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ORIGINAL ARTICLE

Severe rectus diastasis with midline hernia associated in males: high recurrence in mid-term follow-up of minimally invasive surgical technique

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Abstract

Propose The present study aimed to assess clinical results, in terms of postoperative pain, functional recovery and recurrence rates of FESSA (Full Endoscopic Suprapubic Subcutaneous Access) technique compared to endoscopic anterior rectus sheaths plication and mesh, in male patients with midline ventral or incisional hernias and severe rectus diastasis (SRD) associated. Secondary aims were to identify intra- and postoperative complications associated with each technique.

Methods Male patients with midline ventral or incisional hernia and severe rectus diastasis were included in a prospectively maintained databased and retrospectively analyzed from January 2017 to December 2020. From January 2017 to January 2019, male patients underwent to anterior rectus sheaths plication (ARSP) (Control group). From January 2019 to December 2020, male patients underwent to FESSA technique (FT) (Case group).

Results 53 patients were finally included. 28 patients (52%) underwent to FT and 25 patients (48%) to ARSP. Regarding intraoperative complications, no significant differences were identified between the groups. Hospital stay was significantly improved in FT group when compared to ARSP group. No significant differences in terms of postoperative seroma or hematomas, were shown. FT group showed significantly less pain on 1st, 7th and 30th postoperative days than ARSP group. Functional recovery was significantly improved in FT group compared to ARSP group on the 30th day and no differences were observed on the 180th day after surgery. The mean follow-up was 17.3 ± 2.6 months in FT group and 24 ± 3 months in ARSP group. During the follow-up, 1(3%) and 9 (36%) diastasis recurrences were identified respectively, with significant differences in favor of FT group.

Conclusion In males with SRD and symptomatic midlines hernias, ARSP with onlay mesh placement shows high diastasis recurrence rate in mid-term follow-up. We propose FESSA technique in those patients, which decreases the excessive midline tension, improving the postoperative pain, functional recovery and recurrence rate, without increasing postoperative complications.

Keywords Diastasis recti · Rectus diastasis · Endoscopic rectus plication · Subcutaneous hernia · Totally endoscopic hernioplasty

Introduction

When ventral or incisional midline hernias and simultaneous rectus diastasis (RD) are diagnosed, the surgical repair of both pathologies could be recommended [1]. Suprafascial endoscopic repair techniques with anterior rectus sheaths plication and "onlay" mesh placement have been published during recent years with acceptable results in terms of postoperative complications and recurrences [2, 3].

An inter-rectus distance (IRD) greater than 5 cm is labeled as severe diastasis [4].

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Endoscopic anterior rectus sheath plication could result in excessive midline tension that can increase the recurrence rate in patients with severe rectus diastasis (SRD) in mid-term follow-up.

Previously published minimally invasive endoscopic repair (FESSA technique) (FT) was proposed as a surgical alternative in patients to correct both pathologies [5, 6]. The present study aimed to assess clinical results, in terms of postoperative pain, functional recovery and recurrence rates of FT compared to endoscopic anterior rectus sheath application and mesh (ARSP) in male patients with midline ventral or incisional hernias and associated SRD.

The secondary aims of the study were to identify intra- and postoperative complications associated with each technique.

Patients and methods

Study design and population

After approval by the local ethics committee and signing the informed consent, all male patients with midline ventral or incisional hernia and SRD were included in a prospectively maintained databased and retrospectively analyzed from January 2017 to December 2020. Patients were collected from QuironSalud Sagrado Corazón Hospital in Seville, Spain.

The distribution of FT or ARSP approaches was studied and grouped according to different periods:

- From January 2017 to January 2019, male patients with SRD and midline ventral or incisional hernias underwent ARSP.
- From January 2019 to December 2020, male patients with SRD and midline ventral or incisional hernias underwent FT using two different meshes.

The outcomes of patients who underwent ASRP were compared with those of patients who had SRD and midline hernia repairs using FT.

Inclusion criteria

- Male patients aged between 18 and 80 years old.
- Symptomatic midline ventral/incisional hernias with an IRD > 5 cm.

Exclusion criteria

- Previous mesh placed in "onlay" position.
- Contraindication to general anesthesia.
- Incarcerated or strangulated hernias.
- Lateral ventral/incisional hernias.

Surgical technique

All procedures were performed by the same surgeon. The patients were subjected to general anesthetic and antimicrobial prophylaxis with 1 g of amoxicillin–clavulanic in the induction of anesthesia. Patients were placed in supine position with both arms and legs retracted. The surgeon was located between the legs of the patient, with the assistant on the right and the surgical nurse on the left.

A suprapubic incision was performed for 11 mm trocar placement and two smaller incisions on both sides for 5 mm trocars (Fig. 1). The subcutaneous space was developed using 8 mmHg CO_2 pressure to visualize and increase the working space. A suprafascial dissection exposing the anterior aspect of the rectus sheath on both sides reaching the umbilical region was performed. The navel was detached from the hernial sac, reintroducing this into the intra-abdominal compartment and the supra-aponeurotic dissection was resumed above the umbilicus to the sub-xiphoid region. Lateral dissection was performed depending on the hernia and diastasis widths, to minimize the probability of ischemic skin and fat tissue and the appearance of post-operative seroma.

ARSP technique

The plication of both anterior rectus sheaths was carried out from the sub-xiphoid until the suprapubic region with the use of a continuous non-absorbable barbed suture n° 1 (V-LOC™ PBT, Covidien®). After the plication of both aponeurosis, a low-weight (48 g/m^2) wide pore (3.6 × 2.8 mm) polypropylene mesh (Optilene® mesh elastic, B.Braun) was placed in the "onlay" position and fixed with cyanoacrylate drops (Histoacryl® Lapfix, B.Braun) (Fig. 2). The mesh size was routinely 6 cm wide (3 cm overlap each side). The mesh length was dependent on the length of the plication and should overlap 3 cm cranial and caudally.

Fig. 1 Trocar placement

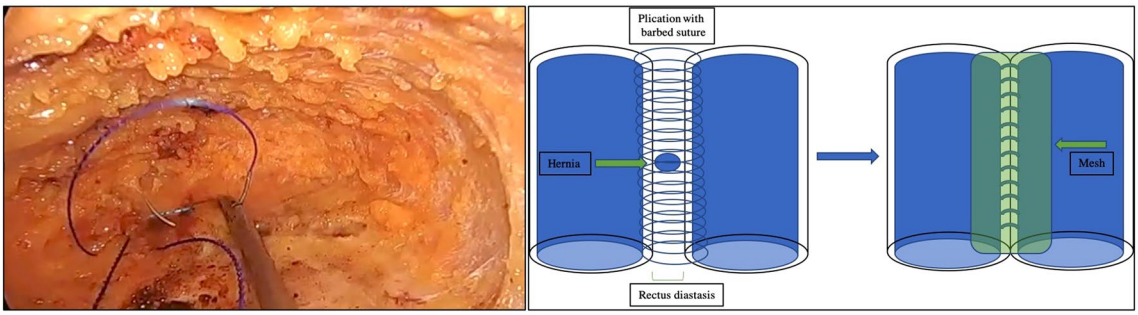


Fig. 2 Anterior rectus sheaths plication using running barbed suture

Fig. 3 Right anterior rectus sheath is incised

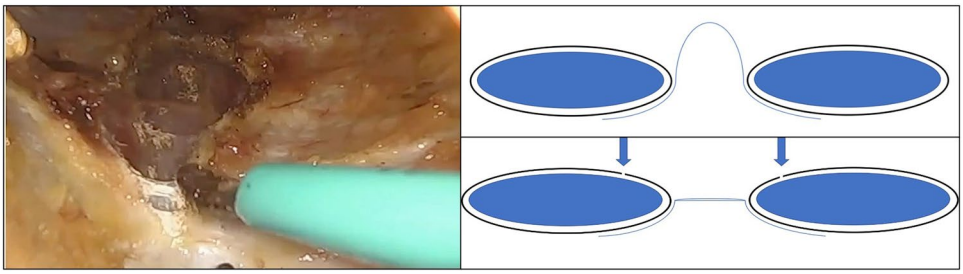


Fig. 4 Both medial aspects of anterior rectus sheaths are brought together in midline

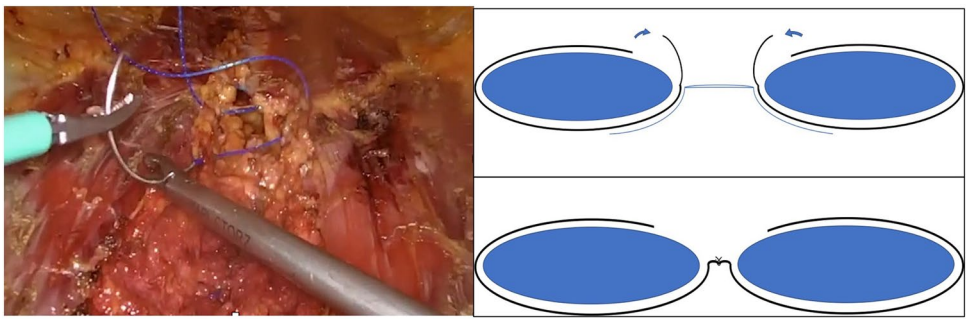
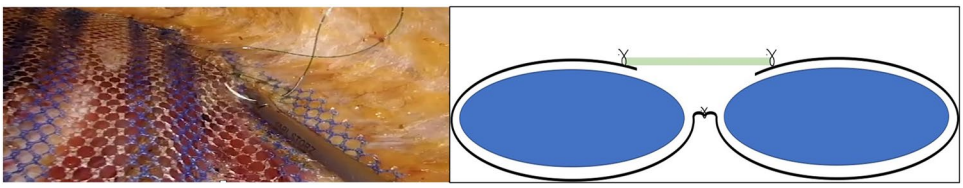


Fig. 5 Mesh fixation to lateral aspect of ARS



FESSA technique

An incision was made on the anterior rectus sheath bilaterally exposing the bellies of both rectus muscles. The two resected medial segments of the anterior layer of the rectus sheath are sutured together in midline using continuous, non-absorbable barbed suture nº 1 (V-Loc™, Medtronic) (Figs. 3, 4). The length of both incisions depends on the length of the diastasis and hernia and the distance from the midline depends on the hernia and diastasis widths. In this way, hernia and diastasis were corrected without tension, re-approximating the midline to its original position. Two meshes were used:

- Low-weight and wide pore polypropylene mesh (Optilene® Mesh elastic,B. Braun Surgical, Rubí, Barcelona). This mesh was rolled and inserted through the 11-mm trocar. It was extended and sutured to the lateral incision margin of the anterior rectus sheath opening using continuous 2/0 barbed suture (Fig. 5).

- Self-adhesive mesh (Adhesix®, AH, Bard, USA) was placed and properly extended covering 2 cm of the external margin of the anterior layers of the rectus sheaths. This mesh was used to:
- Avoid suturing to the lateral margin of the anterior rectus sheaths, making fixation easier.
- Attempt to decrease the postoperative seroma rate, minimizing the dead space between the mesh and the fat tissue due to its adhesion.

Intraoperative hypertonic saline irrigation (20 cc of NaCl 12% left at the site for 10 min) was performed in the last 14 cases in the FT group for seroma formation prevention, as reported by M. Dudai [7].

Both surgeries were completed with the re-insertion of the navel in its original position using cyanoacrylate glue. A suction drain was routinely placed that was removed once the drainage was less than 10–15 ml/day. After this, a compressed bandage was placed to decrease the dead space between the aponeurosis and the subcutaneous cellular tissue. An abdominal girdle was used for at least 1 month after surgery.

For each patient, retrospectively, the following data were collected:

- Demographics: Age, body mass index (BMI), risk factor for hernia recurrence (pulmonary/liver/renal disease, immunosuppression, and smoking) and hernia type using the European Hernia classification [8]. Defect and diastasis widths and lengths were measured using the preoperative CT scan at rest.
- Surgical results:
- Operation time (minutes).
- Intraoperative complications.
- Hospital stay (days).
- Days to drain removal.
- Postoperative complications using Clavien–Dindo classification [9]. Seroma rate (Morales et al. [10] classification), identified by clinical examination and ultrasonography if there were doubts, wound infection, periumbilical skin necrosis and others.
- Pain (VAS) preoperative and on days 1, 7 and 30 using EuraHS Quality of life score for pain [11].
- Functional recovery preoperative and on days 30 and 180 (EuraHS Quality of life score for restriction) [11].
- Hernia and/or diastasis recurrences: Clinical examination after 6 months, 1 year and every year thereafter, as well as through an abdominal CT scan at 6 months and 1 and 2 years after surgery. Diastasis recurrence was considered when IRD > 2 cm during the follow-up in CT scan.

Statistics

Continuous data were tested using normal distribution (Kolmogorov–Smirnov test). Normally distributed data were presented as the mean with standard deviation (SD) and categorical data as the frequency and percentage values in descriptive tables. The χ^2 or Levene tests were used to analyze homogeneity between both cohorts.

Differences between normally distributions were tested using Student's unpaired and paired t test for continuous data (p value) and the χ^2 and Fisher's Exact tests for categorical data (reported as χ^2, p value). In the case of not normally distributed variables, non-parametric tests were used to compare hypothesis.

Reported p values of < 0.05 were considered statistically significant. All statistical data were analyzed with IBM SPSS Statistics for Macintosh Version 25.

Results

Fifty-five male patients were eligible, but two patients were lost during the follow-up. Fifty-three patients were finally included. Twenty-five patients underwent ARSP (48%) and Twenty-eight patients (52%) underwent FT:

– In the first fourteen patients, a low-weight and wide pore polypropylene mesh was placed.
– In the second fourteen patients, a self-adhesive mesh with intraoperative hypertonic saline irrigation was used.

Patient characteristics and hernia types are listed in Table 1.

No significant differences were shown regarding age, BMI, risk factor for hernia recurrence and hernia types. Mean hernia widths and lengths were significantly higher in the FT than the ARSP group ($p < 0.05$), but no significant differences in diastasis size were identified between the two groups.

Regarding intraoperative complications, 2 bleeds were identified (7%) in the FT group and 2 in the ARSP group (8%), with no significant differences between the groups ($p = 1$). All intraoperative bleeds were resolved with cauterisation.

The surgical time in the FT group was higher than in the ARSP group, with significant differences (70.2 ± 8.7 vs 54.8 ± 6.5 min, respectively). Hospital stay was significantly improved in the FT group compared to the ARSP group (1.4 ± 0.5 vs 2 ± 0.4 days, respectively). Mean days to drain removal were 4.6 ± 0.3 in the FT group and 4.2 ± 0.6 days in the ARSP group with no significant differences between the groups.

Postoperative complications:

Table 1 Demographic variables

	FT group	ARSP group	*p*	
Age (years)	52.4 ± 12.3 SD	51.4 ± 1.1	0.763	
BMI (kg/cm^2)	29.1 ± 4.6	29.8 ± 4.5	0.849	
Risk factors				
Smoking	12 (42%)	8 (32%)	0.571	
Immuno-suppression	1 (3.6%)	3 (12%)	0.333	
Pulmonary/liver/renal disease	3 (10%)	2 (8%)	1.0	
Hernia type			Total	
Ventral Hernia	13	16	29	0.271
Incisional Hernia	15	9	24	
Hernia width (cm)	3.7 ± 1.2	3.0 ± 0.7	< 0.05	
Hernia length (cm)	3.5 ± 1	2.8 ± 0.7	< 0.05	
Diastasis width(cm)	5.7 ± 0.7	5.4 ± 0.5	0.065	
Diastasis length(cm)	26.2 ± 4.9	25.8 ± 4.1	0.744	
Operation time (minutes)	70.2 ± 8.7	54.8 ± 6.5	< 0.05	
Hospital stay (days)	1.4 ± 0.5	2.0 ± 0.4	< 0.05	
follow-up (months)	17.3 ± 2.6	24 ± 3	–	
recurrence	1 (3%)	9 (36%)	< 0.05	

Data are expressed mean ± standard deviation

Table 2 Seroma rate in FT group

FT group	First 14 patients	Second 14 patients	total	*p*
Yes	5 (35.7%)	0 (0%)	5 (17.9%)	0.041
No	9 (64.3%)	14 (100%)	23 (82.1%)	—

Seroma rate is compared between first 14 patients and second 14 patients of the FT group with significant differences in favor of second group

- Five postoperative seromas were confirmed (17%) in the FT group and 9 (36%) in the ARSP group, with no significant differences ($p = 0.12$). In the FT group, when the first 14 patients were compared to the second 14 patients in which a self-adhesive mesh was placed and hypertonic saline was left in the surgical field, significant improvements in terms of seroma rate were identified in favor of the second 14 patients in FT group (Table 2). The majority of the seromas were managed in a conservative way (type I of Morales et al. classification). Only 2 patients (1 patient in each group) required evacuative puncture due to the persistence of seroma after the 4th week with associated discomfort (Type IVa).

The rest of the complications were identified as Clavien–Dindo grade I:

- No significant differences were observed regarding postoperative haematomas: 2 patients (7%) in the FT group and 1 (4%) in the ARSP group. All haematomas were treated conservatively.
- One umbilical skin necrosis (4%) was identified in the ARSP group and none in the FT group ($p = 0.47$). These complications were managed with necrosectomy under local anesthetic (Clavien–Dindo grade IIIa).

Regarding postoperative pain measured before surgery, on the 1st, 7th and 30th day after surgery, significant differences were observed when both groups were compared before surgery in favor of the ARSP group. The FT group showed significantly less pain on 1st, 7th and 30th postoperative days than the ARSP group ($p < 0.05$) (Table 3, Fig. 6).

In our study, the evaluation of functional recovery (activity restrictions) demonstrated no significant differences between the FT and ARSP groups preoperatively. Functional recovery was significantly improved in the FT group compared to the ARSP group on the 30th day, and no differences were observed on the 180th day after surgery (Table 4, Fig. 7).

The mean follow-up was 17.3 ± 2.6 months in the FT group and 24 ± 3 months in the ARSP group. During the follow-up, 1 (3%) and 9 (36%) diastasis recurrences were identified, respectively, with significant differences in favor of the FT group (Figs. 8–9).

Table 3 Pre and postoperative pain FT vs ARSP

	Rest	Activities	Prior week	Mean	Standard deviation	*p*
preop						
FT	2.2	6.1	4.5	11.2	2.6	< 0.05
ARSP	1	3	3	6.6	0.9	
1° day						
FT	5	7	5	21.1	1.9	< 0.05
ARSP	7.1	9	8	25.0	2.1	
7° day						
FT	2.2	5.1	4.3	13.3	2.8	< 0.05
ARSP	5.1	8	6	19.6	1.4	
30° day						
FT	1	2.4	2	5.6	1.5	< 0.05
ARSP	1	5	5	12.08	1.8	

Pain is measured using visual analogical scale from 0 (no pain) to 10 (worst imaginable pain) and is graded at rest, during activities and over the prior week at the site of the hernia

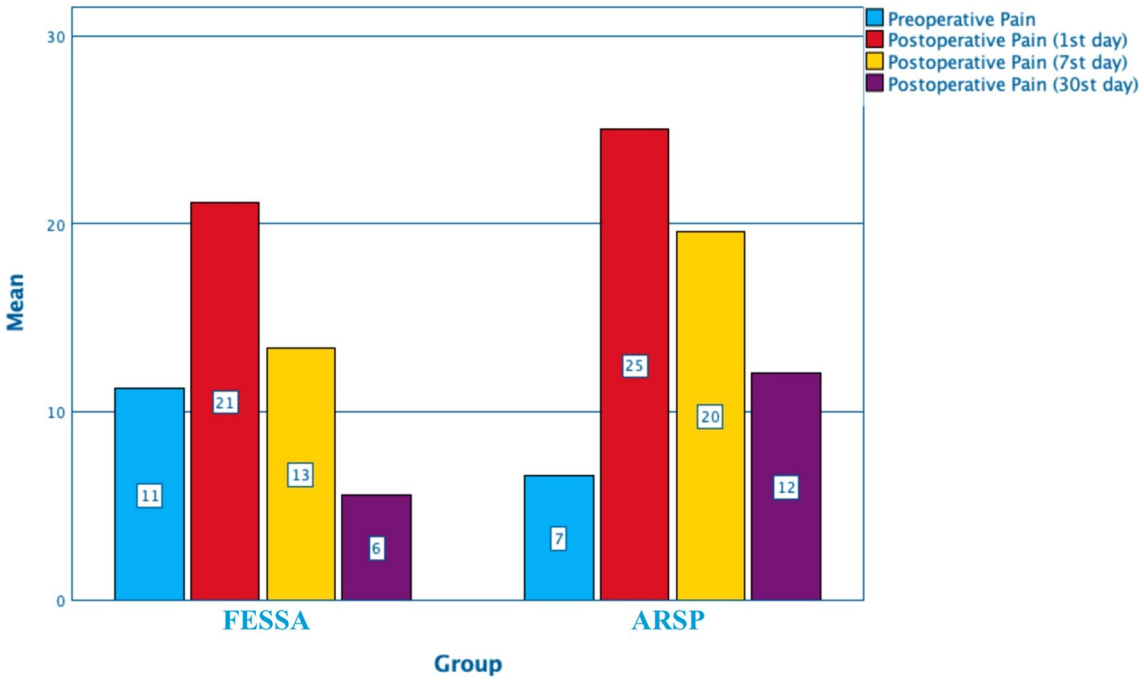


Fig. 6 Pain evolution FT vs ARSP

Discussion

Diastasis recti means a reduction in the consistency of the inter-crossed fibers which make up the linea alba of the abdominal wall, with the consequent increase in the length of these fibers, which causes the consequential separation of both aponeurosis of the rectus abdominis muscles. This is therefore clinically translated as the appearance of a bulging of the midline above and below the umbilicus (if the weakness also affects the infra-umbilical midline), with an esthetic deterioration which produces discomfort at the said level with contraction movements of the abdominal wall [12].

Previous classifications include the Nahas [13] classification based on the myofascial deformity, the Rath [14] classification based on the attenuation level relative to the umbilicus and the patient age and the Beer [15] classification based on the normal width of the linea alba.

Recently, two new classifications have been proposed:

Table 4 Activity restrictions FT vs ARSP

	Daily activities inside house	Outside house	Sport	Heavy labor	Mean	standard deviation	*p*
preop							
FT	1.1	3.2	5.3	6	15.2	5.0	0.149
ARSP	1.4	3.8	6.1	6.1	13.2	4.6	
30º day							
FT	2	3.7	6.5	7	17.8	2.4	< 0.05
ARSP	4.2	6	8.3	8.8	27.8	3.3	
180º day							
FT	1	1.1	2.4	3.3	6.2	1.1	0.4
ARSP	1.3	1.5	2.1	3.3	6.5	1.2	

Activity restriction is graded using a scale of 0 (no restriction) to 10 (completely restricted) from daily activities, outside the house, during sport or during heavy labor because of pain or discomfort at the site of the hernia

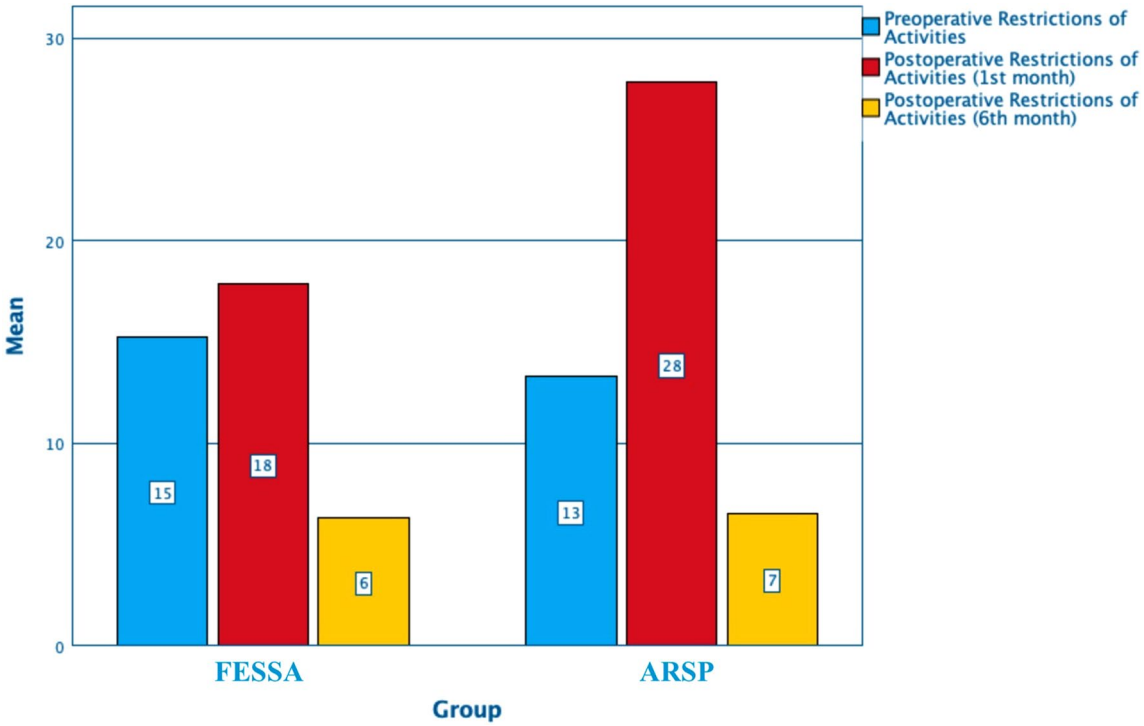


Fig. 7 Activity restrictions FT vs ARSP

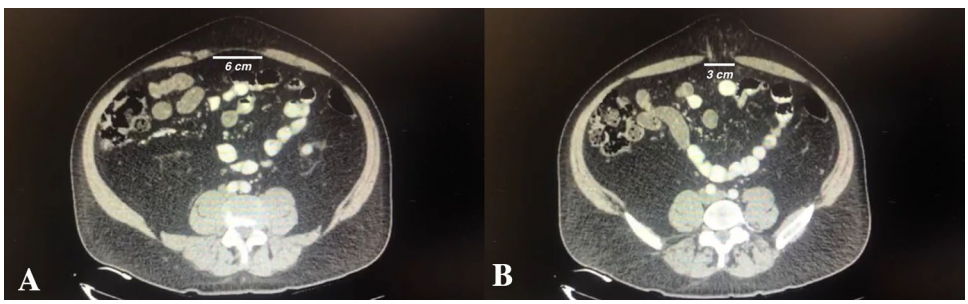


Fig. 8 Preoperative CT scan in FT. **A** 6 cm size rectus diastasis. **B** 3 cm size umbilical hernia

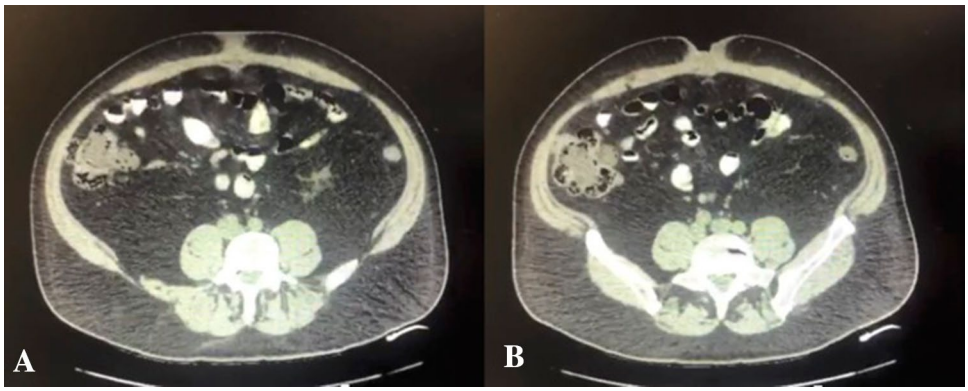


Fig. 9 Six-month postoperative CT scan in FT. **A** Rectus diastasis completely repaired. **B** umbilical hernia fixed

- The International Endohernia Society (IES) proposed a classification of rectus diastasis with concomitant hernias based on its location (subxiphoidal,
- epigastric, umbilical, infra-umbilical, suprapubic) and width (mild < 3 cm, moderate = 3–5 cm and severe > 5 cm) [16].
- A new classification system is proposed by the *European Hernia Society* based on the measured width of the inter-rectus diastasis, post-pregnancy status and presence or absence of a concomitant hernia [4].

An inter-rectus width < 2 cm is considered non-pathological, while an inter-rectus width > 5 cm is classified as severe rectus diastasis [4, 16]. No consensus has been established regarding surgical indications or type of repair.

The presence of an associated ventral hernia may be an indication for surgery, regardless of the size of a concomitant diastasis [17].

In males with symptomatic midline hernias and rectus diastasis, several surgical procedures have been used:

- Open procedure: A midline incision is performed and different mesh repairs in several levels of placement, are performed (onlay, sublay or intraperitoneal) [18].
- Hybrid approach:
- ELAR (Endoscopic Linea Alba reconstruction) plus mesh augmentation [19]: This procedure is a hybrid technique composed of:
- Open approach (periumbilical access): The skin incision is made on the left side, encircling the umbilicus like a half-loop and extending 2–3 cm upwards. This is followed by stepwise diathermy dissection of the subcutaneous tissue, with detachment of the subcutaneous tissue from the anterior rectus sheath on the left and right as well as below the umbilicus. Next, the umbilical hernia sac is opened, the hernia contents repositioned or resected and the umbilicus detached from the abdominal wall fascia.
- Endoscopic approach: Both rectus sheaths are incised around 2–3 cm from the medial margin along their entire length from the xiphoid process to the sub-umbilical area and opened. The two medial parts of the right and left anterior rectus sheaths are sutured together. Using a continuous suturing technique, a mesh (TiMesh strong) for augmentation is then sutured to the incision margin of the right and left anterior rectus sheaths as a replacement for the medial part of both anterior rectus sheaths
- Minimally invasive approaches:
- Laparoscopic Intraperitoneal mesh repair with defect closure (IPOM +): The pneumoperitoneum is created using a Veress needle in the left hypochondrium. The trocars are placed on the left side of the abdomen on the left clavicular midline. Three trocars are used, a 10-mm trocar for the 30° optic, and two 5-mm trocars. Both posterior rectus sheaths are brought together using a running suture and a coated mesh is placed intraperitoneally. This procedure shows different drawbacks: adhesion formation due to intraperitoneal mesh placement and high postoperative pain caused by traumatic fixation (helicoidal sutures) needed to fix the mesh against the abdominal wall [20].
- LIRA technique: The posterior fascia of both rectus muscles is incised longitudinally and parallel to the lateral borders of the defect, creating two flaps of the aponeurosis, which were turned over to the middle line. Both flaps of the aponeurosis are sutured together in the middle line using a continuous suture. Once the flaps of the aponeurosis are sutured together, a reinforcement of the aponeuroplasty is performed by laparoscopy using an intraperitoneal mesh. The mesh size must overlap vertically by at least 5 cm over the original defect but always completely covering the area where the fascia was dissected and including the whole incision in the case of incisional hernias. This technique could be considered an alternative to the IPOM + technique for medium defects with a width of under 10 cm. This procedure obtains a "no tension" effect that could decrease postoperative pain

improving postsurgical recovery compared to IPOM + . The main disadvantages are the same as before (intraperitoneal mesh placement and mesh fixation with traumatic device) [21].

- Anterior rectus sheath (ARS) plication through suprapubic access: Several papers have shown acceptable results by the plication of ARS with a barbed suture and "onlay" mesh placement, using a subcutaneous approach [2, 3, 22, 23]. These all studies describe techniques with a shared surgical approach:
- Development of a subcutaneous or pre-aponeurotic space.
- Plication of rectus diastasis from an anterior approach.
- Repair of the hernias with onlay positioning of the mesh.
- Laparoscopic transabdominal retro-muscular/pre-peritoneal mesh placement [24]: Conventional laparoscopic access is performed. The posterior rectus sheath (PRS) is opened and both retro-muscular spaces are developed. Both ARS are closed in the midline and the retro-muscular mesh is placed, finishing the surgery by closing both opened PRS.
- Totally endoscopic retro-muscular access (eTEP): A 2 cm incision is made below the left costal margin and the left anterior rectus sheath is exposed. This layer is incised as close to lateral edge as possible. A retro-muscular space is created using blunt dissection. One 10 mm balloon trocar is placed for the 30° optic and the retro-muscular space is developed using the optic tip and pneumo-dissection with a pressure of 14 mm Hg. One 5 mm trocar and one 10 mm trocar are inserted in the left iliac fossa and left hypochondrium, respectively, and a complete left retro-rectus space is achieved. The decision where to crossover depends on the defect location. The right posterior rectus sheath is identified and its medial aspect is incised and released in the cephalad to caudal direction. The hernia sac is reduced and the upper portion of the right retro-rectus space is connected with the lower part of it, completely releasing both right and left retro-rectus and pre-peritoneal spaces. Once both retro-rectus spaces are developed, the posterior rectus sheaths are re-approximated to the midline using a non-absorbable, running barbed suture. The anterior rectus sheaths are then brought to the midline in an attempt to reconstruct the original midline, using the same suture. The mesh (low-weight polypropylene mesh (Optilene® Mesh elastic, B. Braun) is rolled and inserted through the 10-mm trocar. The mesh is then properly extended to cover the retro-rectus space completely. Cyanocrylate glue is used for mesh fixation.
- The endoscopic retro-muscular technique (eTEP) shows significantly lower postoperative pain and better functional recovery and cosmesis than IPOM + without differences in intra/postoperative complications [20, 25].
- FESSA technique: After a subcutaneous space is developed by suprapubic access, both ARS are sectioned and both medial edges of the ARS are brought together using a running suture. A polypropylene mesh is placed and secured on the lateral edges of the ARS using running suture or glues [5, 6].
- Compared to ELAR plus mesh augmentation, the FESSA technique is a totally endoscopic technique: one 11 mm and two 5 mm trocars are placed in suprapubic position. The next steps are similar to the ELAR technique but using pneumoperitoneum (Subcutaneous dissection, hernia sac management and both anterior rectus sheaths previously opened, sutured together in midline and mesh augmentation). In the FESSA technique, the length of both incisions depends on the length of the diastasis and hernia and the distance from the midline depends on the hernia and diastasis widths.
- The main advantages of the FESSA technique compared to ELAR could be:
- Better esthetic results: The trocar scars in FESSA are hidden by the underwear. The incision in ELAR is peri-umbilical.
- Wound complication rate reduction: the incision length in ELAR is longer than in FESSA (one 11 mm and two 5 mm scars). This factor could show lower wound complication rates than ELAR.

Nevertheless, these hypothetical advantages in favor of FESSA, are not proven and randomized control trials comparing both techniques are suggested to confirm them.

Open techniques, compared to laparoscopic approaches, were associated with a significantly higher rate of skin dehiscence (6.79% vs 2.86%, $p = 0.003$) and haematoma formation (4.73% vs 1.09%, $p < 0.001$) and a significantly lower rate of post-operative seroma formation (2.47% vs 8.29%, $p < 0.001$) [26].

No significant difference in RD recurrence rates was observed between open and laparoscopic repair (0.22 vs 0.63%, $p = 0.17$) [26, 27].

Both techniques were compared in terms of intra- and postoperative complications and a mid-term recurrence rate. No differences were shown between both groups in terms of intra or postoperative complications. These two techniques share several surgical steps, developing the supra-aponeurotic space using cautery through 3 trocars placed in suprapubic positions with onlay mesh placement; no differences regarding intraoperative complications were identified.

Regarding postoperative seroma formation, no significant differences were shown between the groups. Nevertheless, in the FT group, when first 14 patients were compared to the second 14 patients in which a self-adhesive mesh and intraoperative hypertonic saline irrigation was used, the seroma

rate was dramatically descended to 0, with significant differences between both groups, confirming that the combination of mesh with adhesion on both sides and saline irrigation enhances adhesion formation and reduces the secretion rate in wide subcutaneous dissection spaces as in the FESSA technique.

Other effective strategies for seroma prevention that were used in both groups included the use of closed-suction drains, keeping the drains until their output volume was minimal and maintaining a high-pressure gradient in the drain [28, 29].

When FT was performed in this kind of patient, postoperative pain was decreased at 1, 7 and 30 days after surgery when compared to ARSP with significant differences. These better results in favor of FT could be explained by the higher tension generated in the midline after surgery when both ARS are plicated using the ARSP technique. This factor could again be the reason for the significant functional recovery improvement 30 days after surgery in FT when compared to the ARSP technique.

Both techniques show no differences in terms of functional recovery 180 days after surgery. This is probably caused by the abdominal wall accommodation after several months when the rectus diastasis is plicated under tension.

Our study shows a high rectus diastasis recurrence rate in males with symptomatic midline hernias and severe rectus diastasis when the ARSP was performed (36%). Based on this result, we proposed a different minimally invasive surgical technique (the FESSA technique) trying to solve this drawback in those male patients.

When the recurrence rate was compared between the groups, a significantly higher recurrence rate was shown in the ARSP group compared to the FT group (36% vs 3%). The main reason could be the plication of ARS under excessive tension when IRD > 5 cm.

The small sample size (53 patients) and type of study conducted, are limitations of this study.

Conclusion

In males with SRD and symptomatic midline hernias, ARSP with onlay mesh placement shows high diastasis recurrence rate in the mid-term follow-up. We propose the FESSA technique in those patients, as it decreases the excessive midline tension, improving postoperative pain, functional recovery and recurrence rate, without increasing postoperative complications.

Declarations

Conflict of interest The authors have no conficts of interest to declare.

Ettical approval The study was approved by the local ethics committees of participating hospital (virgen Macarena y virgen del Rocio, internal code 1262-N-21)

Consent to participate This study was conducted according to the Declaration of Helsinki and the guidelines of Good Clinical Practique (World Medical Association, 2013), Written informed consent was obtained from patients, or relatives/next of kin of critically ill patients, prior to enrolment.

Human and animal rights All procedures performed in the study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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