JAWS JOURNAL OF ABDOMINAL WALL SURGERY

August 2025

Open preperitoneal mesh repair for inguinal hernia – new evidence, old arguments

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Journal of Abdominal Wall Surgery
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ISSN 2813-2092
ISBN 978-2-8325-6726-5
DOI 10.3389/978-2-8325-6726-5

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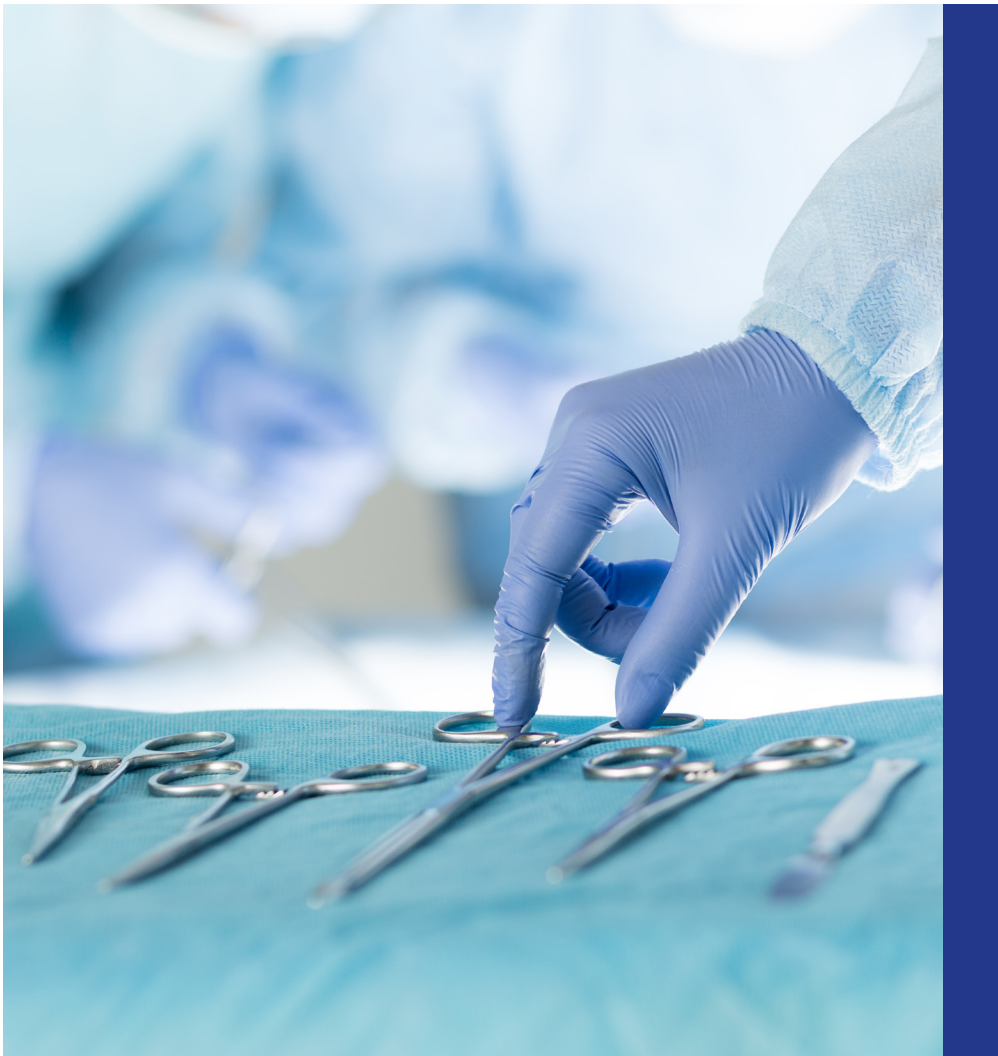
In the recent updated guidelines for inguinal hernias by the European Hernia Society, the open preperitoneal mesh techniques are considered to achieve comparable results in terms of recurrence rate compared to the Lichtenstein technique. On the other hand there is almost no evidence to compare results between various open preperitoneal techniques. Regarding the surgical procedure favourable results have been observed in terms of operating time, acute and chronic postoperative pain and return to work compared to the Lichtenstein repair. Again, very limited evidence compares open and laparoscopic preperitoneal approaches.

Open techniques like the Transinguinal preperitoneal approach (TIPP) or the transrectus extraperitoneal approach (TREPP) are scarcely described in the current literature, while benefits seem clear for those surgeons that regularly use them. Especially, longterm follow-up data, the use of this technique for recurrent inguinal hernias and the experience with recurrences after these types of procedures are limited and fuel the discussion about the pros and cons of these procedures.



JAWS JOURNAL OF ABDOMINAL WALL SURGERY

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JOURNAL OF ABDOMINAL WALL SURGERY | EUROPEAN HERNIA SOCIETY

SPECIAL ISSUE EDITORIAL
published: 12 August 2025
doi: 10.3389/jaws.2025.15294

Editorial: Open Preperitoneal Mesh Repair for Inguinal Hernia – New Evidence, Old Arguments

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Keywords: preperitoneal, inguinal hernia, open surgery, mesh, surgical technique

Editorial on the Special Issue

Open Preperitoneal Mesh Repair for Inguinal Hernia – New Evidence, Old Arguments

INTRODUCTION

Inguinal hernia repair is one of the most common surgical procedures worldwide, yet the quest for further optimization of techniques remains an ongoing debate. Traditionally, the approach to inguinal hernias has relied heavily on open anterior mesh-based techniques or laparoscopic (posterior) mesh placement. However, the open preperitoneal approach has emerged as a compelling alternative, offering distinct advantages in terms of access, low recurrence rates, and excellent patient outcomes regarding chronic pain specifically. This special issue seeks to explore the benefits, challenges, and future directions of open preperitoneal techniques in inguinal hernia repair.

The open preperitoneal technique has already quite a history and in a narrative review by Soler this evolution in technique and approaches is clearly highlighted. Accessing the hernia through an incision in the lower abdomen, exposing the preperitoneal space, and placing a mesh in the space between the peritoneum and the abdominal wall, this technique offers a direct view of the hernia defect while avoiding many of the limitations associated with more conventional approaches.

Secondly, Lorenz et al. illustrated both the need for standardization of techniques as well as the potential advantages of the different open preperitoneal techniques versus the "old establishment" as the Lichtenstein repair and the laparoscopic techniques. Their conclusion is that open preperitoneal approaches for groin hernia repair are straightforward and safe, often yielding results comparable to, or better than other techniques.

Despite its promising benefits, the open preperitoneal technique is not without its challenges. The technique requires advanced knowledge of abdominal anatomy, particularly the preperitoneal space, which can be more difficult to navigate than the more familiar peritoneal or retroperitoneal spaces. This might be one of the main reasons these techniques seem not be implemented broadly. In a Delphi consensus paper the acceptance of open preperitoneal repair was analyzed using an international survey among European Hernia Society members and a clear set of recommendations was formulated to help surgeons mastering these techniques, ensuring good patient outcomes in a practical and cost-effective manner Lorenz et al.

Like all surgical techniques, the open preperitoneal approach may not be suitable for every patient. Patient factors such as the size of the hernia, the presence of comorbidities, and the level of surgical expertise in the operating room must be carefully considered. One of these challenges is the repair of

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Received: *21 July 2025*
Accepted: *23 July 2025*
Published: *12 August 2025*

Citation:
Berrevoet F (2025) Editorial: Open Preperitoneal Mesh Repair for Inguinal Hernia – New Evidence, Old Arguments. J. Abdom. Wall Surg. 4:15294. doi: 10.3389/jaws.2025.15294

scrotal hernias. Two papers in this special issue focus on this type of more complicated inguinal hernia. Gillion et al. compared the different approaches for scrotal hernias and reflects on both the TIPP, the Lichtenstein and the laparoscopic techniques analyzing a large cohort of patients from the Club-Hernie registry, while Soler and Gillion reflects on the Minimal Open Pre-Peritoneal (MOPP) technique. Both analyses show highly acceptable outcomes for the open preperitoneal techniques, even in these more complex indication.

LOOKING FORWARD: A PROMISING FUTURE

The open preperitoneal technique represents an exciting frontier in inguinal hernia surgery. With ongoing advancements in surgical instrumentation and a better understanding of abdominal anatomy, the technique may become a more widely adopted approach, particularly as long-term data solidify its advantages. Although approach as well as outcomes are more similar to those laparoscopic approaches, the open preperitoneal techniques are often categorized with Lichtenstein and tissue-based repairs in the broad category of "open" inguinal hernia repair. In a very interesting paper by Blake et al. from the US, it is stated that these vastly different approaches together makes data Special Issue and interpretation very difficult, leaving the surgical community unable to make clinically meaningful changes to improve patient outcomes. They come up with a proposal for a new classification of inguinal hernia repair techniques, so to identify clear benefits and disadvantages, and to facilitate patients selection for a specific approach or technique.

As we move toward more patient-centered care, the open preperitoneal approach offers a promising solution for many patients suffering from inguinal hernias, combining the benefits of reduced complications, better outcomes, and fewer long-term risks. Refinement and innovation are key to improving patient care and quality of life. As with any emerging technique, it requires proper patient selection, skillful execution, and ongoing research to solidify its place as a gold standard in the field of hernia surgery.

AUTHOR CONTRIBUTIONS

This Special Issue editorial has been drafted by lead guest editor FB.

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JOURNAL OF ABDOMINAL WALL SURGERY | EUROPEAN HERNIA SOCIETY

ORIGINAL RESEARCH
published: 29 July 2025
doi: 10.3389/jaws.2025.13993

Three-Arm Registry-Based Comparison of Trans-Inguinal-Pre-Peritoneal, Laparoscopic, and Lichtenstein Techniques for Scrotal Hernia Repair

J. F. Gillion[1], M. Soler[2], A. Mettoudi[3], A. Lamblin[4], A. C. Couchard[1], O. Oberlin[5], J. P. Cossa[6], N. Maillot[7], F. Jurczak[8] and The Club-Hernie Members*

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Background: Studies on minimal invasive open preperitoneal techniques performed in scrotal hernia repair are very scarce.

Methods: We conducted a comparative study based on the prospectively collected data of the "Club-Hernie." A scrotal hernia was defined as an inguinal hernia which has descended into and causes any distortion of the scrotum. Giant inguinal hernias were not included.

Results: A total of 3,043 scrotal hernias repairs, performed from 01/09/2011 to 30/04/2023, met the inclusion criteria. The late results of 395 Trans-Inguinal-Pre-Peritoneal (TIPP/MOPP), compared with those of 1038 Lichtenstein and those of 1610 laparoscopic (TEP/TAPP) repairs were globally similar. At a median follow-up of 2 years, no significant difference was found between the three groups regarding the rate of identified recurrences (0.6% vs. 0.6% vs. 0.7%; p=0.9191; p=0.7435) and the prevalence of severe CPIP (0.6% vs. 0.4% vs. 0.7%; p=0.6772; p=0.7300, respectively for TIPP, Lichtenstein and TEP/TAPP). Each technique, though, showed some benefits and drawbacks. Laparoscopic repairs, used in this series in less complex patients (lower number of ASA 3-4 patients and/or patients on anticoagulants) and hernias (lower rates of L3/M3 defects), provided a better nerve preservation (nerve resection /= III) postoperative complications and a high rate of day surgery (69.9%). The hernia sac was completely resected in 64% of cases without injury of the spermatic cord nor need for a unilateral orchidectomy. Probably due to preoperative tailoring, the Lichtenstein group significantly collected many of the most complex patients (ASA3-4: 31.8%; anticoagulant therapy: 23.4%) and the most symptomatic hernias (severe preoperative pain: 17.5%). Lichtenstein was not only a default technique but also a fallback procedure: Fifteen (40.5%) of the 37 conversions occurring in laparoscopic or TIPP techniques ended up in a Lichtenstein technique.

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Received: *27 October 2024*
Accepted: *17 June 2025*
Published: *29 July 2025*

Citation:
Gillion JF, Soler M, Mettoudi A, Lamblin A, Couchard AC, Oberlin O, Cossa JP, Maillot N, Jurczak F and The Club-Hernie Members (2025) Three-Arm Registry-Based Comparison of Trans-Inguinal-Pre-Peritoneal, Laparoscopic, and Lichtenstein Techniques for Scrotal Hernia Repair. J. Abdom. Wall Surg. 4:13993. doi: 10.3389/jaws.2025.13993

Conclusion: This study shows that TIPP is feasible, safe and effective in scrotal hernias, providing results close to those of laparoscopic techniques. Thus, TIPP appears as a valid alternative when the aim is to elect both a preperitoneal repair and a minimal invasive open route. Having the choice of effective techniques may help in tailoring the treatment of these so particular types of groin hernias.

Keywords: groin hernia repair, minimal invasive open preperitoneal repair, scrotal hernia, registry-based comparative study, transinguinal preperitoneal technique

INTRODUCTION

Groin hernias represent a significant global health burden, with over 20 million hernia repairs performed annually worldwide. According to a recent systematic review and management guidelines for scrotal inguinal hernias recently published by Tran et al. [1], scrotal hernias account for approximately 6% of all hernia repairs in high-income countries, with this figure potentially rising to 67% [2] in low-income countries. Irrespective of available access to surgical intervention, scrotal hernias present significant challenges even to experienced surgeons because they are associated with higher morbidity and mortality rates compared to non-complex groin hernia repairs [3]. Instead of the classic definition of a scrotal hernia: "Inguinal hernia which has descended into and causes any distortion of the scrotum" the guidelines working group [1] suggests using a more precise definition: S1 (upper third of the thigh), S2 (middle third of the thigh) and S3 (lower third of the thigh/patella). S(IR) is used to denote an irreducible scrotal hernia.

These guidelines discuss various types of repairs, but open-preperitoneal techniques are not included because of the lack of published studies on using these methods for scrotal hernia repairs.

Therefore, we conducted two successive studies, based on the data of the Club-Hernie Registry [4]:

The initial study, which was monocentric, demonstrated that minimally invasive open pre-peritoneal techniques could achieve similar outcomes in both scrotal and non-scrotal hernia repairs [5]. This led to the present multicentric study with the aim of assessing the feasibility, safety, and effectiveness of minimally invasive open preperitoneal techniques for scrotal hernias compared with the Lichtenstein and laparoscopic techniques.

MATERIALS AND METHODS

This retrospective cohort study was conducted in accordance with the STROBE [6] statements and the recommendations of the European Registry of Abdominal Wall Hernias working group [7].

Study Design

We performed a comparative study using registry data that was prospectively collected in the "Club Hernie" database. Out of all the consecutive inguinal hernia repairs recorded from 01 September 2011 to 30 April 2023, we identified scrotal hernia repairs as defined below.

The exclusion criteria were as follows: patients under 18 years old, patients incorrectly registered as female patients, recurrent hernias, emergency surgery, repairs performed after 30 April 2023, and missing day 30 postoperative outcomes.

Five techniques were included in the study: TIPP (Trans-Inguinal-Pre-Peritoneal), MOPP (Minimal Open Pre-Peritoneal), TEP (Totally Pre-Peritoneal), TAPP (Trans-Abdominal-Pre-Peritoneal) and Lichtenstein. These were clustered in three study groups: TIPP group (TIPP/MOPP), the laparoscopic group (TEP/TAPP) and the Lichtenstein group. These were compared head-to-head. The other techniques were not studied.

Studied Surgical Techniques

The Trans-Inguinal-Pre-Peritoneal (TIPP) repair technique has already been widely described in the literature [8–10]. In brief, it is a minimally invasive preperitoneal open technique: after minimal inguinal dissection, preservation of the inguinal nerves, and possible resection of the hernia sac, the preperitoneal space is entered, and a flat mesh is inserted through the deep inguinal ring, in between the peritoneum and the abdominal wall, thus totally pre-peritoneally and widely covering the myo-pectineal area.

The MOPP technique [11], is a variant of the TIPP technique, inspired by the Ugahary technique [12], which uses specific long blade dissectors and retractors to dissect and deploy the mesh through the deep inguinal ring. TIPP and MOPP were grouped together for the analysis.

TAPP, TEP and Lichtenstein techniques are standard techniques, which are well known worldwide and do not require any additional description. TEP and TAPP were grouped together for the analysis.

Club Hernie Registry

The registry is compliant with the European General Data Protection Regulation (GDPR) [13]. The registry-based design of the study guarantees that all data are de-identified and collected with a patient "non-opposition" agreement. It is also compliant with the national ethical standards of the French "Commission Nationale de l'Informatique et des Libertés" (CNIL) (registration number: 1993959v0).

Follow-Up, PROM Assessment and Late Complication Identification

Each Club Hernie member registered themselves with the pre-, intra-, and day 30 postoperative outcomes of their patients in the online database. Data entry was finalised during the first

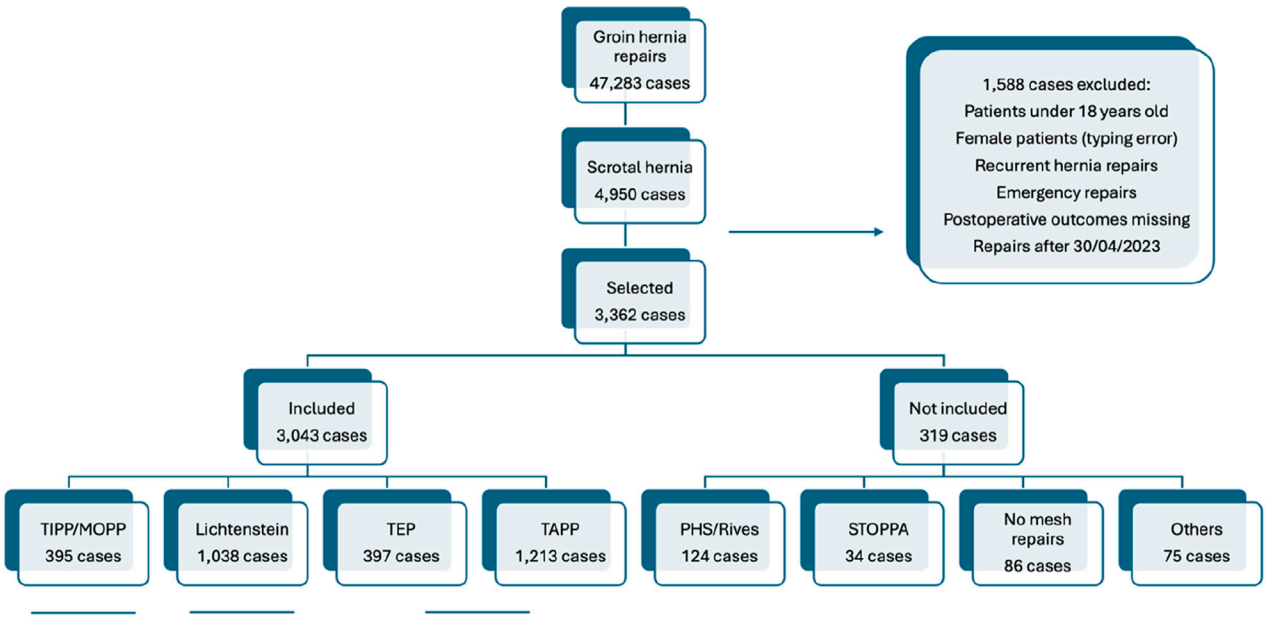

FIGURE 1 | Prisma flowchart. TIPP: Trans-inguinal pre-peritoneal; MOPP: minimal invasive open pre-peritoneal; Lichtenstein: Lichtenstein technique; TEP: totally extraperitoneal; TAPP: trans-abdominal pre-peritoneal.

TABLE 1 | Distribution of hernia repairs in scrotal vs. all groin hernia cohorts.

Surgical technique	Scrotal hernias (N = 3,362)	All groin hernias (N = 47,283)	P Value
TIPP/MOPP	395 (11.8)	5,617 (11.9)	0.9
TEP	397 (11.8)	11,697 (24.7)	0.0001
TAPP	1,213 (36.1)	14,760 (31.2)	0.0001
Lichtenstein	1,038 (30.9)	10,085 (21.3)	0.0001
PHS/RIVES	124 (3.7)	984 (2)	0.05
Stoppa	34 (1)	161 (0.3)	0.001
Suture repairs	86 (2.6)	1,067 (2.2)	0.3
Other	75 (2.2)	2,912 (6.2)	0.0001

Values shown are n (%).
TIPP: trans-inguinal pre-peritoneal; MOPP: minimally invasive open pre-peritoneal; Lichtenstein: Lichtenstein technique; TEP: totally extra peritoneal; TAPP: trans-abdominal pre-peritoneal.

TABLE 2 | Conversion rates among the different types of scrotal hernia repair.

Technique	Intent-to-treat (N*)	Conversion			As treated (N)
		Into	N	Rate (%)	
TEP	416	TAPP	10		
		Lichtenstein	7		
		TIPP	1		
		Other mesh repair	1		
		Total	19	4.6	397
TAPP	1,218	Lichtenstein	5		
		Other mesh repair	7		
		Suture repair	3		
		Total	15	1.2	1,213
TIPP	397	Lichtenstein	3	0.8	395
Lichtenstein	1,041	Rives-Stoppa	1		
		Suture repair	17		
		Total	18	1.7	1,038
Total					3,043

TIPP: trans-inguinal pre-peritoneal; Lichtenstein: Lichtenstein technique; TEP: totally extra peritoneal; TAPP: trans-abdominal pre-peritoneal.
N as an 'Intent to treat' basis = N 'As treated' + N converted–N, coming from a converted other technique.*
For example,: TAPP 'intent to treat' = 1,213 + 15–10.
Conversion rate = N conversions/N 'Intent to treat'.

month (M1) routine clinical visit by the operating surgeon. An optional third-month visit (M3) was scheduled only if any issues were identified at M1. Subsequently, an independent clinical research assistant (CRA) managed the 1-, 2, and 2–5-year follow-up of the patients. This involved using a standardised phone Patient Reported Outcome Measure (PROM) questionnaire, which has been used in our clinical studies since 1999 [14]. During these follow-up interviews, patients were systematically asked about rehospitalisation (either at the same hospital or at a different hospital), reoperation and the causes thereof, confirmed hernia recurrence (whether through reoperation, report of ultrasound or CT scan, and/or surgeon visit), suspected recurrences (identified via the PINQ-Phone questionnaire [15, 16], localised bulging and/or local pain), late abscesses, chronic mesh fistula, mesh removal, and other late complications such as bowel obstruction.

Following five failed attempts to contact the patient on different occasions, they were deemed as lost to follow-up. If there was any deviation from the expected recovery

TABLE 3 | Characteristics of the study population.

Characteristic	TIPP (N = 395)	Lichtenstein (N = 1,038)	P value	TIPP (N = 395)	TEP/TAPP (N = 1,610)	P value
Age (years)	75 (63–83)	75 (64–84)	0.6	75 (63–83)	71 (59–79)	0.6
BMI (kg/m^2)	25 (23–27)	25 (23–28)	1	25 (23–27)	25 (23–28)	1
ASA 1–2	314 (82.4)	702 (68.2)	<0.0001	314 (82.4)	1,347 (83.9)	0.5
ASA 3–4	67 (17.6)	328 (31.8)		67 (17.6)	258 (16.1)	
ASA missing	14	8		14	5	
Personal history of hernia(s)	90 (22.8)	212 (20.4)	0.3	90 (22.8)	309 (19.2)	0.12
Diabetes mellitus	21 (5.3)	82 (7.9)	0.1	21 (5.3)	97 (6)	0.7
Anticoagulant-antiplatelet	75 (19)	243 (23.4)	0.07	75 (19)	229 (14.2)	0.02
Active smoker	77 (19.5)	188 (18.1)	0.6	77 (19.5)	286 (17.8)	0.5
Preoperative PROM (VRS)						
Missing data	10	15		10	34	
No symptoms	66 (17.1)	67 (6.6)		66 (17.1)	225 (14.3)	
Painless disturbances	2 (0.5)	6 (0.6)		2 (0.5)	8 (0.5)	
Any pain	317 (82.3)	950 (92.9)	<0.0001	317 (82.3)	1,343 (85.2)	<0.0001
Mild pain (discomfort)	177 (46)	502 (49.1)		177 (44.8)	952 (59.1)	
Moderate pain	90 (23.4)	268 (26.3)		90 (22.8)	305 (18.9)	
Severe pain	50 (12.7)	179 (17.5)	0.0342	50 (12.7)	84 (5.2)	<0.0001
Impact of pain/discomfort on quality of life						
Missing data	0	9		0	4	
No impact on your daily life	108 (34.1)	241 (25.6)		108 (34.1)	352 (26.3)	
Does not force you to interrupt any ongoing activity	138 (43.5)	357 (37.9)	<0.0001	138 (43.5)	730 (54.5)	<0.0001
Forces you to interrupt some ongoing activities	32 (10.1)	260 (27.6)		32 (10.1)	199 (14.9)	
Forces you to give up some activities	39 (12.3)	83 (8.8)		39 (12.3)	58 (4.3)	
Total	317 (100)	950 (100)		317 (100)	1,343 (100)	

Values shown are median (IQR) or n (%). Percentages were calculated based on non-empty values.
TIPP: trans-inguinal pre-peritoneal; Lichtenstein: Lichtenstein technique; TEP: totally extra peritoneal; TAPP: trans-abdominal pre-peritoneal; IQR: interquartile range; BMI: body mass index; PROM: patient-related outcome measures; VRS: verbal rating scale.

process, scheduling an appointment at the surgeon's office was highly advised. Their entries were, thus, recorded in tabs dedicated to the surgeon. A few surgeons recommended periodic clinical visits during the follow-up period.

Definitions of the Studied Variables

The following hernias were characterised preoperatively: i. Femoral hernia; ii. Inguinal hernia (limited to the groin area); iii. "Inguinofunicular" hernia (descending along the spermatic cord but not extending to the scrotum); iv. Scrotal hernia (inguinal hernia that had descended into the scrotum and caused any type of distortion of the scrotum and intra-operatively L0 to L3, M0 to M3, F0 to F3 according to the European Hernia Society groin hernia classification). On day 30, postoperative complications were clustered as follows [17]: i. General complications; ii. Surgical site occurrences (SSOs) including superficial or periprosthetic SSI (Surgical Site Infection) and superficial or periprosthetic SSO non-SSI (seromas); and iii. Organ space (surgical) complications. In cases of concurrent complications, the Clavien-Dindo [18] grading system was applied to the worst complication.

Chronic postoperative inguinal pain (CPIP), defined as pain lasting more than 3 months, was evaluated during follow-up using a 4-scale (no pain, mild pain, moderate pain, or severe pain) VRS (Verbal Rating Scale) and compared with the preoperative status collected at baseline.

Hernia recurrences were categorised as reoperated recurrences and recurrences not reoperated on but confirmed by CT scan, ultrasound, or surgical clinical visit.

Outcomes of Interest

The feasibility of TIPP was evaluated by the rate of conversion of TIPP into another technique. Safety was based on early and late complications, and effectiveness was assessed by comparing the recurrence rate with that of other studied techniques.

Descriptive Statistics

Discrete variables were presented as absolute numbers with percentages. Continuous variables were displayed as the median and interquartile range (IQR). Discrete variables were compared using the Chi-square or Fisher's exact test, and continuous variables were examined using Student's T test. A p value <0.05 was considered statistically significant. Statistical tests were carried out using the Sorbonne University tool[1].

RESULTS

From 01 September 2011 to 30 April 2023, a total of 47,283 groin hernia repairs were prospectively registered in the Club Hernie database. Of these, 4,950 were scrotal hernias, of which 3,362 (7%)

[1]https://biostatgv.sentiweb.fr/

TABLE 4 | Intraoperative data.

Intraoperative data	TIPP (N = 395)	Lichtenstein (N = 1,038)	P value	TIPP (N = 395)	TEP/TAPP (N = 1,610)	P value
Hernia type						
Lateral	371 (94.4)	919 (88.7)	<0.0001	371 (94.4)	1,408 (87.5)	0.0088
Medial	60 (15.2)	332 (32.0)		60 (15.2)	361 (22.4)	
Lateral + medial	–42 (10.7)	–230 (22.2)		–42 (10.7)	–165 (10.3)	
Femoral ± inguinal	5 (1.3)	15 (1.5)		5 (1.3)	6 (0.4)	
Missing data	1	2		1	0	
Defect size (EHS classification)						
L1 ± medial	11 (2.9)	40 (4.4)		11 (2.9)	43 (3.1)	
L2	40 (10.8)	139 (15.1)		40 (10.8)	476 (33.8)	
L3	320 (86.3)	740 (80.5)	0.0149	320 (86.3)	889 (63.1)	<0.0001
M1 ± lateral	5 (8.3)	39 (11.8)		5 (8.3)	42 (11.6)	
M2	14 (23.3)	71 (21.4)		14 (23.3)	81 (22.4)	
M3	41 (68.3)	221 (66.8)	0.0716	41 (68.3)	238 (66.0)	0.7152
L3 or M3	361 (91.4)	961 (92.6)	0.5665	361 (91.4)	1,127 (70.0)	<0.0001
Hernia sac						
Completely resected	149 (64.0)	528 (67.7)	0.2868	149 (64.0)	110 (15.6)	<0.0001
Incompletely resected	84 (36.0)	252 (32.3)		84 (36.0)	596 (84.4)	
Drains	NS	NS		NS	NS	
Operating surgeons[a]	11	61		11	56	
Anaesthesia						
Spinal alone	19 (4.9)	164 (15.9)	<0.0001	19 (4.9)	3 (0.2)	<0.0001
GA + laryngeal mask	260 (66.3)	413 (39.9)		260 (66.3)	27 (1.7)	
GA + tracheal intubation	109 (27.8)	436 (42.1)		109 (27.8)	1,549 (97)	
Other types	4 (1)	22 (2.1)		4 (1)	17 (1)	
Missing data	3	3		3	14	
Antibiotic prophylaxis						
Yes	120 (93.8)	371 (96.1)	0.26	120 (93.8)	653 (97.2)	0.0193
No	8 (6.2)	15 (3.9)		8 (6.2)	16 (2.8)	
Missing data	267	652		267	938	
Mesh						
Mesh supplier	2	9		2	10	
Mesh references	8	37		8	50	
Mesh fixation[c]						
Sutures	14 (3.5)	613 (59.6)	<0.0001	14 (3.5)	5 (0.34)	<0.0001
Staples	0	144 (14)		0	701 (47)	
Glue	0	45 (4.4)		0	52 (3.5)	
Auto adhesive or self-gripping	0	112 (10.9)		0	30 (2)	
No fixation at all	381 (96.5)	195 (19)		381 (96.5)	959 (64.3)	
Missing data	3	9		3	118	
Nerve resection						
Ilio-hypogastric	7 (1.8)	178 (17.2)	<0.0001	7 (1.8)	0	0.0003
Ilio-inguinal	14 (3.6)	178 (17.2)		14 (3.6)	0	
Genital branch of GF	2 (0.5)	111 (10.8)		2 (0.5)	2 (0.13)	
Femoral branch of GF	0	0		0	2 (0.13)	
Missing data	4	10		4	11	
Intraoperative technical difficulties						
Missing data	4	11		4	14	
None	322 (82.4)	937 (91.2)	<0.0001	322 (82.4)	1,338 (83.8)	0.4789
Any	69 (17.7)	90 (8.8)		69 (17.7)	258 (16.2)	
In creating the workspace	15 (3.8)	58 (5.7)	0.1685	15 (3.8)	55 (3.5)	0.7114
In unrolling the mesh	10 (2.6)	7 (0.7)	0.0037	10 (2.6)	31 (1.9)	0.4456
In closing the peritoneum	0	3 (0.3)	0.2848	0	24 (1.5)	<0.0001
Peritoneal tears	47 (12)	25 (2.4)	<0.0001	47 (12)	168 (10.5)	0.3994
Injury to the epigastric vessels	5 (1.3)	1 (0.1)	0.0022	5 (1.3)	10 (0.63)	0.1827
Intraoperative orchidectomy	0	1 (0.1)		0	0	
Bladder injury (sutured)	2 (0.5)	1 (0.1)		2 (0.5)	3 (0.2)	
Operating time (min)	45 (36–55)	35 (25–43)	<0.0001	45 (36–55)	30 (25–45)	<0.0001

Values shown are median (IQR) or n (%).

TIPP: Trans-inguinal pre-peritoneal; Lichtenstein: Lichtenstein technique; TEP: totally extra peritoneal; TAPP: trans-abdominal pre-peritoneal; IQR: interquartile range; GF: genital-femoral nerve; GA: general anaesthesia; NS: not specified (not registered.

[a]*Among a total of 68 surgeons participating in the present study, many surgeons performed different types of repairs.*

[b]*According to the Herniasurge classification [1].*

[c]*The fixation means were often combined.*

TABLE 5 | Day 30 postoperative outcomes.

Outcomes	TIPP (N = 395)	Lichtenstein (N = 1,038)	P value	TIPP (N = 395)	TEP/TAPP (N = 1,610)	P value
Postoperative complications						
General complications	5 (1.3)	35 (3.6)	0.0232	5 (1.3)	16 (1.1)	0.6381
Missing data	6	60		6	29	
Surgical site occurrences						
Superficial SSO non-SSI (seroma)	35 (9.0)	85 (8.7)	0.8692	35 (9.0)	101 (6.4)	0.07
Periprosthetic SSO non-SSI	4 (1.0)	8 (0.8)		4 (1.0)	6 (0.4)	
Superficial SSI	1 (0.3)	8 (0.8)		1 (0.3)	1 (0.1)	
Periprosthetic SSI	0 (0.0)	0 (0.0)		0 (0.0)	1[a] (0.1)	
Missing data	5	60		5	27	
Organ space complications						
Bowel obstruction	0 (0.0)	0 (0.0)		0 (0.0)	3 (0.2)	
Peritonitis	0 (0.0)	0 (0.0)		0 (0.0)	2[b] (0.1)	
Vx injury revealed postoperatively	0 (0.0)	0 (0.0)		0 (0.0)	2 (0.1)	
Orchitis	1 (0.3)	5 (0.5)		1 (0.3)	2 (0.1)	
Hydroceles	3 (0.8)	4 (0.4)		3 (0.8)	1 (0.06)	
Early (< day 30) recurrence	0 (0.0)	0 (0.0)		0 (0.0)	3 (0.2)	
Missing data	5	61			8	
Reoperation	1 (0.3)	17 (1.7)	0.0355	1 (0.3)	12 (0.8)	0.2967
Missing data	30	70		30	55	
Mesh removal < day 30	0 (0.0)	0 (0.0)		0 (0.0)	1[a] (0.06)	
Clavien-Dindo classification						
Missing data	1	0		1	21	
Patient without complications	343 (87.0)	895 (86.2)		343 (87.0)	1,451 (91.3)	
Patient with any complication	51 (13.0)	143 (13.8)	0.6811	51 (13.0)	138 (8.7)	0.010
Grade I/II	50 (12.7)	126 (12.1)		50 (12.7)	125 (7.8)	
Grade III	1 (0.3)	15 (1.5)		1 (0.3)	12 (0.7)	
Grade IV	0 (0.0)	2 (0.2)		0 (0.0)	0 (0.0)	
Grade V	0 (0.0)	0 (0.0)		0 (0.0)	1 (0.1)	
Clavien-Dindo >/ = III	1 (0.3)	17 (1.7)	0.1559	1 (0.3)	13 (0.8)	0.2311
Postoperative pain (VAS)						
Day 1: median (IQR); missing	3 (2–5); 65	2 (1–3); 111	<0.0001	3 (2–5); 65	2 (1–4); 505	<0.0001
Day 8: median (IQR); missing	1 (0–2); 75	1 (0–2); 152	0.9028	1 (0–2); 75	0 (0–1); 557	<0.0001
Day 30: median (IQR); missing	0 (0–0); 100	0 (0–0); 140	0.6748	0 (0–0); 100	0 (0–0); 612	0.0506
Hospital length of stay						
Missing data	7	15		7	36	
Outpatients	271 (69.9)	611 (59.7)	<0.0001	271 (69.9)	1,250 (79.4)	<0.0001
Inpatients	117 (30.1)	412 (40.3)		117 (30.1)	324 (20.6)	

Values shown are the median (IQR) or n (%). Percentages (in italics) were calculated based on non-empty values.

TIPP: trans-inguinal pre-peritoneal; Lichtenstein: Lichtenstein technique; TEP: totally extra peritoneal; TAPP: trans-abdominal pre-peritoneal; IQR: interquartile range; SSO: surgical site occurrence; SSI: surgical site infection; VAS: visual analogue scale.

Clavien-Dindo classification [18]: in cases of combined complications, the CDC, grading (per patient) was calculated based on the worst complication.

Day 1: Day after the surgical procedure.

[a] *Mesh infection leading to an early mesh removal.*

[b] *Peritonitis (inadvertent enterotomy).*

met the inclusion criteria (L 1). The present comparative study focused on four main techniques (3,043 repairs), which were clustered into three groups: TIPP, Lichtenstein, and laparoscopic techniques (TEP and TAPP). The remaining 319 repairs, less frequently performed, were considered only for an overview of the general distribution of cases (**Figure 1**; **Table 1**). No TREPP (Trans-Rectus-Pre-Peritoneal) repairs were registered in our database and the rare Ugahary procedures were categorised as "others."

The relative rates of using Lichtenstein and TAPP were higher for scrotal hernias than for all groin hernia repairs, while the relative rate was lower for TEP, and the relative rate of TIPP was the same for scrotal hernias as for all groin hernia repairs (**Table 1**).

The conversion rate for the three techniques was low, given the scrotal nature of the treated hernias. TEP was the technique with the highest conversion rate (**Table 2**), with 19 out of 416 cases (4.6%) being converted, to TAPP (10 cases), Lichtenstein (7 cases), TIPP (1 case) and other (1 case). The conversion rate for TAPP was 1.2%. Overall, the global conversion rate for all laparoscopic repairs (TEP/TAPP combined) was 2.1% compared to 0.8% for TIPP. Eighteen out of 1,041 (1.7%) Lichtenstein techniques were converted to suture repairs (17 cases) or the Rives-Stoppa technique via a midline laparotomy (1 case). The differences in conversion rates were not statistically significant, except for TEP versus TIPP (4.6% vs. 0.8%; $p = 0.0008$).

The median age, the median BMI, the rate of diabetes and the rate of active smokers were similar across the three studied groups (**Table 3**).

Lichtenstein patients had higher ASA scores, more symptomatic hernias and experienced more severe

TABLE 6 | Follow-up and cumulative late complications.

Complications	TIPP (N = 395)	Lichtenstein (N = 1,038)	P value	TIPP (N = 395)	TEP/TAPP (N = 1,610)	P value
Patients lost to follow-up	42 (10.6)	63 (6.0)	0.0031	42 (10.6)	238 (14.8)	0.0330
Median follow-up time (months)	59 (23–61)	25 (1–60)		59 (23–61)	26 (3–60)	
Complications during follow-up						
Late (>M3) scrotal collection	0	0		0	0	
Late orchitis/testicular atrophy	0	2 (0.2)		0	0	
Late mesh infection	2[a,b] (0.6)	0	0.0705[c]	2[a,b] (0.6)	0	0.4178[c]
Identified recurrences						
Reoperated	1	0		1	2	
Not reoperated but confirmed	1	6		1	8	
Total hernia recurrences	2 (0.6)	6 (0.6)	0.9191	2 (0.6)	10 (0.7)	0.7435
Total late complications	5 (1.4)	10 (1.3)	0.5516	5 (1.4)	10 (0.7)	0.2146

Values shown are the median (IQR) or n (%). Percentages were calculated based on non-empty values. Percentages of late complications were calculated from the number of patients followed.

TIPP: trans-inguinal pre-peritoneal; Lichtenstein: Lichtenstein technique; TEP: totally extra peritoneal; TAPP: trans-abdominal pre-peritoneal; IQR: interquartile range; PROM: patient-reported outcome measures.

[a]*Mesh removal, no hernia recurrence during the following 5 years.*

[b]*Patient reoperated (mesh removal unknown) then lost to follow-up after FU1.*

[c]*Fisher's exact test.*

TABLE 7 | PROMs at FU1 and FU2.

	TIPP (N = 395)	Lichtenstein (N = 1,038)	P value	TIPP (N = 395)	TEP/TAPP (N = 1,610)	P value
FU1phone questionnaire						
Patients reached	250 (63.3)	469 (45.2)		250 (63.3)	753 (46.8)	
Late pain (VRS): CPIP						
Missing data	11	28		11	30	
Asymptomatic patients	218 (91.2)	372 (84.4)	0.0117	218 (91.2)	629 (87)	0.0817
Painless disturbances	2 (0.8)	7 (1.6)		2 (0.8)	10 (1.4)	
Any pain	19 (8)	62 (14.1)	0.0189	19 (8)	84 (11.6)	0.1118
Mild pain (discomfort)	11 (5)	33 (7.3)		11 (5)	40 (5.5)	
Moderate pain	8 (3)	27 (6.1)	0.0001	8 (3)	41 (5.7)	0.0141
Severe pain	0 (0.0)	2 (0.5)		0 (0.0)	3 (0.4)	
Postop pain/discomfort > Preop	1 (0.5)	3 (0.6)	1	1 (0.5)	6 (0.7)	1
FU2 phone questionnaire						
Patients reached	152 (38.5)	228 (22)		152 (38.5)	417 (25.9)	
Late pain (VRS): CPIP						
Missing data	0	0		0	0	
Asymptomatic patients	133 (87.5)	203 (89.0)	0.7438	133 (87.5)	377 (90.4)	0.3141
Painless disturbances	3 (2.0)	6 (2.6)		3 (2.0)	3 (0.7)	
Any pain	16 (10.5)	19 (8.3)	0.4746	16 (10.5)	37 (8.9)	0.5538
Mild pain (discomfort)	8 (5.3)	9 (3.9)		8 (5.3)	18 (4.3)	
Moderate pain	7 (4.6)	9 (3.9)	0.6772	7 (4.6)	16 (3.8)	0.7300
Severe pain	1 (0.6)	1 (0.4)		1 (0.6)	3 (0.7)	
Postop pain/discomfort > Preop	0	0	1	0	2 (0.5)	1

Values shown are n (%). Percentages were calculated based on non-empty values.

PROM: patient-related outcomes measures; VRS: verbal rating scale; CPIP: chronic postoperative inguinal pain.

preoperative pain than others. Patients who received Lichtenstein and TIPP repairs were more likely to be on anticoagulant therapy than those operated on laparoscopically. Compared with those in the TIPP group, patients in the laparoscopic group were less often on anticoagulants and had less often experienced preoperative severe pain or preoperative symptoms that forced them to give up some activities.

Only hernias registered as scrotal were included. Their distribution according to the EHS classification is shown in **Table 4**. Lateral, medial and/or femoral hernias were combined in 10.3%–22.2% of cases. "Pantaloon hernias" (combining a lateral and a medial defect) were more frequent in the Lichtenstein group. Larger defects (L3 or M3) were less frequent in the laparoscopic group than in the TIPP or Lichtenstein groups (70% vs. 91.4% vs. 92.6%; $p < 0.0001$). Complete resection of the hernia sac was less frequent in the laparoscopic group than in the TIPP or Lichtenstein groups (15.6% vs.64.0% vs. 67.7%; $p < 0.0001$).

Sixty-eight operating surgeons participated in this multicentre study, with an even distribution across the studied techniques. In line with a registry setting, the choice of the technique was left to

the discretion of the surgeon. TIPP procedures were performed by 11 surgeons, Lichtenstein repairs by 61 surgeons and TEP/TAPP procedures by 56 surgeons, making a total of 128 out of the 68 participating surgeons (**Table 4**). This indicates that surgeons have not always used the same technique for all their patients, but rather tailored the technique according to the characteristics of their patients and the hernia.

General anaesthesia with tracheal intubation was almost always used for laparoscopic repairs, while a lighter form of general anaesthesia with a laryngeal mask was primarily used for open repairs, especially for TIPP. Spinal anaesthesia was rarely used except for Lichtenstein repairs.

Nerve resection occurred rarely in laparoscopic repairs, and even rarer in TIPP than in Lichtenstein repairs.

Mesh fixation was not used in almost all TIPP cases, in two-thirds of laparoscopies and only in one-fifth of Lichtenstein repairs.

Intraoperative technical difficulties occurred less often in the Lichtenstein group. Intraoperative complications such as bladder injury or unilateral orchidectomy were very rare, ranging from 0.1% to 0.5% across all three groups.

Operating time was shorter for laparoscopies than for Lichtenstein and TIPP procedures.

The prevalence of serious (Clavien-Dindo >/= III) postoperative complications at day 30 was low (**Table 5**) ranging from 0.3% to 1.7%. Postoperative complications mainly consisted of benign surgical site occurrences. The rare but serious organ space complications were mainly observed in laparoscopic approaches. The differences between groups were not statistically significant.

Outpatient cases were significantly more frequent following laparoscopies than following TIPP, and following TIPP than following Lichtenstein repairs. Early postoperative pain was significantly lower in the laparoscopic group. This difference disappeared during the first postoperative month and at day 30 the median VAS was zero in all three groups.

More than 85% of patients were followed up for a median period of 2 years (**Table 6**). The follow-up was twice as long for TIPP as for the other two groups. The recurrence rate (prevalence of identified recurrences) was the same (approximately 0.6%) in all three groups.

Two cases of unilateral testicular atrophy were identified in the Lichtenstein group, and two late mesh infections occurred in the TIPP group.

At the first follow-up questionnaire (**Table 7**) the prevalence of a relevant (moderate or severe) pain (CPIP) was lower in the TIPP group than in the Lichtenstein group (3% vs. 6.6%; $p = 0.0001$) and lower in the TIPP group than in the TEP/TAPP group (3% vs. 6.1%; $p = 0.0141$). The prevalence of severe pain was 0.5% or less in all three groups. Postoperative pain or discomfort higher than at baseline was reported by less than 1% of patients.

At the second follow-up questionnaire (**Table 7**), pain levels were almost the same as those reported before. No significant differences were found between the three studied groups.

Overall the late results were similar across the three studied groups, specifically with regard to the rates of identified recurrence (approximately 0.6%) and severe chronic postoperative inguinal pain (CPIP < 1%).

DISCUSSION

In this large series of 3,043 "non-giant" scrotal hernia repairs, prospectively registered and followed up for 2 years, the studied techniques resulted in similar late results marked with a very low rate of both identified recurrences and chronic postoperative inguinal pain (CPIP). Each technique had its benefits and drawbacks. Of these, TIPP appeared to be a feasible, safe and effective method of repairing scrotal hernias. Having a choice of effective techniques may help to tailor the treatment of these particular types of groin hernia.

The global results of the entire series included a very low (less than 2%) rate of serious (Clavien-Dindo >/= III) postoperative complications (**Table 6**), a low rate of identified recurrences, and a low rate of late complications (e.g., late infection/mesh removal), at a median follow-up period of 2 years or more (**Table 7**).

From the patients' perspective the repair of scrotal hernias resulted in a considerable reduction in pain or discomfort and a clear improvement in their quality of life (QoL), in both the 30-day postoperative outcomes (**Table 5**) and in the late follow-up. When comparing the preoperative PROMs (**Table 3**) with the late postoperative PROMs (**Table 7**), the relevant (moderate + severe) VRS pain considerably decreased from 43.8%, 36.1%, 24.1% at baseline to 10.3%,6.6%, 3.0%, and 6.1% at the 2-Year follow-up, respectively for Lichtenstein, TIPP and laparoscopic repairs. Which is four to six times less. While the impact of preoperative pain forced patients to interrupt or give up some activities in approximately 20%–30% of cases, fewer than 1% assessed that their postoperative discomfort was more troublesome than their preoperative condition. The fact that patients with scrotal hernias may benefit the most from their surgery has already been underlined in the literature [1, 3].

Of course, the scrotal hernias included in this study are completely different from those encountered in low-resource countries, which are often of the S2 or S3 type according to the recently proposed classification [1]. Such giant hernias are at risk of many technical difficulties [19–21], including loss-of-domain issues [22]. Moreover, our exclusion criteria, (emergency surgery, recurrent hernias, suture repairs, Rives-Stoppa repairs and miscellaneous repairs), probably resulted in the exclusion of some of the most complex cases. On the other hand (**Table 3**), the patients included in the present study were elderly, with a median age ranging from 71 years (TEP/TAPP) to 75 years (Lichtenstein or TIPP), they had comorbidities with an ASA class of 3-4, ranging from 16.1% (TEP/TAPP) to 31.8% (Lichtenstein), and many were on anticoagulant therapies, especially in the Lichtenstein group (23.4%).

Similar patient characteristics were found in 2,710 scrotal hernias registered in the German Herniamed registry, published in 2021 [3]. This major study in the field of scrotal hernias, mainly focused on the pre-, intra- and postoperative results of scrotal hernias, compared to those of lateral and medial

hernias. Additionally, the study compared the results of laparo-endoscopic versus open procedures. Unfortunately, the minimally invasive open techniques were not individualised, and the distribution of the techniques used in the scrotal group (TEP: 8.2%; TAPP: 20.5%; Lichtenstein: 64.3%) was far from the distribution observed in the present series (**Table 1**), which limits comparisons.

In the present study, the late results of TIPP/MOPP, TEP/TAPP and Lichtenstein were almost the same, with regard to identified recurrences (approximately 0.6%) and severe chronic postoperative inguinal pain (CPIP < 1%). Differences between groups were found in terms of demographics, intraoperative events and early postoperative outcomes. Each of the studied techniques showed some benefits and drawbacks, which will be discussed in the context of the literature albeit scarce in the case of scrotal hernias.

Laparoscopic repairs, used in this series both for less complex patients (lower number of ASA 3-4 patients and patients on anticoagulants) and hernias (lower rate of L3/M3 defects), provided better nerve preservation, shorter operating times, higher outpatient rates and lower early postoperative pain. Conversely laparoscopic repairs had a few more conversions and postoperative organ space complications than the open procedures.

Although very rare, and not statistically significant in this large series, these findings have also been reported in both common [23, 24] and scrotal hernia repairs: Bansal et al. [25], in a series of 144 large hernias (including 10 "massive") in Indian patients, reported a conversion rate of 25% in TEP (17.6% converted to TAPP and 7.1% converted to open) and a conversion rate of 10.2% in TAPP (converted to open). These rates may appear high, but this is quite an old series as the first cases date back to 2004. In 2020, Morrell described the Primary Abandon-of-the-Sac (PAS) technique during TAPP [26]. Using this, he operated on 26 scrotal hernias without conversion. In our laparoscopic group, the hernia sac was incompletely resected in 84.4% of the cases. The rate of seromas and hydroceles was not higher in the laparoscopic group than in the open groups in which the hernia sac was completely resected in more than two-thirds of cases. Similarly, Nikolian et al [27] showed in their series, that the primary abandonment of the sac in the management of scrotal hernias did not result in seromas or haematomas requiring procedural intervention.

The recently published guidelines on scrotal hernia repair [1] state: "*TEP may be employed safely with expertise, but one should have low threshold to convert to TAPP or open if technically not feasible. TAPP is the safest MIS approach for irreducible scrotal*". [SIC].

Regarding the TEP technique, Ferzli et al. suggested the systematic division of the epigastric vessels to facilitate the hernia sac reduction [28]. Six years later, they reported on 94 cases of TEP for large scrotal hernias with nine cases (9.5%) requiring conversion to an open procedure, three cases (3.2%) completed with a conventional open preperitoneal approach, whereas six patients (6.4%) underwent repair with a combined approach [29].

In the present series (**Table 2**), 19 (4.6%) TEPs were converted: 10 to TAPPs, 7 to Lichtensteins, 1 to TIPP and 1 to another mesh repair. Fifteen TAPP (1.2%) were converted to 5 Lichtenstein procedures, 7 to other mesh repairs and 3 to suture repairs. As stated in the International Endohernia Society's update of TAPP and TEP guidelines [30], "*TEP inguinal-scrotal hernia repair remains an advantageous approach during the difficult scrotal hernia that requires "conversion" to an open repair, because the pre-peritoneal dissection performed laparoscopically allows for reduction of the hernia and optimal mesh placement once the hernia repair has been converted and is performed from the anterior approach*". [SIC] Similar findings were found in the TEP conversions to TIPP registered in the present series.

Malazgirt et al. [31] suggested using the open posterior approach for large or complex inguinal hernias, as this facilitated the handling and repair of difficult hernias in their experience.

In our series, TIPP repairs had a low conversion rate, better nerve preservation than that of Lichtenstein repairs, the lowest rate of serious postoperative complications and the highest rate of day surgery. The hernia sac was completely resected in 64% of cases without injury to the spermatic cord or need for a unilateral orchidectomy.

As with laparoscopic repairs, the preperitoneal mesh did not require any fixation in almost all the cases (96.5%).

The feasibility, safety, and effectiveness of TIPP are well known for common groin hernia repairs [4, 32, 33], but needed to be demonstrated for scrotal hernias. This was the focus of this study.

The technical feasibility of TIPP in scrotal hernias, suggested (**Table 1**) by a similar frequency of use in the scrotal series (11.8%) and the entire series (11.9%), was confirmed by a very low rate (0.8%) of conversions (**Table 2**). Its safety in scrotal hernia repairs was shown by a very low rate of serious (Clavien-Dindo >/= III) postoperative complications. The effectiveness of TIPP in scrotal repair was demonstrated by a low prevalence of identified recurrences (0.6%) at a median follow-up duration of 59 months.

A common criticism of the TIPP approach is the need for dissection going on in both planes, thus virtually hampering a possible approach on a "virgin" plane [34]. This is true, but not as significant as it seems. As shown in this series, the recurrences after TIPP are rare. They can be fixed either with the TAPP technique or with an open approach [35], because in TIPP the pre-fascial inguinal dissection is not as extensive as what is required for the Lichtenstein technique.

The Lichtenstein technique was mainly used for the most comorbid and the most symptomatic patients (**Table 3**). It was also the most commonly used technique for large M3 or L3 defects and for "pantaloon" hernias (combining lateral and medial defects) (**Table 4**). It was associated with a high number of resections of the inguinal nerves and had the highest rate of mesh fixation. On the other hand, this technique was achieved with fewer intraoperative technical difficulties than in the preperitoneal techniques (**Table 4**). The present study showed that, probably due to preoperative tailoring, the Lichtenstein group significantly collected many of the most

complex patients and hernias. The Lichtenstein technique can be used to treat giant inguinoscrotal hernias [21], while in these challenging cases other teams opt for a preperitoneal mesh, inserted via a para-rectal incision [20] or using a modified Rives technique, often combined with visceral or omentum resections and/or completed with component separation techniques [22]. According to our exclusion criteria, such hernias were not included in the present study (**Figure 1**). In our series, the Lichtenstein technique was not only a default technique but also a fallback procedure: 15 (40.5%) of the 37 conversions occurring in laparoscopic or TIPP techniques resulted in a Lichtenstein procedure (**Table 2**). On the other hand, 18 (1.7%) intended Lichtenstein repairs required a conversion, mainly to a suture repair. This confirms that scrotal hernia repair can be challenging, even in "expert" hands.

The guidelines on scrotal hernia repair [1] also state: "*Depending on expertise, minimally invasive techniques can safely be employed. Although laparoscopic options are feasible, open repair remains the default operation for irreducible scrotal hernias. It is suggested that surgeons treating scrotal hernias are proficient in both anterior and posterior approaches.* As seen in the Results section, the participating surgeons did not always use the same technique for all their patients, but rather tailored the technique according to the characteristics of their patients and the hernia and they were able to easily convert one technique into another.

In the present series no significant difference was found between groups regarding the recurrence rate (0.6%) or the prevalence of severe CPIP (less than 1%).

These results are in line with the recently published late evaluation of recurrences and groin pain 8 years after the TEPLICH RCT [36], which compared TEP and Lichtenstein techniques in common groin hernia repairs.

In TAPP repairs for scrotal hernia repairs, Leibl et al. [37] reported a recurrence rate of 1% at a 30-month follow-up in 191 TAPP. Some years later, the same team [38] performed an analysis of 440 scrotal hernias in a large series of 8,050 TAPP repairs. The overall recurrence rate was 0.7%, compared to 2.7% for scrotal hernias.

Limitations

This study is not without limitations. This is an observational study of a registry and therefore selection bias could not be avoided. Furthermore, it was neither randomised nor propensity-score matched.

Matching on age, BMI, diabetes, and tobacco use was not mandatory because for these parameters, there were no statistical differences among the three groups. Conversely, matching on anticoagulant therapies would have concealed one main asset of open versus laparoscopic techniques and matching on ASA class or preoperative symptoms would have concealed the specific benefits of Lichtenstein as the default technique. Moreover, our aim was not to determine the superiority of one technique over another but rather to assess the feasibility, safety, and effectiveness of TIPP in scrotal repair.

Not all patients underwent clinical examination. Telephone follow-up is not the optimal way to monitor patients after inguinal hernia surgery, and therefore some subclinical hernia recurrences may have been missed. However, the methodology was the same for the three groups studied. Regular follow-up was performed using a formatted phone questionnaire, which is i) more convenient for a large number of patients (currently 65,000 in our registry), and much more efficient than postal/mail questionnaires/reminders [39, 40] ii) reliable to assess chronic pain and Q.O.L. in addition to detecting late events such as rehospitalisations, reoperations, bowel obstructions, and mesh infections.

The S1, S2, and S3 classifications of scrotal hernias [1] were published too recently to be implemented in the dataset of our registry, which was launched in 2011. Scrotal hernia was defined in the present study as an inguinal hernia that had descended into and caused any distortion of the scrotum. Giant hernias were not included in the present study (**Figure 1**). Thus, the external value of this study is limited to 'non-giant' scrotal hernias and to surgeons specialising in hernia surgery.

Strengths

The strength of this study lies in the analysis of a large case series providing real-world data from a registry of high-volume surgeons evenly distributed over the studied techniques.

CONCLUSION

In this study, the TIPP/MOPP, TEP/TAPP, and Lichtenstein techniques resulted in similar late results.

Their respective benefits are useful for tailoring the technique to the patient and their scrotal hernia.

This observational study assessed the feasibility and safety of the TIPP technique for scrotal hernia repair compared with other types of repairs (laparoscopic and Lichtenstein). The study shows that TIPP/MOPP is a feasible, safe and effective option for 'non-giant' scrotal hernia repair, yielding similar late results to those of the TEP/TAPP and Lichtenstein techniques. Thus, TIPP appears to be a valid alternative when the combined aims are to opt for a preperitoneal repair and a minimally invasive open route.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: Data from the Club Hernie registry available on demand. Requests to access these datasets should be directed to JG, jfgillion@wanadoo.fr.

ETHICS STATEMENT

This study is a retrospective study on de-identified data, prospectively collected with a patient "non-opposition" agreement. Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

According to ICMJE recommendations: JG: Study protocol, data extracts, data management, calculations, descriptive statistics, writing and reviewing of the manuscript. MS: Study protocol, co-writing, reviewing. AM: Co-writing, reviewing. All: Registration of their scrotal hernia repairs in the database, either in the TIPP group or in the control groups. All authors contributed to the article and approved the submitted version.

FUNDING

The author(s) declare that no financial support was received for the research and/or publication of this article.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

GENERATIVE AI STATEMENT

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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ACKNOWLEDGMENTS

We would like to thank all the members of the Club Herniea, especially those who have registered more than 10 cases of scrotal hernia repair: L. Arnalsteen (Hôpital Privé La Louvière, Lille, France), (J. Atger (Polyclinique des Alpes du Sud, Gap, France), M. Balkanski (Centre Hospitalier Jura Sud, Lons le Saunier, France), M. Beck (Clinique Ambroise Paré, Thionville, France), D. Binot (MCO Côte d'Opale, Boulogne sur Mer, France), J. Bousquet (Hôpital Privé de la Chataigneraie, Montpellier, France), D. Blazquez (Clinique Jeanne d'Arc, Paris, France), A. Bonan (Hôpital Privé d'Antony, Antony, France), J. Cahais (Clinique St Hilaire, Rouen, France), O. Cas (Centre Médico Chirurgical–Fondation Wallerstein, Arès, France), A. Champault-Fezais (Groupe Hospitalier Paris St Joseph, Paris, France), P. Chastan (Bordeaux, France), J-M. Chollet (Hôpital Privé d'Antony, Antony, France), JC (CMC Bizet, Paris, France), CC (Hôpital Privé d'Antony, Antony, France), A. Dabrowski (Clinique de Saint Omer, Saint Omer, France), T. Delaunay (Clinique St Hilaire, Rouen, France), S. Démaret (Clinique Saint Vincent, Besançon, France), S. Derieux (Groupe hospitalier Diaconesses-La Croix St Simon, Paris, France), V. Dubuisson (CHU Pellegrin, Bordeaux, France), T. Dugué (Clinique St Pierre, Perpignan, France), R. Fara (Hôpital Européen, Marseille, France), G. Fromont (Clinique de Bois Bernard, Bois Bernard, France), JG (Hôpital Privé d'Antony, Antony, France), M. Herjean (Clinique des 2 caps, Coquelles, France), G. Hoch, Hôpital de Metz, Metz), C. Jacquin (CH du Prado, Marseille, France), P. Jannot (Hôpital Privé Pays de Savoie, Annemasse, France), FJ (Clinique Mutualiste, Saint Nazaire, France), H. Khalil (CHRU Rouen, Rouen, France), AL (Hôpital Privé La Louvière, Lille, France), C. Largenton (Polyclinique de la Manche, Carentan, France), M. Launay-Savary (CHU Pellegrin, Bordeaux, France), P Ledaguenel (Polyclinique Jean Villar, Bruges, France), M. Lepère (Clinique Saint Charles, La Roche-sur-Yon, France), D. Lépront (Polyclinique de Navarre, Pau, France), G. Lescure (Hôpital E Roux, le-Puy-en-Velay, France), J. H. Longeville (Clinique du Val-de-Loire, Nevers, France), N. Le Toux (Clinique Jeanne d'Arc, Paris, France), E. Magne (Clinique Tivoli, Bordeaux, France), NM (Clinique du parc, Cholet, France), P. Ngo (Hôpital Américain, Neuilly, France), OO (Clinique Turin, Paris, France), X. Pavis d'Escurac (Strasbourg, France), J. B. Putinier (CH Mutualiste, Grenoble, France), S. Roos (Clinique Claude Bernard, Albi, France), D Sebbar (Hôpital de Saint Brieuc, Saint Brieuc, France), MS (Polyclinique Saint Jean, Cagnes-sur-Mer, France), J-M. Thillois (Hôpital Privé d'Antony, Antony, France), P. Tiry (Clinique de Saint Omer, Saint Omer, France), P. Vu (HPMV, Bry sur Marne, France), R. Verhaeghe (MCO Côte d'Opale, Boulogne sur Mer, France), and C. Zaranis (Clinique de La Rochelle, France).

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JOURNAL OF ABDOMINAL WALL SURGERY | EUROPEAN HERNIA SOCIETY

REVIEW
published: 19 March 2025
doi: 10.3389/jaws.2025.13990

Comparison and Standardisation of Various Open Preperitoneal Techniques in Inguinal Hernia Surgery–Results of a Review and Consensus

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Introduction: Both open and laparoendoscopic preperitoneal mesh techniques are good options for the treatment of inguinal hernias. The 2023 updated HerniaSurge Guidelines recommend open preperitoneal mesh techniques as an acceptable alternative to Lichtenstein repair if a competent and experienced surgeon is available. However, although numerous open preperitoneal surgical techniques have been developed, only a few comparative studies comparing them are available. Because of the lack of scientific evidence and standardisation, the aim of this article is to define comparable standards and compare four frequently used open preperitoneal techniques.

Method: Using a Delphi-consensus process among both the authors and experts in the field, various key steps for each procedure, indications, and outcome parameters were set to allow adequate comparison of different open preperitoneal techniques.

Results: We present four different and frequently used open preperitoneal techniques: Minimal Open PrePeritoneal repair (MOPP), TransInguinal PrePeritoneal repair (TIPP), TransREctus sheat PrePeritoneal repair (TREPP), and Open New Simplifyed Total Extraperitoneal repair (ONSTEP). We provide a clear and comparable standard regarding the best indication, different procedural steps, the use of meshes and fixation, the learning curve involved, and possible complications and limitations. We also identify some similarities for the techniques but also specific differences on different topics.

OPEN ACCESS

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Received: *27 October 2024*
Accepted: *06 March 2025*
Published: *19 March 2025*

Citation:
Lorenz R, Akkersdijk W, De Oliveira GP, Soler M, Gillion J-F, Lourenço A, Da Costa RS, Pelissier E, Ugahary F and Berrevoet F (2025) Comparison and Standardisation of Various Open Preperitoneal Techniques in Inguinal Hernia Surgery–Results of a Review and Consensus. J. Abdom. Wall Surg. 4:13990. doi: 10.3389/jaws.2025.13990

Conclusion: Development, validation, and implementation of these standards for the various open preperitoneal techniques are necessary both for education and training as well as for future comparative studies.

Keywords: groin hernias, open preperitoneal techniques, MOPP, ONSTEP, TIPP, TREPP

INTRODUCTION

Inguinal hernias are one of the most common issues requiring surgical intervention worldwide. While previously there were only a few, mainly open surgical techniques without the use of synthetic meshes, numerous new surgical techniques have been developed in recent decades. The origins of open preperitoneal techniques can be traced back to the pioneering works of Stoppa, Nyhus, Read, and Wantz [1, 2]. Over time, various open surgical methods, both with and without the application of synthetic meshes, have been developed alongside advancements in endoscopic techniques. More recently, the use of surgical robots has also become an option for the treatment of inguinal hernias. To enable a meaningful scientific comparison of these methods, standardisation of surgical techniques is essential. Furthermore, standardise d approaches are critical for providing structured education and training in this field.

The guidelines for the treatment of inguinal hernias recommend a tailored approach depending on the patient's characteristics, available resources, and the experience of the surgeons [3].

For the majority of inguinal hernias, mesh techniques are recommended, which can be performed both open and endoscopically [4]. Recent studies show that endoscopic techniques have advantages over the Lichtenstein technique in terms of chronic pain [4].

For endoscopic techniques, this standardisation has already been achieved over several publications [5–8]. For the Lichtenstein technique, a significant precision of the surgical technique was made decades ago with the Amid-modifications [9]. There have also been several recent publications on the Shouldice technique that aimed to standardise the procedure [10, 11].

Franz Ugahary is the founder of the modern minimally invasive and minimally open preperitoneal technique, developing the gridiron incision in 1995 [12].

The TIPP technique was developed in September 2004 by Edouard Pelissier after the first prosthesis specifically dedicated to being spread forward in the pre-peritoneal space was created: The Polysoft (©C.R.Bard) prosthesis [13, 14].

In 2005, A. Lourenco and R. S. da Costa from Porto developed the Onstep technique. Their goal was to simplify the procedure by placing the prosthesis partially in the preperitoneal space while simultaneously splitting it. This approach eliminated the need for the parietalization step, thereby making the technique easier to learn [15, 16].

In 2006, Willem Akkersdijk introduced the Trans Rectus Sheath PrePeritoneal (TREPP) technique [17, 18], building on the Ugahary technique and utilizing the TIPP (Pelissier) prosthesis. This method represents a precisely codified pure posterior approach, meticulously structured into nine distinct steps.

Building on the principles of Ugahary's dissection and incorporating the steps of the TIPP technique, Marc Soler developed the MOPP technique. This method consistently places a preperitoneal mesh through the deep inguinal ring [12, 19, 20].

However, the diverse range of materials used in hernia surgery further complicates efforts toward standardisation.

Due to the lack of scientific literature and standardisation, this article aims to compile and summarise the essential key points of various open preperitoneal techniques. The goal is to establish a unified standard and provide a straightforward framework for comparing these techniques, serving as a foundation for future comparative studies.

METHODS

A systematic literature search was performed independently by the author's steering group (RL, WA, GO, and MS) and reported on 1st July 2024. The Cochrane Library, PubMed, Embase, and Google Scholar were searched until 30th June 2024, using Medical Subject Heading (MeSH) terms "Open preperitoneal repair, groin hernia, TIPP, MOPP, TREPP, ONSTEP". Records were screened by title and abstract for existing detailed procedure descriptions and technical standards of the following open preperitoneal techniques:

- MOPP = Minimal Open PrePeritoneal repair
- ONSTEP = Open New Simplified Total ExtraPeritoneal repair
- TIPP = Trans Inguinal PrePeritoneal repair
- TREPP = Trans REctus sheat PrePeritoneal Repair

The full texts were independently evaluated by the steering group. Only studies deemed acceptable or of high-quality according to the SIGN checklist were included to minimise the risk of bias. Any disagreements between assessors were resolved through group discussion. The steering group was selected based on their published research and expertise in inguinal hernia surgery.

An additional group of European surgeons experienced in open preperitoneal techniques and inguinal hernia repair (see Author list) discussed these findings from July 2024 to September 2024 to develop a consensus regarding standards of inguinal hernia repair.

Using a modified Delphi methodology, the steering group identified the following four main domains of focus:

TABLE 1 | Comparison of four different open preperitoneal techniques.

	Question	MOPP	TIPP	TREPP	ONSTEP
1	Best or even ideal indication?	Primary groin hernias	Large direct or indirect and combined direct, indirect, and femoral hernias	Primary groin hernias	Non-obese men with small- and medium-size hernias (EHS Classification)
2	Skin incision location and length (**Figure 1**)	Groin transverse incision in front of the internal ring 3-4 cm	Groin transverse incision 4-5 cm along the inguinal canal, 1.5 cm above the pubic bone and, 1.5 cm lateral to the midline	Lower abdomen 5 cm transverse incision almost 2-3 cm above the inguinal canal	Lower abdomen 4 cm transverse incision almost 2-3 cm above the inguinal canal
3	Important preparation steps	Always exact parietalisation to avoid overseen occult indirect hernias and to unroll the prosthesis			
	Use of specific instruments?	Different long Retractors (**Figure 2**)	Two Langenbeck or Kocher Retractor medial and lateral	Two Langenbeck or Kocher Retractor	One Langenbeck, Kocher, or Farabeuf Retractor (**Figure 3**)
4	Handling of the hernia sac or lipomas	Reducing hernia sac Resection of Lipomas	Resection of indirect hernia sac Reducing direct hernia sac Resection of lipomas	Reposition of indirect and direct hernia sac Resection of lipomas	Reposition of indirect and direct hernia sac Resection of lipomas
4	How to create preperitoneal space?	Blunt dissection with counted gauzes (one or two 10 × 10 cm gauzes)			
5	Mesh position	Complete preperitoneal mesh placement in Retzius space medially and Bogros space laterally			Medial: preperitoneal in the Retzius space Lateral: interparietal on top of the internal muscle (**Figure 4**)
		(**Figure 5**)	(**Figure 6**)	(**Figure 7**)	
6	How is access provided for mesh insertion in the groin?	Always *via* internal ring First medial placement than lateral placement of the mesh	Depending on type of hernia, indirect *via* internal ring or direct *via* posterior wall First medial placement than lateral placement of the mesh	Via opened rectus sheath First lateral placement then medial placement of the mesh	The medial part of the mesh is inserted in the preperitoneal space through an opening in the peri-tuberculum transversalis fascia after creating space with a gauze First medial placement than lateral placement of the mesh
7	Mesh size and type Preformed or flat?	Any type of preformed or flat lightweight mesh with large pores is recommended, with a minimum size of 8 × 14 cm. Meshes with a commercially resorbable recoil ring facilitate easier implantation. There appears to be no significant differences between various brands [21]			
		Non-split mesh			Split mesh: lateral to the internal ring surrounding spermatic cord or round ligament (**Figure 8**)
8	Is mesh fixation needed and, if so, how?	No fixation	Mostly no fixation, optional one or two non-resorbable single stitches as fixation on Cooper´s ligament to avoid mesh roll-up in case of large direct hernias	No fixation	No fixation is needed in ideal cases. A single Vicryl stitch to the pubic bone might provide benefits in women
9	Closure of the posterior wall – Augmentation or Bridging?	Normally no, optional augmentation with closure of the posterior wall	Normally no, optional augmentation with closure of the posterior wall	No	No
10	What are the limitations of the techniques?	Unsuitable for morbidly obese patients	Unsuitable for morbidly obese patients	Unsuitable for morbidly obese patients	Scrotal and femoral hernias
		For all techniques, hernia recurrences—especially after mesh repair or hernia repair following oncologic prostate resection with lymphadenectomy or vascular procedures—can present significant challenges			
11	Possible specific complications	For all techniques utilizing the preperitoneal space, complications in this area are possible, including injuries to the vessels (such as the inferior epigastric, iliac, or Corona mortis) or the bladder Recognition of perioperative vascular injury may not be straightforward postoperatively			
12	Average operating time (+ short <20′, ++ midterm 21′ to 40′, +++ longer >41′)	++	++	++	+
13	Learning curve of the technique (+short, ++ midterm, +++ longer)	++	++	+++ [22]	+

- Patient selection and indication (**Table 1**), Prehabilitation
- Technical steps of the preparation (**Table 1**)
- Technical steps of repair of the four different techniques (**Table 1**)
- Rehabilitation and aftercare

All authors were provided with a questionnaire regarding the individual techniques. First, the results of the independent questionnaires were compiled. Subsequently, statements were formulated by the steering group and then submitted for voting. In a final process, formulations were

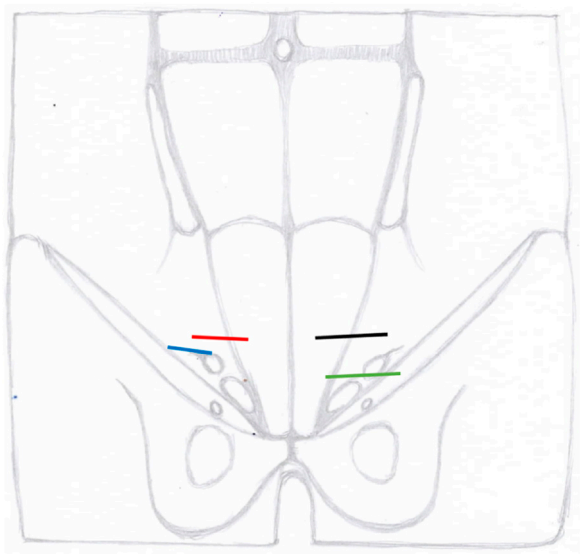

FIGURE 1 | Localisation of skin incisions of different open preperitoneal techniques blue MOPP, red ONSTEP, green TIPP, black TREPP

developed that achieved a minimum consensus of 75% among all authors.

RESULTS

We identified the following eight publications on the most important steps of the different procedures: MOPP, TIPP, TREPP, and ONSTEP [13–19, 23].

The steering group searched and summarised not only technical and procedural steps but also the specific use and fixation of meshes. We also incorporated best indications, limitations, potential complications, operating time, learning curves, and prehabilitation and rehabilitation protocols into the standard.

We concluded with a consensus on the four different and frequently used open preperitoneal techniques as a clear recommendation on how to do them as a standard.

All four techniques have numerous similarities:

- In experienced hands, addressing recurrences after previous anterior mesh or non-mesh repairs is feasible but can be particularly challenging, especially following prior mesh repairs using the Lichtenstein, Plug, or Gilbert techniques.
- Hyperextending the hip facilitates the preparation of the groin area, improving access and visibility during the procedure.
- Surgery under local anaesthesia is feasible for most techniques; however, general anaesthesia with a laryngeal mask is most commonly employed.
- All six layers of the abdominal wall should be identified (Skin, Camper´s fascia, Scarpa´s fascia, External oblique fascia, Internal oblique muscle, and Transversalis fascia).

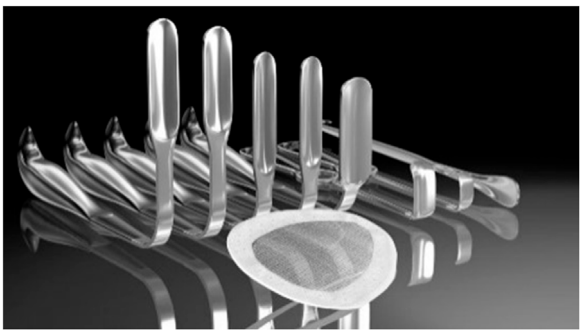

FIGURE 2 | MOPP – Specific retractor instruments (© M. Soler).

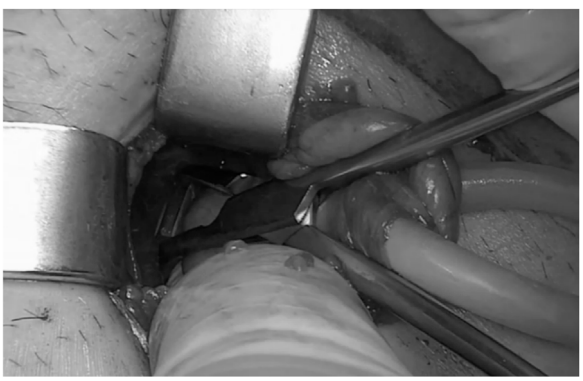

FIGURE 3 | ONSTEP - Preparation of the Retzius space (© G. Oliveira).

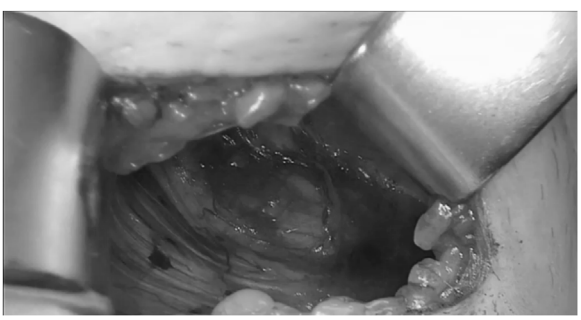

FIGURE 4 | ONSTEP – View into the Retzius space (© G. Oliveira).

- Hydrodissection with local anaesthesia is recommended for improved nerve identification and enhanced postoperative pain management.
- All nerves in the surgical area should always be systematically identified and, whenever feasible, preserved.
- All potential hernia defects (indirect, direct, or femoral) should always be systematically identified, and the exact parietalisation in the deep inguinal ring is mandatory.

FIGURE 5 | MOPP - Control of mesh position in the preperitoneal space (right Cooper's ligament) (© M. Soler).

FIGURE 6 | TIPP - Mesh position in the preperitoneal space (© R. Lorenz).

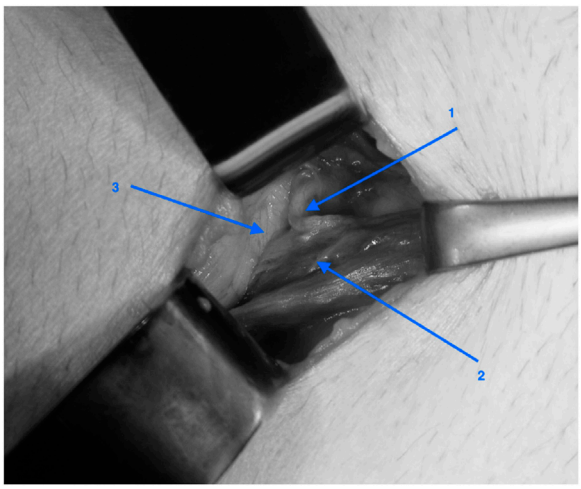

FIGURE 7 | TREPP - Inspection of the cord after dissection of the preperitoneal space: 1: vas deferent, 2: a and v testicularis, 3: peritoneum (© W. Akkersdijk).

FIGURE 8 | ONSTEP – Lateral mesh reconstruction (© G. Oliveira).

- All hernias should be classified regarding the EHS-Classification into M, L, F, and C I, II, and III; Rx [24].
- In all cases, all potential preperitoneal lipomas should be identified and, preferably, excised.

The minimal or not necessary fixation of the meshes in the preperitoneal position seems to be a way to avoid acute and chronic postoperative pain [25].

As part of the prehabilitation, the authors recommend weight reduction and nicotine abstinence if possible. Single-shot antibiotics with cephalosporines are recommended only for high-risk patients according to the current updated HerniaSurge guidelines [4].

The rehabilitation begins intraoperatively with the use of local anaesthesia. After surgery, a therapy regimen could include proper pain medication, local cooling, and early mobilization. Pain-adapted physical rest is recommended during the first few weeks postoperatively. Return to normal work activities typically occurs within one to 2 weeks, while return to sport activities generally takes two to 3 weeks.

DISCUSSION

The laparo-endoscopic techniques TAPP and TEP are currently the gold standard for preperitoneal mesh repair of groin hernias.

The advantage of the open approach in inguinal hernia surgery primarily lies in the possibility of intraoperative tailoring based on the findings during the procedure. This allows the surgeon to adjust the surgical technique in real time, depending on the specific anatomical and pathological conditions encountered, thereby optimizing the outcome and minimizing complications. A disadvantage of open preperitoneal techniques is that they involve both the anterior and posterior planes of the groin.

In this study, we aimed to compare four common open preperitoneal techniques for the treatment of inguinal hernias.

For each technique, there are existing publications outlining the key steps of the procedure. We have attempted to synchronize these key points in a simple, comparable format, and provide recommendations for a tailored approach.

However, there are other open preperitoneal techniques such as Usher, Nyhus Repair, Stoppa Repair, Rives Repair, Read Technique, Wantz Technique, Alexandre technique, Kugel Technique, Ugahary technique, and modified anterior preperitoneal repair = mAPP, that are less commonly performed today and differ from those mentioned in this analysis [26–29]. Fundamentally, all techniques share a common objective: to position a mesh within the preperitoneal space, ensuring effective coverage of the myopectineal orifice. This approach reinforces the abdominal wall and minimises the risk of hernia recurrence.

The differences between the techniques are minimal and primarily involve factors such as the location of entry into the preperitoneal space, the instruments required, the use of mesh fixation, the type of mesh, any additional surgical impact on the abdominal wall, and the visualisation of the preperitoneal space. However, the increasing number of different open techniques reflects the ongoing search by surgeons for the ideal approach to this type of surgery.

There is only one comparative randomised controlled study on open preperitoneal techniques. TIPP and TREPP techniques have been shown to be grossly comparable (fewer recurrences in the TIPP group are related to the learning curve) [30]. Other comparative studies between open preperitoneal techniques do not exist. More recent comparative studies between open preperitoneal and endoscopic techniques have shown either equivalent results [31–33] or, in some areas, better outcomes for open preperitoneal techniques [34].

A recent study compared open preperitoneal techniques with Shouldice and reported a better one-year-outcome for open preperitoneal techniques [35]. Open preperitoneal techniques may be a valuable alternative to the Lichtenstein technique for inguinal hernias. They seem to be associated with lower chronic pain, reduced opioid use and paraesthesia, and has benefits regarding patient-reported QoL [36, 37].

Scientific literature demonstrates that techniques such as TIPP and TREPP can be successfully performed as open preperitoneal procedures under local anaesthesia with analgosedation [23, 38]. In our view, this approach is feasible for all open preperitoneal techniques.

All open preperitoneal techniques can be done as day cases [39], making them suitable even in low-resource settings where laparo-endoscopic equipment is not available.

Open preperitoneal techniques are also suitable for recurrence procedures after anterior surgery with and without mesh [40]. Perhaps we must differentiate pure posterior (Ugahary and TREPP) and posterior approaches via the inguinal canal (TIPP and ONSTEP) as the latter is more difficult to realise after a previous anterior approach. The open posterior approach also appears to be feasible for complex inguinal hernias [41]. In our opinion, complex inguinal hernias are more dependent on the expertise of the surgeon. The MOPP technique seems to be effective for all primary groin hernias [19] and for primary scrotal hernias [20]. The authors believe that primary scrotal hernias can be successfully treated using the TIPP and TREPP techniques but are not ideal for the ONSTEP technique.

Limitations

There is a lack of comparative randomised scientific studies between the different open preperitoneal techniques, as well as studies involving various patient groups, including long-term follow-ups.

Due to the limited scientific evidence, expert bias may influence the statements presented in this article.

CONCLUSION

Over the past three decades, several new open preperitoneal techniques have been introduced for hernia repair. Despite their theoretical advantages, these techniques have not gained broad acceptance. Open preperitoneal approaches for groin hernia repair are straightforward and safe, often yielding results comparable to, or better than, other techniques [22]. Further standardisation of these methods is crucial for education and training purposes and for future comparative scientific studies.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

The remaining authors declare that no financial support was received for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

EP declares a patent agreement with BD, BARD-DAVOL.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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JOURNAL OF ABDOMINAL WALL SURGERY | EUROPEAN HERNIA SOCIETY

ORIGINAL RESEARCH
published: 20 February 2025
doi: 10.3389/jaws.2025.13863

Are "European" Scrotal Hernias Repairable With the Minimal Open Pre-Peritoneal Technique?

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Background: Minimally invasive open preperitoneal techniques are an alternative in groin hernia repair. Scrotal hernias (SH) are frequently difficult to repair laparoscopically, resulting in a significant conversion rate.

Methods: The aim of this exploratory monocentric retrospective study, based on data prospectively collected in the "Club-Hernie" registry, was to assess the feasibility, effectiveness and safety of the MOPP technique in SH repair compared with non-SH repair.

Results: All consecutive MOPP repairs performed from 11 September 2011 to 31 December 2022 were identified in which 2005 MOPP (126 SH and 1879 non-SH) met the inclusion criteria. The results were analysed "as treated" in 125 SH vs. 1879 non-SH. No statistically significant difference was observed between these two groups in terms of age, BMI, and ASA classification. Symptomatic hernias (84% vs. 73%; $p < 0.001$), and lateral hernias (87.80% vs. 62.81%; $p < 0.0001$) were more frequent in the SH group. The mean operating time was longer (58 min vs. 39 min; $p < 0.0001$) in the SH group. The SH procedures were performed under general anaesthesia with a laryngeal mask in 92% of cases. All postoperative complications, except one reoperation in the non-SH group, were classified as Clavien-Dindo Grade I/II. Superficial surgical site occurrences were more frequent in the SH group (14% vs. 3%; $p < 0.0001$). No peri-prosthetic infections were observed. The outpatient rate was 83% vs. 94% in the SH and non-SH groups, respectively. There were four rehospitalisations in the non-SH group and none in the SH group. The postoperative pain was low and similar in the two groups, except at M1, where the mean pain was lower in the SH group ($p < 0.001$). A total of 113 (90%) patients in the SH group vs. 1,553 (82%) in the non-SH group were followed for 1 year or more. The number of identified recurrences and reoperations was low and did not differ between the two groups studied. In total, 98% of patients in both groups assessed their surgery as excellent or good.

Conclusion: This exploratory study shows that the MOPP technique is feasible and safe in scrotal hernia repair, with similar results to those observed in non-scrotal hernias. Our next step will be to compare MOPP with laparoscopic and Lichtenstein techniques in scrotal hernia repair.

Keywords: MOPP, scrotal hernia, open surgery, pre peritoneal, prosthesis

OPEN ACCESS

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Received: *28 September 2024*
Accepted: *23 January 2025*
Published: *20 February 2025*

Citation:
Soler M and Gillion JF (2025) Are "European" Scrotal Hernias Repairable With the Minimal Open Pre-Peritoneal Technique? J. Abdom. Wall Surg. 4:13863. doi: 10.3389/jaws.2025.13863

INTRODUCTION

The concept of minimally invasive open surgery for groin hernia repair dates back to approximately 20 years ago. It adopts the principle of utilising a preperitoneal prosthesis advocated over 60 years ago by Franz Ugahary, who pioneered the minimally invasive concept in groin hernia repair with his supra-inguinal grid-iron technique through a very small incision, thus requiring specific long and smooth retractors [1, 2]. A few years after the TIPP (transinguinal preperitoneal) technique was described [3, 4], using a minimally invasive inguinal route and a mesh equipped with a memory ring [5], which was inserted in the preperitoneal space after parietalisation of the spermatic cord [6, 7]. Another variant is the trans-rectus preperitoneal (TREPP) technique [8, 9], and the last variant is the minimally open pre peritoneal (MOPP) technique which is based on Ugahary's principles (similar set of retractors) but with a deep inguinal ring [10–12]. In the majority of the published comparative studies, the results of the minimally invasive open preperitoneal techniques were found to be superior to those of the Lichtenstein technique, especially in reducing the incidence of chronic postoperative inguinal pain (CPIP) [13, 14]. Other studies show almost similar results between preperitoneal and laparoscopic methods [15, 16], except in the study by Reinhold et al. [17], which demonstrated a potential benefit in short-term quality of life and seroma formation with open posterior mesh placement compared to minimally invasive surgery (endoscopic, robotic) repair.

However, are we allowed to extrapolate these results to larger hernias (e.g., scrotal hernias), which are known to be more difficult to fix [18] Are they repairable with minimally invasive open inguinal techniques, especially the MOPP technique? A scrotal hernia is commonly defined as an inguinal hernia that, in the upright position, descends into and causes any distortion of the scrotum [18].

In the classification proposed by Tran et al. [18] the scrotal hernias are subdivided into S1 (upper third of the thigh), S2 (middle third of the thigh), S3 (lower third of the thigh/patella), and Sn (IR) in case of irreducibility. In high-income countries, where scrotal hernias type S2 or S3 [19] are very rare, recent guidelines [18] recommend an open mesh repair (e.g., Lichtenstein) or a totally extraperitoneal (TEP) laparoscopic repair for a large reducible scrotal hernia, while they recommend a trans-abdominal preperitoneal laparoscopic (TAPP) repair for an irreducible hernia. Due to the lack of published data, open repair other than Lichtenstein have not been considered in the key questions of these scrotal hernia repair guidelines. Thus, the main objective of the present exploratory monocentric prospective study was to investigate the feasibility, effectiveness and safety of the MOPP technique in the repair of S1 scrotal hernias (SH) compared to non-scrotal hernias (NSH).

METHODS

This retrospective cohort study was conducted according to the STROBE [20] statement, and the recommendations of the European Registry of Abdominal Wall Hernias working group [21].

Study Design

We conducted a comparative study of data prospectively collected in the "Club-Hernie" database. All consecutive MOPP repairs performed by the same surgeon from 11 September 2011 to 31 December 2022 for primary groin hernias, either scrotal (SH) or non-scrotal (NSH) were included and compared. The exclusion criteria were as follows: Hernia repair in female patients, history of radical prostatectomy, vascular bypass, or pelvic irradiation; Recurrent hernia, emergent hernia, or pure femoral hernia (not combined with an inguinal hernia).

Club Hernie Registry

The registry complies with the European General Data Protection Regulation (GDPR) [22]. The study's registry-based design, which guarantees that all data are anonymous and de-identified, collected with a patient "non-opposition" agreement, complies with the national ethical standards of the French "Commission Nationale de l'Informatique et des Libertés" (CNIL) (registration number: 1993959v0).

Studied Surgical Technique

The MOPP technique has already been published in scientific articles [10, 12], and book chapters [11]. Briefly, it consists of i) Dissecting the preperitoneal space through minimal inguinal access, smaller than that of TIPP, using long, thin and smooth specific blade dissectors and retractors, ii) Reintegrating the hernia sac into the abdominal cavity, iii) Inserting a preperitoneal flat mesh equipped with a memory ring through the deep inguinal ring, facilitating its deployment. The modifications to the MOPP technique required for treating scrotal hernias are as follows: The skin incision is to be enlarged from 25–40 mm to 40–60 mm. Priority is given to the recognition, dissection and sometimes resection of the sac before isolation of the spermatic cord, which is not spontaneously accessible. Recognition of the hernial sac is difficult as the elements of the cremaster cannot simply be pushed back inside as in the basic MOPP technique [12]. The presence of fibrous tissue around the sac and the cord elements also makes it difficult to identify them, along with the ilioinguinal nerve and the genital branch of the genito-femoral nerve. One solution is to search and gently dissect the sac from its distal part towards its cranial part, separating it from the tissues and vessels that are initially difficult to identify. The management of the cremasteric fibres is different than in other techniques. They must be cut rather than pushed inwards [12]. The fifrous bundles witch have accompanied the evolution of these old hernias mast also be cut to facilitate the access to the deep inguinal ring. Extra care is needed to identify the spermatic vessels, the ilio-inguinal nerve and the genital branch of the genito-femoral nerve. Resection of a damaged nerve is sometimes required [18]. The distal part of the sac, when adherent to the scrotal contents, must be transected and left wide open. The rare medial sacs that are large enough to develop in the scrotal area, are repaired in the same ways as others. When reducing the sac, as visual control of the epigastric

vessels can be difficult, it is necessary to use retractors gradually without exerting strong pressure to avoid injury especially to the vein.

Follow-Up, PROM Assessment and Late Complication Identification

CH members themselves register pre-, intra-, and 30-day postoperative data in the online database. Data entry is completed during the systematic clinical visit at month 1 (M1) scheduled with the operating surgeon. An optional clinical visit at month 3 (M3) is scheduled in case of any problems identified at M1. Subsequently, the dedicated Club-Hernie clinical research assistant (CRA), independent of the surgical teams, will manage the 1-2, and 5-year follow-up of the patients, following a formatted telephone PROM questionnaire, which has been used in our clinical studies since 1999 [23], during which the patients are systematically queried about rehospitalisation (in the same hospital or another one), reoperation and their causes, confirmed recurrence (reoperated, TDM/ultrasound, and/or surgeon visit), suspected recurrence (PINQ-Phone manoeuvre [24], localised bulging and/or local pain), late abscess, chronic sinus, mesh removal, and other late complications (e.g., bowel obstruction). After five unsuccessful attempts to contact the patient at various times and dates, they are deemed lost to follow-up. In the event of any deviation from the normal course, a visit to the surgeon's office is strongly recommended. Additionally, some surgeons, like the first author, encourage their patients to attend systematic clinical visits, the results of which are recorded independently from those of the CRA, in surgeon dedicated tabs.

Variables Used for the Present Study

Baseline variables extracted comprised: age, gender, body mass index (BMI), ASA classification, diabetes mellitus, hernia recurrence, smoking status, emergency surgery, synchronous repair of multiple defects, wound classification (clean, clean-contaminated, contaminated, dirty), type of hernia according to the European Hernia Society groin hernia classification simple and easy to remember [25] and the Tran H.M. et al. classification [18], surgical operative time, and length of stay. Intra-operative complications were defined as one or more of the following complications: peritoneal tear, bladder injury, bowel injury, orchidectomy, severe bleeding, or general complications that occurred during the procedure. Postoperative complications were clustered as follows: i. General complications including isolated or combined medical complications such as heart attack, thrombophlebitis with or without pulmonary embolism, compartment syndrome, neurological, arrhythmia, urinary retention, injection site inflammation within 30 days of surgery; ii. Surgical site infection (SSI) including all wound infections individualised into peri- (deep) or not peri-prosthetic (superficial) infected collections, and surgical site occurrence (SSO) including all peri- or non periprosthetic non-infected collections; iii. Organ space (surgical) complications including intraperitoneal bleeding, peritonitis, bowel obstruction, and immediate recurrence; In the case of concurrent complications, the Clavien-Dindo grading [26] was based on the worst complication. Postoperative pain was evaluated at D1, D2, D8, and D30 using a 0–10 VAS and compared with the 0–10 VAS preoperative status. Chronic postoperative inguinal pain (CPIP), defined as pain lasting more than 3 months, was evaluated during follow-up with 0–10 NRS, and 4 VRS scales (no pain, mild pain, moderate pain, severe pain) and compared with the preoperative status. Recurrences were clustered into reoperated recurrences, recurrences not reoperated but confirmed (CT scan, ultrasound, surgical clinical visit) and suspected recurrences.

Outcomes of Interest

Feasibility, assessed by conversion rate, and intraoperative complicationsSafety, assessed by D30 and late complications Effectiveness, assessed by recurrence rate Patient self-evaluation, assessed with systematic pain evaluations, PROMs, and Q.O.L questionnaires.

Descriptive Statistics

Discrete variables have been presented as absolute numbers and percentages. Continuous variables have been presented as mean +/− standard deviation (SD). Discrete variables have been compared using the Chi-square test or Fischer exact test, and continuous variables have been compared using the Student's T-test.

RESULTS

Flow Chart

From 11/09/2011 to 31/12/2022 a total of 2,325 groin hernias were operated on by the same operating surgeon, of which 2005 hernias, 126 scrotal (SH) and 1,661 non-scrotal hernias (NSH) matched the inclusion criteria (**Figure 1**). In one SH case, MOPP was converted to Lichtenstein due to dissection difficulties. Thus, in this series, the MOPP conversion rate for scrotal hernia repair was 0.79%. The results were further analysed "as treated" for 125 SH vs. 1661 non-SH subjects, and not in an "intend to treat" manner.

Demographics, Pain Status and Q.O.L at Baseline

The two groups were similar in terms of age, BMI, comorbidities and ASA classification (**Table 1**). Patients with any preoperative pain or discomfort, especially VRS severe pain (28.22% vs. 16.67%) $p < 0.01$ or VAS 4–10 (49.45% vs. 35.50%; $p < 0.05$) were significantly more frequent in the SH patients. Their preoperative quality of life (Q.O.L) was significantly more impaired than that of the NSH group.

Hernia Characteristics and Intraoperative Details

In almost 92% of both the NSH and SH groups, MOPP repairs were performed under general anaesthesia with a laryngeal mask

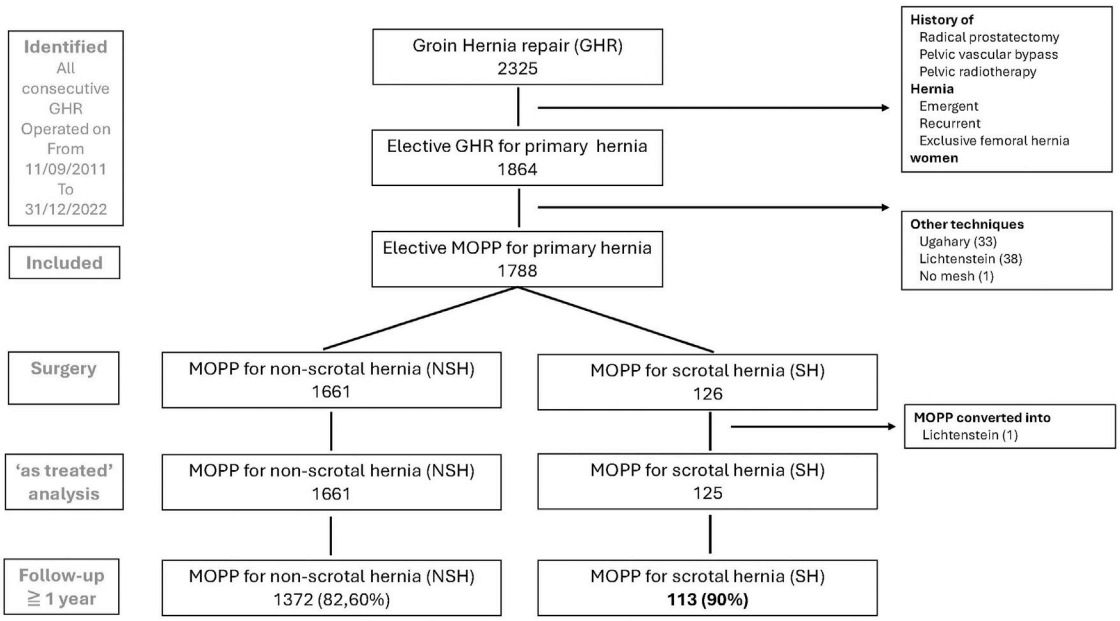

FIGURE 1 | Flow chart.

TABLE 1 | Patients' characteristics.

N (%) or mean +/– SD (range)	NSH	SH	*P*. value
MOPP repairs only Males	1,661	125	
Age (years)	69.08 ± 13.91	68.86 ± 18.1	P > 0.05
BMI (kgs/sqm)	24.62 ± 2.67	24.93 ± 4.3	P > 0.05
Diabetes mellitus	52 (3.13)	1 (0.80)	P > 0.05
Anticoagulant, antiplatelet	234 (14.08)	16 (12.80)	p > 0.05
Active smoker	324 (19.56)	26 (20.80)	p > 0.05
ASA classification			
Missing data	152 (9.15)	14 (11.2)	
ASA 1-2	1,460 (96.76)	106 (95.49)	
ASA 3-4	49 (3.14)	5 (4.50)	p > 0.05
Preoperative pain (0–10 VAS)			
Missing data[a]	492[a]	34*	
VAS 0–3	754 (64.50)	46 (50.55)	P < 0.05
VAS 4–10	415 (35.50)	45 (49.45)	
Preoperative pain (VRS)			
Missing data	6 (0.36)	1 (0.80)	
No pain	452 (27.31)	19 (15.32)	p = 0.01
Any pain	1,203 (72.68)	105 (84.67)	
Mild pain with uncommon pain	485 (29.30)	42 (33.87)	
Moderate	442 (26.70)	28 (22.58)	
Severe	276 (16.67)	35 (28.22)	P < 0.05
Preoperative PROM (Q.O.L)			
Missing data	9 (0.54)	1 (0.80)	
No preoperative symptom	447 (27.058)	19 (15.32)	P < 0.05
Preoperative symptoms	1,205 (72.94)	105 (84.68)	
Do not interfere with your daily life	479 (28.99)	29 (12.39)	
Allow to pursue the ongoing activity	195 (11.80)	26 (20.96)	
Cause a temporary interruption of your activity	174 (10.59)	13 (10.48)	
Prevent certain activities (impairment)	357 (21.61)	37 (29.63)	

VRS, Verbal Rating Scale; VAS, Visual Analogic Scale; NRS, Numeric Rating Scale Preoperative VAS.
[a]Was introduced in the registry in 2015.
Percentages were calculated on not-blank values.

TABLE 2 | Hernia characteristics/Intraoperative details.

N (%) or mean +/− SD (range)	NSH	SH	*P*. value
Cases	1,661	125	
Type of anesthesia			
Missing data	3 (0.18)	0 (0)	
General anesthesia intubation	52 (3.13)	6 (4.80)	p > 0.05
General anesthesia laryngeal mask	1,536 (92.64)	115 (92.00)	
Spinal	8 (0.48)	0 (0)	p < 0.0001
Local or regional block	62 (3.74)	4 (3.20)	p > 0.05
Altemeier			
Missing data	750 (45.15)	59 (47.20	p > 0.05
Clean	911 (100)	66 (100)	
Hernia EHS classification			
Missing data	3	2	
Lateral	1,017 (61.33)	108 (87.80)	p < 0.0001
L1	167 (16.12)	0 (0.00)	
L2	793 (77.97)	24 (22.22)	
L3	57 (5.60)	84 (77.77)	
Medial	687 (41.43)	15 (12.19)	P < 0.0001
M1	41 (5.96)	0 (0.00)	
M2	458 (66.66)	2 (13.33)	
M3	188 (27.36	13 (86.66)	
Lateral + medial	46 (2.77)	1 (0.81)	P > 0.05
Femoral only	0 (0.00)	0 (0.00)	p > 0.05
Femoral et lateral	12 (1.18)	2 (0.81)	p > 0.05
Femoral et medial	4 0.40)	0 (0.00)	p > 0.05
Mesh type			
Missing data	9 (0.54)	0	
Surgimesh™	745 (45.09)	45 (36.00)	P < 0.05
Polysoft™	54 (3.27)	7 (5.6)	
Onflex™	850 (51.45)	73 (58.40)	p > 0.05
Other	3 (0.18)	0	
Mesh size			
Missing data	12 (0.72)	0	
Large	1,077 (65.31)	104 (83.20)	p < 0.0001
Medium	572 (34.69)	21	
Mesh fixation			
Missing	5 (0.30)	0	
No	1,651 (99.70)	125 (100)	P > 0.05
Yes	5 (0.30)	0	
Intra operative adverse events			
Iliac vessels injury	0	0	
Bowel injury	0	0	
Bladder injury (sutured)	1 (missing data = 20) (0.06)	0	
Operating time			
Mean +/− SD (min)	39 (9.87)	58 (21)	p < 0.0001

Percentages were calculated on non-empty values.

without tracheal intubation (**Table 2**). Spinal anaesthesia was rare but significantly more frequent (0% vs. 0.48%; p < 0.0001) in the NSH group. The groin hernias treated were significantly different between the SH and NSH groups: Lateral inguinal hernias were more frequent (87.80% vs. 61.33%; p < 0.0001) in the SH group. Combined inguinal and femoral hernias were encountered in 1.58% vs. 0.81% of cases (p > 0.05). All SH hernias were S1 type according to the Tran H.M. classification [18]. Three types of preperitoneal mesh were successively used depending on their availability on the market during the study period. A large mesh (according to the manufacturer's specifications) was used more frequently (83.20% vs. 65.31%; p < 0.0001) in the SH group. No mesh fixation was used in the scrotal group or in all but five cases (0.30%) in the NSH group. Intraoperative adverse events were very rare in each group and were not more frequent in the SH group. The operating time was longer (58 min vs. 39 min; p < 0.0001) in the SH group.

Day-30 Postoperative Outcomes

General (non-surgical) complications occurred rarely, with the same frequency (1.52% vs. 1.60%; p > 0.05), in each group. Surgical site occurrence (SSO), were more frequent (14.40% vs. 2.98%; p < 0.0001) in the SH group, consisting only of seromas (**Table 3**). One superficial (non-periprosthetic) surgical site infection occurred in the NSH group. Two organ-space complications, orchitis (N = 1) and deep haematomas (N = 1) occurred in the control group, and

TABLE 3 | Day-30 postoperative outcomes.

N (%) or mean +/− SD	NSH	SH	*P*. value
Cases	1,661	125	
Postoperative complications			
Missing data	20 (1.20)	0 (0.00)	
General	25[a] (1.52)	2[b] (1.60)	P > 0.05
SSO			
SSO non-SSI	49[c] (2.98)	18[d] (14.40)	p < 0.0001
Non-periprosthetic SSI	0	0	
Periprosthetic SSI	0	0	
Surgical non SSO	2[e,f]	0	
Reoperation	1[e]	0	
Mesh removal	0	0	
Rehospitalization	4[g]	0	
Clavien classification			
Missing data	25	0	
Patient without complication	1,606	105	
Patient with any complication	30	20	P < 0.001
Grade I/II	29 (1.77)	20 (16.00)	
Grade III b	1 (0.06)	0	
Grade IV	0	0	
Grade V	0	0	
Postoperative pain (0–10 VAS)			
D1: mean (SD); missing	4.35 (2.12); 44	4.1 (2.01); 4	p > 0.05
D8: mean (SD); missing	1.8 (1.77); 45	1.7 (1.9); 4	p > 0.05
D30: mean (SD); missing	0.71 (1.41); 191	0.40 (0.99); 20	p < 0.0001
Missing data	9	0	
Outpatients	1,570 (95.04)	104 (83.20)	<0.0001
Inpatients	82 (4.96)	21 (16.80)	

Percentages were calculated on non-empty values.
SSO, Surgical site occurrence; including SSI, Surgical site infection.
Clavien Dindo classification (REF.): In case of combined complications the CDC grading (per patient) was calculated on the worse complication VAS: Visual analogic scale; D1: The day after the surgical procedure.
[a]*Heart rhythm disorder (1 case), veinitis or lymphangitis (4 cases), thrombophlebitis (1 cases), localized hypoesthesia under the inguinal incision (7 cases), urinary retention (5 cases), Parkinsonian decompensation (1 case), other (6 cases).*
[b]*Urinary retention (2 cases).*
[c]*Subcutaneous seromas or hematomas healing spontaneously (n = 42), not infected deep hematomas (n = 7).*
[d]*Subcutaneous seromas (18 cases).*
[e]*Deep hematoma, reintervention at D7 simple outcome.*
[f]*Orchitis (1 case).*
[g]*Deep hematoma requiring transfusion (1 case), hematoma re-operated on day 7 (1 case (f)), pulmonary embolism with hematoma treated as an outpatient (1 case), urinary retention managed by urologists (1 case).*

none in the SH group. No bowel obstruction, peritonitis, mesh removal occurred in the entire MOPP series. No reoperation or rehospitalisation were required in the SH group vs. one and four respectively in the NSH group. With the exception of one complication in the NSH group, all postoperative complications were benign, classified as Clavien I or II. Compared to the control group, the mean postoperative pain (VAS) in the SH group was (4.1. vs. 4.35; p > 0.05) at D1, (1.7 vs. 1.8; p > 0.05) at D8 and (0.40 vs. 0.71; p < 0.0001) at D30; the difference was statistically significant only at D30, in favour of SH.

Two-Year PROM

In total, 100 of 125 (80%) SH patients and 1,470 of 1,661 (88.50%) NSH patients were reached by the clinical research assistant and answered all or almost all the questions of the formatted questionnaire (**Table 4**). In total, 99% of patients in each group assessed their groin to be solid. One (1%) in the SH group and 11 (0.80%) described a bulge or a tumefaction in their operated groin. Five (5%) in the SH group and 34 (2.49%) in the NSH group mentioned either moderate or severe pain. The difference was not statistically significant (p > 0.05). Similarly, the potential impact of these late symptoms (if present) on their daily life was extremely low. Only 1 (0.98%) in SH and 6 (0.44%) in NSH assessed their late symptoms as more bothersome than their preoperative symptoms. Overall, no statistically significant difference was found between the two studied groups in terms of their late PROM.

Identified Late Complications

At 1 year, 84 of the 125 SH patients, and 870 of the 1879 NSH patients had already completed their first annual telephone questionnaires; additionally, 29 of the 125 SH patients, and 502 of the 1879 NSH patients attended their systematically proposed clinical visits (**Table 5**). These combined controls allowed for the identification of the following late complications: In the SH group, only one complication (superficial infection) was recorded, which was resolved after

TABLE 4 | Two-year patient related outcomes measure (PROM).

	NSH	SH	
N (%)	1,661	125	
Patients not reached/phone questionnaire (N, %)	191 (11.50)	25 (20)	P < 0.01
Q1. Since your operation does your abdominal wall seem (N answers)	1,470	100	
Solid	1,466 (99.72)	99 (99)	p > 0.05
Not solid	4	1 (1)	
Q2. Do you have a new hernia or bulge in the operated groin? (N answers)	1,363	100	
No	1,352 (99.19)	99 (99)	p > 0.05
Yes	11 (0.80)	1 (1)	
Q3. Do you currently feel any pain or local discomfort? (N answers)	1,362	100	
No (asymptomatic)	1,237 (90.82)	91 (91)	p > 0.05
Yes	125 (9.18)	9 (9)	
Mild pain or discomfort	91 (6.68)	4 (4)	
Moderate pain	28 (2.05)	5 (5)	p > 0.05
Severe pain	6(0.44)	0 (0)	
Q4. Impact of symptoms (N answers)	1,494	112	
No symptoms	1,378 (92.23)	103 (91.96)	p > 0.05
Symptoms	116 (7.76)	9 (8.03)	
Do not interfere with your daily life	105 (7.03)	8 (7.14)	
Allow to pursue the ongoing activity	6(0.40)	0 (0)	
Cause a temporary interruption of activity	2 (0.13)	1 (0.89)	
Prevent certain activities (impairment)	3(0.20)	0 (0)	
Q5. Late vs pre-operative symptoms. (N answers)	1,361	102	
No late symptoms	1,243 (91.32)	94 (92.15)	p > 0.05
Late symptoms	118(8.67)	8 (7.84)	
Less bothersome than the hernia	112 (8.23)	7 (6.86)	p > 0.05
More bothersome than the hernia	6 (0.44)	1 (0.98)	
Q6. How do you assess the result of your hernia operation (N answers)	1,352	98	
Excellent or good	1,339 (99.03)	86 (97.95	p > 0.05
Medium	10 (0.74)	1 (1.02)	
Bad	3 (0.22)	1 (1.02)	

TABLE 5 | Identified late complications.

N *(%)*	NSH	SH	*P*. value
Patients	**1,661**	125	
Missing data	***289 (17.39)***	*12 (9.60)*	**p < 0.01**
Patients followed	**1,372** ***(82.60)***	*113 (90.40)*	**p = 0.02**
Phone questionnaire completed	**870*(52.38)***	*84 (67.2)*	**p = 0.01**
Patients attending the clinical visit	**502** ***(30.22)***	*29 (23.20)*	p > 0.05
Complications/patients	**6 complications/4 patients**	1 complication/1 patient	p > 0.05
Testicular atrophy	**0**	0	
Bowel obstruction or erosion	**0**	0	
Late superficial infection operated	**1**	1	
Chronic sinus	**1**[a]	0	
Mesh removal	**2**[b,c]	0	
Recurrences	**3**	0	
Reinterventions	**5 (0.36)**	1 (0.9)	p > 0.05[d]

Percentages (in italics) were calculated on non-empty values; p values < 0.05 are in bold Chronic sinus operated twice

[a]*(Mesh removal, recurrence) Mesh removal for meshoma.*

[b]*(in other center), for abscessed sigmoid diverticulosis.*

[c]*(in other center).*

[d]*Fischer exact test.*

reoperation. In the NSH group, six complications (5 reoperations) occurred in four patients, including two hernia recurrences, one superficial infection, one chronic sinus, and two mesh removals (**Table 5**). These late complications were rare in both studied groups, with no statistically significant difference between them.

DISCUSSION

Key Results

In the present comparative study, the first to be published on scrotal hernia repaired with the MOPP technique, the conversion rate was less than 1%, while complications (postoperative and late) and

recurrence were low and similar to those observed in non-scrotal MOPP repair. Thus, this study shows taht the MOPP techniqueis feasible, safe and effective for scrotal SH S1 encountered in Europe [18, 27]. In the classification proposed by Tran et al. [18] the scrotal hernias are subdivided into S1 (upper third of the thigh), S2 (middle third of the thigh), S3 (lower third of the thigh/patella), and Sn (IR) in case of irreducibility. All scrotal hernias treated in this series were type S1, according to the previously mentioned classification. Thus, the external validity of the present study does not apply to types S2 and S3 encountered in low- or middle-income countries (LMIC). Moreover, the considerable experience in this field of our LMIC colleagues [19] may help us to figure out how to operate on the rare S3 cases we may 1 day be faced with. In the recently published "Systematic review and guidelines for the management of scrotal inguinal hernias" [18] three techniques were evaluated: the Lichtenstein technique, the totally extraperitoneal laparoscopic (TEP) repair, and the trans-abdominal laparoscopic (TAPP) repair. Due to a lack of published data, open repair other than the Lichtenstein techniques was not considered in the key questions of these guidelines. The present monocentric prospective exploratory study showed that i) the MOPP technique is feasible, safe and effective in scrotal repair for the scrotal hernias (S1) encountered in Europe, ii) the overall results of MOPP used in scrotal hernia (SH) repair were not statistically different from those of MOPP used in common groin hernia repair (NSH), iii) the conversion rate in S1 scrotal hernia repair, was 0.8% (1/126), which is very low compared to what has been published for laparoscopic techniques, especially TEP.

The conversion rate of TEP in SH repair was 25% in the 23 selected series reviewed in Tran et al. systematic review and guidelines [18]. In the series by Bansal et al. [28], TEP repair was successful in 64 patients (75.3%), converted to TAPP in 15 patients (17.6%) and to open in six patients (7.1%). TAPP repair was successful in 53 patients (89.8%) and was converted to open repair in six patients (10.2%).

In the event of technical difficulties, conversion from MOPP to Lichtenstein is easier, and quicker than from laparoscopic techniques in which a resettlement is required. Additionally, unlike African SH patients who are predominantly young, European SH patients are older and have comorbidities, as shown in the present study in which the mean age was close to 70 years, with 5 (4.5%) patients classified as ASA 3 or ASA4. In the present MOPP study, 92% of the patients received a "light" general anaesthesia with a laryngeal mask, without tracheal intubation or curarisation. The conversion rate observed in the present study was low for three main reasons: i) all the SH hernias were S1 type; ii) due to the inclusion/exclusion criteria, the cases studied were, hence, highly selected cases (**Figure 1**); While only one planned MOPP had to be converted to Lichtenstein, in 43 other cases Lichtenstein was our first choice. Thus, the Lichtenstein technique remains our fallback technique. Additionally, a disadvantage of the TIPP approach that is regularly cited is the need for dissection in both planes thus virtually hampering a possible approach in a "virgin" plane. In fact, this is not as significant as it appears to be. As shown in this series, the recurrences are rare after this preperitoneal open technique and can be repaired by open (because the initial superficial inguinal dissection was not extensive) or laparoscopic TAPP technique. All repairs were performed by a surgeon very experienced in this procedure.

The Results of MOPP Were Globally the Same in SH Hernias Compared With Non-SH Hernias

The aim of the present study was not to assess the benefit/drawback balance between MOPP and other techniques in SH repair, which is the point of our following study [29] comparing head-to-head TIPP/MOPP versus Lichtenstein and TIPP/MOPP versus laparoscopic repair. Rather, the aim of this first step was to investigate whether MOPP is feasible and safe in scrotal hernias to use NSH as a control population. What we found is that, in expert hands, MOPP is feasible and effective in S1 scrotal hernias, with overall results similar to those of non-scrotal groin hernias. In particular, the low rate of identified recurrences (**Table 5**) the low rate of chronic postoperative inguinal pain (CPIP), both severe (0% vs. 0.44%; $p > 0.05$), and moderate pain (5% vs. 2.05%), $p > 0.05$ (**Table 4**). Some differences remain to be underlined: In terms of pain/discomfort/Q.O.L. SH patients benefitted the most from their surgery (high improvements) with, in addition, an extremely low rate of late complications (**Table 5**). The preoperative pain/discomfort and the Q.O.L alterations were significantly more important in the SH patients (**Table 1**), while their postoperative pain and PROM (**Table 4**) were low and similar to those of the NSH patients. On the other hand, the rate of postoperative SSO on day 30 (**Table 3**) was significantly higher in the SH group than in the NSH group (14.40% vs. 2.98%; $p < 0.0001$). These surgical site occurrences (SSO) consisted only of non-infected seromas. No early periprosthetic infection occurred in either group. All day 30 postoperative complications in the SH group were classified as Clavien I/II, none as Clavien III or higher. Similar findings were reported in the Herniamed registry [27], in which scrotal hernias demonstrated an unfavourable association with postoperative complication rates but a favourable association with chronic pain rates. In both groups, probably due to the minimally invasive nature of the MOPP technique, general complications were rare and benign (**Table 3**). Thus the longer hospital stay in SH patients was probably related to their higher rate of SSO and to intraoperative difficulties. The operating time was longer (58 min vs. 39 min; $p < 0.0001$) in the SH group, due to technical difficulties and modifications to the standard MOPP technique.

Technical Modifications to the Standard MOPP Technique Required for S1 Hernia Repair

It is advisable not to dissect the sac too far distally and therefore to leave its bottom after having opened it widely. An increased risk of seroma is preferable to an increased risk of testicular ischaemia and haematoma [18]. As much as possible, it is preferable to implant a large mesh that broadly covers the entire Fruchaud's myo-pectineal area. A memory ring or a peripheral reinforcement of the mesh, greatly helps the deployment of the mesh. In the present series, a

large mesh was implanted significantly more often in SH than in NSH patients (83.20% vs. 65.31%; $p < 0.0001$). In NSH patients, mesh fixation was rarely used (**Table 2**). In large defects, especially medial ones, using a suture to fix the prosthesis to the Cooper's ligament is recommended by the guidelines [18, 27]. In series reported in the Herniasurge guidelines [27] scrotal hernias are largely drained. Similarly, in the systematic review by Tran et al. [18], some articles [30] suggest that drainage may reduce the occurrence of either haematomas or seromas. In the present monocentric experience, the surgeon never used a drain even in the repair of the largest S1 hernias. While 18 cases (14.40%) of seromas or small haematomas occurred, they never required specific treatment and gradually resolved without significant patient discomfort.

Limitations

This study has several limitations. This is a non-randomised comparative study but it is based on monocentric exhaustive prospectively collected data in a national registry. The two groups may appear poorly comparable (**Table 1**), suggesting the need for propensity score matching. In fact, due to the large number of patients, small differences may be statistically significant while being clinically poorly significant. This is the case in our two populations: Mean age (69.08 vs. 68.86), mean BMI (24.62 vs. 24.93), frequency of patients on anticoagulant therapy (14.08% vs. 12.80%), active smokers (19.56% vs. 20.80%), ASA 1–2 (96.76% vs. 95.49%). Preoperative pain (and discomfort) was found to be higher in scrotal hernias than in non-scrotal ones. This is well-known and the subject of many studies and is inherent to the scrotal nature of the hernia. This is a monocentric series, from one surgeon who is highly skilled in this technique, which limits the external validity of the study. Regular follow-up was mainly achieved by telephone questionnaire and not all the patients had a late clinical visit. Thus, small sub-clinical recurrences may have been missed. However, the methodology was the same in the two studied groups. While a telephone questionnaire is not the best tool for detecting small asymptomatic recurrences, even with the PINQ-Phone manoeuvre [24], it is a reliable tool to detect rehospitalisation (in the same or another hospital), reoperation and its causes, late infections, late mesh removals, and other late complications such as bowel obstructions (all events not ignored by the patients). And an excellent tool to assess PROM, Q.O.L and CPIP [31].

Strengths

On the other hand, this study has several strengths. This is a monocentric, single-operator (homogeneous) study based on an exhaustive registration of cases and a high follow-up rate. Almost 90% (SH) and 83% (NSH) of the patients were followed up for more than 1 year, either by a telephone questionnaire conducted by a specialised clinical research assistant, independent from the surgical team or by clinical visits to the surgeon's office, which patients were systematically encouraged to attend.

CONCLUSION

The present study clearly demonstrated the feasibility and the safety of the MOPP technique in S1 scrotal hernia repairs. The results of this first step study led us to set up a complementary study in scrotal hernia repairs, comparing head-to-head the results of TIPP/MOPP versus Lichtenstein technique and TIPP/MOPP versus laparoscopic techniques.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

MS: Study protocol, data extracts, data management, calculations, descriptive statistics, writing and reviewing of the manuscript. JG: Study protocol, calculations, descriptive statistics, co-writing, reviewing. All authors contributed to the article and approved the submitted version.

FUNDING

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. Publication costs are covered by the Research and Education Department on the Ramsay Santé compagny.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

GENERATIVE AI STATEMENT

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JOURNAL OF ABDOMINAL WALL SURGERY
EUROPEAN HERNIA SOCIETY

REVIEW
published: 17 February 2025
doi: 10.3389/jaws.2025.13861

Groin Hernia Repair, the History of the Open Pre-Peritoneal Route Towards a Minimally Invasive Approach. Narrative Review

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The history of pre peritoneal groin hernia surgery start only after solving the problems related to asepsis, antisepsis and anesthesia. Fundamental work on the use of a new form of polyethylene to create synthetic meshes was carried out in the 1950s by C. Usher. L. Nyhus was the first to popularize the use of a mesh. But the inventor of the first synthetic prosthesis was Don Eugène Acquaviva in 1944, and the first surgeon to discuss the installation of a pre-peritoneal prosthesis for the treatment of hernias of the groin is Jerome Corti in his thesis in 1949. In the 50 s and 60 s H. Fruchaud had particularly and directly influenced Jean Rives and René Stoppa, and due to the poor results of techniques without prosthesis, particularly for complex hernias Rives and Stoppa techniques were then disseminated with lots of variations, (G. Wantz, J.H. Alexandre, R. D. Kugel. . ..) But the parietalization step was difficult to achieve for many colleagues and the development of endoscopy has made it possible to clearly demonstrate this crucial step in order to properly unroll the prosthesis. Franz Ugahary put up resistance against endoscopy with the Grid Iron technique in 1995, the fist open minimal invasive pre peritoneal approach. In 2004, Pelissier invented a specific semi-rigid prosthesis, which made it possible to codify with colleagues the Trans Inguinal Pre-Peritoneal (TIPP) technique. But it was also necessary to master the step of parietalization of the cord, this is probably why the ONSTEP technique was created in 2005. It is a partially preperitoneal technique without parietalization W. Akkersdick has tackled the challenge with the Trans Rectus sheath Pre Peritoneal (TREPP) technique in 2006, a pure posterior approach. For my part I modified the TIPP technique in 2011 using Ugahary's dissection principles, the Minimal Open Pre Peritoneal (MOPP) technique was created. It is only in recent years that the literature has provided data about TIPP, TREPP, MOPP, with comparisons with others techniques. Now the new route, preperitoneal, minimal open and minimal invasive has its place in the treatment of groin hernias!

Keywords: prosthesis, groin hernia, history, open, preperitoneal

OPEN ACCESS

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Received: *28 September 2024*
Accepted: *15 January 2025*
Published: *17 February 2025*

Citation:
Soler M (2025) Groin Hernia Repair, the History of the Open Pre-Peritoneal Route Towards a Minimally Invasive Approach. Narrative Review. J. Abdom. Wall Surg. 4:13861. doi: 10.3389/jaws.2025.13861

INTRODUCTION

Since antiquity, the history of inguinal hernia surgery is rich in anecdotes with most often fatal conclusions for patients [1], and this continues even during the second half of the 19th century where the subject of this article, dedicated to the preperitoneal approach to treat inguinal hernias, begins. The 19th century brings knowledge in terms of anatomy and in terms of hygiene to allow the surgeon to penetrate the preperitoneal space, the 20th century brings the synthetic prostheses to gain in efficiency, and finally the end of the 20th century and the beginning of the 21st century are decisive to define resolutely minimally invasive techniques on the basis of classical procedures. This new way then expresses itself fully by giving the first scientific guarantees that we are entitled to expect. The main objective of this article, besides recalling historical facts by sometimes correcting certain injustices concerning underestimated and sometimes even forgotten authors, is to put into perspective the links which exist between surgeons of several generations who had the same ambition, to perform a surgery that was *a priori* complex in the least invasive way possible and which was aimed at the greatest number of patients.

DEVELOPMENT

The anatomical data were clarified and shared by A.P. Cooper in 1807 [2], A. Bogros in 1823 [3], A Thomson in 1836 [4], A.A. Retzius, 1858 [5], completed by E. Bassini in 1887 [6], and later by E.E. Shouldice in 1945 [7], H. Fruchaud in 1956–1957 [8, 9] (**Figure 1**), C.B. McVay in 1958 [10] and R.E. Condon in 1971 [11]. Even though knowledge of anatomy might have allowed it, therapeutic means were very ineffective before the use of asepsis, antisepsis and anesthesia. Thus, during the first part of the 19th century, the pioneers were mainly interested in these patients in very poor condition with an irreducible hernia whose outcome was in any case spontaneously fatal. They also used the posterior approach, but most often patients died of gangrene [1]. Most other patients who were not directly at risk for complications were not operated on.

FIGURE 1 | Henri Fruchaud (1894–1960).

During the same decades, the British surgeon Joseph Lister described in 1867 the success of a method to combat postoperative infections: antisepsis [12]. This idea came to him from the demonstration made by Louis Pasteur a few years before, which highlighted the role of microbes in the origin of infections. Asepsis came to complement Lister's antisepsis, which had only been accepted very gradually. Ultimately, the two processes allowed a real development of surgery from 1885, and particularly allowed the opening of parietal spaces with a drastically reduced rate of fatal post-operative infection [1].

It is precisely around these same decades that research concerning local and general anesthesia would be published and spread [13]. From nitrous oxide to chloroform in the 1840s for general anesthesia, cocaine for local anesthesia, Freud 1884, P. Reclus (7,000 cases) Paris, and the invention of the spinal anesthesia in August 1898 by August Bier. All the pillars (anatomy, anesthesia, antisepsis, asepsis) were in place and would be immediately used for hernia surgery from the second part of the 18th and beginning of the 19th century.

The pioneers for the posterior approach are, according to Chavasse, Crompton of Birmingham [14], followed by Niven [15] and Annandale who repeated the Crompton's procedure in 1876 [16]. He was followed by Lawson Tait [17] from Birmingham, then by Bates [18] and G.L. Cheatle 1920 from the England- King's college hospital London, who was a devoted disciple of Lister [19]. Patino clarifies: "Cheatle, in 1920, described an operation for the radical cure of inguinal and femoral hernias through a medial abdominal section, without entering the peritoneal cavity" [20, 21], and in 1921 Cheatle reported on the use of the Pfannenstiel incision. In 1936 Henry [22] emphasized the advantages of Cheatle's approach in the cure of bilateral femoral hernias with a little impact before World War II. At this period, we spoke about the Cheatle-Henry procedure that provides excellent exposure of anatomic structures adjacent to the femoral canal. And it is finally Henry who popularized the posterior approach among the pioneers of the second half of the 20th century, with Mc Evedy [23], but always without the help of a prosthesis. The gold standard at that time was the anterior approach, following the works of Bassini [6] and Shouldice [7]. For femoral hernias, McVay described his eponymous technique in 1938 [10], but surgeons did not accept his original description. They omitted making the relaxation incision and results were not as good as those published by McVay. So, everything was in place for the next decisive step which was the birth of synthetic prostheses.

The inventor of the first synthetic prosthesis was Don Eugène Acquaviva from Marseille. He personally had manufactured, patented and used a nylon mesh for an incisional hernia in 1944 [24, 25] (**Figure 2**), and the first surgeon to discuss the installation of a pre-peritoneal prosthesis for the treatment of a groin hernia, which was a femoral hernia (but without realizing it himself), was his son-in-law Dr Jérôme Corti in his thesis in 1949 [26] (**Figure 3**). Don Eugène Acquaviva was particularly

FIGURE 2 | Don Eugène Acquaviva (1897–1976).

FIGURE 3 | Dominique Corti (1919–1983).

innovative in terms of the design of synthetic mesh and its use in ventral surgery. His work was published thanks to the interest shown by Lucien Leger from Hospital Cochin in Paris, who was the editor of the "notes of surgical techniques" in the "Presse Medicale" journal. These notes were widely distributed and were serious references at the French as well as at the international level. The nylon prosthesis patented by Acquaviva would soon be used by Bourgeon and would also be inserted into the preperitoneal space [27, 28].

However, the fundamental work was carried out by C. Usher (**Figure 4**) in his private practice in Houston, Texas [29]. He used a new ethylene polymer woven into a mesh, the Marlex prosthesis, which was fabricated to his design, and used for groin hernia surgery in 1958. A knitted Marlex product was introduced in 1961. The same year a braided Marlex suture appeared [30]. Polypropylene monofilament, an isotactic polymer which retains its tensile strength, was introduced in 1962, recommended as an inert suture to close contaminated wounds [31, 32]. Monofilament polypropylene suture is still the preferred synthetic material today! Usher therefore carried out numerous experimental and clinical studies resulting in 20 papers on hernia between 1958 and 1967 [30–38]. As Read said [29], "Usher realized Billroth's vision," (1878) as quoted by Vincenz Czerny in his textbook, "If we could artificially produce tissues of the density and toughness of fascia and tendon, the secret of the radical cure of hernia would be discovered."

But the acceptance of prosthetic materials in parietal surgery was very low. As Read reminds us [39] Usher said, "surgeons are usually reluctant to use a prosthesis for fear of wound complications and a natural disinclination to use foreign materials." Note that before Usher, and thanks to his own experimental work [31], early polymers such as Nylon (Acquaviva), Dacron, Orlon and Teflon had been the most studied, but the results were disappointing. Foreign body reaction, sepsis, stiffness, fragmentation, loss of tensile strength, and encapsulation have prevented their widespread use. Metal prostheses (Tantalum Gauze) had also given disappointing results, as Debord recalls [40], even though stainless-steel mesh had enthusiastic users until the 80s [41]. This hostility against protheses would last a long time and this was confirmed to me by Jean Rives (**Figure 5**). He told me during a 2-h recorded interview on 6 October 2011, that he had been heavily criticized in the 1960s and 1970s, because of his practice of using prosthetic material for simple non-recurrent hernias, even by his colleagues who were also his friends [42].

Moreover, even though Usher widely used prostheses in the preperitoneal space with parietalization of the cord, the official

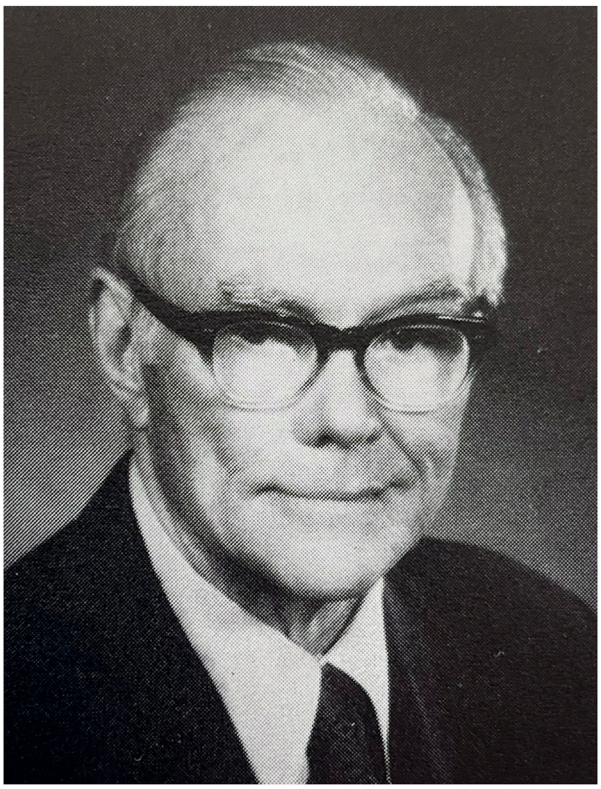

FIGURE 4 | Francis C. Usher (1908–1980).

FIGURE 5 | Jean Rives (1922–2012).

laurels would preferentially go to Nyhus (**Figure 6**) and too few colleagues who popularized the use of a mesh allowed the Cheatle-Henry and Mc Evedy incision [19–21]. In their 1959 paper, Nyhus and colleagues described the use of a synthetic sponge (Ivalon®) to reinforce the posterior wall of a recurrent hernia [43, 44]. Due to its poor tolerance, the Ivalon sponge would quickly be abandoned in favor of the Marlex mesh created by Usher. At that time, many surgeons applied the principles published by Nyhus: Sheehan (1961), Mahorn and Goss (196, Smith (1962), Huguier (1963), Estrin (1963), Andrews (1968) and Read (1968).

In 1956, only a few years before Usher Nyhus and Henry, Fruchaud [9] had insisted on the need for broad coverage of the musculo-pectineal orifice which bears his name. Henry Fruchaud had particularly influenced Jean Rives and René Stoppa (**Figure 7**) who had worked in the anatomy laboratory of the Faculty of Medicine of Algiers. During this period Fruchaud worked on his two famous books [8, 9], never translated before Robert Bendavid in 2006 [45] and therefore largely unknown in the Anglo-Saxon world despite the efforts of R. Stoppa to promote them. So, in the 70s, directly influenced by their mentor, J. Rives [46, 47], and then R. Stoppa [48–50] described their techniques in a general context still unfavorable to the use of parietal prostheses, except gradually for complex groin hernias. The polyester Dacron mesh

FIGURE 6 | Llyod Milton Nyhus (1923–2008).

FIGURE 7 | René Stoppa (1921–2006).

FIGURE 8 | George Wantz (1923–2000).

(mersilene) was first used in France by J. Rives following the presentation of the mesh by the laboratory that marketed it [41]. R. Stoppa was inspired by the Rives' technique for bilateral hernias by creating his eponymous technique. Eventually, and probably partly due to the popularity of Lichtenstein's technique, the gold standard in the 1980s, the idea of using a prosthesis had finally become commonly accepted. Even surgeons who were still against the use of prostheses admitted the advantages for the most complex cases, and the techniques of Rives and Stoppa were then disseminated with lots of variations, such as G. Wantz [51], (**Figure 8**), and J.H. Alexandre [52, 53], (**Figure 9**) techniques.

Jean Henri Alexandre's technique is a step to remember towards less invasive solutions. It could be considered as a precursor of the TIPP technique. The approach was a classic anterior approach as it provided for the ligation of the inferior epigastric vessels to facilitate access to the preperitoneal plane, the prosthesis being fixed. But at the time these techniques required regional or general anesthesia and classic hospitalization.

Another variation is the R.D. Kugel technique [54]. The initial Kugel mesh had an abundant amount of foreign material present. Problems with the initial recoil ring resulted in pain and

FIGURE 9 | Jean Henry Alexandre (1931–2019).

FIGURE 10 | Franz Ugahary.

FIGURE 11 | Edouard Pelissier.

even bowel perforation. Another version of this mesh type contained a resorbable memory ring. The Kugel technique has often been compared to the TIPP technique [55]. This is where Franz Ugahary [56, 57] (**Figure 10**) and Edouard Pelissier [58] (**Figure 11**) come in and are seen as the two true pioneers of minimally invasive preperitoneal surgery: During the early 1990s they were thinking about how to place a prosthesis in the preperitoneal space in a decidedly less invasive way than the Stoppa and Rives techniques, used for complex cases by these authors and without wanting to embark on endoscopic surgery, which they found more invasive. In this period the TAPP was the most used endoscopic technique. Pelissier was convinced and familiar with techniques using the anterior route (modified Bassini, Shouldice) under local anesthesia, with the desire to promote outpatient care [59, 60]. He used the Stoppa Rives procedure for the more complex cases. In May 1990 he had the idea of using a pre-peritoneal prosthesis after hearing Gilbert [61] presenting his plug [62] at a conference in Nice during the first French international hernia surgery symposium. The plug was a 5 cm square of polypropylene opened from the middle of one side to the center and inserted through the deep inguinal opening, with the cord passing through the slit. However, the technique was not easy to achieve and there were not many indications. The second influence came from Rutkow and Robbins [63] who had designed the plug, which was introduced through the hernial orifice, but the prosthesis was not spread flat. Although the results seemed very good in terms of recurrence, it came at the cost of a rate of chronic pain (8.6%) due to the shrinkage of the prosthesis, which ended up forming a sort of hard core [64]. These two relative failures confirmed our pioneer in his first idea; to invent a prosthesis that spreads flat in the pre-peritoneal space, introduced through the hernia orifice, self-deploying, and by performing an intervention preferably under local anesthesia. Local anesthesia was associated with an outpatient procedure at this period, and already widely practiced in many countries, but unfortunately not in several others where it was almost impossible for reasons of organization of the health system, including France. But the idea of outpatient surgery was still on the minds of many. Pelissier began to work extensively from 1999 with the development of different prototypes which finally led in September 2004 to the launch of the first prosthesis specifically dedicated to being spread forward in the pre-peritoneal space: the Polysoft prosthesis. The prosthesis would first be split to allow passage for the cord [58], using the principle of the split prosthesis as in the Gilbert and Liechtenstein procedures, which was easier. Very quickly interested in Pelissier's principle, Frederik Berrevoet (**Figure 12**) and Stephen de Gendt had invited E. Pelissier to the University Hospital of Ghent for a workshop. Frederik Berrevoet was not satisfied with Lichtenstein's technique which was mainly used in Belgium at that time and not convinced by the intraperitoneal route of the TAPP endoscopic technique which was spreading more quickly than the TEP technique. They immediately used the technique with the specific prosthesis but without splitting he prosthesis and therefore parietalizing the cord [65, 66]. And

FIGURE 12 | Frederik Berrevoet.

FIGURE 13 | Jean François Gillion and Jean Michel Chollet.

Pelissier would quickly make the parietalization, because of two recurrences through the split in the prosthesis [61]. It is very interesting to point out that the technique was thus finalized by E. Pelissier, F. Berrevoet, S. De Gendt and colleagues in Belgium and quickly disseminated in France by J.F. Gillion and J.M. Chollet [67, 68] (**Figure 13**) and finally called Trans Inguinal Pre-Peritoneal (TIPP). It still appeared difficult to achieve for certain colleagues who returned to the Lichtenstein technique, after having learned the technique from the first promoters who organized workshops in their respective operating rooms, as observed by E. Pelissier [61]. And for the same reason two authors rom Porto, A. Lourenco and R. S. da Costa, developed the Onstep technique in 2005, pursuing the idea of splitting the prosthesis and simplifying the learning of the technique by avoiding the parietalization step [69]. Onstep technique is a partially preperitoneal technique as the lower and medial part of the prosthesis are in the preperitoneal space and the upper and lateral part are positioned as in the Lichtenstein technique, under the aponeurosis of the external oblique muscle.

We can thus realize that in this adventure one of the points of friction remains the notion of parietalization ! Let's look at this:

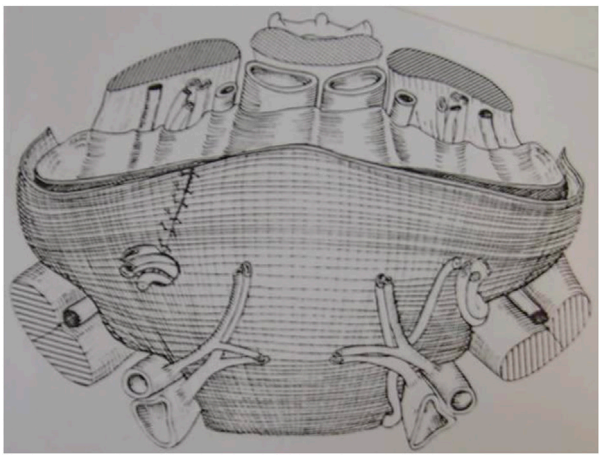

FIGURE 14 | Stoppa: The great prosthesis for the reinforcement of the visceral sac (GPRVS).

Due to the not the experience of surgeons, this step of parietalization has slowed down the dissemination of the posterior route. This is why René Stoppa in 1973 published the drawing of his intervention "the Giant Preperitoneal Repair" (GPPR), one side with parietalization and the other side with a slit in the prosthesis even though in his practice he never split the prosthesis (**Figure 14**). If Acquaviva [24, 25] and Bourgeon [27, 28] were pionners to develop the principle of spreading a prosthesis in the preperitoneal space, it was Usher, who was the first in 1959 to publish the principle of parietalization of the cord as Read recalls [29]. Read said: "Another valuable concept he (Usher) documented was the use of unsplit groin prostheses with overlap and interrupted suturing lateral to the internal inguinal ring to allow extended preperitoneal obliquity of the spermatic cord. In his own (Usher) words: "Rather than cut a notch in the mesh, we prefer to suture the lateral border of the mesh well lateral to the curving border of the internal oblique muscle, providing a 'shelf' for the cord to rest on, and preserving the normal obliquity of the internal ring." Here is yet another reason to highlight Usher, this formidable precursor who epitomizes the best of 20th Century Herniology" [29]. In 1992, Jean Henri Alexandre was the first to propose the parietalization of the cord by an anterior inguinal incision, making his technique an early version of TIPP [52, 53]. Everything accelerated with the arrival of endoscopic surgery during the early 90s, with very gradually an acceptance of the posterior approach using the principles of Stoppa (Totally Extra Peritoneal technique, (TEP)) and facilitating the understanding and realization of the necessary parietalization, thanks to the magic of video images.

After this brief digression we can address the contribution of Franz Ugahary. At this period, it was interesting to note that exactly like Pelissier, Ugahary used Bassini and Lichtenstein as basic techniques, and Stoppa-Wantz for complex cases. In Ugahary's mind the idea was to precisely reproduce the unilateral Stoppa (Wantz technique) by minimally invasive and purely posterior route. Thus, the Grid Iron type technique

was born in 1995, influenced by the seamstress talents of the author's grandmother, perfectly explaining Ugahary's specific way of unrolling a classic or even lightweight mesh through a small incision [57]. With his technique, Ugahary is the true founder of the minimally invasive and minimal open totally preperitoneal and totally posterior technique. Ugahary's strength was to propose new surgical principles, small "grid-iron" incision and specific dissection technique with special valves, to succeed in reproducing Wantz's technique, with the possibility of using any regular or lightweight flat mesh and above all, allowing a technique that can be carried out under local anesthesia on an outpatient basis. For Pelissier, it was the invention of the prosthesis which allowed the realization of the TIPP technique, while Ugahary created a new operating technique that could use the then available basic meshes. Initially also being a vascular surgeon and having extensive experience in the extraperitoneal approach to large vessels [70], Ugahary took his perfect knowledge of anatomy, and he was very close to René Stoppa and Georges Wantz particularly. Finally, it was Ugahary who succeeded Wantz's project, which was to perform a unilateral Stoppa in outpatient settings. His technique was immediately adopted by Georges Wantz, a very renowned hernia surgeon in New York, in the same way as his personal technique, especially after a demonstration carried out by F. Ugahary at the medical Hospital-Cornell Medical Center New York [70].

In 1997 René Stoppa, a close friend of Wantz and who directly inspired his technique, had visited Franz Ugahary in Tiel, Netherlands, who then immediately praised his technique as we can read in this letter addressed to F. Ugahary on 31 October 1997 [71]. "... I appreciated the principles of your operation: a posterior approach of Fruchaud myopectineal hole, a large piece of prosthetic mesh, your trend toward minimization of the wall surgical aggression (mini and grid-iron incision) ... For me, your technical proposition seems to take place between Nyhus' or Wantz' operations through supra-inguinal incisions on one hand, and ours on the other hand ... For transmitting, publishing, and teaching your technique, I suggest that you accurately describe every step and guide-marks. Mentioning pitfalls and errors are also a well-advised pedagogical precaution. Don't forget that you are a gifted skilled surgeon, compared to many colleagues ... " The last sentence was loaded with meaning: is the technique easily reproducible? Stoppa asked me the same question directly while I was presenting the technique to the French academy of surgery in 2004 [72].

The first step of the original technique is the 3 cm incision above the deep inguinal ring as a McBurney incision without the incision of the peritoneum (Grid iron); the huge dissection in the preperitoneal space, typical for the Ugahary technique with different sizes of atraumatic retractors; the reduction of a medial sac, if any; the parietalization of the cord with a dissection of a lateral sac, if any; the checking of the femoral and obturator areas; the use of a 15 by 10 cm regular flat mesh or a lightweight mesh unrolled in the dissected space. No mesh fixation needed. No suture on the musculo fascial plane (transversalis fascia) [57].

In 2000, I was informed of the existence of the Kugel technique [73, 74] which was not yet available in Europe. At that time, I used to operate groin hernias usually with the endoscopic TAPP technique. I asked Stoppa for his opinion on the Kugel technique, He informed me that he knew the technique and had spoken twice with Kugel and without further comment he quickly advised me to visit F. Ugahary ... After two short stays in Tiel (Netherlands), and the time necessary to assemble specially manufactured (and patented) instrumentation, I was able to carry out the technique in 2001. It quickly and definitively replaced my TAPP endoscopic technique. I preferentially used the original Ugahary technique between 2001 and 2011 for more than 1,000 hernia repairs with good results. A prospective study on the first 300 operated hernias has been published [72] by the French National Academy of Surgery in 2004. It showed the good results of the technique in terms of recurrence and chronic pain.

The unrolling of the flat mesh through the small incision according to the initial Ugahary technique appeared difficult to reproduce for many colleagues. To successfully carry out the intervention through a 3 – 4 cm incision, it was also necessary to have experience in the dissection of the pre-peritoneal spaces, to be familiar with the parietalization of the spermatic cord, to know how to handle the flexible parietal prostheses (flat polyester or polypropylene mesh, lightweight meshes ...) available at this period and to have the appropriate instrumentation (specific valves). For all these reasons, most surgeons still preferred the Lichtenstein technique, with less frequently endoscopic techniques, and while a few surgeons successfully used Ugahary's principles, there were not many. I remained very motivated because I thought i had a very promising technique: on the one hand the good principles of a pure posterior preperitoneal approach: on the other hand, its resolutely minimally invasive nature, and finally with these very promising results in some hands. And even after having organized workshops in Cagnes sur Mer and after having presented the technique and its results in all directions (Congresses, French Academy of Surgery, publications) [72, 75, 76], it still appeared difficult to understand for many colleagues and therefore difficult to reproduce.

But as we detailed above, with the same state of mind (except that it is not a pure posterior route), we were joined by the TIPP technique. Following the ingenuity of Edouard Pelissier, it was easier to manipulate the prosthesis specifically created to be placed from the front in the preperitoneal space, which was very difficult to do with prostheses used endoscopically or with other prostheses available at this period.

So, I had the idea (**Figure 15**) of combining some principles of Ugahary with others of TIPP. I visited Frederik Berrevoet, and Steven De Gendt in Ghent University Hospital in Oct 2007, and Jean François Gillion and Jean Michel Chollet in Antony Private Hospital near Paris to see the TIPP technique in some of the best hands. I carried out this project in 2011. The MOPP technique follows most of the steps of the TIPP technique: from the incision (which is somewhat reduced), the passage at the level of the inguinal canal through the deep inguinal ring, to the spreading of a large prosthesis in the preperitoneal space, with the specific method of Ugahary: dissecting the planes using different sizes of

FIGURE 15 | Marc Soler.

dissectors and retractors. This particularly atraumatic technique eliminates the need for any haemostasis procedures in the deep planes.

The innovation hinges on the identification of the transversalis fascia (TF) during two pivotal steps: The TF covers the deep inguinal orifice. Recognizing it at this juncture initiates the entry into the preperitoneal space, paving the way for preperitoneal dissection. The TF also constitutes the internal spermatic fascia. Identifying and severing it systematically commences the parietalization of the cord elements. Rationalizing these two essential steps for placing a large prosthesis in the preperitoneal space makes the technique more easily reproducible and teachable. The publication with the help of the specific French database (only used by parietal specialists) have shown very good results on the technique in the hands of the author [77, 78]. More long-term results and a very precise presentation of all the stages of the technique were published in 2024 [79]. The results concerning 1,401 patients show a very low recurrence rate and chronic pain.

Willem Akkersdijk has also tackled the challenge in 2006 with the Trans Rectus sheath Pre-Peritoneal (TREPP) technique [80], a sutureless technique in the same spirit as the Ugahary technique but using the TIPP (Pelissier) prosthesis! TREPP added a significant advantage to the open and minimally invasive preperitoneal approach. It is a perfectly codified [81], with 9 steps, pure posterior approach therefore leaving the anterior planes completely untouched unlike the TIPP and MOPP techniques which are techniques that open the inguinal canal. The TREPP technique is perfectly suitable for nearly all kind of groin hernias, including some of recurrent ones [82–84]. As W. Akkersdijk said [85], "TREPP was developed in the era of endoscopic surgery. The preperitoneal space had gained popularity and the upstream principle was advocated as a logical way to keep the mesh in the right position, even without fixing it and to minimize the chance of recurrences. TREPP has not always been called the same. In the beginning it was called the rectus sheath approach. The absence of a posterior rectus fascia was one of the reasons this route was chosen to reach the preperitoneal spaces just beneath the lateral edges of the rectus muscle. Compared to other open preperitoneal techniques, Ugahary, Pelissier, Rives-Stoppa, with the TREPP technique, the dissection was minimized and the view on the internal ring was optimized by the point of entrance of the preperitoneal space." W. Akkersdijk insists on the fact that "muscle tension may also cause problems in the creation of the preperitoneal space. Optimal muscle relaxation can be reached by spinal anesthesia or like in endoscopic groin surgery, general anesthesia."

It seemed obvious to all the pioneers of the new open approach that this minimal open route was much less invasive than endoscopic techniques known as minimally invasive techniques (MIS)! But these were only expert opinions without published studies with a high level of evidence. . .

It is only in recent years that the literature has provided data about TIPP and TREPP, with comparisons to other techniques and has shown good results of this third way of operating on inguinal hernias. However, drawing parallels to other preperitoneal techniques suggests that MOPP's outcomes might align with other open or endoscopic methods such as TREPP, TEP and TAPP. Hurel and colleagues [86] support this assumption in their conclusion from a recent propensity score matching analysis comparing 1-year postoperative chronic pain using Lichtenstein, TIPP (including MOPP), TAPP and TEP techniques. Their findings highlight Lichtenstein's clear disadvantage and an indistinguishable difference between TIPP (including MOPP), TAPP and TEP. To further explore the potential benefits of the open preperitoneal approach, consider this study by M. Reinhorn and colleagues [87] which emphasizes the potential benefits of open posterior mesh placement (TREPP) over endoscopic repair in terms of short-term Quality of Life (QoL) and seroma formation, with equivalent hernia recurrence rates. Agarwal et al. [88] show the advantages of TREPP/MOPP over Lichtenstein regarding patient-reported QoL, sustained for a year, and reduced opioid intake 30 days post-surgery. Zwols [89] and Koning [90] also highlight the superiority of preperitoneal techniques over the Lichtenstein method. J.L. Faessen [91] shows in pilot study that TREPP is comparable to TEP and Lichtenstein in terms of recurrence rates, chronic post-operative inguinal pain, and clinically significant adverse events.

CONCLUSION

Ongoing studies expert are published in the same JAWS special issue provide additional information regarding the treatment of scrotal hernias using the MOPP technique [92], as well as another study comparing the results of the treatment of scrotal hernias using TIPP/

MOPP versus Lichtenstein and endoscopic techniques [93]. I hope that this article and the special issue dedicated to the modern preperitoneal minimally invasive route will open lots of eyes. New studies, randomized, or as I think, using smart data from specific databases, must confirm the advantages or equivalences of these techniques compared to the other two groups. It should be interesting to highlight the advantages due to the minimally invasive nature, making it possible to operate on more complex hernias and the most fragile or elderly patients, using a large preperitoneal prosthesis and thus avoiding the Lichtenstein technique more commonly used in these patients. But, at this moment, this is still only the idea of a small percentage of surgeons. As Usher experienced as reported by Read, as Rives experienced and expressed to me, as Fruchaud experienced as reported by Stoppa, innovators often struggle to move their ideas forward and bring them to fruition. This is perhaps what is happening to the promoters of minimally invasive preperitoneal surgery who for nearly 30 years have been campaigning for this third way, having the virtues of the great principles currently accepted and the virtues of less invasiveness, and more economical and more ecological. Time will tell whether this path will have its place or whether it will only delay the use of new technologies for all.

AUTHOR CONTRIBUTIONS

MS writing, reviewing.

FUNDING

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

GENERATIVE AI STATEMENT

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JOURNAL OF ABDOMINAL WALL SURGERY | EUROPEAN HERNIA SOCIETY

ORIGINAL RESEARCH
published: 04 February 2025
doi: 10.3389/jaws.2024.13840

Acceptance of Open Preperitoneal Repair in Inguinal Hernia Surgery Delphi-Consensus After an Anonymous International Survey Among European Hernia Society Members

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Introduction: For years, the Lichtenstein technique was the gold standard for open repair, but several open pre-peritoneal techniques have developed since the fifties of the 20th century that offer some benefits over the Lichtenstein technique in terms of post-surgical incidence of pain. Since the 2023 update of the International HerniaSurge Guidelines, open preperitoneal mesh techniques have been an acceptable alternative, providing available expertise and competence with at least equal results as Lichtenstein repair.

Aim: The aim of this project is to understand the views of surgeons regarding the approach to inguinal hernia repair and determine best practice principles for optimal surgical outcomes.

Methods: Using a modified Delphi method, a panel of experts developed 43 Likert scale statements across six key domains. These statements were used to develop an online survey distributed to surgeons in Europe involved in inguinal hernia repair. The threshold for consensus was set *a priori* at 75%.

Results: A total of 202 responses were received from surgeons involved in inguinal hernia repair over three rounds of survey. After the initial survey round, seven statements were revised and reissued for a further round. At the conclusion of the survey phase, 31 of the 38 remaining statements achieved consensus (of which 13 achieved ≥90% agreement). From these results, the panellists developed a set of 3 recommendations to help define principles for optimal approach to inguinal hernia repair. Accordingly Open preperitoneal techniques seems to be an alternative to Lichtenstein technique if expertise is available and should be included in a tailored concept. Knowledge of anatomy, Education and Training in open preperitoneal techniques is crucial for the acceptance of these techniques.

OPEN ACCESS

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Received: 22 September 2024
Accepted: 20 December 2024
Published: 04 February 2025

Citation:
Lorenz R, Akkersdijk W, Paiva De Oliveira G, Warren T and Soler M (2025) Acceptance of Open Preperitoneal Repair in Inguinal Hernia Surgery Delphi-Consensus After an Anonymous International Survey Among European Hernia Society Members. J. Abdom. Wall Surg. 3:13840. doi: 10.3389/jaws.2024.13840

Conclusion: The proposed set of recommendations provides some principles for surgeons to consider when selecting an approach to inguinal hernia repair, ensuring good patient outcomes in a practical and cost-effective manner.

Keywords: inguinal hernia, groin hernia, open preperitoneal techniques, Delphi-consensus, tailoring

INTRODUCTION

Groin hernia repair is one of the most common surgeries performed globally on around 20 million people annually [1, 2]. There are two main types of groin hernias: femoral hernias and inguinal hernias [3]. The majority of inguinal hernias are symptomatic, and surgery is the only curative treatment. Even amongst the minority of patients who are asymptomatic and managed with a watch-and-wait approach, surgery will be required within 5 years in approximately 70% of cases.

Hernia repair may be undertaken as open ("classical") or laparoscopic [4] surgery. In addition, the specific surgical technique chosen for a repair is influenced by several factors: the need to use a synthetic mesh for reinforcement of the repaired posterior wall, individual patient factors (such as obesity), primary or recurrent hernia, patient preference, and surgeon experience.

Both open and laparoscopic techniques are associated with low rates of recurrence, but laparoscopic surgery is generally associated with lower rates of chronic pain (when compared to some open techniques). Chronic pain after inguinal hernia surgery can occur in up to 10%–12% of cases [5].

While surgery is successful in most cases, recurrence of hernia affects over 10% of cases, with 57% occurring within 10 years of surgery [6].

Open preperitoneal mesh techniques are a long-standing and globally accepted option for the treatment of inguinal hernias. Since the fifties of the 20th century, numerous surgical techniques have been developed. Since the 2023 Update of the Herniasurge Guidelines, an open preperitoneal mesh technique has been an acceptable alternative, providing available expertise and competence with at least equal results as Lichtenstein repair [7]. Regarding the use of mesh, international HerniaSurge guidelines recommend the use of a mesh in the majority of cases, noting that "Although there is strong evidence that mesh repair is superior to non-mesh, there are cases in which a non-mesh repair can be suggested" [7].

Both open and laparoscopic techniques are associated with low rates of recurrence, but laparoscopic surgery is generally associated with lower rates of chronic pain. However, laparoscopic surgery requires access to endoscopic equipment with suitably trained surgeons and is therefore associated with greater costs and a steeper learning curve [8, 9].

Open tension-free mesh repair (Lichtenstein) is a popular technique due to its easy reproducibility by non-specialist surgeons [9]. Whilst this technique is associated with low recurrence and complication rates, there are concerns over reported chronic post-surgical pain [10]. Over time, alternative open repair techniques (e.g., open new simplified totally extraperitoneal, "ONSTEP"; TransREctus sheath Preperitoneal, "TREPP"; TransInguinal Preperitoneal repair, "TIPP" and Minimal Open PrePeritoneal repair, "MOPP") have strived to offer the simplicity of the Lichtenstein method while reducing the risk of chronic post-surgical pain. Open approaches have been used safely and effectively for a number of years, but their evidence is limited, and the choice of approach may be based on surgeon experience [5]. Due to difficulties in conducting an RCT in surgery, there is often a lack of comparative data to determine the optimal approach. An alternative, albeit with weaker evidence, is to capture the expert opinion of European surgeons regarding aspects of inguinal hernia repair [11].

The aim of this project is to understand the views of surgeons regarding approach to inguinal hernia repair, and determine best practice principles for optimal surgical outcomes.

METHODS

Following an independent facilitator (Triducive Partners Ltd.)'s review of available literature, a steering group of European surgeons experienced in inguinal hernia repair (see Author list) convened in December 2022 to discuss surgical methods employed in inguinal hernia repair. The steering group was selected based on published research and experience in inguinal hernia surgery.

This project was funded by BD Medical Ltd. by supporting the costs of the methodological process, which was performed by Triducive Partners Ltd. Ian Walker and Tim Warren are employees of Triducive Partners Ltd. and acted as facilitators during the expert group discussions to identify key topics and to generate the consensus statements. The survey distribution was supported by the European Hernia Society (EHS), and Triducive Partners Ltd. performed an independent analysis of the results.[1]

Using a modified Delphi methodology (see **Figure 1**) guided by the independent facilitator, the steering group identified six main domains of focus:

1. Indication and diagnosis
2. Selection of patients (the right patient for the right procedure)
3. Technical considerations and best practice
4. Management of complications and risk
5. Wider impact of various surgical approaches
6. Education support required to support outcomes

These domains were each discussed by the steering group and 42 statements were initially agreed. The steering group members reviewed the statements independently to remove, add or change

[1]Triducive privacy policy can be found at https://triducive.com/privacy-policy/

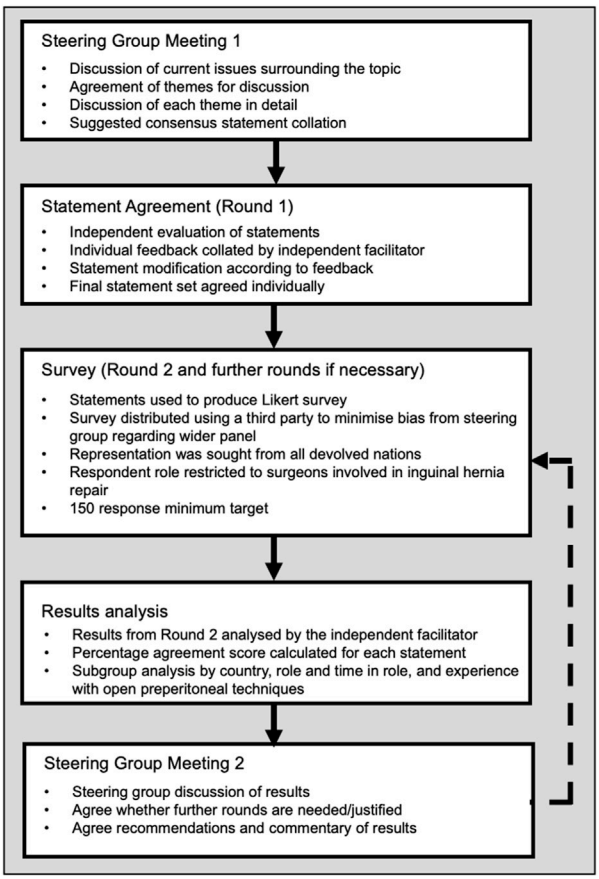

FIGURE 1 | Modified Delphi study design.

any statements. Suggestions were upheld if either they provided more clarity to a statement or were agreed by a simple majority of the group. The resulting 41 statements were then used to develop the final agreed statement set for wider testing. This constituted the first round of the process.

The survey was distributed using a snowball method by the steering group members to inguinal hernia surgeons and professional societies, including the European Hernia Society (EHS), for distribution to their membership. A further review by EHS for accuracy and balance resulted in a finalised set of 43 statements. A consequence of using this approach is that it is not known how many individuals the survey was sent to, and so a response rate cannot be calculated. In October and November 2023, this anonymised survey with these statements was sent out to EHS members. Each online questionnaire response entered an MS-Excel-based program. The results were evaluated as part of a Delphi Consensus (>90% agreement = strong consensus, >75–90% consensus, <75% no consensus).

The survey presented each statement along with a 4-point Likert scale ("strongly disagree," "tend to disagree," "tend to agree," and "strongly agree") to allow respondents to indicate their corresponding level of agreement. The survey also captured some demographic data for further analysis. Demographic data captured included surgical speciality, country, time in a professional role, and general experience with open preperitoneal inguinal hernia repair (and specifically familiarity with open new, simplified, totally extraperitoneal (ONSTEP) technique). All responses collected from respondents based in Europe were included in the final analysis.

Stopping criteria were established as the minimum target of 150 responses in Round 2, with 90% of statements passing the threshold for consensus and a threshold for consensus set at 75% (a widely accepted threshold [12]). Consensus was then further defined as "strong" at ≥75% and "very strong" at ≥90%. If these criteria were not met, the steering group had the opportunity to modify those statements that fell below the threshold for consensus and reissue them for subsequent rounds of the survey.

A statement of consent was included at the start of the survey and consent was implied by completion and submission of the survey. As this study only collected the anonymous opinions of surgeons and no patient specific data was captured, ethical approval was not sought.

Completed surveys were collated and analysed by the independent facilitator to produce an arithmetic agreement score for each statement. This information was then reviewed by the members of the steering group to determine what recommendations and conclusions could be developed based on the responses received.

RESULTS

During the first round of consensus testing with the members of the steering group, the initial set of 42 statements was critically reviewed to determine the final set of statements for broader testing. From this first round, one statement was removed, 18 statements were modified and agreed upon, no new statements were included, and 23 statements were agreed upon for inclusion without modification, producing a final set of 41 statements for testing with a broader panel of experts. Distribution by EHS was pursuant to an additional review for balance and accuracy. This review resulted in the addition of two statements and further modification of 10 existing statements, which the steering group agreed upon, resulting in a final set of 43 statements.

221 (180 + 41) surgeons responded after the first, second and third rounds of the survey.

Surgeons from 37 countries worldwide took part in this survey.

The second round of testing comprised the broader body of European inguinal hernia surgeons.

Of this second round, 180 responses were collected, of which 18 were from non-European respondents, which were not included in the final results set. Of the 162 responses included in the analysis, 105 were from general surgeons, 26 gastrointestinal surgeons, 15 abdominal wall surgeons, 14 hernia surgeons and 2 colorectal surgeons. Responses were received from 27 European countries, the largest responder groups being Portugal (n = 44), Germany (n = 27), Italy (n = 19), France (n = 17), and Spain (n = 14); all other country responses were ≤5.

Results from Round 2 showed very strong agreement (≥90%) in 13/43 (30%) statements, strong agreement (<90%

TABLE 1 | Defined consensus statements and corresponding levels of agreement attained (R2: n = 162, R3: n = 40) Statements with Strong consensus, consensus, No consesus.

No.	Statement	Agreement
Topic A: Indication and diagnosis		
1	The indication for surgery will be overestimated less frequently if the patient is informed and an active part of the decision-making process	82%
2	Decisions regarding surgery should always involve understanding the patient history and should take into account the patient's views	97%
3	All other reasons for groin pain should be identified and excluded prior to any hernia surgery	94%
4	The patient must know the objectives of the surgery, and know that in some cases there will be persistence of all or part of the preoperative pain	98%
5	A physical examination is the basis for identifying and assessing inguinal hernia in patients with groin pain	96%
6	Symptomatic hernias should be operated on if the patient understands the potential outcomes and makes an informed decision	98%
7	Asymptomatic hernias should be operated on if they are at high risk of complication or there are patient factors such as significant anxiety, lifestyle requirements, etc.	89%
Topic B: Selection of patients for open pre-peritoneal approach		
8	Open pre-peritoneal procedures are valid options for inguino-scrotal hernias and incarcerated hernias	78%
9	Obesity is a complicating factor for inguinal hernia surgery	88%
10	Laparoscopic techniques are preferred for morbidly obese patients with inguinal hernias	86%
11	Open inguinal hernia repair offers more intraoperative opportunity for tailoring the approach in inguinal hernia repair	68%
Topic C: Technical considerations and best practice in open pre-peritoneal approach		
12	It is possible to change technique without conversion (that is, changing the technique without changing the plane to place the mesh) during surgery when using open pre-peritoneal surg…	77%
13	Open pre-peritoneal approaches allow for a range of anaesthetic approaches (e.g., general, local and spinal) to be used	89%
14	Open pre-peritoneal approaches reduce the need for curarisation and endotracheal intubation	75%
15	A pre-peritoneal approach covers the whole myopectineal orifice (MPO) with a prosthesis whose size is adapted to the patient and the type of hernia	81%
16	There are several open preperitoneal approaches (e.g., TREPP, TIPP, Open new simplified totally extra peritoneal (Onstep), and MOPP) leading to a pre-peritoneal mesh position that cover…	86%
17	Open preperitoneal techniques such as TREPP (TransREctus Sheath PrePeritoneal) and TIPP (TransInguinal PrePeritoneal Technique) are associated with a shorter operating time compared to Lichtenstein repair (assuming all techniques are delivered by properly trained surgeons)	50%
18	Open preperitoneal techniques are associated with an earlier return to normal daily activities compared to Lichtenstein repair (assuming techniques are delivered by properly trained surgeons)	55%
19	Open preperitoneal techniques are associated with fewer postsurgical complications compared to Lichtenstein repair (assuming techniques are delivered by properly trained surgeons)	50%
20	Open new simplified totally extraperitoneal (ONSTEP) surgery is well suited to non-obese patients with small to medium sized hernia	73%
Topic D: Management of complications and risk		
21	Contrary to Lichtenstein repair (where the femoral control is not always well realised), open pre-peritoneal approaches diminish the risk of missing a femoral hernia	75%
22	Contraindications relating to both the patient and the type of hernia should inform the choice of surgery provided	95%
23	Open pre-peritoneal techniques have a comparable incidence of acute post-operative pain compared to endoscopic techniques (assuming both techniques are delivered by properly trained surgeons)	65%
24	Open pre-peritoneal procedures have a comparable incidence of chronic (>1 year) post-operative pain compared to endoscopic techniques (assuming both techniques are delivered by properly trained surgeons)	75%
25	Open pre-peritoneal approaches reduce the impact of mesh nerve contact	76%
Topic E: Education support required for open pre-peritoneal surgery		
26	Knowledge of the surgical anatomy of the anterior and posterior approach is crucial in future education	100%
27	Poor understanding of the surgical anatomy anterior and posterior leads to poor outcomes in Inguinal Hernia Surgery	99%
28	Open pre-peritoneal surgery is easier to learn than laparoscopic surgery	47%
29	Step-by-step modules exist to help education of the techniques available for Inguinal Hernia Surgery	81%
30	Education about Inguinal Hernia Surgery should be led by experts in the field, as part of a specialized education (specific diploma) or with personalised tutoring	88%
Topic F: Technical aspects of use		
31	Many patients are unaware of the different available inguinal hernia surgery options	95%
32	Any hernia surgery option should involve joint decision-making discussions between the patient and surgeon	93%

(Continued on following page)

TABLE 1 | (*Continued*) Defined consensus statements and corresponding levels of agreement attained (R2: n = 162, R3: n = 40) Statements with Strong consensus, consensus, No consesus.

No.	Statement	Agreement
33	The needs/expectations of the patient should be sought and considered before agreeing the appropriate hernia surgery	96%
34	Improving patient education about hernia surgery options would be beneficial	90%
35	The management of environmental resources should be an increasingly important component when considering hernia surgery options	90%
36	Open surgery using a local anaesthetic has a lower environmental impact than laparoscopic surgery requiring general anaesthesia	75%
37	The management of financial resources is an increasingly important component when considering hernia surgery options	86%
38	The resources of the surgical institution may impact the range of options available for use	92%

and ≥75%) in 16/43 (37%) statements and failure to achieve consensus agreement threshold in 14/43 (33%) statements. Of those that failed to achieve consensus, five statements were removed, seven were reworded, and it was agreed that the remaining two would be reported but not revised. Seven statements were retested with the more comprehensive panel in Round 3.

The final results from Rounds 2 and 3 show consensus agreement for 31 of the 38 remaining statements (of which 13 achieved ≥90% agreement), consensus agreement was not achieved for 7/38 statements (n = 202), results are shown in **Table 1** and **Figure 2**.

DISCUSSION

Topic A: Indication and Diagnosis

There was strong agreement for all statements in Topic A, suggesting a recognition of two key principles:

1. Patients should be informed of the objectives of surgery and involved in the decision-making process and the likelihood of continuance of preoperative pain.
2. The need for and objectives of inguinal repair surgery should be based on a thorough physical examination of the patient, including careful consideration of the patient's history and exclusion of all other reasons for groin pain.

Given that more than 2 in 3 individuals with asymptomatic hernias will require surgery within 5 years, surgery for asymptomatic hernias should be considered if there is a high risk of complication or the patient has significant anxiety or lifestyle requirements.

Topic B. Selection of Patients for Open Pre-Peritoneal Approach

Respondents agree that open preperitoneal procedures are valid for inguinal hernia repair (S8, 78%). The respondent group also supports the use of laparoscopic techniques for inguinal hernia repair in obese patients, reflecting evidence that open surgery in these patients is associated with a greater incidence of deep surgical site infection, wound dehiscence, or return to the operating room [13].

Topic C: Technical Considerations and Best Practice in Open Pre-Peritoneal Approach

The responder panel reached a consensus agreement regarding some of the valuable features of open pre-peritoneal repair techniques:

- They offer the possibility of changing the technique used without changing the plane used to place the mesh (S12, 77%).
- They can be used with a choice of anaesthetic approaches (as opposed to laparoscopic methods, which require general anaesthesia), potentially reducing the need for curarisation and endotracheal intubation (S14, 75%).
- Employs a mesh to cover the whole MPO, thereby reducing the risk of hernia recurrence in this area comprising Hasselbach's triangle, deep inguinal ring, and the femoral canal (S15, 81%) [14].
- In addition, open pre-peritoneal techniques allow a complete exposure of the MPO to aid in the identification of all possible hernias in the inguinofemoral region [5].

Agreement levels for statements 17–19 are interesting; there is evidence to suggest that some open preperitoneal techniques offer advantages over Lichtenstein repairs, and conversely, there is evidence that there is no significant difference [15–17]. A meta-analysis comparing postoperative outcomes in inguinal hernia repair with transinguinal preperitoneal (TIPP) versus Lichtenstein techniques found that TIPP was associated with a lower operating time, less chronic pain, and lower rates of paresthesia compared to Lichtenstein [15].

A prospective study by Berri et al. found that ONSTEP surgery required significantly less time (42 vs. 62 min; $p < 0.001$), with fewer postsurgical complications (5 vs. 19; $p = 0.001$), and that patients resumed daily activities sooner (5.94 ± 3.9 days vs. 8.56 ± 5.14 days; $p = 0.009$) and expressed better satisfaction with the cosmetic result ($p = 0.041$) compared with Lichtenstein [16].

Analysis of statements 17–19 by responder who declared employment of open preperitoneal techniques in clinical practice shows a predictable response: those who use these techniques as their primary surgical approach (n = 13) tend to agree with these statements, those who used them "rarely" or "never" tended to disagree. This supports the idea that the optimal technique to use in inguinal hernia repair is one that the surgeon is experienced and skilled in performing.

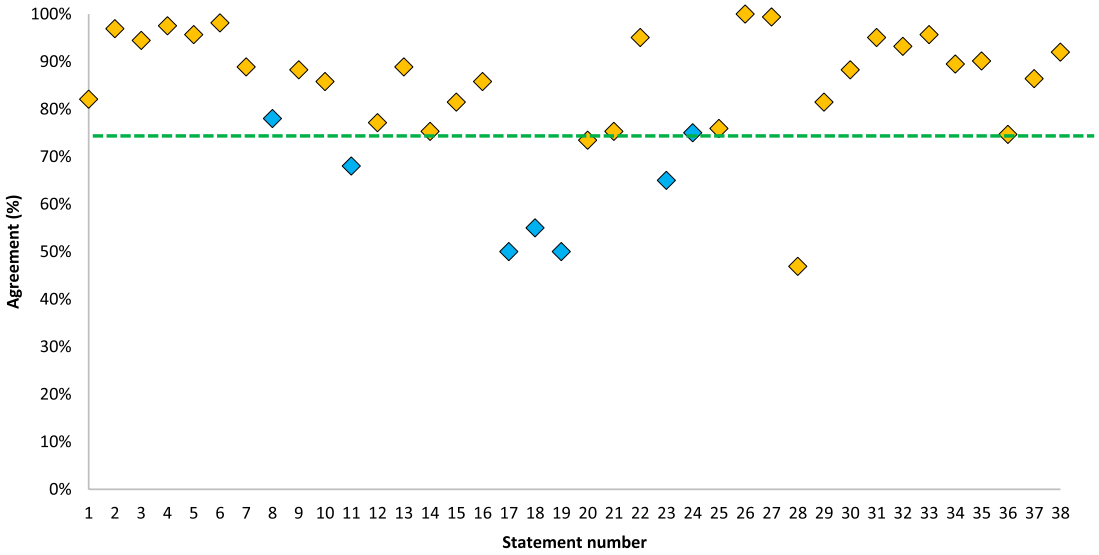

FIGURE 2 | Combined consensus scores across 39 statements. The green line represents the threshold for consensus (75%). Points in orange = Round 2 (n = 162) accepted results, Blue = Round 3 (n = 40) results.

Responses to statement 20 (which just fell short of consensus at 73%) also follow a similar pattern to statements 17–19; the specific wording of the statement may have caused some lack of agreement to clarify whether the statement was intended to provide some definition of the patient characteristics that ONSTEP is most suitable for, not establish a preference. As stated, inguinal hernia in obese patients may be better suited to laparoscopic repair; therefore, logically, open techniques are better suited to non-obese patients. The authors, therefore, suggest that ONSTEP is most suitable in non-obese patients with small-to-medium-sized hernias.

Topic D: Management of Complications and Risk

Respondents agree that open pre-peritoneal approaches are associated with a lower risk of missing a femoral hernia, this is due to the nature of the approach which provides a good view of the ileopectineal orifice and therefore a greater opportunity to examine for femoral hernia [18].

Regarding pain, respondents did not agree overall that the incidence of acute post-operative pain was comparable between open pre-peritoneal and laparoscopic techniques (S23; 65%) but did agree that chronic pain incidence was comparable (S24, 75%). These results are representative of the limited available evidence. Whilst comparative data exists to support similar incidences of post-surgical pain for open pre-peritoneal and laparoscopic techniques [19, 20], these studies do not specifically discuss acute pain. However, they are limited to reported pain at intervals of weeks or months after surgery. In contrast, there is some evidence to suggest that laparoscopic trans-abdominal pre-peritoneal (TAPP) repair is associated with lower acute post-surgical pain than open pre-peritoneal or Lichtenstein methods [21].

There was also consensus that open preperitoneal approaches reduce the impact of nerve contact from the mesh. Anatomically, this is due to the lack of nervous structures in the preperitoneal space, which renders interaction between the mesh and nerves absent [22].

Topic E: Education Support Required for Open Pre-Peritoneal Surgery

Throughout the results dataset, it is observed that those who use open pre-peritoneal approaches tend to answer more positively regarding statements concerning the efficacy and practical use of these techniques than those who prefer a laparoscopic approach. This is perhaps expected, and different methods should be considered for different surgical circumstances. A cohort study of 107,073 patients in the US [23] found no significant difference in complications between laparoscopic surgery and open repair under local anaesthesia, but operative time for laparoscopic repair was significantly longer (10.42 min). In summary, Meier et al. suggest that laparoscopic and open repair with local anaesthesia were reasonable options for patients with initial unilateral inguinal hernias, and the decision should be made considering both patient and surgeon factors.

Level of training, learning curve of procedure and surgeon volume are all factors that impact the outcome of a surgery [24]. Respondents very strongly agree that it is important that surgeons (particularly general surgeons) have a good knowledge of the of the surgical anatomy of both the anterior and posterior approaches and that future education should include this (S27, 100%; S28, 99%).

The lack of agreement with S28 is interesting, given that it is well established that laparoscopic techniques are associated with a steeper learning curve than open methods. HerniaSurge (2018) reports that trainees achieve proficiency after an average of

64 open repairs compared with more than 100 for laparoscopic repairs [1]. This should make open approaches a valuable choice for general surgeons or those with limited access to laparoscopic surgical resources.

Topic F: Technical Aspects of Use

It is concerning that respondents strongly agree that many patients are unaware of different surgical options for inguinal hernia repair (S31, 95%), particularly given the very strong agreement that shared decision-making is crucial between surgeon and patient (S32, 93%), and this is supported by HerniaSurge guidelines [7]. It is recommended that local processes are in place to ensure appropriate patient education and consultation are provided and decisions are made in alignment with the patient's individual needs.

Healthcare is responsible for almost 5% of global greenhouse gas emissions, and the growing climate crisis has been described as the greatest threat to global health in this century [25]. Respondents appear to recognise their personal responsibility for good carbon stewardship in the operating room and support the need to consider the environmental impacts of hernia surgery (S35, 90%). Anesthesia is a recognised carbon hot spot in surgery, and the use of local/regional anaesthesia is associated with lower environmental impact than general anaesthesia (particularly inhaled anaesthesia) [26].

Another concern amongst healthcare providers is the delivery of cost-effective and value-based healthcare, and surgeons agree that this is increasingly important when considering options for inguinal hernia repair (S37, 86%). Tied to this is the variation in resourcing of different surgical institutions, some of which may struggle to justify the associated additional cost/resource requirements of laparoscopic surgery, which is reported to be 41% greater in a US analysis [27]. The authors suggest that where access to laparoscopy is limited, open pre-peritoneal approaches should be considered.

Limitations

There are limitations to the statements due to the total number of hernia specialists participating in this survey. Furthermore, surgical colleagues interested in open preperitoneal techniques could be more represented in this survey which could increase adhesions and could influence the recommendations.

RECOMMENDATIONS

Based on the results obtained during the survey phase of this study and the following discussion held by the steering group, the authors offer the following set of recommendations:

1. A Tailored Approach to groin hernia surgery should include endoscopic and open techniques with and without mesh. The decision as to which technique is optimal for the patient should always be made individually, depending on the hernia and the patient's characteristics.
2. With open preperitoneal techniques, there are alternatives to the Lichtenstein technique, if expertise is available.
3. Knowledge of anatomy, Education and Training in open preperitoneal techniques is crucial for the acceptance of these techniques.

CONCLUSION

The acceptance of open preperitoneal procedures depends primarily on surgical expertise.

The advantages of open preperitoneal techniques lie primarily in the concept of intraoperative tailoring and in the selection of anaesthesia procedures up to and including implementation under local anaesthesia. In expert hands, there could also be advantages in terms of operating time, return to everyday activities and the occurrence of chronic pain.

Training plays a decisive role in this.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

This study was initiated and funded by BD. All authors RL, WA, GP, TW, and MS received honoraria from BD while undertaking this study. BD commissioned Triducive Partners Limited to facilitate the project, analyse the responses to the consensus statements in line with the Delphi methodology, and write the draft manuscript. BD reviewed the consensus statements and draft manuscript for technical accuracy only.

PUBLISHER'S NOTE

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JAWS JOURNAL OF ABDOMINAL WALL SURGERY | EHS EUROPEAN HERNIA SOCIETY

OPINION
published: 03 January 2025
doi: 10.3389/jaws.2024.13868

A Call to Change the Nomenclature of "Open" Inguinal Hernia Repair

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Keywords: inguinal hernia repair, laparoscopic inguinal hernia repair, MIS hernia repair, OPP, open preperitoneal inguinal hernia repair

In this edition of JAWS, many researchers have described numerous benefits of open preperitoneal (OPP) inguinal hernia repair. Overwhelming data suggests OPP inguinal hernia repair is a structurally sound, cost-effective approach for inguinal hernia repair with negligible rates of chronic groin pain and hernia recurrence [1–17]. The 2023 HerniaSurge Guidelines state that "open preperitoneal mesh techniques can achieve favorable results in terms of operating time, acute and chronic postoperative pain and return to work compared to Lichtenstein repair [17]." This is based on several recent randomized controlled trials that favor OPP to Lichtenstein for decreased pain and quicker recovery [18–21]. The guidelines also found that OPP and laparo-endoscopic approaches have comparable outcomes in terms of postoperative pain, recurrences and recovery, citing three randomized controlled trials [22–24]. Thus, OPP has outcomes that more similarly resemble those of Minimally Invasive Surgery (MIS) inguinal hernia repair [14, 17, 22–24] as opposed to Lichtenstein repairs.

Although OPP outcomes are more similar to those of MIS approaches, OPP is often categorized with Lichtenstein and tissue-based repairs in the broad category of "open" inguinal hernia repair [15]. We believe that categorizing these vastly different approaches together makes data collection and interpretation very difficult, leaving the surgical community unable to make clinically meaningful changes to improve patient outcomes. Furthermore, there are advantages of OPP compared to MIS approaches, such as decreasing cost, avoiding MIS equipment, and providing the opportunity to avoid general anesthesia [10, 14, 25–37]. We consider open preperitoneal repairs less invasive than the standard MIS operations as they do not enter the peritoneal cavity and are performed through one 3–4 cm incision instead of multiple incisions. The current standard, particularly in the United States, requires MIS equipment and general anesthesia to perform a preperitoneal inguinal hernia repair. In our view, this has created a platform for surgeons and device companies to market expensive technologies that may offer little to no benefit to individual patients while detrimentally increasing the cost of healthcare within our society. OPP provides a solution to this dilemma but needs more widespread acceptance, training opportunities and dedicated research with appropriate classification efforts to increase evidence-based recommendations.

The first step to distinguishing the benefits of OPP compared to other inguinal hernia repair techniques requires that the surgical community change the nomenclature regarding "open" inguinal hernia repairs. We have already done this for laparoscopic and robotic hernia surgery. We identify procedures by the anatomical planes, technology used, and location of mesh placement. We use terms like TAPP, TEP, and rTAPP to describe repairs that use laparoscopic or robotic technology to either enter the peritoneal cavity or stay in the pre-peritoneal plane. All of these procedures place mesh in the preperitoneal space and are commonly grouped together as "MIS" approaches in studies and publications. Similarly, several inguinal hernia repair techniques exist using an "open" approach. However, as previously mentioned, these approaches are significantly different from one another – both in planes dissected and placement of mesh - and have expectedly

OPEN ACCESS

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Received: *29 September 2024*
Accepted: *09 December 2024*
Published: *03 January 2025*

Citation:
Blake K, Fullington N and Reinhorn M (2025) A Call to Change the Nomenclature of "Open" Inguinal Hernia Repair. J. Abdom. Wall Surg. 3:13868. doi: 10.3389/jaws.2024.13868

different outcomes. These open techniques must be clearly delineated in the literature and accepted in our surgical community in order to unify research efforts and guidelines. Therefore, we propose the following categorization of open inguinal hernia repair approaches:

- "Open tissue (OT)" repairs: This dissection occurs in the space below the external oblique aponeurosis and superficial to the pre-peritoneal space. These repairs include Bassini, Shouldice, Desarda and others.
- "Open Anterior Mesh (OAM)" repairs: This uniquely describes an anterior onlay mesh above the internal oblique musculature and deep to the external oblique aponeurosis, classically known as the Lichtenstein repair.
- "Open preperitoneal (OPP)" repairs: Describes open approaches where mesh is placed behind the abdominal wall, in the pre-peritoneal space. Examples include: TIPP, MOPP, TREPP, Kugel and various permutations of these repairs.
- "Open Anterior and Posterior Mesh (OAPM)" repairs: Although discouraged in international guidelines, many surgeons still utilize a hybrid technique where mesh is placed in both the anterior and posterior planes, such as Prolene Hernia System and Plug and Patch.

It is crucial that we correct the generalization that all "open" inguinal hernia repairs are equal. We must also overcome the marketing barrier that preperitoneal repairs require a laparoscope or robot. Only then can we objectively review the outcomes associated with various repairs, and identify specific operations that offer the best value to our patients, institutions and society as a whole.

AUTHOR CONTRIBUTIONS

MR, KB, and NF all heavily edited the document. All authors contributed to the article and approved the submitted version.

FUNDING

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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