



Appropriate mesh size in the totally extraperitoneal repair of groin hernias based on the intraoperative measurement of the myopectineal orifice

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Abstract

Background Insufficient coverage of the area of a possible groin hernia is an important risk factor in hernia recurrence. To prevent recurrence, it is important to use the appropriate mesh size based on the size of the myopectineal orifice (MPO), which is the weak area of the abdominal wall where inguinal hernias occur. We aimed to estimate the appropriate mesh size for groin hernias by investigating MPO size.

Methods Four hundred and six patients underwent groin hernia repair using a totally extraperitoneal (TEP) approach at the Zeze Hospital between July 2009 and December 2017. We investigated patients' backgrounds, MPO components dimensions, and hernia recurrence, and evaluated the appropriate mesh size.

Results The 359 male and 47 female patients had an average age of 63 ± 15 years. In 171, 147, and 88 cases, hernias were localized to the right, left, and bilaterally, respectively. The number of lateral, medial, femoral, and combined hernias was 317, 124, 11, and 42, respectively. The 95th percentile for the horizontal and vertical lengths in cases of hernia orifice ≥ 3 cm were 9.6 cm and 7.0 cm, respectively, while it was 9.2 cm and 6.4 cm in cases of hernia orifice < 3 cm. We added 2 cm and 3 cm to the 95th percentile for the length and width of the MPO, resulting in 13.2×10.4 cm and 15.6×13.0 cm in cases with hernia orifice < 3 cm and ≥ 3 cm, respectively. Relapse after TEP occurred in 1 patient (0.2%).

Conclusion The appropriate mesh size for TEP repair, derived from intraoperative MPO measurements, was estimated as 13.2×10.4 cm and 15.6×13.0 cm when the hernia orifice was < 3 cm and ≥ 3 cm, respectively. Using appropriate mesh sizes based on MPO measurement may reduce groin hernia recurrence after TEP.

Keywords Groin hernia · Mesh size · Myopectineal orifice · Totally extraperitoneal approach

The inadequate detachment and incomplete coverage of all potential hernia sites are important risk factors in groin hernia recurrence [1]. The target anatomical region to be meshed in a groin hernia surgery is represented by the myopectineal orifice (MPO), a weak region of the lower abdominal wall, as proposed in a previous report [1, 2]. The MPO is defined as a collagenous weak area without muscles, extending between the ramus superior ossis pubis and the caudal

border of the musculus obliquus internus abdominis, with its medial and lateral borders consisting of the musculus rectus abdominis and the iliopsoas muscle, respectively. The MPO is the site of lateral, medial, femoral, and some interstitial hernias. Rath et al. showed preperitoneal dissection and discovered coincidental occult hernias in 6.25% of patients [3].

Key elements that need to be considered when determining the appropriate mesh size for hernia repairs include the size of the hernia orifice and the length of the mesh overlapping the hernia edge. According to a study by Knook et al., the mesh overlap length must be at least 2 cm if the hernia orifice diameter is within 3 cm and at least 3 cm if the orifice diameter is 4–6 cm [4]. Therefore, an accurate measurement of the MPO is an important factor in optimizing the mesh size for coverage of the groin hernias. To our knowledge, there are currently no reports that determine mesh size

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based on the measured length of the MPO of hernia patients. According to the European Hernia Society (EHS) Guidelines on the treatment of inguinal hernia, at least 10×15 cm of the mesh should be considered in an endoscopic hernia surgery [5]. However, this was not a recommendation based on the measurement of the patient's MPO. There was no specific rule for mesh size in inguinal hernias in the guidelines for laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia of the International Endohernia Society (IHES) and in the International Guideline for Groin Hernia of the Netherlands [6, 7]. In this study, we aimed to estimate the appropriate mesh size for patients who underwent TEP groin hernia repair based on intraoperative MPO measurements. Further, we aimed to evaluate the recurrence rate following this procedure.

Materials and methods

This single-center, retrospective, cohort study included 406 patients who underwent TEP repair for new-onset groin hernias at the Zeze Hospital between July 2009 and December 2017. Patients with groin hernias were counted separately. The study protocol was approved by the Oita University Clinical Trial Review Committee and the Institutional Review Board of each affiliated hospital (approval number 1534). Written informed consent was obtained from all patients. We recorded the following patient data: age, sex, type of groin hernia (lateral, medial, femoral, or combined), herniated side (right/left), postoperative recurrence, length of the MPO components, and length of the hernia orifice. The appropriate mesh sizes for the groin hernias were then evaluated.

Surgical procedures

The incision was made under the umbilical skin while the patient was in a supine position under general anesthesia. A transverse incision was made on the recto-abdominal anterior sheath on the side of the hernia, and an endoscopic balloon dissection system (PDB™ Balloon; Covidien Japan; Tokyo, Japan) was inserted between the rectus abdominis muscle and the sheath toward the pubic bone. The preperitoneal space was expanded, foliated by 30 air pumps using the PDB™ Balloon. After 2014, the PDB™ Balloon was no longer used to reduce postoperative pain. Thereafter, 0.2% bupivacaine was injected into the extra-peritoneal space, 0.2 mL of adrenaline and 180 mL of saline was administered, and the laparoscopic surgery was performed. A Covidien™ Blunt Tip Trocar (Covidien Japan; Tokyo, Japan) was inserted into the preperitoneal space from the umbilical region, and the preperitoneal space was inflated using 8–10 mmHg of carbon dioxide.

Two 5 mm trocars were inserted into the pre-peritoneal cavity of the lower abdomen, one on the pubic head and the other midway between the pubis and the umbilicus. Both trocars were inserted from the midline to the contralateral hernia at one finger width. The peritoneum was identified, the hernia sac was completely detached from the surrounding tissue, the testicular vein, and the spermatic cord, and the hernia sac was dissected. Further, we exposed the pubic bone, Cooper's ligament, and the femoral ring, and fully exfoliated the peritoneal edge to the superior anterior iliac crest.

The MPO was verified, and its components were measured. When anatomical landmarks, such as Cooper's ligaments, rectus abdominis, transversus abdominis fascia arch, and femoral ring that form the MPO outline were difficult to recognize due to fat or objects, we removed either all or a part of the fat that covered them. As a result, these structures and the outer edge of the MPO were identified. A 10×14 cm or larger (10.3×15.7 cm or 10.0×14.0 cm) type 3D Max™ Light Mesh (L size, Bard Inc., USA) or JG 3D™ Lightweight Mesh (MicroVal Inc., Netherlands) was attached to the MPO. A 10×14 cm mesh was used for cases with a hernia orifice less than 3 cm, while a 10.3×15.7 cm mesh was used for cases with a hernia orifice 3 cm or larger. Our methods to cover the hernia orifice and the MPO area fully are as follows: First, place the mesh in a position that allows 2 or 3 cm of overlap from the outer edge of the hernia orifice, depending on the diameter of the hernia orifice. Next, adjust the edges of the mesh to cover the anatomical MPO landmarks, the intersection of the rectus abdominis and Cooper ligaments, the intersection of the rectus abdominis and the transversus abdominal muscle arch, the intersection of the iliopsoas muscle, the femoral ring, and Cooper's ligament. Finally, ensure the mesh is flat against the abdominal wall. In patients with a direct hernia, the hernia ostium shrunk or was lost due to the introversion of the redundant traverse fascia and the stapler fixation to Cooper's ligament. To prevent the peritoneal edge from sneaking into the dorsal side of the mesh, hold the peritoneal edge to the cranial side with the forceps, and stop supplying carbon dioxide, remove the trocar, perform degassing, and finally remove the forceps. The rectum muscle sheath was sutured using a 1–0 Polysorb™ suture (Covidien Japan, Tokyo, Japan) while the skin was sutured using a 4–0 PDS™ suture (Ethicon, Inc., Ohio, USA). In patients with a direct hernia, the hernia ostium shrunk or was lost due to the introversion of the redundant traverse fascia and the stapler fixation to Cooper's ligament. The rectum muscle sheath was sutured using a 1–0 Polysorb™ suture (Covidien Japan, Tokyo, Japan) while the skin was sutured using a 4–0 PDS™ suture (Ethicon, Inc., Ohio, USA).

Myopectineal orifice dimensions

According to Fitzgibbons et al. [8], the myopectineal orifice is bordered by the arch formed by the termination of the aponeurotic fibers of the transversus abdominis muscle cranially, the rectus abdominis muscle medially, the iliopsoas muscle laterally, and the superior pubic ramus with attached Cooper's ligament inferiorly. Based on this definition, the horizontal and vertical lengths of the MPO region were defined as $A + D$ and $C + D$, and the respective outer anatomical landmarks were set as follows. During surgery, we measured the dimensions of the MPO, including lengths A , B , C , D , and E , and the diameter of the hernia orifice, using a ruler (Surler, Matsuyoshi & Co. Ltd., Japan, attached to ME-71TM) (Fig. 1A, 1B). The method used to measure A , B , C , D , and E during surgery is shown in Fig. 2. Length "A" was defined as the distance from the intersection of Cooper's ligament and the outer edge of rectus abdominis to the inferior epigastric vessels (IE) at the iliopubic tract (IPT)

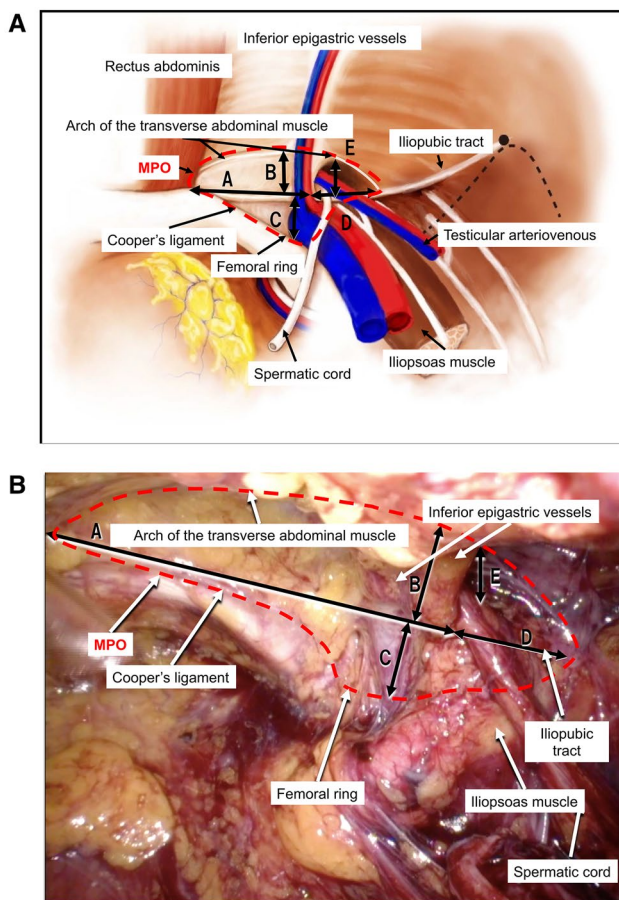


Fig. 1 The MPO components in the surgical field during TEP repair. The MPO area is indicated by a red dashed line. **A** Schema of the MPO components, **B** Representative photograph of the MPO components **MPO** Myopectineal orifice, **TEP** Totally extraperitoneal

(Fig. 2A). Length "B" was defined as the maximum distance from the IPT to the arch of the transverse abdominal muscle (Fig. 2B). Length "C" was defined as the distance from the IPT to the medial dorsal margin of the external iliac vein (Fig. 2C). The length "D" was defined as the distance from the IE at the IPT to the intersection of the arch of the transverse abdominal muscle and the iliopsoas muscle (Fig. 2D). Length "E" was defined as the maximum diameter of the hernia orifice (Fig. 2E). The length of "E" in combined hernias was the largest diameter of each hernia orifice. "B + C" and "A + D" corresponded to the horizontal length and the vertical length of the MPO, respectively. The appropriate mesh size was calculated by adding 2 or 3 cm to the length of the mesh overlap from the outer edge of the MPO, if the hernia orifice diameter was < 3 cm or ≥ 3 cm, respectively. We divided patients into two groups: those with a hernia orifice < 3 cm and those with a hernia orifice ≥ 3 cm. The mesh overlap length was added to the 95% percentiles for the MPO major and minor axes.

Statistical analysis

Data are presented as the mean \pm standard deviation (SD). Statistical data were analyzed using a single-variable analysis, Student's *t*-test. One-way ANOVA with a post-hoc test was used in multi-group comparisons. Shapiro–Wilk's test was used to confirm that the data were normally distributed. All demographic variables with *P*-values lower than 0.05 in the univariate analyses were considered statistically significant. Statistical analyses were performed using SPSS software (version 25.0; SPSS; Chicago, IL, USA).

Results

The patients' demographics are shown in Table 1. The average age was 63 ± 15 years.

The groin hernia was located on the right side in 171 patients, on the left side in 147 patients, and on both sides in 88 patients. The number of lateral inguinal, medial inguinal, femoral, and combined hernia cases was 317, 124, 11, and 42, respectively.

The average values of the horizontal length ($A + D$) and the vertical length ($B + C$) of the MPO were 7.7 ± 1.1 cm and 4.7 ± 0.9 cm, respectively (Table 2). The dataset of cases with hernia orifice < 3 cm showed normal distribution ($P > 0.05$). The horizontal length ($A + D$) range and 95th percentile in cases of hernia orifice < 3 cm were 4.0–10.0 cm and 9.2 cm, respectively. The vertical length ($B + C$) range and the 95th percentile in cases of hernia orifice < 3 cm were 2.7–7.5 cm and 6.4 cm, respectively (Fig. 3, Table 2). The dataset of cases with hernia orifice ≥ 3 cm showed normal distribution ($P > 0.05$). The horizontal length ($A + D$)

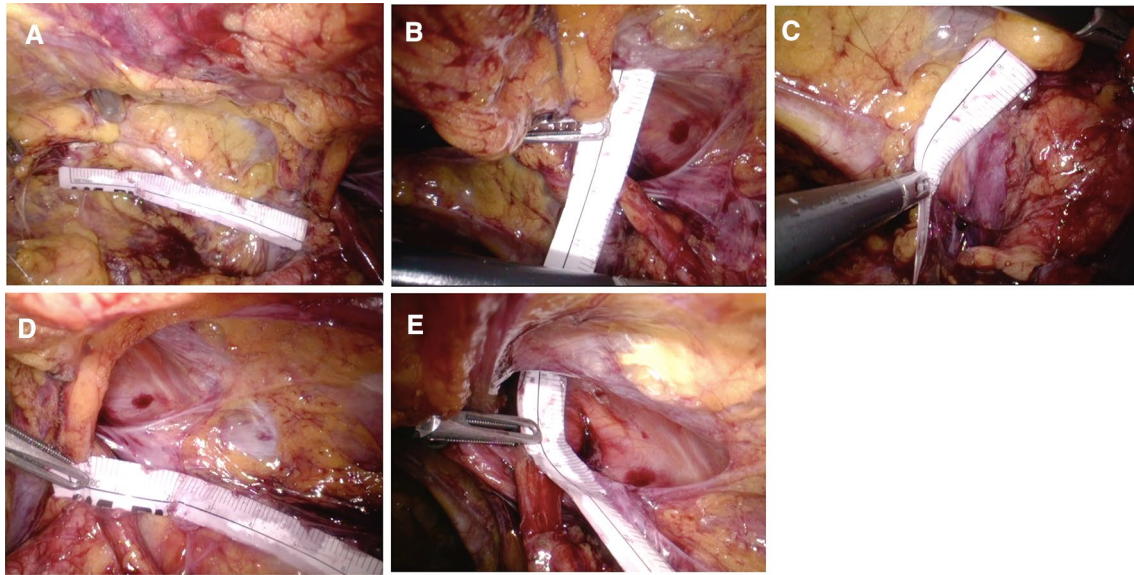


Fig. 2 Measurement methods of the MPO components. **A** The distance from the intersection of Cooper's ligament and the outer edge of rectus abdominis to the IE at the IPT (**A**). **B** Maximum distance from the IPT to the arch of the transverse abdominal muscle (**B**). **C** The distance from the IPT to the medial dorsal margin of the exter-

nal iliac vein (**C**). **D** The distance from the IE at the IPT to the intersection of the arch of the transverse abdominal muscle and iliopsoas muscle (**D**). **E** Maximum diameter of the hernia orifice (**E**). **E** is the largest diameter of each hernia orifice in combined hernias. *MPO* myopectineal orifice, *IE* inferior epigastric artery, *IPT* iliopubic tract

Table 1 Patient characteristics

Characteristics	Number of patients (N=406)
Sex (male/female)	359/47
Age (mean ± SD)	63 ± 15
Laterality of Hernia Type	406
Right only	171
Left only	147
Bilateral	88
Classification of Hernia Type ^a (Total number)	494
Lateral hernia	317
Medial hernia	124
Femoral hernia	11
Combined hernia	42

^aThe Japan Hernia Society (JHS) Classification for groin hernias

range and 95th percentile in cases of hernia orifice ≥ 3 cm were 5.5–11 cm and 9.64 cm, respectively. The vertical length (B + C) range and 95th percentile in cases of hernia orifice ≥ 3 cm were 2.7–7.5 cm and 7.0 cm, respectively (Fig. 4, Table 2). The horizontal length (A + D) and the vertical length (B + C) were not significantly different between men and women in cases where hernia orifice were ≥ 3 cm (men vs. women; 7.98 ± 1.00 , 5.04 ± 1.02 vs. 7.45 ± 1.77 , 5.0 ± 0.0). The horizontal length (A + D) and D in men with hernia orifice < 3 cm, 7.64 ± 1.04 cm and 3.62 ± 0.76 cm,

Table 2 Length of MPO components

MPO components	Length (cm)		
	Total number (N=494)	Hernia gates < 3 cm (N=369)	Hernia gates ≥ 3 cm (N=125)
A	4.05 ± 0.88	3.98 ± 0.84	4.26 ± 0.95
B	2.88 ± 0.88	2.79 ± 0.49	3.13 ± 0.62
C	1.77 ± 0.54	1.72 ± 0.61	1.90 ± 0.68
D	3.59 ± 0.63	3.56 ± 0.80	3.70 ± 1.05
E	2.56 ± 0.88	2.16 ± 0.44	3.74 ± 0.77
A + D	7.66 ± 1.08	7.55 ± 1.09	7.97 ± 1.01
95 percentile for A + D	–	9.2	9.64
B + C	4.65 ± 0.87	4.52 ± 0.78	5.04 ± 1.01
95 percentile for B + C	–	6.4	7.0

Values are presented as the mean \pm SD

A The distance from the intersection of Cooper's ligament and the outer edge of rectus abdominis to the IE at the IPT

B The maximum distance from the IPT to the arch of the transvers abdominal muscle

C The distance from the IPT to the medial dorsal margin of the external iliac vein

D The distance from the IE at the IPT to the intersection of the arch of the transverse abdominal muscle and iliopsoas muscle

E Maximum diameter of the hernia orifice

MPO myopectineal orifice, *IE* inferior epigastric artery, *IPT* iliopubic tract

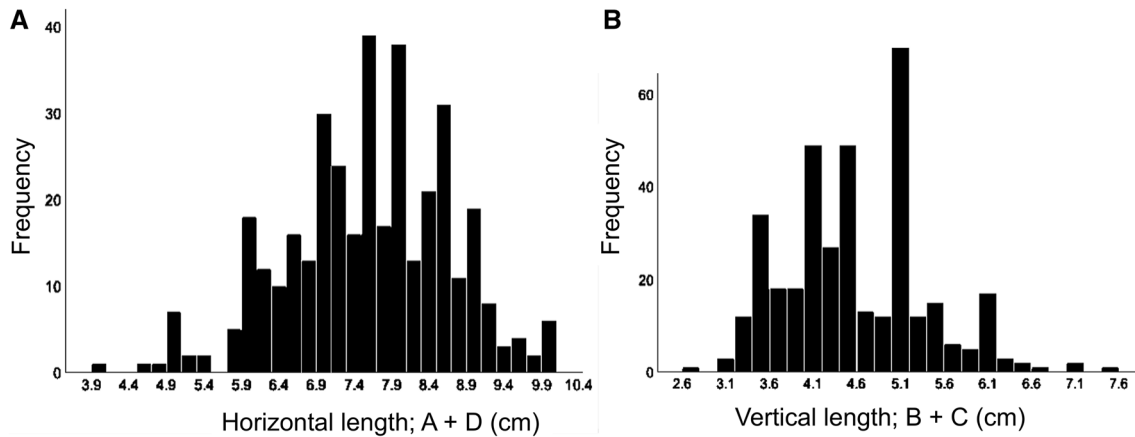


Fig. 3 Distribution of horizontal and vertical lengths of the MPO in patients with hernia orifice ≥ 3 cm. **A** Horizontal length of the MPO, **B** Vertical length of the MPO

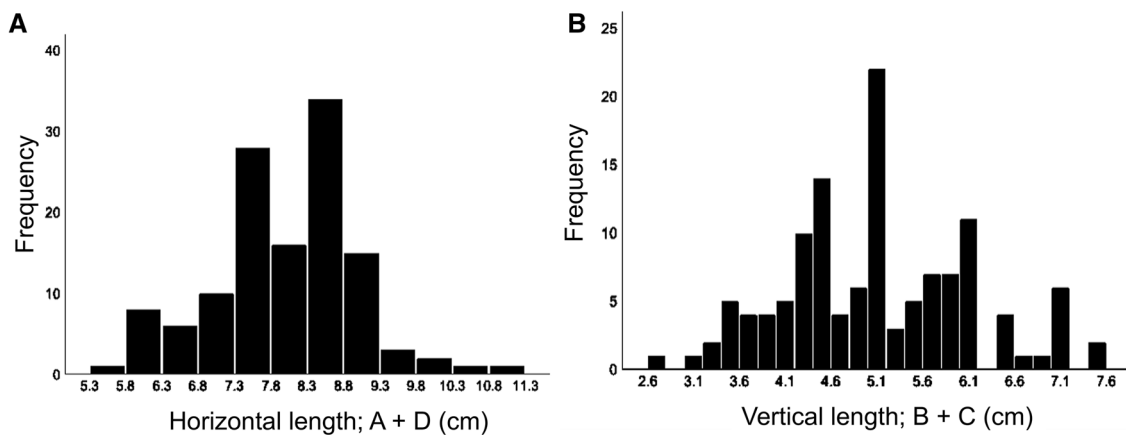


Fig. 4 Distribution of horizontal and vertical lengths of the MPO in patients with hernia orifice < 3 cm. **A** Horizontal length of the MPO, **B** Vertical length of the MPO

were significantly longer than that in women, 6.97 ± 1.22 cm and 3.13 ± 0.91 cm ($P < 0.05$). An overlap of 2 cm was added to the 95th percentile for the horizontal length (A + D) and to the 95th percentile for the vertical length (B + C) in cases of hernia orifice < 3 cm, making the optimum mesh size 13.2×10.4 cm. An overlap of 3 cm was added to the 95th percentile for the horizontal length (A + D) and to the 95th percentile for the vertical length (B + C) in cases of hernia orifice ≥ 3 cm, making the optimum mesh size 15.6×13.0 cm. The horizontal length (A + D) was longest in patients with combined hernias while the vertical length (B + C) measurement was longest in patients with medial hernias (Table 3). In 97.6% of cases where the hernia orifice was less than 3 cm, an overlap of 2 cm or more from the outer edge of the MPO was secured. Lateral hernia occurred in 73.1% of these patients (Table 4). In only 25.5% of the cases where the hernia was 3 cm or larger, an overlap of

3 cm or more from the outer edge of the MPO was secured. Medial hernias accounted for 71% of the cases where 3 cm could not be secured (Table 5). In addition, hernia recurrence occurred in one patient (0.2%) who had an insufficient overlap of the mesh dorsally. After the recurrence was identified, we identified the cause of the recurrence by reviewing the patient's surgical video. The median observation period was 999 days. The proportion of patients with a follow-up period of more than one year after surgery was 420/494 (85%). Diagnosis of recurrence was made through physical examination and telephone questions by two surgeons (T.H and Y.S). Patients who answered affirmatively to pain or a groin bulge in response to the telephone question were instructed to visit the hospital; physical examination and computed tomography were conducted to check for recurrence.

Table 3 Length of MPO components by hernia type

MPO components	Type of hernia (N=494)				P value ^a
	Lateral	Medial	Femoral	Combined	
A (cm)	3.81 ± 0.81	4.56 ± 0.80	4.28 ± 0.58	4.34 ± 0.97	< 0.05
B (cm)	2.78 ± 0.46	3.09 ± 0.64	2.60 ± 0.44	3.09 ± 0.59	< 0.05
C (cm)	1.67 ± 0.60	1.96 ± 0.64	2.26 ± 0.63	1.77 ± 0.69	< 0.05
D (cm)	3.86 ± 0.78	3.04 ± 0.75	2.72 ± 1.10	3.49 ± 0.87	< 0.05
E (cm)	2.31 ± 0.62	3.16 ± 1.06	1.86 ± 0.67	2.87 ± 0.98	< 0.05
A + D (cm)	7.67 ± 1.08	7.61 ± 1.03	7.10 ± 1.26	7.85 ± 1.13	0.211
B + C (cm)	4.46 ± 0.77	5.05 ± 0.94	4.95 ± 0.65	4.86 ± 0.99	< 0.05

Values are presented as the mean ± SD

^aSignificant difference between the four groups were tested using analysis of variance

MPO myopectineal orifice

Table 4 Hernia type according to the size of overlap in cases with hernia gate less than 3 cm

Variable	Type of hernia (N=369)				
	Lateral (%)	Medial (%)	Femoral (%)	Combined (%)	Total number (%)
^a Cases in which 2 cm overlap from the outer edge of MPO was secured	264 (71.5)	59 (16.0)	11 (3.0)	26 (7.0)	360 (97.6)
^b Cases in which 2 cm from the outer edge of MPO overlaps was not secured	6 (1.6)	2 (0.5)	0 (0)	1 (0.3)	9 (2.4)

^aMPO horizontal length(A + D) + 4 cm ≤ 14 cm and MPO vertical length (B + C) + 4 cm ≤ 10 cm

^bMPO horizontal length(A + D) + 4 cm > 14 cm and MPO vertical length (B + C) + 4 cm > 10 cm

Table 5 Hernia type according to the size of overlap in cases with hernia gate over 3 cm

Variable	Type of hernia (N=125)				
	Lateral (%)	Medial (%)	Femoral (%)	Combined (%)	Total number (%)
^a Cases in which 3 cm overlap from the outer edge of MPO was secured	20 (16)	8 (6.4)	0 (0)	4 (3.2)	32 (25.6)
^b Case in which 3 cm from the outer edge of MPO overlaps was not secured	27 (21.6)	55 (44.0)	0 (0)	11 (8.8)	93 (74.4)

^aMPO horizontal length (A + D) + 6 cm ≤ 9.7 and MPO vertical length (B + C) ≤ 4.3

^bMPO horizontal length (A + D) + 6 cm > 9.7 and MPO vertical length (B + C) > 4.3

Discussion

This study is the first report investigating the optimal mesh size for a groin hernia based on accurate measurements of the MPO during TEP repair surgery. Knook et al. demonstrated that the mesh overlap length must be at least 2 cm and 3 cm if the hernia orifice diameter is within 3 cm and 4–6 cm, respectively. Mesh coverage without proper overlap to the hernia orifice causes mesh protrusion and hernia

recurrence [4]. Based on this theory, the maximum lengths and widths of the appropriate mesh for TEP repair in patients with hernia orifice diameters of < 3 cm and ≥ 3 cm are 14 × 11.5 cm and 17 × 13.5 cm, respectively. Using the 95th percentile measurements for the MPO components, the appropriate mesh sizes for patients with hernia orifice < 3 cm and ≥ 3 cm were found to be 13.2 × 10.4 cm and 15.6 × 13.0 cm, respectively.

A recent systematic review showed that recurrent factors for inguinal hernia were hereditary, female gender, obesity,

smoking (level 2), non-mesh repair, and TEP approach for unilateral inguinal hernia (level 1). On the other hand, the surgical approach (laparoscopic or incision), mesh type, and fixation with a level 1 evidence do not affect recurrence [9]. In 2015, the Japanese Society of Endoscopic Surgery mentioned the recurrence rate in TEP repair of inguinal hernias is higher than that in other procedures (TEP: 3.4%, TAPP: 3%, mesh plug: 1.3%, bilayer patch device method: 1.3%, Kugel: 0.7%, Direct Kugel: 1.6%, conventional method: 0.9%) [10]. Hernia recurrence after TEP repair occurred in four cases with mesh erosion, two cases with insufficient mesh coverage, and two cases with a recurrence occurring from outside the mesh [10]. Therefore, all cases of postoperative recurrence were caused by insufficient mesh coverage. Up-rolling of the mesh is another main cause of recurrence. Insufficient preperitoneal dissection (parietalization) is the main cause of the up-rolling of the mesh [11].

The interspinous distance correlates well with the height of the MPO in a small number of cadavers [12]. However, there is no correlation with MPO width, and there is no evidence that the physique and MPO area are correlated. The MPO area is different due to muscle mass in addition to skeletal size, because MPO is formed of bones and muscles. Muscle mass depends not only on the skeleton, but also on age, sex, and activity, and there are no reports to estimate the exact MPO area. Therefore, measurement is considered important for knowing the exact MPO area. Wolloscheck et al. measured the size of a cadaver's MPO, and the width and height of 32 MPOs averaged 7.8 ± 3.0 cm and 6.5 cm ± 1.9 cm, respectively. They concluded that a mesh measuring 10×8 cm is suitable for both genders [12]. However, patient numbers were small in this study, and their proposed mesh size did not take into consideration mesh protrusions, an important mechanism of hernia recurrence. In a recent report, the recurrence rate of endoscopic hernia repair using a small mesh of dimensions $\leq 8 \times 12$ cm in 69% of the total number of patients was as high as 27.3% [13]. Anitha et al. measured the landmarks of the body surface, the distance from the superficial inguinal ring (SIR) to the deep inguinal ring (DIR), and proposed an optimal mesh size of 9×15 cm for inguinal hernias. However, this theory is also not based on the size of the MPO [14].

In our cases, 9 (2.4%) of the cases with a hernia orifice less than 3 cm could not secure a 2 cm overlap from the outer edge of the MPO with a 10×14 cm mesh. The recurrence rate was 1 (0.2%), a low rate. Based on these results, a mesh size of 10×14 cm may be sufficient to cover the MPO for inguinal hernias with at least 3 cm of hernia orifice. On the other hand, 93 cases (74.4%) were unable to secure a 3 cm overlap from the outer edge of the MPO with a 10.3×15.7 cm mesh in cases with a hernia orifice 3 cm or larger, but there was no recurrence. In cases where the hernia sac was 3 cm or larger, and 3 cm overlap from the

outer edge of the MPO could not be secured, the percentage including medial hernia was 71%, higher by 37.5% in cases where 3 cm overlap was secured. In all cases in this study, the medial hernia sac was completely dissected, turned over to the side of the preperitoneal space, and then secured to the Cooper's ligament using a tucker (ProTack™, Covidien, USA). There was no report that the technique of fixing the transversal fascia inverted to the Cooper's ligament in an endoscopic hernia surgery reduced recurrence. These reports differed from our procedure: the thread used was absorbent, the transversal fascia was fixed on the ventral side of the mesh, and the observation period was short [15, 16]. Our procedure may affect reducing hernia recurrence. Furthermore, MPO measurements required the dissection and recognition of anatomical MPO landmarks, leading to the choice of the appropriate size of the mesh. The measurement process could have affected our positive results.

This study has some limitations. First, it was conducted in a single institution and only included Asian individuals. Second, research on the theory of overlap length required for hernias is based on experimental validation in circular hernia orifice. Therefore, in the inguinal region, where a near-elliptic hernia orifice is found, the overlap length may differ from the current theory. Furthermore, no verification experiments have yet been performed using meshes of exactly the same size as deemed appropriate based on MPO measurements. In the future, it will be necessary to conduct verification experiments with the mesh size proposed in this study. In addition to these, the mesh we used was lightweight. Heavyweight mesh has high tear strength, and the optimal mesh size may vary.

In conclusion, based on intraoperative MPO measurements, the appropriate mesh sizes for TEP repairs with hernia orifice < 3 cm and ≥ 3 cm were estimated as 13.2×10.4 cm and 15.6×13.0 cm, respectively. Using appropriately sized mesh based on MPO measurements may reduce the recurrence rate of groin hernias.

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Compliance with ethical standards

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