

# Endoscopic Hernia Repair: A Novel Technique for the Repair of Inguinal Hernia in a Cadaver Model

Nihat Gülaydin, MD,\* Feyzullah Ersöz, MD,† Mustafa Kalaycı, MD,\*  
and Erdoğan Kara, MD‡

**Background:** The techniques of total extraperitoneal and transabdominal preperitoneal hernia repair have been conducted for laparoscopic repair of inguinal hernia since long. However, they offer significant disadvantages of requiring general anesthesia, producing negative cosmetic outcomes, and other serious complications. We examined the feasibility of applying an endoscopic method alternative to total extraperitoneal and transabdominal preperitoneal for laparoscopic repair of inguinal hernia in a cadaver model so as to overcome the disadvantages of the presently available techniques.

**Methods:** A total of 4 male and 2 female cadavers [aged 18 y and above, body mass index (BMI) < 40 kg/m<sup>2</sup>], who were planned for a routine autopsy between January 24 and 26, 2020 were selected for the present study conducted at the Forensic Medicine Institute. Twelve laparoscopic repair surgeries of inguinal hernia were performed in 6 of these cadavers using both the inguinal areas.

**Results:** We conducted a total of 12 surgeries on 4 male (mean age: 43.25 y; BMI: 29.05 kg/m<sup>2</sup>) and 2 female cadavers (mean age: 76.50 y; BMI: 26.60 kg/m<sup>2</sup>). A 7×5-cm-shaped mesh was used for both the sexes. For the fixation of the mesh, a titanium tacker was used in pubic tubercle and tendon conjoint, whereas for the fixation of ligamentum inguinale, 2/0 PDS was used in 3 surgeries, 2/0 15-cm V-Loc was used in another 3 surgeries, and titanium tacker was used in 6 surgeries.

**Conclusions:** We demonstrated that the technique of endoscopic surgery that offers the advantages of open inguinal surgery in a cadaver model can be combined with the presently used laparoscopic intervention so as to combine all the advantages, especially for patients who are not suitable for general anesthesia, who are experiencing a recurrence after laparoscopic intervention, and who do not want any visible scars resultant from the surgery. For future studies, we suggest that the proposed technique be applied to inguinal hernia patients to ascertain clearer results.

**Key Words:** inguinal hernia, laparoscopic repair, cadaver

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From the \*General Surgery Clinic, Istanbul Atlas University Medical Faculty; †General Surgery Clinic, Istanbul Training and Research Hospital; and ‡Autopsy Unit of Forensic Medical Institute, Istanbul, Turkey.

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Reprints: Nihat Gülaydin, MD, Barbaros mah. H. Ahmet Yesevi Cad No: 149, Bağcılar, Istanbul 34203, Turkey (e-mail: gulaydin66@hotmail.com).

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Laparoscopic repair of inguinal hernia has been widely conducted since the 1990s.<sup>1,2</sup> The techniques of total extraperitoneal (TEP) and transabdominal preperitoneal (TAPP) hernia repair, which are alternative techniques to open inguinal surgery technique, offer certain laparoscopic advantages, along with the significant disadvantages of requiring general anesthesia, producing negative cosmetic outcomes, the long learning curve, and potential serious complications.<sup>1–5</sup>

We aimed to propose an endoscopic technique to serve as an alternative to TEP and TAPP laparoscopic repair of inguinal hernia in cadaver models so as to overcome the limitations of the current technique in patients who are not suitable for general anesthesia, who experience a recurrence after laparoscopic intervention, and do not want to have any visible scars resultant from the surgery.

## METHODS

### Patients

After obtaining the relevant ethical approval from the Forensic Medical Institute, 4 male and 2 female cadavers were used in this study conducted at the Forensic Medicine Institute between January 24 and 26, 2020. A total of 6 cadavers aged 18 years and above of body mass index (BMI) < 40 kg/m<sup>2</sup>, without any scar tissue or injury in the inguinal region, whose tissue deterioration had not yet began, and who were planned for a routine autopsy were enrolled in the study. A total of 12 surgeries were performed in the cadavers by using both the inguinal areas.

### Statement of Human and Animal Rights

This study was performed in line with the principles of the Declaration of Helsinki. The study was approved by the Ethics Committee of Autopsy Unit of Forensic Medical Institute, Istanbul, Turkey (Date: December 10, 2019; Protocol no: 21589509/2019/1003). Obtaining informed consent was not applicable as the subjects were cadavers. The study did not include any animal trial.

### Surgery

Standard laparoscopic hand tools and trocars were used to perform the surgery. The insertion points of trocars in both the sexes were marked before the procedure. A 1 cm transverse skin incision was made on the medial side of the spina iliaca anterior superior (SIAS). Using a clamp, m. externus abdominis muscle fascia was reached. Then, a 1 cm incision was made along the fibers on the fascia. A small amount of the bottom fascia was decollated bluntly and radially from the opened window toward the medial side using the clamp. The ilioinguinal nerve can be thus protected using this technique. Starting from the lateral side, a U-suture was inserted into the opening in the fascia with



FIGURE 1. Trocar entries.

0 no. Vicryl. Next, a 12 mm Hasson trocar was inserted under the external fascia and fixed (Fig. 1). Then, insufflation was performed with CO<sub>2</sub> at 10 mm Hg pressure.

Using a 30-degree camera, the operation area was opened with blunt dissections. Tendon conjoint in the superior, ligamentum inguinale in the inferior, pubic tubercle in the medial, and ligamentum rotundum in the midline of women, and the spermatic cord and regional nerves in men were exposed. The ilioinguinal nerve can be easily seen extending to the annulus inguinalis superficialis from where the Hasson trocar is located. The hypogastric nerve was located on the upper side of the ilioinguinal nerve and the genital branch of genitofemoral nerves was located on the lower side of the ilioinguinal nerve. The anatomic structures can be observed and dissected much more clearly with  $\times 15$  magnification. A line was then drawn from the SIAS to the pubis, and 2 more 5 mm trocars were placed. Next, 5 mm trocars were placed laterally at 3-cm superior medial and 3-cm inferior medial positions such that it formed an isosceles triangle with SIAS (Fig. 2).

**Surgical Team and Equipment Placement**

The cadavers were placed on the operating table in the supine position. The camera was placed opposite to the field of study. In the study area, the surgeon stood on the cranial side, the camera assistant stood next to the surgeon on the foot side, and the surgical nurse stood on the foot side.

Inguinal anatomic structures were opened through blunt and sharp dissections.

In the female cadavers, the ligature rotundum was dissected, and the presence of indirect and direct hernia was investigated and incised from the proximal region.

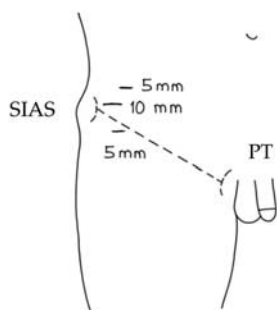


FIGURE 2. Trocar entry points. PT indicates tuberculum pubicum; SIAS, spina iliaca anterior superior.

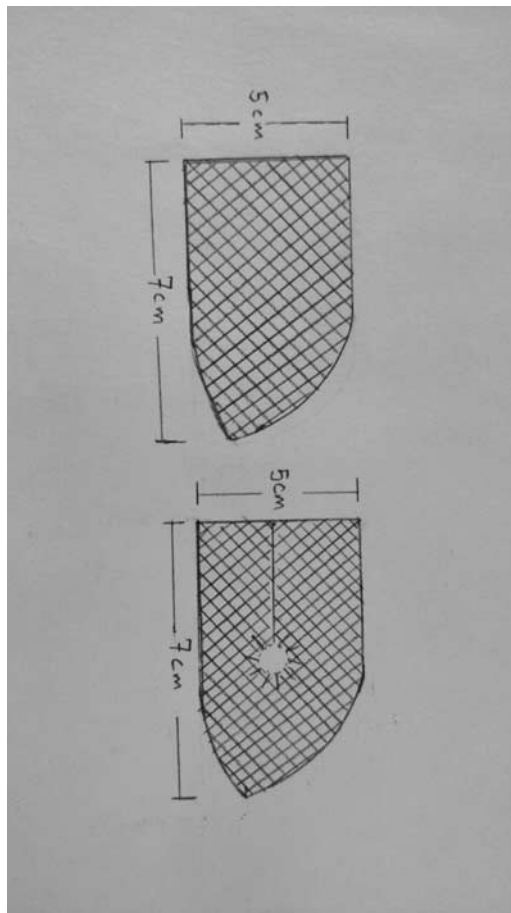


FIGURE 3. Polypropylene mesh use in female and male cadavers.

In male patients, the spermatic cord was dissected, and the cord elements were protected. The presence of an indirect hernia was investigated. By rotating the cord, the presence of direct hernia on the posterior wall was investigated (Video 1, Supplemental Digital Content 1, <http://links.lww.com/SLE/A279>). Next, the cord was suspended from the outside by way of an external suture.

Then, a 7x5-cm Prolene mesh was pushed through the Hasson trocar and placed in the inguinal area (Fig. 3). For fixing the mesh to the anatomic structures, titanium tacker was used in tendon conjoint and pubic tubercle, whereas 2/0 15-cm nonabsorbable V-Loc, 2/0 PDS or 3 or 4 of titanium tackers were used in the fixation of ligamentum inguinale (Figs. 4, 5). Later, the trocars were removed and the wounds were closed.

**RESULTS**

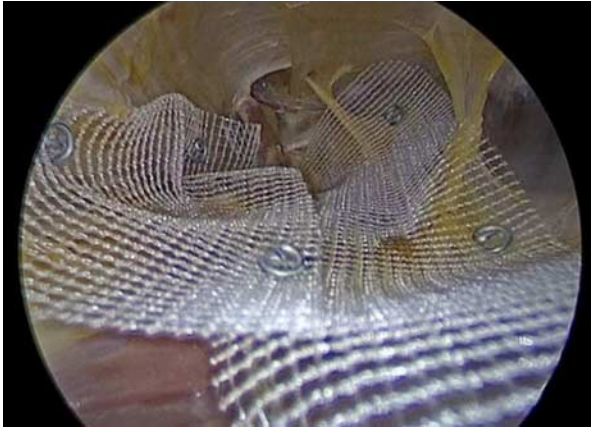
A total of 12 surgeries were performed on 4 male and 2 female cadavers.

The mean age and BMI of the male and female cadavers were 43.25 years, 29.05 kg/m<sup>2</sup> and 76.50 years and 26.60 kg/m<sup>2</sup>, respectively.

The mean operation time was 33.50 minutes for the male cadaver and 35.75 minutes for the female cadaver.

No direct or indirect hernia was recorded in any of the cadavers.

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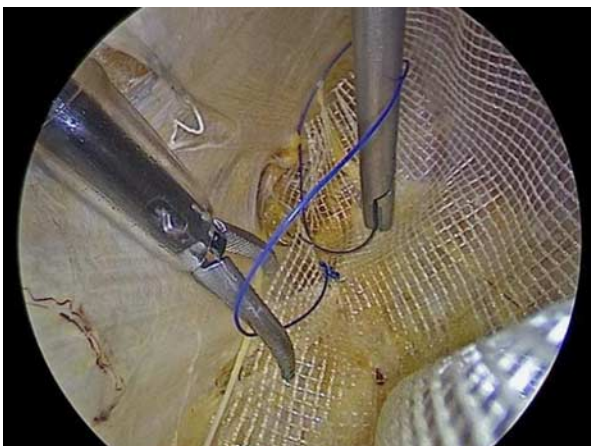
**FIGURE 4.** Fixation of the mesh with tacker.

In the exploration performed in the anteromedial area of the spermatic cord in the 2 male cadavers, the cord was dissected by observing the lipomas and incised at the level of a. inguinalis superficialis. The external suture used for cord elevation provided ease of operation. However, we are not aware of the effect of this procedure on the blood flow in living tissues. For this reason, it would not be appropriate to pull too much and for a long time.

Ilioinguinal nerve injury was not observed in any of the cadaver model applications, and all neural structures could be clearly observed. To be found the nerves and dissection of these were easy. During dissection, some nerves and branches were not found to be preserved because of cadaver work.

A 7×5-cm-shaped mesh was used in both the sexes. For the fixation of mesh, a titanium tacker was used in the pubic tubercle, and tendon conjoint; 2/0 PDS was used for fixing of ligamentum inguinale in 3 of the surgeries; 2/0 15-cm V-Loc was used in another 3 surgeries; and titanium tacker was used in 6 surgeries (Table 1).

The mesh fixation with the tacker was applied for the purpose of visualization. In our clinical practice, we do not use tacker application in open surgery. We recommend using nonabsorbable V-Loc and Prolene sutures. Furthermore, we



**FIGURE 5.** Fixation of the mesh with nonabsorbable sutures into ligamentum inguinale.

believe that other materials such as glue can be applied in mesh fixation.

## DISCUSSION

Inguinal hernia operations are the most common surgeries performed in the field of general surgery, with ~20 million operations being performed for inguinal hernia every year across the world.<sup>1</sup>

Tensioned open surgery has been performed since the 19th and mid-20th centuries, which has been replaced by tension-free surgical methods using tension-free suturing techniques, such as Moloney darn (net knitting), or by using a mesh since the beginning of the mid-20th century.<sup>2,6</sup>

In 1992, the first report of the development of a laparoscopic technique based on a TAPP approach for inguinal hernia was presented by Arregui et al<sup>7</sup> and by Dion and Morin.<sup>8</sup> Thereafter, other researchers recommended a TEP approach to avoid any peritoneal complications.<sup>9,10</sup> In this study, we developed an endoscopic method that can serve as an alternative to TEP and TAPP laparoscopic repair of inguinal hernia in cadaver models. This method may be performed in patients who are not suitable for general anesthesia, who experience a recurrence after laparoscopic intervention, and who do not desire any visible traces of the surgical scar.

Presently, the hernia repair techniques vary largely in terms of the settings, experience level of the surgeons, available resources, insurance reimbursement systems, and logistical capabilities. Open mesh repair, principally the Lichtenstein repair, is the most common technique used for hernia repair. Endolaparoscopic surgery for the repair of inguinal hernia also differs across the world, ranging from 0% to 55% of repairs performed in some developed countries. Although the average rate of incidence in most of the countries is unknown, the corresponding rates have been determined to be 55% in Australia, 45% in Switzerland, and 28% in Sweden. Sweden maintains a National Registry with complete coverage that records the rate at which each technique has been performed. For instance, the Lichtenstein rate was 64%; TEP rate was 25%; TAPP rate was 3%; a combined open and preperitoneal technique rate was 2.7%; and tissue repair rate was 0.8%.<sup>2</sup> The Hernia Medical Registry indicates that an extensive variety of hernia repair techniques have been performed between 2009 and 2016, including TAPP (39.0%), TEP (25.0%), Lichtenstein (24.0%), plug (3.0%), Shouldice (2.6%), Gilbert Prolene hernia system (2.5%), and Bassini (0.2%). However, reliable data from Asia and the United States are lacking for any conclusive understanding.<sup>11</sup>

Selection of the best technique for inguinal hernia repair is a challenge in surgical intervention. Unfortunately, there is no gold-standard repair technique for groin hernias.<sup>1,12</sup> Therefore, there is no single technique available to manage the different presentations of hernia. The paramount operative technique should guarantee a fast recovery, should be enduring, and present with a low risk of complications such as pain and recurrence, should be economical, and should produce reproducible and best cosmetic outcomes. Currently, laparoscopy and robotics are being used as advanced surgical tools, offering a range of opportunities for general surgeons involved in investigating critical novel procedures.<sup>6</sup>

Lichtenstein and laparoendoscopic repair techniques are some of the advanced surgical entities to be investigated,

TABLE 1. Characteristics and Data of the Study Subjects

| Patient No. | Age (y) | Sex | BMI  | Operation Duration (min) |      | Fixation to Ligamentum Inguinale |                    |
|-------------|---------|-----|------|--------------------------|------|----------------------------------|--------------------|
|             |         |     |      | Right                    | Left | Right                            | Left               |
| 1           | 67      | F   | 35.2 | 37                       | 40   | Continue 2/0 PDS                 | Continue 2/0 V-Loc |
| 2           | 86      | F   | 18.0 | 28                       | 38   | Tacker                           | Continue 2/0 PDS   |
| 3           | 44      | M   | 27.1 | 25                       | 24   | Tacker                           | Tacker             |
| 4           | 73      | M   | 23.5 | 38                       | 44   | Continue 2/0 V-Loc               | Continue 2/0 PDS   |
| 5           | 30      | M   | 31.7 | 29                       | 42   | Tacker                           | Continue 2/0 V-Loc |
| 6           | 26      | M   | 33.9 | 35                       | 31   | Tacker                           | Tacker             |

BMI indicates body mass index; F, female; M, male.

whereas several other techniques require further evaluation.<sup>1</sup> Our proposed method offers elimination of the disadvantages of laparoscopy in hernia repair while combining the advantages of open surgery in an endoscopic approach.

In the study conducted on the cadaver model, we believe that all pathologies present in the inguinal area can be intervened from this angle. These can be listed as preparation of the hernia sac, performing herniectomy, hernia reduction and transversalis fascia plication, and mesh application. Although we believe that a large hernia sac will be a limitation in male patients, the feasibility of these procedures under spinal and epidural anesthesia will not differ from that in a usual open surgery performed under spinal or epidural anesthesia.

TEP and TAPP are the present methods requiring general anesthesia and long learning curves, which may cause severe vascular and urinary injuries due to regional anatomic structures, and cause serious issues in mesh reactions, although they offer the cosmetic advantages of no visible scars in the abdominal areas.<sup>3,4,12,13</sup> As compared with TEP and TAPP, the concerned area is a familiar field in open surgery, which may provide the ease of learning. In addition, any potential serious complications can be avoided. It may also be advantageous cosmetically if the incisions are made in less visible areas of the abdomen.

Laparoendoscopic interventions have been performed since the past 30 years from 1990s onward, and it is still performed, albeit in limit capacities, in several countries. This situation can be attributed to the factors of the ease of learning curve of open surgery technique, the easy access to the area in which an open surgery has to be performed, the fact that the incision remains under the bikini area and does not create any serious cosmetic concern, cost-effectiveness, and no severe complications.<sup>5</sup>

It is thus questionable as to how laparoscopic surgical interventions are not considered as the gold-standard-like laparoscopic cholecystectomy, which, as per several case studies, have reported difficulties in technical applications. In fact, the development and application of new laparoendoscopic approaches that are easy to implement and learn should be encouraged.

In conclusion, we demonstrated, through a study on a cadaver model, that the endoscopic surgical technique offers the advantages of open inguinal surgery, which can be combined and performed by employing the advantages of laparoscopic intervention. In the future, the application of this technique to a certain number of inguinal hernia patients may provide more clarity of the outcomes. This method has not yet been applied in a living patient.

However, a prospective study may be planned after the publication of this study.

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