

Video Article

Introduction of Intracapsular Rotary-cut Procedures (IRCP): A Modified Hysteromyomectomy Procedures Facilitating Fertility Preservation

Liping Zeng^{1,2}, Weixia Wei^{1,2}, Huiru Tang^{1,2}, Fang He^{1,2}, Shilin Zhong^{1,2}, Wei Zhang^{1,2}, Yuting Xiang¹, Xinfeng Qu³, Ruifang Wu^{1,2}

¹Department of Obstetrics and Gynecology, Peking University Shenzhen Hospital, China

²Shenzhen Key Laboratory of Gynecological Diagnostic Technology Research, China

³Specialist of SZSM Project, Peking University Shenzhen Hospital, China

Correspondence to: Ruifang Wu at wurf100@126.com

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Abstract

Uterine fibroids are common benign tumors in the female reproductive system. A hysterectomy is the most effective treatment for symptomatic fibroids. For patients desiring pregnancy, laparoscopic intracapsular myomectomy (LM) is an alternative surgery option. Although LM is widely accepted to treat fibroids, it is technically demanding with risk of excessive bleeding and difficult suturing, especially in cases with large fibroids or tumors in unusual locations. Therefore, we developed an intracapsular rotary-cut procedure (IRCP) as a modification of laparoscopic intracapsular myomectomy, with the intention to minimize risks of LM and help uterine healing. A summary of the improvements to the IRCP is described: 1) making an incision at the site of the fibroid with a length of one-third to one-half of the fibroid's diameter at a depth reaching the fibroid's surface; 2) holding the fibroid stably and making rotary cuts on the fibroid at a depth of 0.5–1 cm within its pseudo-capsule while pulling it outward slightly, making sure not to cut off any pieces of the fibroid; and 3) repeating the cutting-and-pulling until the longest dimension of the fibroid is outside the incision. The multiple cuts are to minimize the diameter and extend the length of the fibroid. When the multiple cuts cause half of the fibroid body to "shrink", the fibroid is squeezed out by contraction of the surrounding myometrium. Evaluation of the outcomes of IRCP showed that the time of enucleation and suturing, intraoperative bleeding, and decline of hemoglobin were significantly lower in the IRCP group than the LM group. As for reproductive outcomes, the full-term live birth rate of the IRCP group was significantly higher than that of LM group. However, there was no difference in delivery modes between the two groups. In conclusion, IRCP significantly benefits fertility preservation by minimizing damage to the uterus, protecting myofibers of the pseudo-capsule, and resulting in a shallower residual cavity, which eases stitching and causes less bleeding. It is worthwhile to adopt IRCP in younger patients who desire preservation of their fertility.

Video Link

The video component of this article can be found at <https://www.jove.com/video/58410/>

Introduction

Uterine fibroids are the most common pelvic tumors observed in gynecologic practice. The incidence is estimated to be about 20–25% worldwide¹. Most uterine fibroids are asymptomatic but sometimes cause abnormal uterine bleeding, pelvic pressure, pelvic pain, and adverse reproductive outcomes, thus diminishing the quality of life of women^{2,3}. Management of fibroids depends on individual situations and includes options such as surgery, medication, and revisit observation⁴. A hysterectomy is an important method to treat uterine fibroids and is a radical surgery that can prevent recurrence^{3,5}. Myomectomy, however, is becoming popular as doctors are paying more attention to the fertility preservation of patients at reproductive ages, especially during the era of the two-child policy in China⁶.

As Tinelli and his colleagues have described, in the procedure of laparoscopic myomectomy (LM)⁷, the visceral peritoneum is incised in the midline longitudinally by monopolar scissors or a crochet needle electrode, proceeding at a certain depth into the myometrium to identify the pseudo-capsule. The pseudo-capsule is opened longitudinally by monopolar scissors or a hook electrode at a low wattage (30 W) to expose the fibroid. Then, the fibroid is hooked by a myoma screw for gentle enucleation with help from an irrigator cannula that is inserted in the space between the pseudo-capsule and fibroid. Hemostasis of the small vessels is made to free the base of the myoma and connective bridges from the pseudo-capsule. The myometrium is then closed in a single layer for subserous fibroids and as double layers for intramural fibroids.

Although LM is widely applied around the world, there are still some limitations of this procedure. Since LM is more technically demanding than laparotomy, it should be applied to selected cases with relatively smaller sizes and numbers of fibroids^{8,9}. It remains a great challenge to remove intramural fibroids greater than 8 cm or subserous ones greater than 12 cm with laparoscopy¹⁰. Published data have shown that transfusion-requiring bleeding and postoperative hematomas significantly increased when applying LM to removal of intra-broad ligamentous fibroids¹¹. Other researchers believe that excessive bleeding, prolonged operation time, and potential dissemination of cells when applying morcellation are concerning problems with LM^{12,13}. The risk of during-pregnancy uterine rupture after LM is reported to be higher than abdominal myomectomy due to the technical difficulties of suturing¹⁴. The safety of pregnancy succeeding LM remains controversial¹⁵. As postoperative healing of the

myometrium is very important for patients who need to maintain fertility either clinically or by request, LM procedures need to be more applicable, which can be accomplished by reducing the technical difficulties and promoting uterine healing after the surgery.

In order to minimize the damage to the patient's fertility, here we present a modified myomectomy procedure, the intracapsular rotary-cut procedure (IRCP)¹⁶. This procedure shortens the incision on uterine wall as much as possible and reduces the technical difficulties of LM. Also, it helps to protect fibers and blood vessels of the pseudo-capsule that plays an important role in uterine healing after myomectomy, ultimately reducing the risk of postoperative hematoma and uterine rupture in subsequent pregnancy. After being reviewed and approved by the Institutional Review Board of Peking University Shenzhen Hospital on December 15, 2012, we began the application of IRCP and evaluation of the outcomes of IRCP by comparison with traditional LM.

Protocol

All the procedures in the following protocol were reviewed and approved by the Institutional Review Board of Peking University Shenzhen Hospital for application on patients on December, 15, 2012.

1. Patient Preparation

1. Use the following inclusion criteria: abnormal uterine bleeding; fibroids compressing surrounding organs and causing urinary, digestive, or sexual symptoms; infertility; fibroid is larger than 4 cm while the patient is preparing for pregnancy.
2. Use the following exclusion criteria: suspected malignancy; suspected fibroid degeneration; pedunculated, cervical, or intra-broad ligamentous fibroids; preoperative use of gonadotrophin-releasing hormone analogues; acute systemic inflammation or pelvic inflammatory disease; patient is currently pregnant, within puerperium, or within three months after abortion; severe coagulation disorders; any other contraindications for general anesthesia or laparoscopy.
3. Conduct a pelvic palpation and ultrasound examination to determine the location, number, and size of the fibroids.
4. Inform the patient of the benefits and risks of surgery and obtain written consent, discussing the risks of excessive bleeding and blood transfusion, conversion to laparotomy, tumor cell dissemination during the operation, and postoperative infection.
5. Perform the surgery under general anesthesia with endotracheal intubation. Administer to each patient a prophylactic antibiotic dosage of 2 g of cefamandole intravenously 30 min before induction of anesthesia.

2. Pre-IRCP Preparation

1. After standard skin sterilization, establish the ports by standard techniques: a 10 mm umbilical port, and 5 mm and 10 mm ancillary ports in the lower abdomen. Connect the 5 mm port with a plastic tube for vacuum drainage, which can suck the smoke during surgery.
2. During the surgery, have an anesthesiologist carefully monitor vital signs of the patient.
3. Maintain the intraabdominal pressure and gas flow rate at 13 kPa and 12 L/min, respectively.

3. Intracapsular Rotary-cut Procedure (IRCP)

1. Inspect the pelvis carefully to confirm the size, number, and location of the fibroids. Inject an ischemic solution (6 U pituitrin and 20 U oxytocin diluted in 10 mL of saline) into the myometrium around the fibroids with a 10 mL syringe.
2. Determine the incision position on the most-protruding site of the fibroid and incise longitudinally by a monopolar hook electrode at low wattage (30 W), ensuring the length is no longer than half of the fibroid diameter. Open the pseudo-capsule by a longitudinal cut to expose the fibroid surface (**Figure 1A**).
3. Hold the fibroid with the laparoscopic forceps and pull it outward, keeping a certain tension to expose the boundary between the fibroid and the pseudo-capsule (**Figure 1B**).
4. **Perform multiple rotary cuts on the fibroid (Figure 1C1) with a monopolar electrical knife in depths of 5–10 mm, shrinking the diameter of the tumor (Figure 1C2) and ensuring not to cut any pieces of the fibroid off.**
 1. Meanwhile, keep pulling outward to facilitate further exposure of the gap between the fibroid and the pseudo-capsule. Remove the smoke by vacuum drainage to keep a clear field.
5. Repeat the cutting-pulling procedures on the fibroid in the manner described above with 10 mm intervals, ensuring that each cut is at a certain distance with the prior cut, until the longest dimension of the fibroid is outside the incision. Then, the fibroid will be squeezed out by contraction of the pseudo-capsule and myometrium (**Figure 1D**). Avoid pulling too hard and blunt dissection to protect fibers and vessels of the pseudo-capsule.
6. Gently pull the fibroid outward, and the pseudo-capsule should slip off to the base of the fibroid. Continue the cuts on the fibroid until the base of the fibroid is exposed and isolate it from its pseudo-capsule (**Figure 1E**). Use bipolar electrocautery forceps to coagulate and cut off the blood vessels, always at 30 W. After removal of the fibroid, only a shallow residual cavity is left (**Figure 1F**).
7. Close the residual cavity in a single layer with a 30 cm 1-0 polyglyconate unidirectional barbed thread. Begin the running suture at 5 mm outside of the incisal edge with 1 cm increments. Make sure that the stitching passes through the bottom of the residual cavity, and leave no dead space.
NOTE: Generally, a single-layer suture is enough to close the residual cavity (**Figures 1G and 1H**). Occasionally, the fibroid was over 12 cm in diameter and occupied more than 2/3 of the myometrium. In these cases, a "folding suture" can be adopted, in which the myometrium on one side of the incision can be sutured on top of the other side to close the residual cavity and strengthen the myometrium.
8. After suturing, enlarge the 10 mm port to a 15–20 mm port for the introduction of the morcellator. Morcellate the fibroids with a reusable morcellator.

4. Postoperative Management

1. Document the intra- and post-operative parameters carefully, including the diameters of the fibroids (represented by the diameter of the largest one in cases of multiple fibroids), operation time (from the beginning of incision to the end of suturing), blood loss (calculated by vacuum drainage), and rate of conversion to laparotomy.
2. Follow up patients by pelvic examination and ultrasound as well as phone interviews.
3. Evaluate the outcomes of IRCP by comparison with those of traditional LM around the same period. Perform statistical analysis by SPSS software and consider $p < 0.05$ as statistically significant.

Representative Results

IRCP was performed on 41 patients with uterine fibroids and traditional LM was performed on 72 patients from 2013 to 2016. 9 cases (12.5%) in the LM group were converted to laparotomy because of massive bleeding, difficulty in enucleation, or suturing, while laparoscopy was performed successfully in all cases in the IRCP group. The percentage of conversion to laparotomy was significantly higher in the LM group ($p = 0.025$). Excluding the 9 cases converted to laparotomy, the average age of patients in the IRCP group ($n = 41$) and LM group ($n = 63$) were 38.6 ± 5.9 years and 38.1 ± 6.2 years, respectively, suggesting no difference between the two groups ($p = 0.632$). As is shown in **Table 1**, the mean diameters of the fibroids were also comparable between the two groups ($p = 0.265$). However, the time of enucleation and suturing, intraoperative bleeding, and decline of hemoglobin were all significantly lower in the IRCP group than the LM group ($p = 0.015$, $p = 0.014$, $p = 0.024$). Postoperatively, none of the 113 cases experienced fever, urinary infections, postoperative hematomas, or other complications.

After discharged, the patients were followed up by outpatient visits and telephone interviews. When evaluating reproductive outcomes, only those who desired fertility after surgery were included. In the IRCP group, all patients were successfully followed up. Among them, 31 (75.6%) patients achieved full-term births, including 2 vaginal births and 29 caesarean sections. On the other hand, in the LM group, 56 (88.9%) patients were successfully followed up, and the rate of full-term live birth was 23.2% (13/56), consisting of 1 vaginal birth and 12 caesarean sections. The full-term live birth rate of the IRCP group was significantly higher than that of the LM group ($p = 0.000$). However, no difference existed between the delivery modes in the two groups ($p = 1.000$). In addition, there was no uterine rupture observed in either group during follow-up.

	LM group (n=63)	IRCP group (n=41)	t	P
age (year)	38.1±6.2	38.6±5.9	0.480	0.632
diameter (cm)	6.7±2.1	7.2±2.3	1.120	0.265
time of enucleation and suture (min)	56.8± 32.4	42.4± 26.9	2.5	0.015
intraoperative bleeding (ml)	103.1±150.4	43.1±38.5	2.5	0.014
decline of hemoglobin (g/L)	18.0±10.3	13.4±9.5	2.3	0.024

Table 1: Comparison of perioperative outcomes between two groups. The average age of patients and diameter of fibroids were comparable between the two groups. However, the time of enucleation and suturing, intraoperative bleeding, and decline of hemoglobin were all significantly lower in the IRCP group than in LM group.

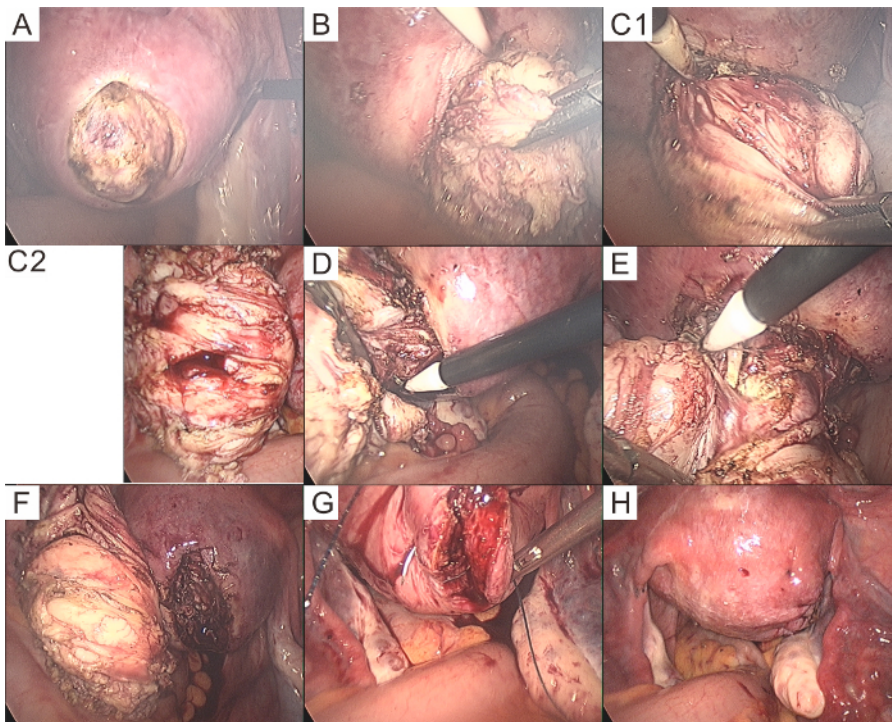


Figure 1. Steps of intracapsular rotary-cut procedures (IRCP). (A) longitudinal incision was applied on the uterine wall that the fibroid located at, using monopolar electrical knife, with an incisive length of 3 cm (1/3 of the fibroid diameter). (B) The fibroid was held with forceps and pulled outward to keep a certain tension to expose the boundary of the fibroid with its pseudo-capsule. (C1) Multiple rotary-cut was performed on the fibroid by monopolar electrical knife with careful protection to the fibers and vessels of pseudo-capsule. (C2) The fibroid were shaped from spheroid to lobulated during multiple rotary-cut. (D) Repeat rotary-cut, the longest dimension of the fibroid is exposed to the incision on the muscle layers of its capsule, pushed out fast by the pressure created from the contraction of its pseudo-capsule. (E) Continue the semicircular cuts on the fibroid in the same manner until the basis of the fibroid is exposed and isolated from its pseudo-capsule. (F) Removed the fibroid (left) and shallower residual cavity in uterine incision (right). (G) Single layer suture on the uterine incision. (H) Postoperative uterine.

Discussion

Uterine fibroids are the most common benign tumors of the female reproductive system, affecting 20–25% of all women¹ and causing abnormal uterine bleeding, recurrent miscarriage, pelvic pain, premature birth, and infertility in 10–30% cases². As most patients with uterine fibroids are asymptomatic, the actual incidence may be higher than recognized¹. Management of uterine fibroids are generally based on various factors including the age and symptoms of the patient, size and location of the fibroids, patient desire to preserve the uterus, techniques and experience of the gynecologists, and accessibility of technical equipment¹⁷. Technically, hysterectomy is the most effective treatment for symptomatic uterine fibroids. As reported, uterine fibroids accounted for most cases of hysterectomy from 1990 to 1997 in the United States¹⁸. According to a cross-sectional study conducted from 2009 to 2011 in China, the major indication for hysterectomy is still uterine fibroids in rural regions of China, accounting for 70.67% of all cases¹⁹. For patients who desire pregnancy, however, myomectomy is an alternative that can be performed by laparotomy or laparoscopy. A systemic review of nine randomized controlled trials has demonstrated that LM is associated with less subjectively reported postoperative pain, lower postoperative fever occurrence, and shorter hospital stays compared to open myomectomy; furthermore, there was no difference in recurrence risk²⁰. Also, LM resulted in less adhesion formation⁹. Because of its superiority, LM is the most frequent choice for patients who desire preservation of uterus and subsequent pregnancy, especially for subserous or intramural fibroids.

In recent years, researchers have achieved a better understanding about the vascular structure surrounding uterine fibroids, namely the pseudo-capsule. It is believed that the pseudo-capsule is a part of myometrium compressed by the tumor and is contains abundant collagen fibers, blood vessels, and neurofibers²¹. The integrity of the pseudo-capsule is important for blood supply and uterine healing after myomectomy. Therefore, the widely accepted principle is to perform an intracapsular myomectomy. During this procedure, the fibroids are stretched and extracted directly from the pseudo-capsule. Since detachment of the fibroids is performed inside the pseudo-capsule, it causes decreased blood loss²². Tinelli⁷ has postulated that laparoscopic intracapsular intramural and subserous myomectomy spares the intact fibrovascular network surrounding the myoma, reducing bleeding and damage to the myometrium, which can also maximize the potential for future fertility and minimize risk of uterine rupture during pregnancy. However, the risk of massive bleeding, difficulty of suturing, and demands of the required techniques are major limitations of traditional LM. Based on this, we developed the modified myomectomy procedure, IRCP.

In an earlier article on the evaluation of IRCP published by our team, we have demonstrated that IRCP was associated with smaller incision, less time of suturing, less intraoperative blood loss, and reduced decline of hemoglobin, compared to traditional LM¹⁶. The results of this study were consistent with the previous data, confirming the advantages of IRCP over traditional LM. Meanwhile, the full-term live birth rate was higher in the IRCP group than the LM group, suggesting that IRCP facilitated fertility preservation. Researchers have illustrated that previous laparoscopic myomectomy with adequate suturing of the myometrium was not a contraindication for vaginal delivery²³. The reported rate of vaginal birth after traditional LM was 67.0%⁷, but in our study, the rate of vaginal birth was much lower than reported.

The past decades have witnessed a remarkable increase of the caesarean section rate in mainland China²⁴, which has resulted from various factors, including patient concerns about pain and uneasy doctor-patient relationships. Also, some women believe that a caesarean section is safer for the fetus. Thus, for women with previous history of myomectomy, obstetricians tend to be more cautious and are more likely to recommend scheduled caesarean sections because of the concerns about uterine rupture²⁵. Uterine rupture is a rare but devastating complication during post-myomectomy pregnancy, especially in the third trimester^{26,27}. In spite of the extreme low incidence, it may cause unfavorable outcomes for the mother and fetus. Reported risk factors included excessive use of electrical equipment and inadequate suturing²⁸. No case of uterine rupture was observed in our study. By IRCP, the application of electrical equipment is limited, and suturing is less technically demanding due to the shallower residual cavity, which may contribute to a lower risk of uterine rupture; however, more evidence is needed.

As discussed, the advantages of laparoscopic IRCP are clear in comparison to traditional LM. First, a smaller incision of the uterus is made. Traditional LM requires an incision over half of the fibroid diameter. For multiple fibroids with unregular shapes, the incision may be equal to the diameter of the fibroid, which may cause severe damage to the pseudo-capsule. IRCP, however, enables the fibroid to be removed from an incision that is no more than half of its diameter, protecting the integrity of the pseudo-capsule as much as possible. Second, IRCP causes less bleeding. Traditional LM causes bleeding due to damage to the blood vessels of the pseudo-capsule. Specifically, blunt dissection of the fibroid and its pseudo-capsule usually leads to blood vessel breakage and massive bleeding. IRCP significantly lessens bleeding, as it avoids blunt dissection. Instead, IRCP protects the vessels with rotary-cuts on the fibroid, which has no blood vessels and eases handling of the blood vessels at the base of the fibroid. IRCP achieves detachment of the fibroid by shrinking its diameter and contraction of the surrounding myometrium. The blood vessels at the base of the fibroid can be coagulated by bipolar electrocautery forceps, resulting in less blood loss. Third, a smaller and shallower residual cavity was left. Traditional LM is based on blunt dissection on the muscle layer of the pseudo-capsule, which causes fracture of the muscle fibers to form a residual cavity equal to the fibroid size after it is removed. IRCP enables removal of the fibroid in its pseudo-capsule without damage to the muscle fibers. Therefore, the fairly protected muscle layer can contract after the fibroid is removed, leaving a smaller and shallower residual cavity. Although both traditional LM and IRCP emphasized removing the fibroid within its pseudo-capsule, the residual cavity is much smaller and shallower in IRCP due to injection of ischemic solutions, better contraction of the myometrium, and a smaller incision. Lastly, IRCP makes suturing easier; as IRCP requires smaller incisions in the uterus, it enables the achieving of smaller and shallower residual cavities and little bleeding, making it easy to suture with no dead space remaining. Usually, a single-layer suture is enough to close the residual cavity, and no layered suture is needed. Also, it is less technically demanding for the surgeon.

Still, we acknowledge that there are still some limitations of IRCP. For example, IRCP is not suitable for pedunculated subserous fibroids or submucous ones. Also, it remains to be determined whether IRCP should be applied to degenerated fibroids. Red degeneration, cystic degeneration and fatty degeneration all lead to softer texture of the tumor and impaired contraction of the myometrium. In this case, it is not easy to detach the fibroid from its pseudo-capsule by IRCP. Besides, as a moderated morcellation procedure, IRCP may result in potential dissemination if malignancy exists. However, with a careful pre-operative evaluation for risk of malignancy and by strictly following the procedures to perform inside of the pseudo-capsule, this risk can be minimized. In addition, it is difficult to operate when the major part of the fibroid is still inside the pseudo-capsule, and it requires patience. However, when most of the fibroid is outside the incision, it will slip out spontaneously.

Eventually, we concluded that IRCP significantly shortens operation time and reduces intraoperative bleeding. This procedure also better protects the integrity of the pseudo-capsule and myometrium by shrinking the diameter of the fibroid and facilitating uterine healing, which is of fundamental importance for subsequent pregnancy and vaginal delivery. It is worthwhile to adopt IRCP in young patients who desire maintenance of fertility. IRCP is especially suitable for cervical and intra-ligamentous fibroids. Although fibroids in unusual locations are not illustrated in the current article, we have achieved successful experience in managing cervical and intra-ligamentous fibroids with IRCP. As the surgery is performed inside the pseudo-capsule, it effectively avoids injury to uterine blood vessels and ureters. Usually, the pseudo-capsule of intra-ligamentous fibroids is looser, so it is easier and safer to perform IRCP. As for cervical fibroids, we have successfully performed IRCP on 9 patients with large cervical fibroids, which will be illustrated in detail in later reports.

Disclosures

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