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*CORRESPONDENCE
R. Lorenz,
lorenz@3chirurgen.de

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Shouldice versus Lichtenstein repair for recurrent groin hernia following laparo-endoscopic repair: a propensity score–matched analysis of the herniamed registry

R. Lorenz[1,2]*, S. Arand[3], J. Conze[4,5], R. Fortelny[6,7], K. Kilk[8], A. Koch[9], F. Köckerling[10], F. Mayer[11], H. Pokorny[12], H. Riediger[10], M. Wiese[8], M. Hukauf[13] and R. Wiessner[14]

[1]Hernia Center 3+CHIRURGEN, Berlin, Germany, [2]Department of General and Abdominal Surgery, Clinic for General and Abdominal Surgery, University Hospital Brandenburg an der Havel, Hochstrasse, Germany, [3]Department of General and Abdominal Surgery, Ernst von Bergmann Hospital Potsdam, Potsdam, Germany, [4]UM Hernienzentrum Dr. Conze, München, Germany, [5]Department of General, Visceral, Pediatric and Transplant Surgery, University Hospital Aachen, Aachen, Germany, [6]Department of General Surgery, Klinik Ottakring, Vienna, Austria, [7]Medical Faculty, Sigmund Freud University, Vienna, Austria, [8]Hernia Center Kelkheim, Rhein-Main Martin G. Wiese, Kelkheim, Germany, [9]Hernia Center Dr. Andreas Koch, Cottbus, Germany, [10]Hernia Center, Vivantes Humboldt Hospital, Academic Teaching Hospital of Charité, University Medicine, Berlin, Germany, [11]Department of Surgery, University Hospital, Paracelsus Medical University, Salzburg, Austria, [12]Franziskus Spital Margareten, Wien, Austria, [13]StatConsult GmbH, Magdeburg, Germany, [14]Department of General and Visceral Surgery, Kardinal Schwarzenberg Klinikum, Pongau, Austria

Background: International guidelines recommend an anterior mesh-based Lichtenstein repair for recurrent groin hernias following previous laparo-endoscopic repair. Whether the mesh-free Shouldice technique provides comparable outcomes in this setting remains unknown. This study compared perioperative and one-year outcomes after Shouldice and Lichtenstein repair using data from the Herniamed Registry.

Methods: Adult patients undergoing elective repair of a first unilateral recurrent groin hernia after previous laparo-endoscopic repair were identified from the Herniamed Registry. Patients treated with either Shouldice or Lichtenstein repair and with complete one-year follow-up were eligible. A 1:1 propensity score matching was performed using demographic, clinical, hernia-related, and operative variables to minimize baseline differences. All outcome variables such as intraoperative, postoperative and general complications, complication-related reoperations, surgical site complications, hernia recurrence at 1 year and patient-reported pain outcomes at 1 year were analysed in this study.

Results: Of 12,498 eligible patients, 253 underwent Shouldice repair and 12,245 underwent Lichtenstein repair. Propensity score matching yielded 248 well-balanced patient pairs. No significant differences were observed between the two procedures regarding one-year recurrence, intraoperative or postoperative complications, complication-related reoperations, postoperative haemorrhage, seroma, surgical-site infection, or patient-reported pain outcomes after adjustment for multiple testing. Pain on

exertion at 1 year was reported less frequently after Shouldice repair than after Lichtenstein repair (18.5% vs. 27.0%; P=0.031), although this difference did not remain statistically significant after Bonferroni correction.

Conclusion: In this propensity score–matched registry analysis, no statistically significant differences in perioperative and one-year outcomes were detected between Shouldice repair and guideline-recommended Lichtenstein repair for first recurrent groin hernias following previous laparo-endoscopic repair. Given the small number of Shouldice procedures and the wide confidence intervals, clinically relevant differences cannot be excluded. In carefully selected patients and when performed by experienced surgeons, the Shouldice technique may nevertheless represent a mesh-free option. Larger comparative studies with long-term follow-up are required to confirm these findings and further define its role in the management of recurrent groin hernia.

KEYWORDS

database study, groin hernias, Lichtenstein, recurrent inguinal hernia, Shouldice

Introduction

Despite the widespread adoption of mesh-based techniques over the past 3 decades, recurrent groin hernia remains a significant clinical challenge. Alongside chronic postoperative pain, recurrence continues to represent one of the most important adverse outcomes following groin hernia repair [1, 2]. Data from several national hernia registries consistently demonstrate that approximately 10% of groin hernia operations are performed for recurrence, a proportion that has remained remarkably stable over time [3, 4]. Moreover, recurrent groin hernias may present many years after the index operation, underscoring the importance of long-term follow-up when evaluating treatment outcomes [5]. The mechanisms underlying hernia recurrence are multifactorial and remain incompletely understood. In addition to technical failure, impaired connective tissue integrity, biological predisposition, and mesh-related factors have all been implicated [5].

The management of recurrent groin hernia is guided by the principle of changing the surgical plane ("*vice versa*" principle), which is strongly endorsed by current international guidelines [6]. Consequently, an open anterior repair is recommended for recurrence following a previous laparo-endoscopic repair, whereas a posterior laparo-endoscopic approach is advised after failure of a previous open repair [6, 7]. Accordingly, Lichtenstein repair remains the guideline-recommended procedure for recurrent groin hernias after prior laparo-endoscopic repair.

Comparative studies of the Shouldice and Lichtenstein techniques have shown that tissue-based repair is associated with a modestly higher recurrence [8, 9]. Evidence regarding chronic postoperative pain is inconsistent: one meta-analysis reported a lower risk of chronic pain after Shouldice repair [9], whereas another found no significant difference [8]. Nevertheless, in carefully selected patients, tissue repair without implantation of an additional mesh may represent an attractive alternative, particularly after previous posterior mesh placement. Interest in tissue-based techniques, especially the standardized Shouldice repair, has therefore increased in recent years. Current evidence and the updated international guidelines identify the Shouldice technique as the preferred tissue-based repair whenever a non-mesh approach is indicated [7, 10]. This recommendation is supported by high-quality long-term outcome data and the exceptional degree of procedural standardization achieved by the Shouldice technique [11, 12].

This registry-based propensity score–matched study compared perioperative and one-year outcomes following Shouldice and Lichtenstein repair for recurrent groin hernias after previous laparo-endoscopic repair. All outcome parameters such as intraoperative, postoperative and general complications, complication-related reoperations, surgical site complications, hernia recurrence at 1 year and patient-reported pain outcomes at 1 year were analysed in this study.

Materials and methods

Herniamed registry

The Herniamed Registry is a multicentre, internet-based quality assurance and outcomes registry established in 2009 to prospectively document hernia surgery and facilitate clinical outcomes research [13]. At the time of the present analysis, 1,088 hospitals and surgical practices in Germany, Austria, and Switzerland were contributing data.

Written informed consent was obtained from all participants before inclusion in the registry. Patients were instructed to report postoperative complications to the treating institution, where additional clinical evaluation was performed if indicated. Standardized follow-up questionnaires are distributed by the treating hospital or surgeon to both patients and their general practitioners at 1, 5, and 10 years after surgery. These questionnaires document further postoperative complications, recurrence, pain at rest, pain on exertion, and chronic pain requiring treatment. Recurrence, pain at rest, pain on exertion, and pain requiring treatment were recorded as reported in the standardized 1-year follow-up questionnaires by the patient and/or the general practitioner, with clinical examination if indicated. Smoking was documented in the registry as a binary variable

(yes/no); current, former, and occasional smoking cannot be distinguished.

The Herniamed Registry has received ethical approval from the Ethics Committee of the Canton of St. Gallen (BASEC No. 2016-00123), the Ethics Committee of the University of Tübingen (287/2017 BO2), the Ethics Committee of the State Medical Association of Baden-Württemberg (F-2022-111), and the Ethics Committee of the University of Cologne (24-1115-retro).

Study population

Patients were identified from the Herniamed Registry according to predefined eligibility criteria. Eligible patients fulfilled all of the following criteria:

- groin hernia repair;
- the patient master data as well as the procedure-related data have the entry-state key "complete", i.e., only completely documented cases regarding the mandatory entries;
- unilateral repair;
- first recurrent groin hernia following previous laparo-endoscopic repair;
- age ≥18 years;
- elective surgery;
- EHS classification limited to medial, lateral, femoral, or combined defects (scrotal hernias excluded);
- repair using either the Shouldice (non-mesh) or Lichtenstein (mesh-based) technique;
- approved mesh implantation for Lichtenstein repair (Physiomesh excluded);
- operation date up to and including April 30, 2025 (later operations only if 1-year follow-up information was already available); and
- complete documentation of 1-year follow-up with completely documented visit.

Following application of all eligibility criteria and data plausibility checks, 12,498 patients formed the eligible study cohort (Figure 1).

Statistical analysis

All analyses were performed with the software SAS 9.4 (SAS Institute Inc., Cary, NC, USA). The univariate analyses describing the patient population were deliberately conducted at the full significance level of 5% for exploratory purposes. The analyses of the twelve outcome variables were Bonferroni-adjusted to account for multiple testing, i.e., only p-values of $p \leq 0.00417$ (0.05/12) were considered significant. The estimation of the odds ratio for paired samples was performed analogously, with a confidence interval adjusted according to the significance level of alpha = 0.00417.

After checking the plausibility and inclusion criteria, pairwise comparisons were conducted for analysis of patients with Shouldice and Lichtenstein. The following steps were taken:

Univariate analysis of the patient population was first performed with regard to the matching parameters–for exploratory purposes only. For unadjusted homogeneity tests of the OP technique, the chi-square test and the robust t-test (Satterthwaite) were used for categorical and continuous variables, respectively, whereby analysis of non-normal distributed data (mesh size) was conducted on log-transformed values.

For comparisons taking into account potential confounders, a propensity score matching was performed: pairs of hernia repairs with Shouldice and Lichtenstein were matched in a 1:1 propensity score matching using a robust greedy algorithm and a caliper of 0.2 standard deviations of the logit of the propensity score. The propensity score model included the following matching variables, which were a-priori selected based on their clinical relevance:

- Age (in years)
- ASA score [I, II, III-IV]
- EHS classification [medial, femoral, lateral, combined]
- Preoperative pain [yes, no, unknown]
- COPD [yes, no]
- Diabetes mellitus [yes, no]
- Aortic aneurysm [yes, no]
- Immunosuppression [yes, no]
- Corticoids [yes, no]
- Smoking [yes, no]
- Coagulopathy [yes, no]
- Anticoagulant medication [yes, no],
- Antithrombotic medication [yes, no],

In addition, sex [male, female], BMI [underweight, normal weight, overweight, obese/morbid], defect size [I (<1.5 cm), II (1.5–3 cm), III (>3 cm)] and timepoint of recurrence [≤2 years, 2–10 years, >10 years] were defined as exact matching variables, in which no variability was allowed between matched pairs. Matching variables were selected *a priori* on the basis of clinical plausibility as potential confounders of both treatment choice and outcome, irrespective of their univariable p-values.

Balancing of matching parameters before and after matching was quantified via standardized differences. As a rule of thumb, a good balance is assured for the variables included in the model with a standardized difference of less than 10% (<0.1).

All outcome variables of the matched-pairs (Shouldice vs. Lichtenstein) such as intraoperative, postoperative and general complications, complication-related reoperations, surgical site complications, hernia recurrence at 1 year, pain at rest, pain on exertion, pain requiring treatment, trocar hernia, secondary hemorrhage, seroma, and infection on 1-year follow-up were analysed in this study. For these categorical outcome variables, the exact McNemar test (test for systematic difference between paired patients) was performed, wherein the p-value must be interpreted in accordance with the significance level of 0.417%, Bonferroni-adjusted for multiple testing. As a conservative approach, the Bonferroni correction was applied to all twelve outcome variables. Further, results were quantified using the odds ratio for matched pairs with Bonferroni-adjusted confidence interval and additionally presented in a forest plot (Supplementary Figure S1).

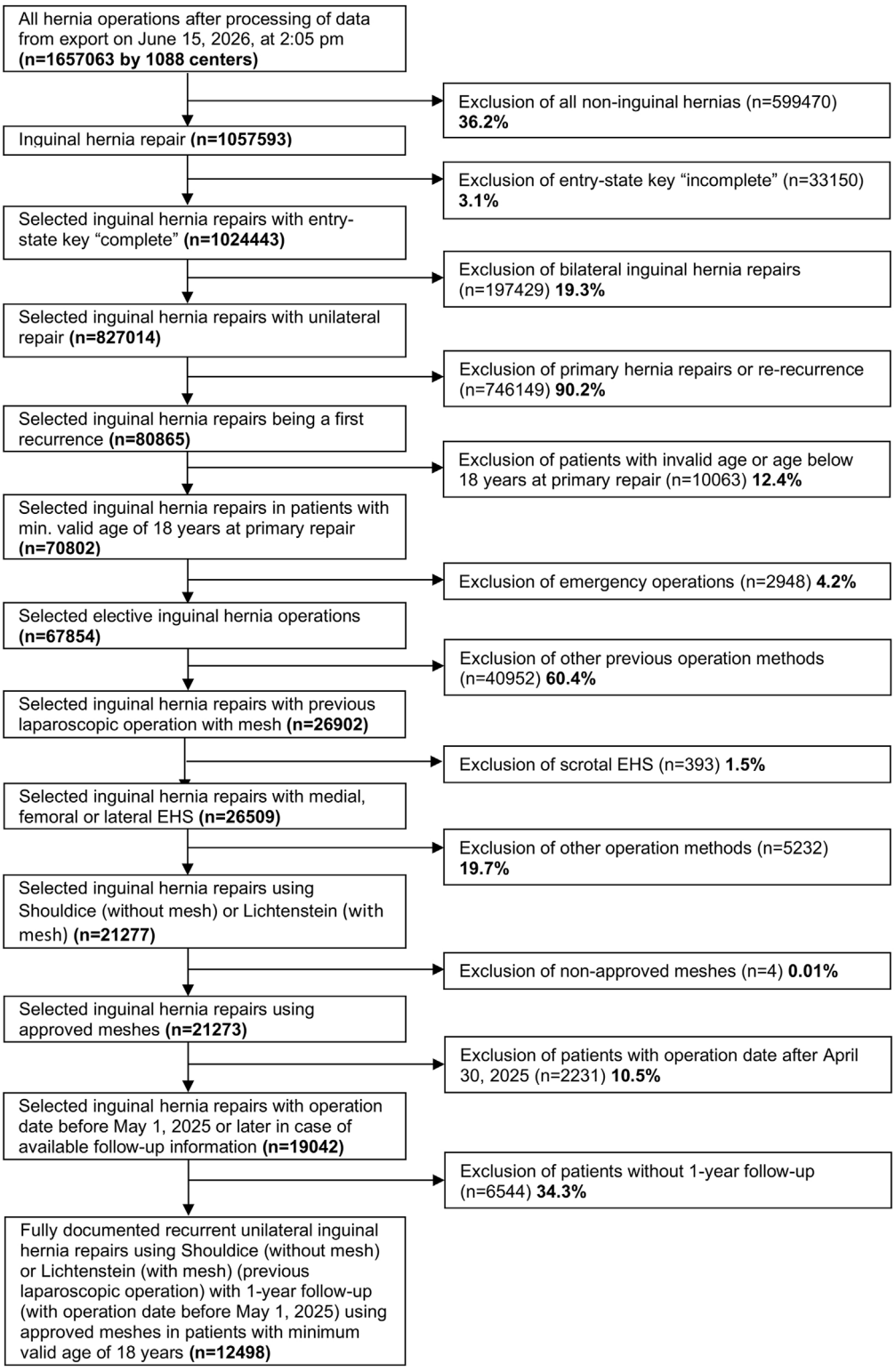


FIGURE 1
Flowchart of patient inclusion.

We assessed the reporting of this registry-based study against the STROBE guidelines and the RECORD extension for routinely collected health data. The completed RECORD checklist is provided as Supplementary Table S1. Emergency procedures were excluded because incarceration, strangulation, or bowel compromise substantially influence perioperative outcomes independently of the repair technique. The age criterion refers to the patient's age at the time of the recurrent hernia repair under investigation.

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TABLE 1 Unadjusted analysis results for homogeneity between Shouldice vs. Lichtenstein for categorical variables before matching.

		OP technique				
		Shouldice		Lichtenstein		
		N	%	N	%	p-Value
Sex	Male	216	85.4	11,762	96.1	<0.001
	Female	37	14.6	483	3.9	
BMI	Underweight	1	0.4	48	0.4	<0.001
	Normal weight	127	50.4	4616	37.8	
	Overweight	102	40.5	5922	48.5	
	Obesity/Morbid	22	8.7	1620	13.3	
ASA	I	79	31.2	2722	22.2	<0.001
	II	145	57.3	7408	60.5	
	III/IV	29	11.5	2115	17.3	
Defect size	I (<1.5 cm)	92	36.4	2461	20.1	<0.001
	II (1.5–3 cm)	129	51.0	6857	56.0	
	III (>3 cm)	32	12.6	2927	23.9	
EHS classification	Medial	108	42.7	5537	45.2	0.008
	Lateral	109	43.1	5235	42.8	
	Femoral	5	2.0	39	0.3	
	Combined	31	12.3	1434	11.7	
Preoperative pain	No	50	19.8	3014	24.6	0.042
	Yes	173	68.4	8223	67.2	
	Unknown	30	11.9	1008	8.2	
Timepoint of recurrence	≤2 years	109	43.1	4895	40.0	0.364
	2–10 years	107	42.3	5164	42.2	
	>10 years	37	14.6	2186	17.9	
Risk factors - total	Yes	55	21.7	3944	32.2	<0.001
	No	198	78.3	8301	67.8	
- COPD	Yes	13	5.1	662	5.4	1.000
	No	240	94.9	11,583	94.6	
- Diabetes	Yes	6	2.4	782	6.4	0.006
	No	247	97.6	11,463	93.6	
- Aortic aneurysm	Yes	0	0	71	0.6	0.407
	No	253	100	12,174	99.4	
- Immunosuppression	Yes	2	0.8	118	1.0	1.000
	No	251	99.2	12,127	99.0	
- Corticoids	Yes	2	0.8	117	1.0	1.000
	No	251	99.2	12,128	99.0	

(*Continued*)

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TABLE 1 Continued

		OP technique				
		Shouldice		Lichtenstein		
		N	%	N	%	p-Value
- Smoking	Yes	19	7.5	1394	11.4	0.056
	No	234	92.5	10,851	88.6	
- Coagulopathy	Yes	1	0.4	180	1.5	0.277
	No	252	99.6	12,065	98.5	
- Antithrombotic medication	Yes	17	6.7	1273	10.4	0.060
	No	236	93.3	10,972	89.6	
- Anticoagulant medication	Yes	1	0.4	228	1.9	0.095
	No	252	99.6	12,017	98.1	
- Liver cirrhosis	Yes	0	0	15	0.3	1.000
	No	77	100	4626	99.7	
- Anticoagulants	Yes	4	5.2	166	3.6	0.359
	No	73	94.8	4475	96.4	

Results

Study population

Patient selection is illustrated in Figure 1. After application of the predefined eligibility criteria and data plausibility checks, 12,498 patients formed the eligible study cohort. Of these, 253 patients (2.0%) underwent Shouldice repair and 12,245 (98.0%) underwent Lichtenstein repair. The matched outcome analysis comprised 248 pairs (n = 496).

Baseline characteristics before matching

Baseline patient and hernia characteristics of selected cases before propensity score matching are summarized in Table 1 and Supplementary Table S2. Compared with patients undergoing Lichtenstein repair, those treated with Shouldice repair were significantly younger (57.6 ± 15.9 vs. 62.4 ± 13.3 years, $P < 0.001$). Significant differences were also observed for sex, BMI, ASA classification, defect size, EHS classification, preoperative pain, overall prevalence of risk factors, and diabetes mellitus. No significant differences were found regarding the time to recurrence, COPD, smoking status, coagulopathy, immunosuppression, corticosteroid therapy, antithrombotic medication, anticoagulant medication, or aortic aneurysm.

Propensity score matching

Propensity score matching successfully identified 248 matched patient pairs for final analysis, corresponding to 98.0% of all patients who underwent Shouldice repair (Supplementary Table S3).

Covariate balance improved substantially after matching (Table 2; Figure 2). Standardized differences were below 0.10 for all matching variables, indicating good balance between the treatment groups and successful reduction of measured baseline confounding.

Matched outcome analysis

Perioperative and one-year outcomes of the matched cohort are summarized in Table 3, with corresponding odds ratios presented in Figure 3.

No statistically significant differences were observed between Shouldice and Lichtenstein repair for any predefined outcome after Bonferroni correction. Specifically, rates of intraoperative complications, postoperative complications, general complications, complication-related reoperations, and one-year recurrence (2.4% vs. 2.8%; OR 0.83, adj. CI 0.10–5.98), did not differ significantly between both procedures.

Similarly, no significant differences were detected for surgical-site complications on 1-year follow-up, including postoperative haemorrhage, seroma formation, surgical-site infection, or trocar-site hernia.

With respect to patient-reported outcomes, pain at rest and pain requiring treatment at 1 year did not differ significantly between the groups. Pain on exertion was numerically less frequent after Shouldice repair than after Lichtenstein repair (18.5% vs. 27.0%; discordant pairs 33 vs. 54; OR 0.61, adj. CI 0.31–1.17); however, this difference did not remain statistically significant after adjustment for multiple comparisons (unadj. P=0.031).

Overall, no outcome parameter demonstrated a statistically significant advantage for either operative technique.

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TABLE 2 Standardized differences in continuous and categorical matching variables for Shouldice vs. Lichtenstein before and after matching.

		OP technique		Standardized difference	
Variable	Statistics	Shouldice	Lichtenstein	Matched sample	Original sample
Age [years]	Mean ± SD	57.5 ± 16.0	58.6 ± 14.8	0.072	0.327
Male‡	N/%	215/86.7	215/86.7	0	0.374
Underweight‡	N/%	1/0.4	1/0.4	0	<0.001
Normal weight‡	N/%	126/50.8	126/50.8	0	0.255
Overweight‡	N/%	100/40.3	100/40.3	0	0.162
Obesity/Morbid‡	N/%	21/8.5	21/8.5	0	0.146
ASA score I	N/%	78/31.5	80/32.3	0.017	0.204
ASA score II	N/%	143/57.7	138/55.6	0.041	0.065
ASA score III-IV	N/%	27/10.9	30/12.1	0.038	0.166
Defect size I (<1.5 cm)‡	N/%	88/35.5	88/35.5	0	0.367
Defect size II (1.5–3 cm)‡	N/%	128/51.6	128/51.6	0	0.101
Defect size III (>3 cm)‡	N/%	32/12.9	32/12.9	0	0.294
EHS medial	N/%	137/55.2	143/57.7	0.049	0.037
EHS lateral	N/%	137/55.2	137/55.2	0	0.013
EHS femoral	N/%	4/1.6	5/2.0	0.030	0.139
Preoperative pain	N/%	169/68.1	172/69.4	0.026	0.026
No preoperative pain	N/%	50/20.2	47/19.0	0.031	0.117
Unknown preoperative pain	N/%	29/11.7	29/11.7	0	0.121
Timepoint of recurrence (<=2 years)‡	N/%	109/44.0	109/44.0	0	0.063
Timepoint of recurrence (2–10 years)‡	N/%	106/42.7	106/42.7	0	0.002
Timepoint of recurrence (>10 years)‡	N/%	33/13.3	33/13.3	0	0.088
COPD	N/%	12/4.8	12/4.8	0	0.012
Diabetes	N/%	5/2.0	3/1.2	0.064	0.197
Aortic aneurysm	N/%	0/0	0/0	-	0.108
Immunosuppression	N/%	2/0.8	3/1.2	0.040	0.019
Corticoids	N/%	2/0.8	4/1.6	0.074	0.018
Smoking	N/%	19/7.7	18/7.3	0.015	0.133
Coagulopathy	N/%	1/0.4	0/0	0.090	0.112
Antithrombotic medication	N/%	16/6.5	17/6.9	0.016	0.132
Anticoagulant medication	N/%	1/0.4	1/0.4	0	0.139

‡exact matching variables (same expression forced within a pair) EHS medial and EHS lateral include combined defects (counted in both categories).

Analysis population versus excluded patients without 1-year follow-up data

According to the inclusion criteria, the analysis population with 1-year follow-up data comprised 12,498 patients (corresponding to a 1-year follow-up rate of 65.6%, i.e. 12,498 of 19,042 patients fulfilling all other inclusion criteria). Due to missing 1-year follow-up data, 6,544 patients were excluded (Figure 1). To assess a possible selection bias in this regard, standardized differences between patients with and without 1-year follow-up data were calculated. Standardized differences of more than 10% were noted only for age, and smoking (Supplementary Figure S1). Patients in the analysis population were, on average, 3.2 years older, and were less frequently smokers (11.3% vs. 15.1%). For all other variables, including the perioperative complication rates, standardized differences of less than 0.1 were found, which do not indicate any selection bias.

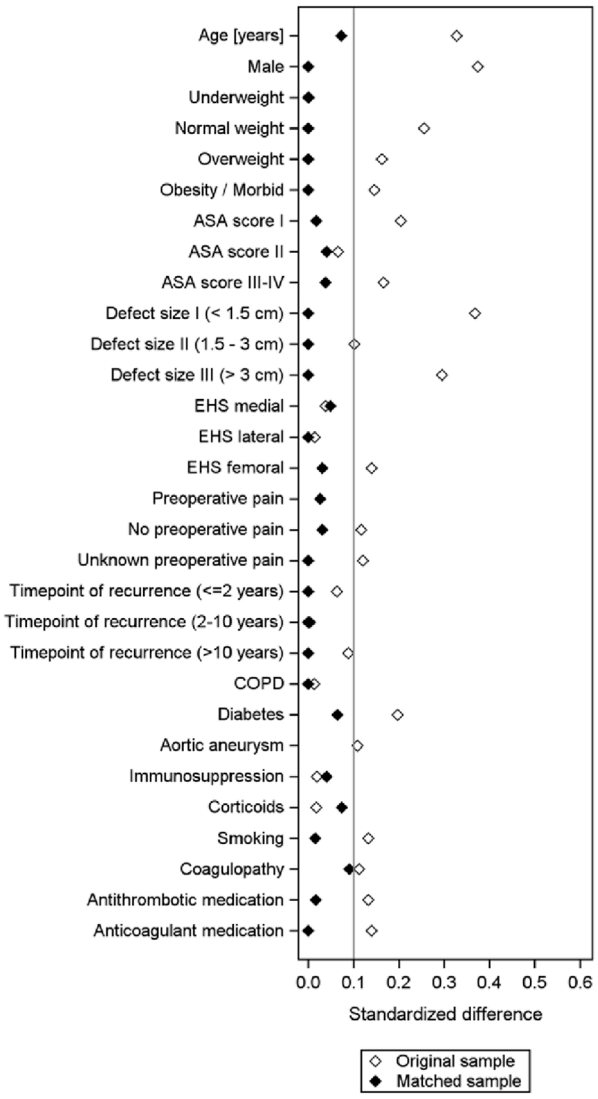


FIGURE 2
Scatter plot - Standardized differences (before and after matching) when comparing Shouldice vs. Lichtenstein.

Discussion

In this propensity score–matched registry analysis, no statistically significant differences in perioperative and one-year outcomes were detected between Shouldice and Lichtenstein repair for first recurrent groin hernias following previous laparo-endoscopic repair. In particular, no significant differences were observed with respect to recurrence, perioperative complications, complication-related reoperations, surgical-site complications, or patient-reported pain outcomes after adjustment for multiple testing. Although pain on exertion occurred less frequently after Shouldice repair, this difference did not reach statistical significance after Bonferroni correction.

To our knowledge, this is the first propensity score–matched registry study directly comparing Shouldice and Lichtenstein repair in patients with recurrent groin hernias after previous laparo-endoscopic repair. Consequently, direct comparisons with the existing literature are limited.

Most comparative studies have focused on primary inguinal hernias. A recent meta-analysis of 14 randomized controlled trials involving 2,784 patients reported higher recurrence rates after Shouldice repair than after Lichtenstein repair, although the overall recurrence rate following Shouldice repair remained low (4.2%), supporting its use in appropriately selected patients, while no significant difference in chronic postoperative pain was found [8]. In contrast, another meta-analysis found lower rates of chronic postoperative pain after Shouldice repair at the expense of a modest increase in long-term recurrence [9]. More recently, a propensity score–matched registry analysis from the United States demonstrated comparable 30-day postoperative outcomes between both techniques while reporting reduced postoperative opioid requirements after Shouldice repair [14].

Current international guidelines recommend an anterior mesh-based repair, most commonly the Lichtenstein technique, for recurrent groin hernias following previous posterior repair [6, 7]. This recommendation is primarily based on the principle of changing the surgical plane rather than on direct comparative evidence between tissue- and mesh-based anterior repairs. The present analysis provides initial comparative data on this question: in a carefully matched cohort, no statistically significant differences in short-term outcomes were detected between the two procedures, although clinically relevant differences cannot be excluded.

The pathogenesis of recurrent groin hernia is multifactorial and includes both technical and patient-related factors [15]. Following laparo-endoscopic repair, recurrence is frequently attributed to inadequate coverage of the myopectineal orifice, mesh displacement, shrinkage, or fixation failure [16, 17]. In addition, laparo-endoscopic repair does not involve reconstruction of the inguinal canal, which could be a cause of recurrence, particularly in large lateral hernias. Early recurrence is generally considered to reflect technical failure, whereas late recurrence is more likely related to impaired tissue quality and biological predisposition [18, 19]. In the present cohort, the recurrence under investigation had occurred within 2 years after the index laparo-endoscopic repair in more than 40% of patients (Table 1). This baseline variable describes only the interval between the index operation and the recurrence treated in this study and is not an outcome of the present analysis; nevertheless, it may suggest that technical factors contributed in a substantial proportion of patients.

The increasing use of laparo-endoscopic techniques for primary groin hernia repair inevitably results in a growing number of patients presenting with recurrence after previous posterior mesh implantation. In this setting, implantation of an additional anterior mesh may not always be desirable. Tissue-based repair may therefore represent an attractive alternative in carefully selected patients, particularly when avoidance of additional prosthetic material is preferred. A further potential advantage of the Shouldice technique may arise in the event of a re-recurrence, as subsequent anterior mesh implantation may be technically easier in a previously mesh-free anterior field. Long-term studies have demonstrated durable results after standardized Shouldice repair, and contemporary international guidelines continue to

TABLE 3 Summary of analysis results for systematic difference between the comparison groups, incl. odds ratio for paired samples (n=248 paired operations).

	Concordant cases N (%)		Discordant cases N (%)			OR for matched samples		
Outcome variables	Event in both patients	No event in both patients	Event in 'shouldice' only	Event in 'lichtenstein' only	p-Value	OR	Lower limit	Upper limit
Intraoperative complications*	0 (0%)	246 (99.2%)	2 (0.8%)	0 (0%)	0.250	2.414	0.069	-
General complications*	0 (0%)	247 (99.6%)	1 (0.4%)	0 (0%)	0.500	1.000	0.004	-
Postoperative complications	0 (0%)	231 (93.1%)	8 (3.2%)	9 (3.6%)	1.000	0.889	0.182	4.148
Complication-related reoperations	0 (0%)	245 (98.8%)	2 (0.8%)	1 (0.4%)	1.000	2.000	0.027	1436.848
Recurrence on 1-year follow-up	1 (0.4%)	236 (95.2%)	5 (2.0%)	6 (2.4%)	1.000	0.833	0.104	5.979
Pain on exertion on 1-year follow-up	13 (5.2%)	148 (59.7%)	33 (13.3%)	54 (21.8%)	0.031	0.611	0.310	1.165
Pain at rest on 1-year follow-up	6 (2.4%)	189 (76.2%)	22 (8.9%)	31 (12.5%)	0.272	0.710	0.299	1.624
Pain requiring treatment on 1-year follow-up	1 (0.4%)	205 (82.7%)	21 (8.5%)	21 (8.5%)	1.000	1.000	0.389	2.569
Trocar hernia on 1-year follow-up*	0 (0%)	247 (99.6%)	1 (0.4%)	0 (0%)	0.500	1.000	0.004	-
Secondary hemorrhage on 1-year follow-up	0 (0%)	241 (97.2%)	5 (2.0%)	2 (0.8%)	0.453	2.500	0.202	97.675
Seroma on 1-year follow-up	0 (0%)	233 (94.0%)	6 (2.4%)	9 (3.6%)	0.607	0.667	0.109	3.397
Infection on 1-year follow-up	0 (0%)	242 (97.6%)	4 (1.6%)	2 (0.8%)	0.687	2.000	0.129	82.471

*Median unbiased estimate, one-sided p-value and one-sided CI.

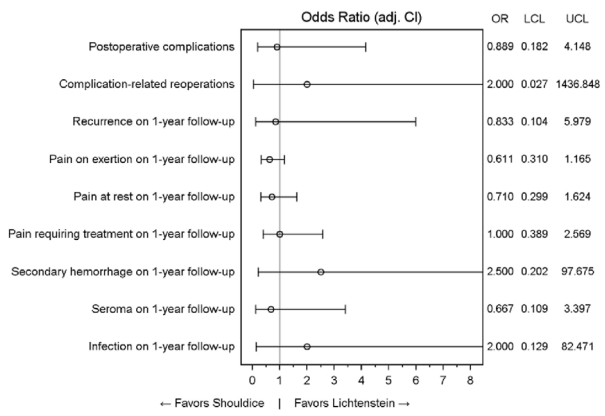


FIGURE 3
Forest plot - odds ratios (incl. Bonferroni-adjusted confidence interval) for outcome parameters for Shouldice vs. Lichtenstein (n=248 paired operations; outcomes with valid two-sided CI only).

recommend the Shouldice technique as the preferred non-mesh repair whenever a tissue-based approach is indicated [7, 10–12]. Our findings support this concept by showing no statistically significant difference in perioperative safety or short-term recurrence between Shouldice and Lichtenstein repair; as this study was not designed or powered as a formal non-inferiority comparison and several outcome estimates have wide confidence intervals, these results should be interpreted as reassuring rather than as definitive evidence of equivalence.

Limitations

The strengths of this study include the use of a large multicentre prospective registry and rigorous propensity score matching, which resulted in excellent covariate balance between treatment groups. Nevertheless, several limitations should be acknowledged. First, only a small proportion of patients

underwent Shouldice repair, reflecting current clinical practice and limiting statistical power. The low proportion of Shouldice repairs (2.0%) suggests that the technique is used selectively, probably by surgeons and centres with particular expertise, which may limit the transferability of the results to routine practice. No *a priori* sample size calculation or predefined clinically relevant difference was used. In addition, we checked whether the selected patient group with a complete 1-year follow-up is also representative of all patients without a complete follow-up (Supplementary Figure S1). Standardized differences above the guideline value of 10% can be found for age and smoking. The patients in the analysis population are on average 3.2 years older and have a lower proportion of smokers. In our view, there is no clear clinical relevance to this. For all other variables, including further perioperative complication rates, there are standardized differences of less than 0.1 and only very small descriptive differences, which thus do not indicate relevant biases in patient selection.

Second, although propensity score matching reduced measured confounding, residual as well as unobserved confounding inherent to observational registry studies cannot be excluded. In particular, surgeon- and centre-related factors, such as individual experience with the Shouldice technique or institutional volume, could not be included in the matching and may represent residual confounding.

Third, follow-up was limited to 1 year. Because recurrent groin hernias may occur many years after surgery, meaningful conclusions regarding long-term recurrence and chronic pain cannot yet be drawn.

Fourth, this study was not designed as a formal non-inferiority trial; confidence intervals for several outcomes, particularly rarer events such as recurrence and complication-related reoperation, were wide, and the absence of a statistically significant difference should not be interpreted as proof of equivalence between the two techniques.

Fifth, participation in the Herniamed Registry is voluntary. Although numerous institutions in Germany, Austria and Switzerland contribute data, the proportion of all groin hernia repairs captured in these countries is unknown, and participating institutions may differ from non-participating ones. In addition, the small number of selectively performed Shouldice repairs may limit the representativeness of the matched cohort. The results should therefore not be generalized uncritically to all patients undergoing repair of recurrent groin hernia.

Conclusion

In carefully selected patients with first recurrent groin hernia following previous laparo-endoscopic repair, Shouldice repair showed perioperative safety and one-year outcomes not significantly different from those of guideline-recommended Lichtenstein repair. These findings suggest that, when performed by experienced surgeons, the Shouldice technique may represent a valuable mesh-free alternative in this clinical setting. Given the limited sample size and wide confidence intervals, clinically relevant differences cannot be excluded. Confirmation by larger studies with long-term follow-up is warranted before broader recommendations can be made.

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.

Ethics statement

The studies of the Herniamed Registry involving human participants were reviewed and approved by Ethics Committee Kanton St. Gallen (BASEC Nr. 2016-00123), Ethics Committee University of Tübingen (287/2017 BO2), Ethics Committee State Medical Association Baden-Württemberg (F-2022-111), and Ethic Committee University of Cologne (24-1115-retro). The patients/participants provided written informed consent to participate in this study.

Author contributions

All authors (RL, SA, JC, RF, KK, AK, FK, FM, HP, HR, MW, MH, and RW) participated in the design, interpretation of the studies and analysis of the data and review of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

Author MH was employed by StatConsult GmbH.

The remaining author(s) declared that this work 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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontierspartnerships.org/articles/10.3389/jaws.2026.17769/full#supplementary-material

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