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Prediction of the operative time for hysteroscopic myomectomy for leiomyomas penetrating the intramural cavity using leiomyoma weight and clinical characteristics of patients

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Abstract

Purpose: To preoperatively predict the operative time (OT) for hysteroscopic myomectomy for G1 or G2 leiomyoma based on leiomyoma weight.

Methods: The data from 544 patients who underwent one-step hysteroscopic myomectomy were analyzed retrospectively. A total of 340 patients with leiomyoma penetrating the intramural cavity were identified as suitable candidates for calculation of the OT based on leiomyoma weight; we considered leiomyoma weight to be the most objective parameter for evaluating leiomyoma tissues. Additionally, 460 patients with a single leiomyoma were analyzed to estimate the weight of the resected leiomyoma based on its diameter.

Results: Considering total leiomyoma weight (TLW) and two additional coefficients (1.5: G2 leiomyoma, 0.75: vaginal parity of the patient), we demonstrated that our formula correlated well with OT (R^2 = 0.72). TLW also correlated well with the cube of the average diameter (AD) of leiomyomas (R^2 = 0.89). Predicting TLW significantly improved the application of specific coefficients depending on its value (1.0: AD 0.1-2.0 cm, 0.8: AD 2.1-3.0 cm, 0.7: AD 3.1-5.7 cm).

Conclusion: The OT for hysteroscopic myomectomy of intracavital leiomyoma can be predicted prior to surgery using simple clinical information of the target leiomyoma and the patient.

KEYWORDS
average diameter, degree of protrusion, operation time, patient parity, total leiomyoma weight

1 | INTRODUCTION

Hysteroscopic removal of submucosal leiomyomas is considered a minimally invasive procedure with little postoperative pain and a short recovery time because this method does not require abdominal incisions.[1,2] However, this technique has several limitations related to the characteristics of the target leiomyoma, including the location, size, and degree of protrusion into the uterine cavity, and the choice and success of this surgery depends on the skill of each physician.[3-5] Therefore, standardized selection criteria for hysteroscopic myomectomy are lacking, except for the Wamstecker criteria published in 1993.[6] An easy-to-use scoring system is needed to determine the degree of difficulty of the operation. Previous reports have demonstrated that the characteristics of leiomyomas significantly affect the prediction of difficulties in hysteroscopic myomectomy. The European Society of Gynaecological Endoscopy (ESGE) and STEPW (size, topography, extension, penetration, wall) classifications are important systems for predicting surgical difficulties.[7] Additionally, ESGE classification, size, and age are considered important factors for predicting the operative time for hysteroscopic myomectomy.[8] Other researchers have also reported that the size and location of leiomyomas are crucial factors for determining potential difficulties of hysteroscopic myomectomy,[9] but these researchers did not investigate operative time (OT) or its prediction. Predicting difficulties of hysteroscopic myomectomy may be a necessary preoperative step because resecting leiomyomas, especially G2 leiomyomas, can be problematic due to the inherent challenges of hysteroscopic myomectomy.[7-9]

This research mainly focused on G1 and G2 leiomyomas as hysteroscopic resection of G0 leiomyomas is considered relatively easy. In some cases, we must treat multiple leiomyomas. The total weight of the resected tumor was regarded as the most important and objective parameter for determining the difficulty of hysteroscopic myomectomy because weight that can be measured soon after the operation and is not affected by drugs such as GnRH analogue. As we aimed to analyze patients diagnosed with multiple leiomyomas, we did not adopt the diameter of the target leiomyoma as a primary index for the estimation of OT. In this study, more than 500 cases of hysteroscopic myomectomy performed exclusively by one physician using the same method, namely one-step complete resection, were analyzed. First, we identified the relationship between the diameter of the target leiomyoma and total leiomyoma weight (TLW) by calculating the correlation coefficient between the diameter measured before surgery and the TLW obtained after surgery. Furthermore, we considered each patient's parity because cervical dilatation prior to intervention is often crucial for intrauterine manipulation.[10,11] Altogether, the effects of the lesion and patient characteristics were evaluated to estimate the OT required for hysteroscopic myomectomy.

2 | MATERIALS AND METHOD

2.1 | Subjects

This retrospective study consisted of 544 patients who underwent hysteroscopic surgeries to remove submucous leiomyomas between January 2006 and March 2016. Thirteen cases with insufficient clinical data were excluded (Figure 1). We collected the data on the OT

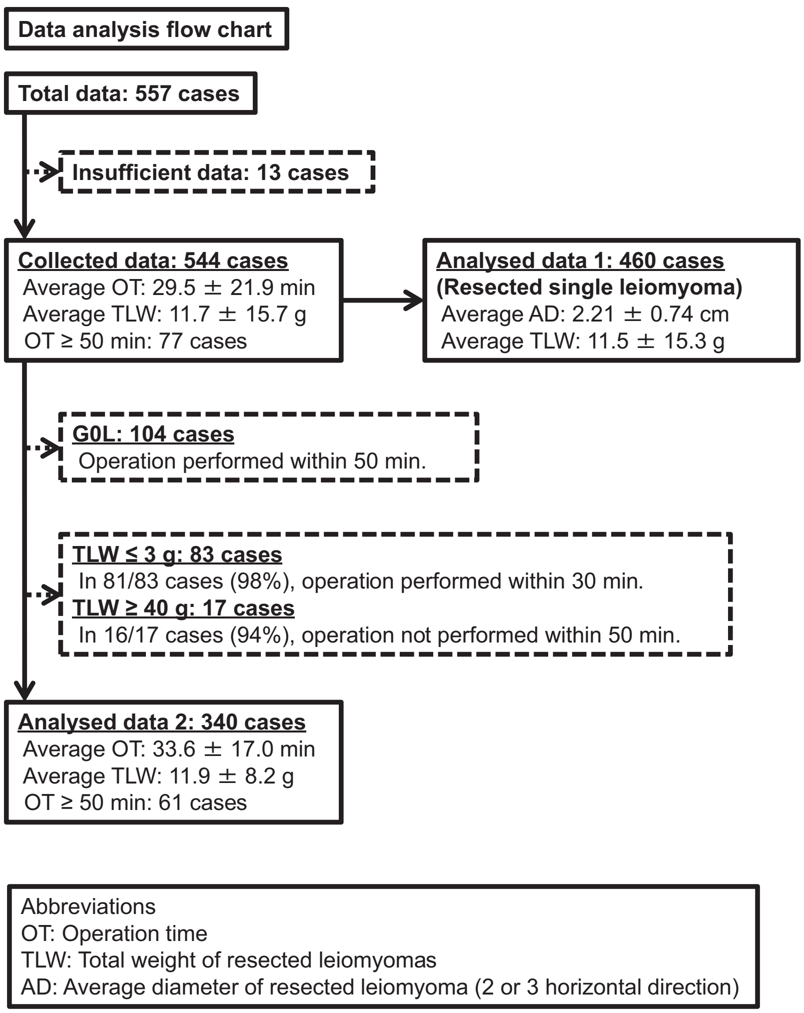

FIGURE 1 Data analysis flow chart. In total, hysteroscopic myomectomy was performed on 557 patients between January 2006 and March 2016. After excluding 13 cases due to insufficient clinical data, 544 cases were analyzed. Among them, 460 cases in which a single leiomyoma was removed were analyzed to assess the relationship between the AD and the TLW. Three hundred forty cases were analyzed to provide a formula to predict the degree of surgical difficulty. For practical utility, the following 204 obviously easy or difficult cases were excluded: (a) 104 G0 cases in which all operations were completed within 50 minutes; (b) 83 cases with a TLW <3 g in which 98% of all operations were completed within 30 minutes; and (c) 17 cases with a TLW >40 g in which 94% of all operations could not be performed within 50 minutes

and TLW from intraoperative findings. The other characteristics of the target leiomyoma, including the number, size, and location, were determined via transvaginal ultrasonography immediately prior to surgery. The degree of protrusion from the endometrium was measured during an outpatient hysteroscopic examination. Submucosal leiomyomas were classified according to the European Society of Gynaecological Endoscopy Classification as G0 (no penetration into the intramural cavity), G1 (<50% penetration), or G2 (>50% penetration).[7] In this study, locations, including the anterior wall, posterior wall, sidewall, and fundus, were also considered.[9,12,13] Patient parity was also recorded because cervical dilatation is an important factor for hysteroscopy.[5]

2.2 | Hysteroscopic myomectomy

All operations were performed exclusively by one physician (M. M.), who had been a highly skilled specialist of hysteroscopy accredited by Japan Society of Gynecologic and Obstetric Endoscopy and Minimally Invasive Surgery. Prior to surgery, two laminaria tents were administered for cervical dilatation one day prior to surgery. After sufficient vaginal space was provided with self-retaining speculum and cervical dilatation was performed with a Hegar dilator, a 26-Fr monopolar resectoscope equipped with a loop electrode was used (KARL STORZ GmbH & Co., Tuttlingen, Germany). After incising the endometrium and myometrium, the target submucosal leiomyoma was enucleated by shaving it into pieces repeatedly to reduce its volume. In principle, the lesions were not removed by rugged methods, for example, twisting pedunculated fibroids off by forceps.

2.3 | Definition of OT/TLW

Because the most important factor for OT was the size of the target leiomyoma,[3] we focused on the OT/TLW ratio, which was calculated by dividing the OT by the TLW. Using this index, we attempted to calculate the degree of influence of the leiomyoma type, including the location and degree of protrusion, and patient parity, specifically vaginal parity (VP), on OT.

2.4 | Statistical analyses

The statistical analyses were performed using Microsoft Excel 2016 (Microsoft, Washington, DC, USA) and JMP version 12 for Windows (SAS Institute Inc, Tokyo, Japan). Chi-squared tests and the Mann-Whitney *U* test were performed. The odds ratios (ORs) and 95% confidence intervals (CIs) were estimated to determine the strength of these correlations. *P* values <0.05 were considered significant.

3 | RESULTS

3.1 | Characteristics of the extracted 340 cases

In 544 cases, the average OT was 29.5 ± 21.9 minutes (2-150 minutes), and the average TLW was 11.7 ± 15.7 g (0.1-195.5 g). First, we confirmed that a more precise prediction of OT could be achieved by using TLW rather than the average diameter of the target leiomyoma (AD) or the cube of AD (AD^3). The largest sagittal view of the lesion was first defined, and the longest part of the lesion (x) and the orthogonalizing part (y) was measured, and then, $(x + y)/2$ = AD (cm) was calculated and defined as the average diameter. In the analysis of 459 cases with data for both TLW and AD, the correlation coefficient (R) between the OT and TLW was greater than that between the OT and AD or AD^3 (TLW: 0.80 vs square: 0.59 or one: 0.37). Next, clearly difficult or easy cases (204 cases) were excluded because operative maneuvers were unlikely to be typical in these procedures. All 104 G0 cases were completed within 50 minutes. Similarly, 83 cases of small leiomyomas (≤3 g) and 17 cases of large leiomyomas (≥40 g) were excluded because of an obviously short or long OT (Figure 1). The remaining 340 cases were analyzed to estimate the degree of difficulty of hysteroscopic myomectomy. The average OT and TLW were 33.6 ± 17.0 minutes and 11.9 ± 8.2 g, respectively. When the relationship between the OT and TLW was assessed, the correlation coefficient (R) was 0.66. The OT/TLW index was also calculated by dividing the OT by the TLW in each case, and the average OT/TLW was 3.5 ± 1.7 minutes/g.

3.2 | Significant impacts of target leiomyoma characteristics and patient parity

In some reports, the location of the target leiomyoma was classified into four types (anterior wall, posterior wall, sidewall, and fundus) because of the substantial difficulty of fundal leiomyoma removal.[9,12,13] In this study, 340 cases were classified into four subgroups based on the location of the target leiomyoma: anterior wall (125 cases), posterior wall (86 cases), sidewall (88 cases), and uterine fundus (41 cases). Unlike previous reports, the OT/TLW in these four types was not significantly different according to the Mann-Whitney *U* test: (a) 3.6 ± 1.9 minutes/g for the anterior wall; (b) 3.1 ± 1.5 minutes/g for the posterior wall; (c) 3.5 ± 1.8 minutes/g for the sidewall; and (d) 3.3 ± 1.5 minutes/g for the uterine fundus. However, the type of the target leiomyoma (G1 and G2) significantly affected the OT/TLW. Compared with nulliparous patients, a significant impact of vaginal parity (VP) on the OT/TLW was observed. The impact of G2 (113 cases) and VP (171 cases) on the OT/TLW was evaluated using the Mann-Whitney *U* test. When comparing the cases with and without each factor, the OT/TLW value increased approximately 1.5-fold in G2 cases (n = 113, 4.4 ± 1.9 vs n = 227, 3.0 ± 1.4 minutes/g, $P < 0.01$) and decreased approximately 0.75-fold in VP cases (n = 171, 3.0 ± 1.4 vs n = 169, 3.9 ± 1.9 minutes/g, $P < 0.01$).

3.3 | Relationship between corrected TLW and OT

A new index named "corrected TLW (cTLW)" was provided to predict OT, and the cTLW was calculated by multiplying the measured TLW by these two coefficients. By referring to the aforementioned results, the rate of increase in the cTLW was defined as 1.5 or 0.75 in patients with G2 leiomyomas or VP, respectively. A strong relationship between OT and cTLW was indicated by the correlation coefficient (*R*) of 0.72 (>0.70). This correlation coefficient was higher than that calculated using only one of the two coefficients (1.5 or 0.75 for patients with G2 leiomyomas or VP).

To predict the feasibility of hysteroscopic myomectomy, seven subgroups were created according to the cTLW value: <5, 5.1-10, 10.1-15, 15.1-20, 20.1-25, 25.1-30, and >30.1 (Figure 2). Referring to the average OT of 340 cases (33.6 ± 17.0 minutes), the operations that the physician (M. M.) could not perform within 50 minutes were defined as difficult hysteroscopic myomectomy (DHM) in this analysis. In each subgroup, we calculated the probability of DHM by dividing the number of DHM cases by the number of total cases. In this process, the relationship between OT and cTLW could be visualized more easily. To verify the suitability of this index, which considers the influence of G2 disease and VP, for OT prediction, the same analysis was performed on the TLW (g). The increase in OT reached a peak when the TLW exceeded 20.1 g. However, OT exhibited a linear increase with the increase in cTLW (Figure 2). Therefore, the cTLW enabled a more precise OT prediction when the target leiomyoma was heavy, although a significant difference was not detected among the subgroups.

3.4 | Estimated weight of the target submucosal leiomyoma and a formula of hysteroscopic myomectomy

Next, to estimate the weight of the resected leiomyoma preoperatively, we assessed the relationship between the TLW and the leiomyoma diameter determined using transvaginal ultrasound. Among 544 cases, 460 cases in which a single leiomyoma was removed by hysteroscopic myomectomy were analyzed (average TLW: 11.5 ± 15.3 g; range: 0.1-195.5 g, average AD: 2.2 ± 0.8 cm; range: 0.1-5.7 cm, Figure 1). The cube of the AD was adopted to estimate the leiomyoma weight because the correlation coefficient (*R*) between the TLW and AD^3 was greater than that between the TLW and AD or the square of AD (cube: 0.89 vs square: 0.85 or one: 0.77). Second, five groups were created to determine the best proportion to assess the cube of the AD to the TLW: AD of 0.1-1.0 cm; AD of 1.1-2.0 cm; AD of 2.1-3.0 cm; AD of 3.1-4.0 cm; and AD of 4.1-5.7 cm. TLW/AD^3 values were calculated by dividing the TLW by the cube of AD in each group (Table 1). For the 460 cases, the average TLW/AD^3 was 0.86 ± 0.52 g/cm^3; however, this rate tended to decrease with increasing AD: 0.95 ± 0.66 g/cm^3 for an AD of 0.1-2.0 cm; 0.80 ± 0.34 g/cm^3 for an AD of 2.1 to 3.0 cm; and 0.69 ± 0.22 g/cm^3 for an AD of 3.1-5.7 cm (Table 1). Given these considerations, three coefficients of TLW/AD^3 for calculating the TLW before surgery could be defined: 1.0 for an AD of 0.1-2.0 cm, 0.8 for an AD of 2.1-3.0 cm, and 0.7 for an AD of 3.1-5.7 cm. We attempted to calculate the estimated TLW by multiplying AD^3 by these coefficients. When using these coefficients (1.0 or 0.8 or 0.7), the average estimated weight became 11.5 ± 12.7 g. The average difference between the estimated weight and measured weight was −0.05 ± 6.98 g. This calculation method seemed to be more accurate than the simple estimation using one coefficient (0.85), which was determined based on the aforementioned average TLW/AD^3 (0.86 ± 0.52 g/cm^3). The same values were 12.5 ± 15.6 g and −1.04 ± 7.21 g. The difference between the estimated weight and the measured weight tended to decrease in the Mann-Whitney *U* test when using these three coefficients classified by AD (−0.05 ± 6.98 g vs −1.04 ± 7.21 g, $P = 0.42$). Taken together of our result, we established a formula to forecast the operation time of hysteroscopic myomectomy (Figure 3).

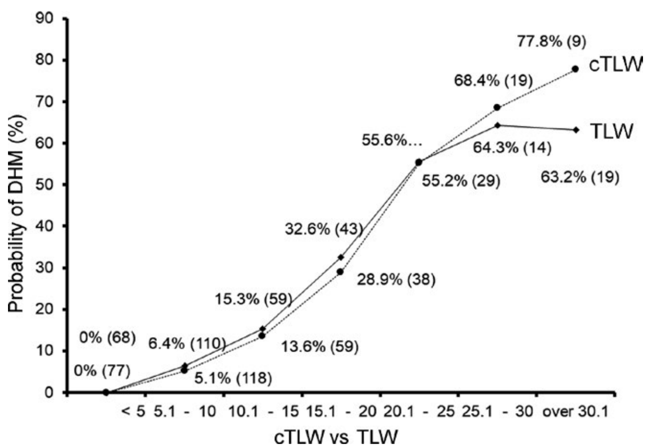

FIGURE 2 Estimated risk of difficult operation. To assess the validity of the cTLW for predicting OT, seven subgroups were created according to the values of the cTLW or TLW: <5, 5.1-10, 10.1-15, 15.1-20, 20.1-25, 25.1-30, and over 30.1. In each subgroup, the probability of difficult hysteroscopic myomectomy was calculated and it was defined as the probability of DHM. The solid line with black squares and dotted line with black circles showed the values of TLW and cTLW. The number of cases is displayed in brackets. DHM, difficult hysteroscopic myomectomy; OT, operation time; TLW, total leiomyoma weight

4 | DISCUSSION

Preoperative information about the degree of difficulty affects the selection criteria for choosing a treatment method. As the degree of difficulty for hysteroscopic myomectomy is reflected in OT, the ultimate goal of this retrospective study was to estimate approximate

TABLE 1 Relationship between the TLW and the cube of the AD

AD (cm) (n)	TLW/AD^3 (g/cm^3)	
0.1-1.0 (19)	0.97 ± 0.52	0.95 ± 0.66
1.1-2.0 (200)	0.95 ± 0.67	
2.1-3.0 (188)	0.80 ± 0.34	0.80 ± 0.34
3.1-4.0 (44)	0.69 ± 0.22	
4.1-5.7 (9)	0.69 ± 0.25	0.69 ± 0.22

AD, average diameter of the target leiomyoma; TLW, total leiomyoma weight.

The correlation coefficient between AD^3 and the TLW was 0.89. The average and standard deviation of each value (TLW/AD^3), obtained by dividing the TLW by AD^3 with a 1-cm unit, are listed on the left side of this table. These values decreased with increasing AD. By referring to this result, 460 cases were divided into three groups, and the AD and TLW/AD^3 are listed on the right side of this table.

OT before operation. Although we could not assess the results prospectively due to the analytic procedure, all operations, including a relatively large number of 557 cases, were performed by one specialist and were conducted using the same procedure to avoid bias derived from the skills of individual physicians. In general, to reduce distending media-related hysteroscopy complications, hysteroscopic surgeries should be completed within 60 minutes.[14,15] Previous reports have adopted the diameter of the target leiomyoma as an index for the prediction of difficulties.[7,8,16] However, in the analyzed cases, we could not directly assess the relationship between the AD and OT because approximately 15% involved multiple leiomyomas. Moreover, a more precise prediction of OT could be achieved using TLW rather than AD or AD^3. In the analysis of 459 cases with data for both TLW and AD, the correlation coefficient (*R*) between the OT and TLW was greater than that between the OT and AD^3 (0.80 vs 0.59). Therefore, two process steps were adopted: assessment of the relationship between the AD and TLW and assessment of the relationship between TLW and OT. Ultimately, we tried to predict the OT before surgery, but we could not directly compare AD and OT.

In this study, we first evaluated the degree of influence of the characteristics of the target leiomyoma and other factors on OT. Similar to previous studies, the size and degree of protrusion of the target leiomyoma significantly affected the analysis of OT. However, the location, which was classified as anterior wall, posterior wall, sidewall or uterine fundus, did not influence the OT. Unlike previous studies, our analysis also demonstrated that the parity of the patient, as well as the characteristics of the leiomyoma, affected OT. These differences might be derived from physician's technique, and we hypothesize to use different coefficients, especially "a" (Figure 3), to apply our formula for different physicians. The influence of patient parity was assessed as a factor affecting cervical dilatation, as the repeated resection of target leiomyomas with a loop electrode passed through the uterine cervix was the primary procedure. When estimating the degree of influence these factors, we focused on OT/TLW, which was calculated by dividing the OT by the TLW in each case. The most important factor was the size of target leiomyoma; the correlation coefficient (*R*) between the TLW and OT was 0.66.

$$OT = AD^3 \times a \times b \times c \text{ (min)}$$

a = 1.0: (AD 0.1-2.0 cm)
 = 0.8: (AD 2.1-3.0 cm)
 = 0.7: (AD 3.1-5.7 cm)

b = 1.5: (if the target leiomyoma is G2)
 = 1.0: (if the target myoma is G0 or G1)

c = 0.75: (if the patient has had an experience of vaginal delivery)
 = 1.0: (if the patient has had no experience of vaginal delivery)

FIGURE 3 Formula of estimated OT. Formula of OT (min) is consisted of AD and 3 coefficients. AD is defined as the average diameter of the target leiomyoma. After defining the largest sagittal view of the lesion, the longest part of the lesion (x) and the orthogonalizing part (y) was measured, and then, $(x + y)/2$ = AD (cm) was calculated.

When assessing these two significant factors, the OT/TLW value increased approximately 1.5-fold in patients with G2 leiomyomas and decreased approximately 0.75-fold in multiparous patients. The new index was termed cTLW, which was calculated by multiplying the TLW by two specified coefficients, the presence of G2 leiomyoma (1.5) and multiparity (0.75). cTLW exhibited a strong relationship with OT (R = 0.72). OT tended to increase linearly with increasing cTLW, even when the cTLW exceeded 20. This result indicates the validity of this index for predicting the degree of operative difficulty. Further research on the influence of other factors on the OT/TLW should be performed if possible.

Next, similar to some previous reports,[4,17] the relationship between the average diameter of the target leiomyomas measured by ultrasound (namely, the "AD" in this study) and the weight of the resected leiomyomas was also studied for the purpose of predicting the TLW prior to surgery. In total, 460 cases with a single submucosal leiomyoma were analyzed. The cube of the diameter correlated well with the TLW (R = 0.89), and the ratio of the TLW to AD^3 tended to decrease as the AD increased (Table 1). By defining three groups according to the AD (0.1-2.0 cm, 2.1-3.0 cm, and >3.1 cm), we propose a more accurate prediction of the TLW before surgery. The average difference between the estimated weight and measured weight was −0.05 ± 6.98 g.

To the best of our knowledge, this is the first report to verify the possibility that the specific gravity of leiomyoma changes with size. This estimated TLW is an objective data and might enable us to evaluate the degree of difficulty of hysteroscopic myomectomy with some degree of accuracy before surgery (Figure 3). We have to admit that the formula has been calculated by one trained surgeon, and the utility of this study would be further apparent if other operators utilize this formula prospectively, and future studies to establish the validity of the new formula is warranted, but our idea might be helpful for properly managing hysteroscopic operations.

By considering the weight of the resected leiomyoma, the degree of protrusion, and patient parity, we have generated a new formula to predict the operation time of hysteroscopic myomectomy. Furthermore, by estimating the leiomyoma weight from the cube of the diameter of the target leiomyoma, difficult cases might be predicted before surgery. This prediction model would provide selection criteria for choosing better surgical methods.

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CONFLICTS OF INTEREST

These authors declare that they have no conflict of interests to disclose.

ETHICAL CONSIDERATION

This retrospective study was approved by the Institutional Review Board of the Maruyama Memorial General Hospital. The registry number of this study, registry name, and date of registration are as follows: 2017-01, Examination of surgical methods for leiomyoma, 2017/8/3.

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