



# Laparoscopic versus open repair of groin hernias in children: a systematic review and meta-analysis

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## Abstract

**Background** Regarding groin hernia repair in children, guidelines do not favor open or laparoscopic repair. Even so, most surgeons prefer an open technique. The aim of this systematic review was to compare short- and long-term outcomes after laparoscopic and open groin hernia repair in children.

**Methods** Systematic searches were conducted in three databases, and all randomized controlled trials comparing laparoscopic and open groin hernia repair in children under 18 years were included. Outcomes were postoperative complications, intraoperative complications, operative time, length of hospital stay, time to recovery, and wound appearance. The outcomes were compared between open and laparoscopic repairs in meta-analyses.

**Results** We included ten studies with 1270 patients involving 1392 hernias. We found no differences in recurrence rate, testicular atrophy, hydrocele, hematoma, seroma, infection, pain, length of hospital stay, or time to full recovery. Laparoscopic repair was superior regarding wound appearance. Laparoscopic repair had shorter operative time than open repair for bilateral groin hernias. For unilateral groin hernias, extraperitoneal laparoscopic repair was faster than open repair, but open repair was faster than intraperitoneal laparoscopic repair.

**Conclusion** Our results indicate similar outcome after laparoscopic and open techniques for groin hernia repair in children. The surgeon's preference as well as the wishes of the patient and parents should therefore determine the surgical approach.

**Keywords** Groin hernia · Laparoscopic repair · Open repair · Children

Laparoscopic groin hernia repairs are rarely performed in children. In Denmark, nearly all pediatric groin hernias are repaired using open surgery [1], and an international survey from 2014 found that 83% of the surgeons preferred open repair for inguinal hernias in children [2]. A guideline recommends that all inguinal hernias in children are repaired as there is a risk of strangulation, which may lead to ischemic necrosis of the intestine [3]. Still, no guidelines state which operative technique is favored in children. Laparoscopic repair seems beneficial in adults due to less postoperative pain and faster recovery [4]. However, results for adults cannot be adopted for children since the anatomy of the inguinal canal changes with natural growth, and pain and recovery characteristics may differ. In infants, the inguinal canal has

a total length of about 1–1.5 cm with the internal and the external inguinal rings superimposed upon one another. In adults, the inguinal canal is about 4 cm with the internal and the external rings clearly separated [5]. Different methods exist for open groin hernia repair in children. These methods are technically similar [6] and have comparable complication rates [7]. In contrast, the laparoscopic methods differ notably [6]. In general, they can be divided in extraperitoneal approaches (with extracorporal suturing) [8, 9] and intraperitoneal approaches (with intracorporal suturing) [10, 11]. Earlier systematic reviews comparing complications after laparoscopic and open groin hernia repair in children indicate that laparoscopic repair may result in fewer complications and shorter operative time for bilateral hernias [12, 13]. However, a new systematic review including studies of the highest level of evidence is justified due to new available evidence.

The aim of this study was to compare intraoperative as well as short-term and long-term postoperative outcomes

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after laparoscopic and open groin hernia repair in children, reported by randomized controlled trials.

## Methods

This systematic review is reported according to the PRISMA guideline [14] and registered at PROSPERO with registration number: CRD42018111305. Approval from ethics committee was not needed for this study.

All randomized controlled trials that compared laparoscopic and open repair of groin hernias (inguinal or femoral) in children under 18 years were included. Furthermore, the rate of at least one of the outcomes had to be reported for inclusion of a study. The outcomes were postoperative complications, intraoperative complications, operative time (for unilateral and/or bilateral hernias), length of hospital stay, time to full recovery, and postoperative wound appearance. The following postoperative complications were registered: recurrence, testicular atrophy, iatrogenic ascent of the testis, hydrocele, hematoma, seroma, infection, and acute and chronic pain (defined as lasting minimum 6 months [15]). Language was restricted to English, Danish, Swedish, Norwegian, German, or French.

Systematic searches were conducted in PubMed, Embase, and Cochrane Library. The last search date was August 28, 2018. The search strategy, which was developed in cooperation with a professional research librarian, was subdivided in four blocks: groin hernia AND children AND laparoscopy AND randomized controlled trial. The full search for PubMed was: (“Hernia, Inguinal“[Mesh] OR “Hernia, Femoral“[Mesh] OR ((inguinal OR groin) AND hernia)) AND (“Adolescent“[Mesh] OR “Child” OR “Children” OR “Infant“[Mesh] OR Infan\* OR newborn\* OR perinat\* OR neonat\* OR baby\* OR babies OR toddler\* OR minors\* OR boy OR boys OR boyhood OR girl\* OR kid OR child\* OR children\* OR schoolchild\* OR adolescen\* OR juvenil\* OR youth\* OR teen\* OR under\*age\* OR pubescen\* OR pediatric\* OR prematur\* OR preterm\*) AND (“Laparoscopy“[Mesh] OR laparoscopic OR endoscopy) AND (“Randomized Controlled Trials as Topic“[Mesh] OR “Randomized Controlled Trial“[Publication Type] OR “Controlled Clinical Trial“[Publication Type] OR randomized OR randomised OR RCT). The search strategy was adopted for the other databases. Furthermore, we performed a snowball search in the reference lists of older reviews and in the included articles in the final paper, trying to identify further studies to include in the title and abstract screening [16].

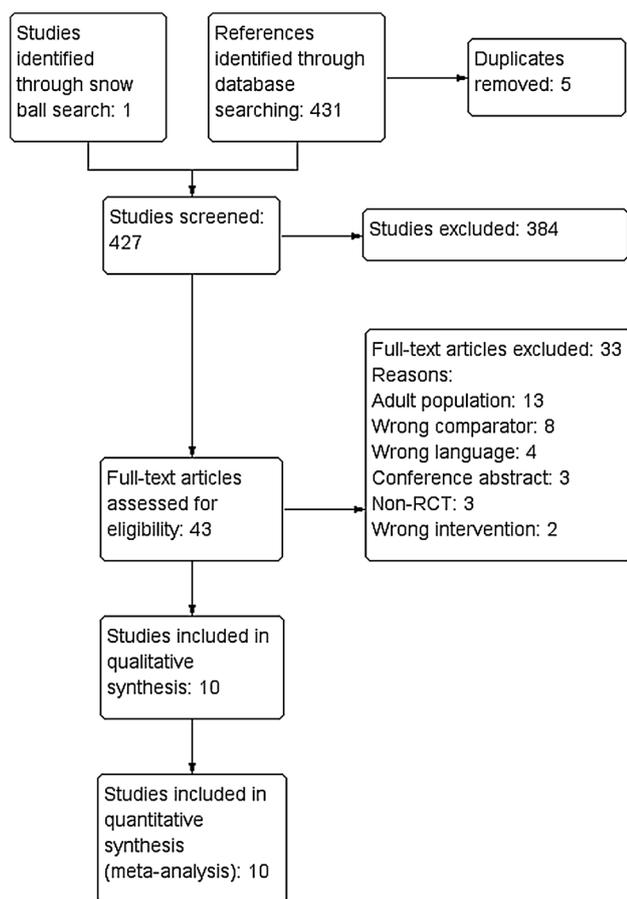
Screening of “title and abstracts” and “full text studies” was performed in Covidence [17] by two reviewers independently, and discrepancies were discussed until consensus was reached. The data extraction was conducted by the

first author twice to a preformed Excel sheet. The extracted data included: study type, number of patients and hernias, sex, age, type of hernia, surgical method, operative time, the surgeons’ level of experience, intraoperative and postoperative complications, follow up (time, completion, and type), length of hospital stay, time to resume full activity, and wound appearance. The risk of bias was assessed with the Cochrane bias assessment tool [18] independently by two reviewers, and a risk of bias summary was created in Review Manager 5.3 [19].

For binary categorical data, the weighted estimates of the outcome incidences with 95% confidence intervals were calculated for laparoscopic and open repairs in OpenMeta[analyst], version 0.1504 [20]. The calculations were conducted with the binary random effect method and the DerSimonian–Laird method [21]. For outcomes with zero events, a correction factor of 0.5 was used. Forest plots of outcomes were created in Review Manager 5.3 [19]. In a forest plot,  $I^2$  is a measure of the heterogeneity of the studies (the higher the  $I^2$ , the higher the heterogeneity). Only forest plots with  $I^2 < 75%$  are presented [22]. For continuous outcomes, only studies reporting mean and standard deviation (SD) are included in the meta-analyses. Sensitivity analyses were conducted for all outcomes, by including and excluding studies with high risk of bias and studies reporting the use of mesh from the meta-analyses. Furthermore, sensitivity analyses were conducted for recurrence and testicular atrophy with and without studies that reported a planned clinical examination  $\geq 6$  months postoperatively for all children. The risk of publication bias was assessed with funnel plots.

## Results

A flow diagram of the study selection process is presented in Fig. 1. Ten randomized controlled trials, comprising 1270 patients with 1392 hernias, fulfilled the eligibility criteria [23–32]. A total of 736 patients underwent laparoscopic groin hernia repair, and 534 patients underwent open groin hernia repair. In both groups, 20% of the repaired children were female. The studies reported a mix of mean and median age of the patients ranging from 3 months to 15 years. Regarding the surgical techniques, only one study with 13–18-year-old children inserted mesh during the repair. In this study, they used open Lichtenstein repair with a permanent mesh as well as laparoscopic transabdominal preperitoneal (TAPP) repair and total extraperitoneal (TEP) repair with insertion of a partly absorbable mesh [31]. The open surgical method was similar in the remaining nine studies, in which the repair was done with dissection and high ligation of the hernia sac and closure of the skin in layers [23–31]. In contrast, the laparoscopic techniques differed. Five studies reported on an intraperitoneal laparoscopic



**Fig. 1** Flow diagram of study selection. *Non-RCT* non-randomized controlled trial

technique using purse string suturing around the internal ring and intrabdominal knotting [23–27]. Four studies used extraperitoneal laparoscopic techniques [28–31]: one study [28] reported on a method using the Reverdin needle [33]; one study [29] reported on a technique called “subcutaneous endoscopically assisted ligation” (SEAL) [34]; one study [30] reported on a technique called “percutaneous internal ring suturing” (PIRS) [35]; and the fourth study reported on a technique using a Z-suture purse string with swaged needle introduced through the abdominal wall [31].

Study characteristics are presented in Table 1. The studies included groin hernias with the following specification: primary inguinal hernias [23, 25, 29, 30]; unilateral inguinal hernias [24, 27, 30, 31]; bilateral inguinal hernias [26]; a mix of unilateral inguinal hernias in obese children ( $n=53$ ), bilateral inguinal hernias ( $n=92$ ), recurrent inguinal hernias ( $n=27$ ), inguinal hernias with concomitant umbilical hernia ( $n=40$ ), and “inguinal hernias with questionable contralateral side” ( $n=38$ ) [28]; and a mix of femoral hernias ( $n=16$ ), indirect ( $n=442$ ), and direct inguinal hernias ( $n=48$ ) [32]. Three studies reported the surgeons’ level of

experience with all having “considerable experience” [24, 26, 32]. One study reported that the authors performed all operations without mentioning the level of experience [28].

Assessment of risk of bias in individual studies, made with the Cochrane risk of bias tool, is presented as a summary (Fig. 2).

## Complications

Nine studies reported on postoperative complications [23–26, 28–32]. No significant difference in any individual study was reported for recurrence, testicular atrophy, hydrocele, hematoma, seroma, or infection. One study found a significant difference in postoperative iatrogenic ascent of the testis in favor of laparoscopic groin hernia repair ( $p=0.049$ ) [28]. The total number of events and estimated incidences of the outcomes are shown in Table 2. Assessment of postoperative outcomes was performed in outpatient clinics with clinical examination in five studies [23, 24, 28, 30, 31], with telephone interview in one study [29], and with no report on method of assessment in the remaining studies [25, 26, 32]. The studies that reported on testicular atrophy assessed the testis with ultrasound [28, 30], measure of length and position [24], or did not report on method of assessment [23, 25, 26, 29]. Time to last follow-up in the studies ranged from 1 to 34 months (Table 1).

Meta-analyses of postoperative outcomes (except pain) are presented in Fig. 3A–G. No differences between laparoscopic and open repair were found. The heterogeneity was  $<75\%$ , and sensitivity analyses did not change the results. No indication of risk of publication bias was found in funnel plots assessed by visual inspection (not shown).

Chronic pain was only reported in one study, without any differences between laparoscopic and open repair [32]. Short-term postoperative pain was reported in six studies [23, 24, 26, 29, 31, 32]. The results of these studies cannot be compared because pain was reported differently: as doses of pain relieving medication [23, 24, 29], with a visual analog scale [26, 32], with an objective pain score [24], with “The Children and Infants Postoperative Pain Score” (CHIPPS) and “Children’s Hospital of Eastern Ontario Pain Score” (CHEOPS) [23, 31], or with the “Face, Legs, Activity, Cry, Consolability Scale” (FLACC) [29]. Two studies, one with a last follow-up of pain on the 7th day [23] and the other without a specification on follow up [32], found that laparoscopic repair was less painful than open repair ( $p<0.05$ ). One study, which had a last follow up of pain at 24 h, reported that laparoscopic repair was less painful the first hour postoperatively ( $p<0.05$ ), but afterward, there was no difference [26]. One study, with a last follow-up of pain 3 days postoperatively, reported that more children needed rescue analgesia after laparoscopic repair than after open repair ( $p<0.05$ ) [24]. The last two studies found

**Table 1** Study characteristics

References	Repair	Patients, <i>n</i>	Female, <i>n</i> (%)	Hernias, <i>n</i>	Age	Follow-up
Chan et al. [23]	Total	83	16 (19)	98	–	–
	OH	42	9 (21)	44	46 (34.2) m*	11.8 (2.5) m*
	LH	41	7 (17)	54	56 (45.67) m*	12.2 (2.8) m*
Bharathi et al. [31]	Total	69	7 (10)	69	–	3.5 m*
	OH	34	2 (6)	34	3.14 (0.92) y*	–
	LH	35	5 (14)	35	5.58 (3.52) y*	–
Koivusalo et al. [24]	Total	89	23 (26)	89	–	(6–24) m**
	OH	42	12 (29)	42	6.1 (1.6–15) y**	–
	LH	41	11 (23)	41	6 (0.65–15) y**	–
Shalaby et al. [28]	Total	250	71 (28)	342	61.6 (2.3) m*	24 m* (16–30) m**
	OH	125	33 (26)	173	–	–
	LH	125	38 (30)	169	–	–
Saha et al. [25]	Total	62	8 (13)	70	–	–
	OH	32	4 (12.5)	37	6.6 (2.7) y*	22.5 (10.5) m*
	LH	30	4 (13)	33	5.9 (2.1) y*	24.5 (10.5) m*
Celebi et al. [26]	Total	62	0	124	–	(3–24) m**
	OH	32	0	64	7.83 (1.58) y*	–
	LH	30	0	60	8.24 (2.60) y*	–
Gause et al. [29]	Total	41	10 (24)	55	–	2 (2.7) y*
	OH	15	3 (20)	20	Uni: 199.8 (139.7) d* Bi: 93.2 (66.7) d*	–
	LH	26	7 (27)	35	Uni: 376.3 (225.2) d* Bi: 288.7 (335.6) d*	–
Niu et al. [27]	Total	68	24 (35)	68	–	Until discharge
	OH	22	7 (32)	22	5.4 (1.0) y*	–
	LH (LP)	20	6 (30)	20	5.8 (1.5) y*	–
	LH (HP)	26	11 (42)	26	6.0 (1.0) y*	–
Cui et al. [32]	Total	506	99 (20)	–	–	16 (5–34) m**
	OH	170	38 (22)	–	15.18 (1.55) y*	–
	LH (TAPP)	168	27 (16)	–	14.83 (1.75) y*	–
	LH (TEP)	168	34 (20)	–	14.84 (1.45) y*	–
Oral et al. [30]	Total	40	0	40	–	1 m
	OH	20	0	20	5.15 (3.41) y*	–
	LH	20	0	20	6.80 (3.5) y*	–

Total all children included in study, OH open herniorrhaphy, LH laparoscopic herniorrhaphy, LP low-pressure laparoscopic herniorrhaphy, HP high-pressure laparoscopic herniorrhaphy, uni unilateral hernia, bi bilateral hernia, TAPP transabdominal preperitoneal herniorrhaphy, TEP total extraperitoneal herniorrhaphy, *n* number, *m* month, *y* year, *d* day, – not available

\*mean (standard deviation); \*\*median (range)

no differences in pain, with a last follow-up of 7 days and 3.5 months, respectively [29, 31].

Five studies, including 490 children, reported on intraoperative complications and found none [26–29, 31].

## Operative time

A single study reported operative time collectively for unilateral and bilateral hernias and found no significant difference between laparoscopic and open repair [32].

Operative time for unilateral groin hernias, examined in seven studies, was reported as mean or median values ranging from 8 to 63 min for laparoscopic repair and from 13 to 53 min for open repair (Table 3) [23–25, 27–29, 31]. Four studies showed significantly shorter operative time for open repair [23–25, 27]. Operative times of all unilateral laparoscopic repairs versus open repairs could not be analyzed in one meta-analysis due to high heterogeneity ( $I^2 = 88\%$ ). A meta-analysis comparing only extraperitoneal laparoscopic repair with open repair for unilateral hernias showed that extraperitoneal laparoscopic repair was significantly faster

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bharathi RS et al 2008	+	+	+	+	?	+	?
Celebi S et al 2014	+	?	+	+	?	?	+
Chan KL et al 2005	+	+	+	+	+	?	?
Cui Z et al 2018	?	?	?	?	+	?	?
Gause CD et al 2017	+	+	+	+	+	?	?
Koivusalo AI et al 2009	+	+	+	+	+	+	?
Niu X et al 2017	+	?	+	+	+	?	+
Oral A et al 2018	?	?	?	?	+	?	?
Saha N et al 2013	+	?	?	+	+	?	?
Shalaby R et al 2012	+	?	?	?	?	?	?

**Fig. 2** Risk of bias summary. +: low risk of bias; -: high risk of bias; ?: unclear risk of bias

(Fig. 4a). Operative times for unilateral intraperitoneal laparoscopic repair were too heterogeneous for a meta-analysis ( $I^2 = 79%$ ). We performed a sensitivity analysis excluding one outlier with a much longer operative time than described elsewhere [25] from the meta-analysis. This lowered the heterogeneity ( $I^2 = 67%$ ). The meta-analysis favors open repair over intraperitoneal laparoscopic repair (Fig. 4b).

The operative times for bilateral groin hernias, examined in five studies, were reported as mean or median values ranging from 22 to 50 min for laparoscopic repair and from 11 to 63 min for open repair (Table 3) [23, 25, 26, 28, 29]. One study reported lower operative time for open repair [25], and one study reported lower operative time for laparoscopic repair [28]. The remaining studies found no difference. Operative time of all bilateral laparoscopic repairs compared with open repair was too heterogeneous for meta-analysis ( $I^2 = 89%$ ). When comparing open repair with extraperitoneal and intraperitoneal laparoscopic repair separately in meta-analyses, both laparoscopic techniques were found to be faster than open repair for bilateral groin hernias (Fig. 4C, D).

**Length of hospital stay, recovery, and wound appearance**

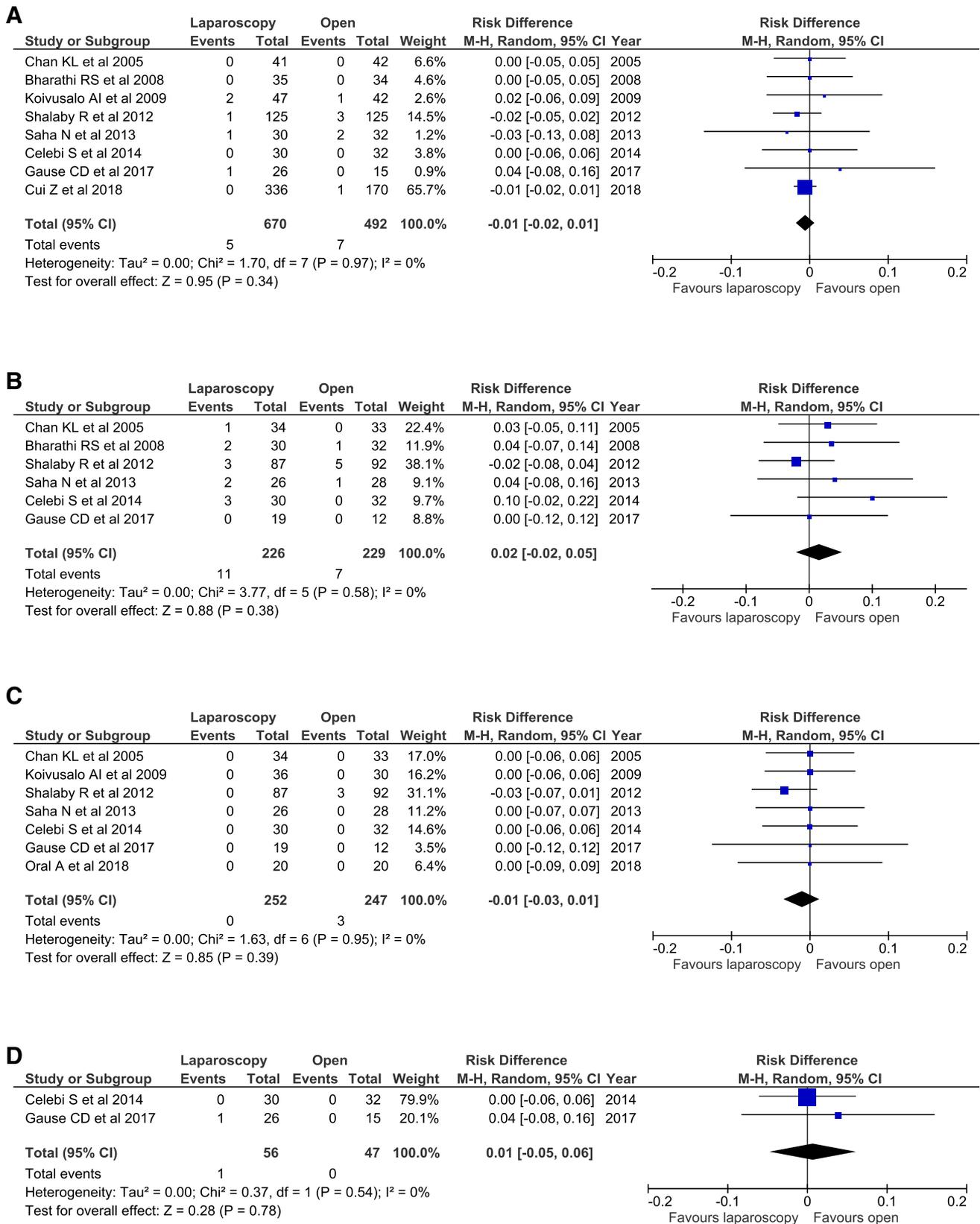
Length of hospital stay was reported in six studies with mean or median values ranging from 5 to 83 h for laparoscopic repair and from 5 to 109 h for open repair [23–25, 27–29]. One study found a significantly shorter hospital stay after laparoscopic repair with a mean (SD) of 3.4 days (0.5) versus 4.6 days (0.5) ( $p < 0.001$ ) [27], and one study found a significantly shorter hospital stay after open repair with a median (range) of 230 min (145–432) versus 300 min (185–635) [24]. The remaining studies found no difference [23, 25, 28, 29]. The reports of hospital stay were too heterogeneous for a meta-analysis ( $I^2 = 93%$ ), but the heterogeneity

**Table 2** Postoperative complications with estimated incidences

Postoperative complication	Studies, <i>n</i> [references]	Laparoscopic repair		Open repair	
		Events/patients, <i>n/n</i>	Estimated incidence, % (95% CI)	Events/patients, <i>n/n</i>	Estimated incidence, % (95% CI)
Recurrence	8 [23–26, 28, 29, 31, 32]	5/670	0.3 (–0.1; 0.7)	7/492	1.1 (0.2; 2.0)
Testicular atrophy	7 [23–26, 28–30]	0/252	–	3/252	2.1 (0.3; 3.9)
Iatrogenic ascent of the testis	3 [23, 25, 28]	0/196	–	4/199	2.6 (0.1; 5.2)
Hydrocele	6 [23, 25, 26, 28, 29, 31]	11/226	4.1 (1.5; 6.7)	7/229	2.8 (0.7; 4.9)
Hematoma	2 [26, 29]	1/56	2.2 (–1.6; 6.0)	0/47	–
Seroma	2 [26, 32]	48/366	8.0 (–4.4; 20.4)	15/202	5.2 (–2.0; 12.3)
Infection	2 [26, 29]	0/56	–	1/47	2.0 (–1.9; 6.0)

The estimated incidences and confidence intervals are not shown for outcomes with zero events

CI confidence interval, *n* number

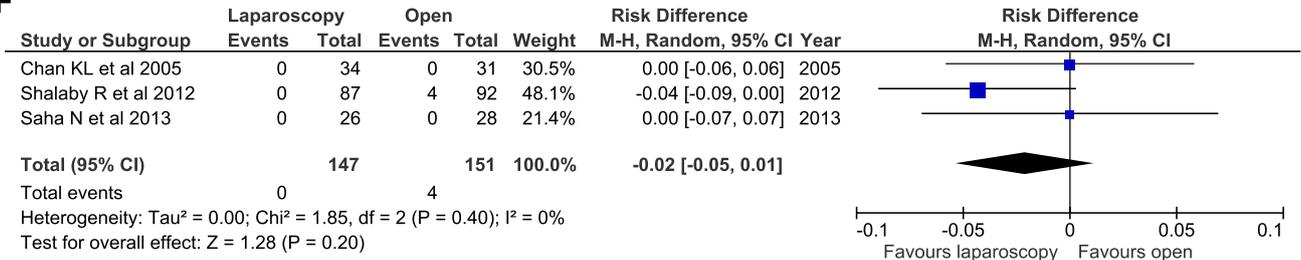


**Fig. 3** A–G Forest plots of postoperative complications: **A** recurrence rate, **B** hydrocele, **C** testicular atrophy, **D** hematoma, **E** seroma, **F** iatrogenic ascent of the testis, and **G** infection

**E**



**F**



**G**



Fig. 3 (continued)

Table 3 Operative time

Reference	Operative time for unilateral hernias			Operative time for bilateral hernias		
	LH (min)	OH (min)	p-value	LH (min)	OH (min)	p-value
Chan et al. [23]	23.3 (6.3)*	18.4 (5.7)*	0.001	34.0 (6.3)*	39.1 (13.4)*	0.623
Bharathi et al. [31]	25.3 (13.0)*	30.7 (10.3)*	0.0652	–	–	–
Koivusalo et al. [24]	33 (15–59)**	15 (8–35)**	<0.001	–	–	–
Shalaby et al. [28]	7.6 (3.5)*	12.8 (4.5)*	<0.005	11.4 (2.7)*	21.9 (7.2)*	<0.001
Saha et al. [25]	62.7 (52.8)*	29.4 (9.4)*	0.0001	64.7 (49.7)*	35.7 (11.5)*	0.01
Celebi et al. [26]	–	–	–	32.7 (3.2)*	38.6 (3)*	0.067
Gause et al. [29]	27.9 (15)*	53.2 (30.4)*	0.007	38 (19.9)*	50.4 (19)*	0.28
Niu et al. [27] <sup>a</sup>	LP: 28.0 (4.4)* HP: 31.0 (4.8)*	22.6 (4.6)*	<0.001	–	–	–

LP low-pressure laparoscopic herniorrhaphy, HP high-pressure laparoscopic herniorrhaphy, – not available

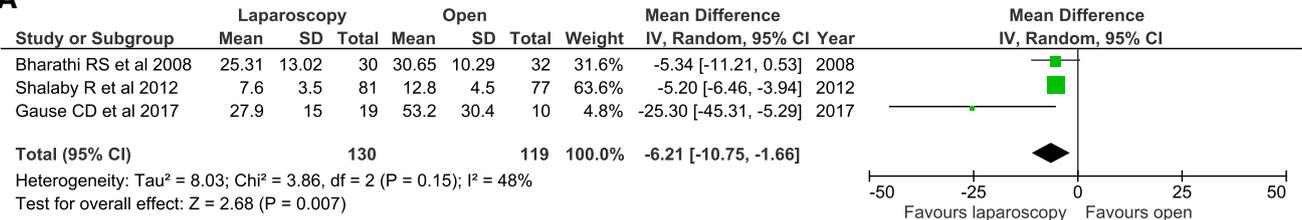
\*mean (standard deviation); \*\*median (range)

<sup>a</sup>Report of two laparoscopic techniques with low pressure and high pressure

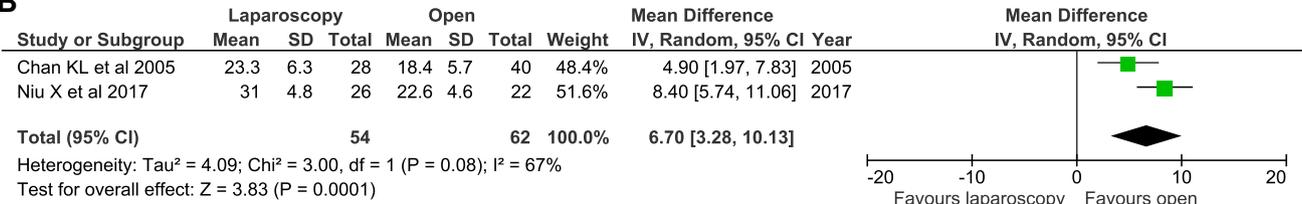
was lowered by exclusion of one outlier [27]. No difference between laparoscopic open repair was found in the meta-analysis (Fig. 5).

Time to full recovery was reported in four studies with mean or median values ranging from 2.0 to 3.7 days for laparoscopic repair and from 1.8 to 4.3 days for open repair

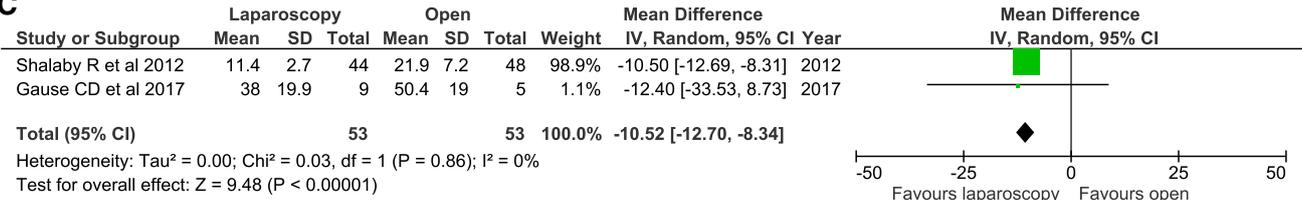
**A**



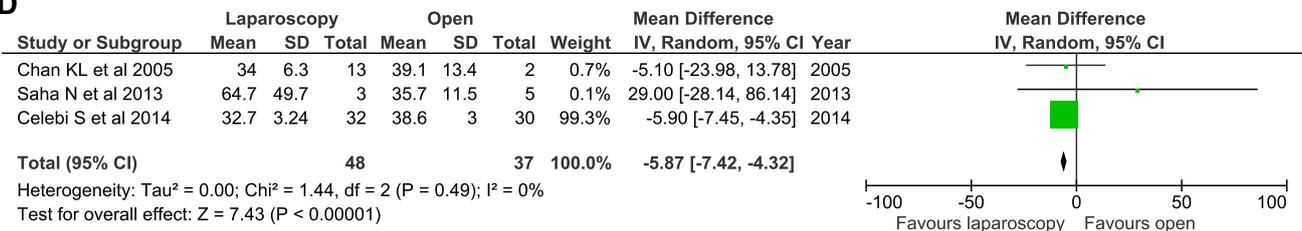
**B**



**C**

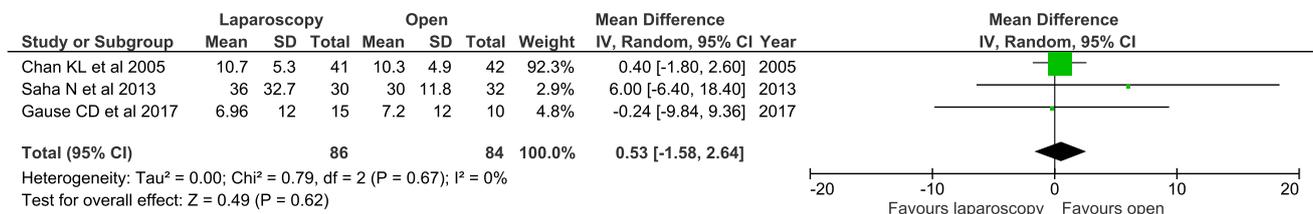


**D**



**Fig. 4 A–D** Forest plots of operative time in minutes for **A** unilateral hernia repair with extraperitoneal laparoscopic and open surgery, **B** unilateral hernia repair with intraperitoneal laparoscopic and open

surgery, **C** bilateral hernia repair with extraperitoneal laparoscopic and open surgery, and **D** bilateral hernia repair with intraperitoneal laparoscopic and open surgery



**Fig. 5** Forest plot of length of hospital stay in hours

[23, 24, 26, 29]. No significant difference was found in the individual studies or in the meta-analysis (Fig. 6).

Wound appearance was reported in five studies of which four studies showed significantly better results for laparoscopic repair [23, 26, 28, 31], and one study showed no difference [24]. The wound appearance was graded differently: by parents on a scale from 0 to 100 [23, 26], by parents, nurses, and surgeons on a scale from 0 to 3 [24], or followed up in outpatient departments without a scale [28, 31]. Thus, the results are reported too heterogeneously for quantitative comparison.

## Discussion

This systematic review of randomized controlled trials compared complications after open and laparoscopic groin hernia repair in children. The studies reported no intraoperative complications and a low overall rate of postoperative complications. Only one study reported a significant difference in complication rate, being a lower incidence of iatrogenic ascent of the testis after laparoscopic repair. Regarding recurrence, testicular atrophy, hydrocele, hematoma, seroma, and infection, neither the individual studies nor the meta-analyses showed significant differences between open and laparoscopic repairs. Due to different assessments of postoperative pain in the studies, we were unable to analyze which operative technique resulted in less pain. In most studies, wound appearance was better after laparoscopic repair. The meta-analyses on operative time showed that extraperitoneal laparoscopic repair was faster than open repair for unilateral groin hernias, but open repair was faster than intraperitoneal laparoscopic repair. For bilateral groin hernias, both laparoscopic techniques were faster than open repair.

Another systematic review was published in 2015 that exclusively included randomized controlled trials [12]. The review concluded that laparoscopic repair was superior to open repair regarding postoperative complications when all complications were pooled. Additionally, the authors concluded that extraperitoneal laparoscopic repair was superior regarding operative time for unilateral and bilateral hernias. In our study, including new evidence and analyzing each complication separately, we cannot support

the conclusion regarding postoperative complications. Our results support the conclusion that extraperitoneal laparoscopic repair is faster for unilateral and bilateral groin hernias. Furthermore, we found that intraperitoneal laparoscopic repair is faster than open repair for bilateral hernias but slower for unilateral hernias. We minimized the risk of overseeing studies eligible for inclusion by conducting the review systematically with a comprehensive search strategy, and we only included randomized controlled trials to report on studies with the highest level of evidence. There are some limitations in this systematic review. The included studies used different surgical techniques, and it is difficult to say how small differences can affect the results. This is especially evident for operative time, which may also be recorded differently. The age range is another limitation since all children from newborns to teenagers were included, leading to large variations in anatomy of the groin. It is problematic that most studies did not report on the surgeons' level of experience, because the learning curve of laparoscopic repair is found to be longer than for open repair [36]. The length of follow-up may also be a limitation. Only one study had an adequate follow-up of pain, enabling assessment of chronic pain. Furthermore, the follow-up time may have been too short to observe recurrence and testicular atrophy. We tried to reduce the effect of this limitation with sensitivity analyses removing studies with a follow-up shorter than 6 months from the meta-analyses. Still, 6 months may be too short regarding both recurrence and testicular atrophy [37, 38]. Additionally, there is some unclarity regarding risk of bias in individual studies because many risks could not be assessed.

In conclusion, based on the available data laparoscopic repair was found to be superior to open repair regarding operative time and wound appearance. However, on all other outcomes, such as recurrence, pain, and postoperative complications, the two methods were similar. Therefore, the overall conclusion is that laparoscopic groin hernia repair can be used in the pediatric population if local expertise is available. Thus, the surgeon's preference and expertise in open and/or laparoscopic techniques as well as the wish of the patient and parents should determine the surgical approach. Well-designed randomized controlled trials with long follow-up and thorough evaluation

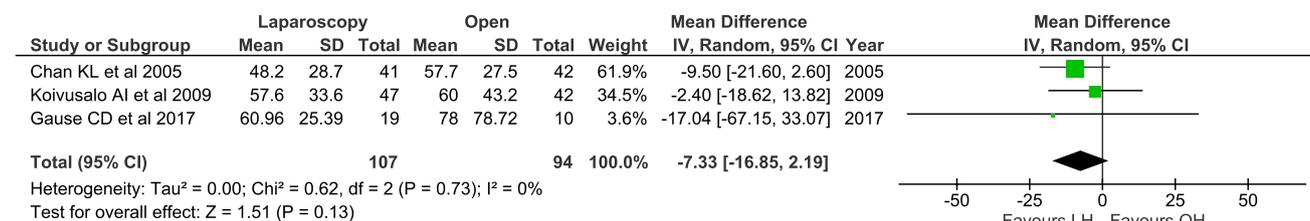


Fig. 6 Forest plot of time to full recovery in hours

of complications including pain are needed to qualify this clinical recommendation.

## Compliance with ethical standards

**Disclosures** Jacob Rosenberg declares conflict of interest not directly related to the submitted work (Jacob Rosenberg has received personal fees outside the submitted work from Bard and Merck). Christoffer Skov Olesen, Kristoffer Andresen and Stina Öberg declare no conflict of interest or financial ties to disclose.

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