (b) This suture is introduced into the vaginal opening for extraction. (c) Extraction from the vagina. (1) Suture connecting the fibroids is pulled out of the vagina, introducing the fibroids into the vaginal opening. (2) The fibroids are grasped with two Museux forceps. (3) We core the fibroids with scissors. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

Hemostasis and Irrigation

Clots or blood coagula is completely removed as coagula is one cause of the intraperitoneal adhesion. At this time we confirm complete hemostasis. According to the guidelines of JSGOE (Japanese Society of Gynecology and Obstetrics Endoscopy), the usage of an antiadhesion barrier is beneficial, however, we do not use it. From our experience, most of the cases that have undergone a cesarean section after our myomectomy have not had any adhesions found. After placing a drain, the port sites are closed (–Fig. 9).

Conclusion

In LM, there are three important steps—enucleation, repair, and extraction. Each of them requires advanced laparoscopic skills. Laparoscopic suturing and knot tying are important prerequisites for attempting this kind of surgery. We need to

continually train ourselves in basic laparoscopic skills like suturing, knot tying, and needle driving using a dry box to achieve the level required to manage this kind of surgery safely. To achieve healthy wound healing, accurate intra-corporeal suturing is vital. Until suturing and ligation are complete, bleeding from the wound continues and when the speed of suturing and ligation is slow, blood loss is increased. Thus, the role of speed in these basic skills is of extreme importance (–Fig. 10).

Even when preoperative diagnosis shows a benign fibroid, we sometimes encounter a sarcoma or malignant uterine tumor, so we need to explain the risks of these possibilities to the patient. However, in our institute, the incidence of malignant disease is very low compared with published data from Europe and the United States. In our data, 9,645 cases underwent hysterectomy or myomectomy from 1994 to 2015. A total of 9,594 of these were leiomyoma, three cases were STUMP (Smooth muscle Tumor of Uncertain Malignant

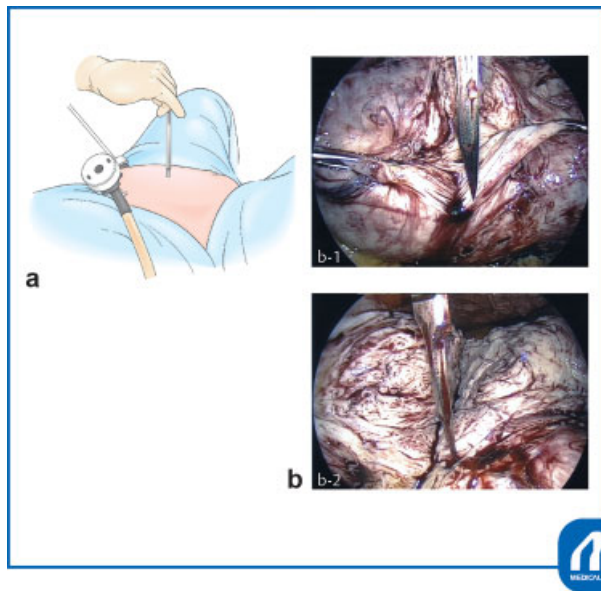


Fig. 7 Transabdominal morcellation. (a) Introduction of a long handled scalpel into the abdominal cavity via the midline port site. (b) Real surgery long scalpel morcellation. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

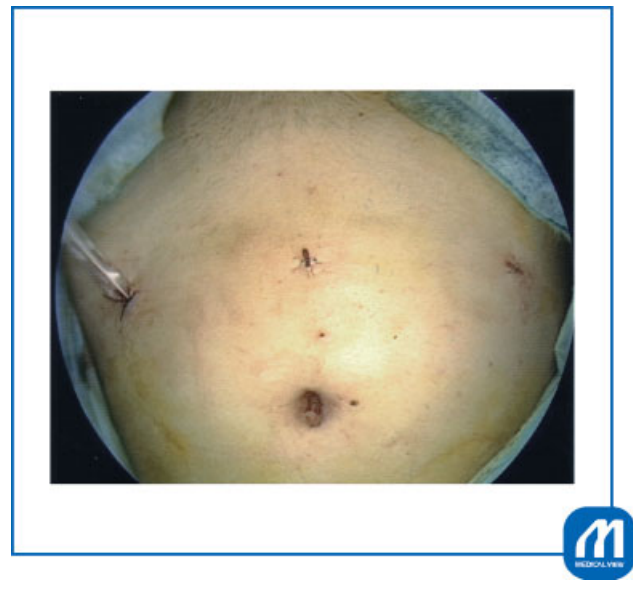


Fig. 9 Abdominal wounds—One 12-mm umbilical port and three 5-mm manipulation ports. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

Potential), 13 cases leiomyosarcoma, six cases of endometrial stromal sarcoma, two cases of adenosarcoma, and 27 cases of carcinosarcoma. Among these cases, preoperatively undetected cases were 3 per 9,645 (0.00031%). Of course, this kind

of incidence means that it is difficult to encourage patients of child-bearing age to undergo hysterectomy, but we need to obtain informed consent and accurately explain the risks of more conservative approaches.

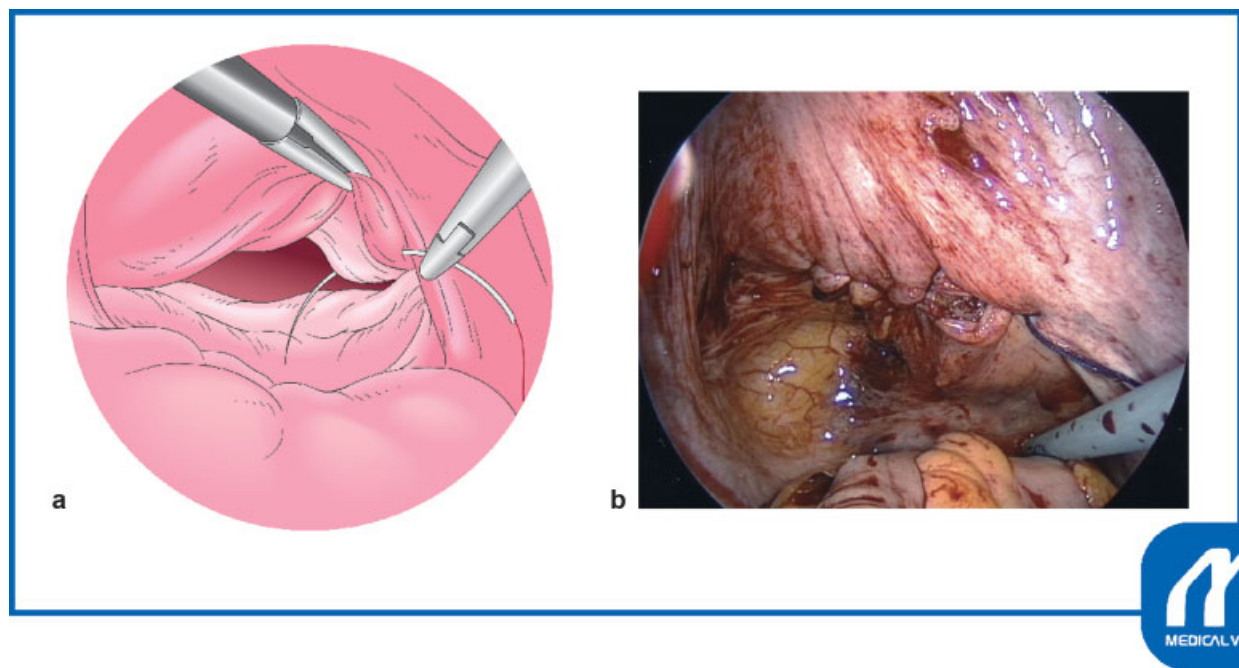


Fig. 8 Closure of the vaginal opening. (a) How to suture the opening of the vagina—needle driving. (b) Postclosure status in real surgery. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)

Conflict of Interest
None declared.



Fig. 10 Postdissection status. (a) Closure status from the view of the vagina. (b) The specimen. (Reproduced with permission from Andou M, Ota Y, Hada T, Kanao H. Laparoscopic Myomectomy for huge fibroid- focusing on difficult cases. In Hiramatsu Y, Konishi I, Sakuragi N, Takeda S eds. Mastering the Essential Surgical Procedure. OGS Now, No.11 Uterine fibroid (Japanese). Tokyo: Medical View; 2010:58–69. Copyright © Medical View.)