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SCIENTIFIC REVIEW

Open Versus Laparoscopic Surgical Management of Rectus Diastasis: Systematic Review and Pooled Analysis of Complications and Recurrence Rates

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Abstract

Background Rectus diastasis (RD) is defined as widening of the linea alba and laxity of the abdominal muscles. It can be treated via a wide array of both conservative and surgical modalities. Due to the quickly evolving nature of this field coupled with the multiple novel surgical modalities described recently, there is a need for an updated review of surgical techniques and a quantitative analysis of complications and recurrence rates.

Methods A systematic review of PUBMED and EMBASE databases was preformed to retrieve all clinical studies describing surgical management of RD. Pooled analyses were preformed to assess recurrence and complication rates after both open and laparoscopic RD repairs (after controlling for herniorrhaphy).

Results A total of 56 papers were included in this review. In patients who underwent both an RD and a herniorrhaphy, there was no significant difference in recurrence rates between open (0.86%) and laparoscopic repairs (1.6%) ($p > 0.05$). Similarly, in patients who underwent RD repair *without* a herniorrhaphy, there was no significant difference in recurrence rates between open (0.89%) and laparoscopic repairs (0%) ($p > 0.05$). The most common complications reported were seroma, skin dehiscence, hematoma/post-operative bleeding, and infection. After controlling for a herniorrhaphy, there were no significant difference in total complication rates between open and laparoscopic RD repair. The total complication rates in patients who underwent an open RD repair with a herniorrhaphy were 13.3% compared to 14.5% in patients who underwent laparoscopic repairs ($p > 0.05$). Similarly, the total complication rates in patients who underwent RD repair *without* a herniorrhaphy were 11.8% in patients who underwent open repairs compared to 16.2% in their counterparts who underwent laparoscopic repairs ($p > 0.05$).

Conclusion Both open and laparoscopic approaches are safe and effective in repairing RD in patients with and without concurrent herniorrhaphy. Future research should report patient reported outcomes to better differentiate between different surgical approaches.

Introduction

Rectus diastasis (RD) is defined as widening of the linea alba and laxity of the abdominal muscles [1]. It presents as an abdominal protrusion in the setting of strain causing increased intra-abdominal pressure, making it easy to misclassify it as a ventral hernia. However, ventral hernias are differentiable from RD based on the musculofascial discontinuity of the abdominal aponeurosis (i.e., the presence of a true hernia defect) and concomitant potential risk

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of strangulation. Although RD is frequently misconstrued as a cosmetic condition, it can present with significant functional issues including lower back pain, increased risk of pelvic and spinal injury, and pelvic floor weakness [2–4].

RD can be treated conservatively or surgically, with physiotherapy often prescribed as the first line treatment. This includes active range of motion exercises aimed to strengthen abdominal and lower back muscles [2, 5]. However, the efficacy of physiotherapy alone in treating this condition is inconclusive and there is no strong evidence of its efficacy in treating severe cases [3, 6–9].

Surgical management of symptomatic RD is the mainstay treatment when physiotherapy fails [10]. Previous studies have demonstrated the effectiveness of both open and laparoscopic surgeries in treating RD [11]. However, due to the quickly evolving nature of this field coupled with the multiple novel surgical modalities described recently, there is need for an updated review of surgical techniques and pooled complications and recurrence rates associated with the different techniques.

To this end, the goal of this study is to review all the clinical studies describing open and minimally invasive surgical management of RD in adults and present a pooled analysis of recurrence and complication rates associated with different approaches. The results of this paper will provide surgeons and patients with the most updated complication and recurrence rates of RD repair with the overall goal to help improve the process of informed consent.

Methods

Search strategy

The National Library of Medicine (PUBMED) and the EMBASE databases were searched according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses to retrieve all clinical studies on surgical management of RD in adults from inception to December 2021. The search strategy used the following terms: divarication, diastasis, plication, abdominal muscles, and rectus abdominis linked by the BOOLEAN terms AND & OR. The search strategy used in PubMed was the following: (divarication OR diastasis OR plication) AND (recti OR rectus OR abdomen OR abdominal OR abdominis). All articles were initially screened based on title and abstract. Articles deemed relevant underwent full text review.

Inclusion and exclusion criteria

The inclusion criteria for this review consisted of any clinical study that assessed outcomes or complications of surgical RD repair. Case reports and case series with less than 10 patients were excluded. Animal and cadaveric studies were also excluded. Studies that did not report on surgical techniques were excluded. Studies that included a mixed group of patients who did and did not undergo a concurrent herniorrhaphy were included in the results but not included in the pooled analysis of outcomes since we were unable to differentiate the outcomes based on the presence of a herniorrhaphy.

Data collection and synthesis

Articles retained during the screening process underwent data extraction. Data collected included type of study, patient demographics, surgical technique, usage of mesh reinforcement, surgical outcomes (including operative time, length of hospital stay, post-operative pain, and patient satisfaction), complications and recurrence rates. Given the significant confounding effect of herniorrhaphy, all outcomes were stratified based on its presence or absence. Pooled analyses of complication and recurrence rates were performed. Only studies that explicitly reported on complications and recurrence rates were included in the pooled analysis to avoid under/over estimation of the overall rates.

Statistical analysis

Chi-Square tests were used to assess for significant differences in complication and recurrence rates between groups. Statistical significance was pre-set at $p < 0.05$. All the analyses were preformed using SPSS statistical program version 26.0 (IBM, New York, NY, USA).

Results

The initial search returned 1307 studies after elimination of 121 duplicates. Following abstract and title review, 101 unique articles were retained for full text review. Of these, 56 met our inclusion criteria and underwent data extraction (Fig. 1).

Of the 56 included studies, 31 described open RD repairs (multiple studies described several approaches amounting to a total of 39 technical variations described) [12–42] while 28 studies described laparoscopic RD repairs [19, 38, 42–67]. Three studies described both open and laparoscopic repairs [19, 38, 42].

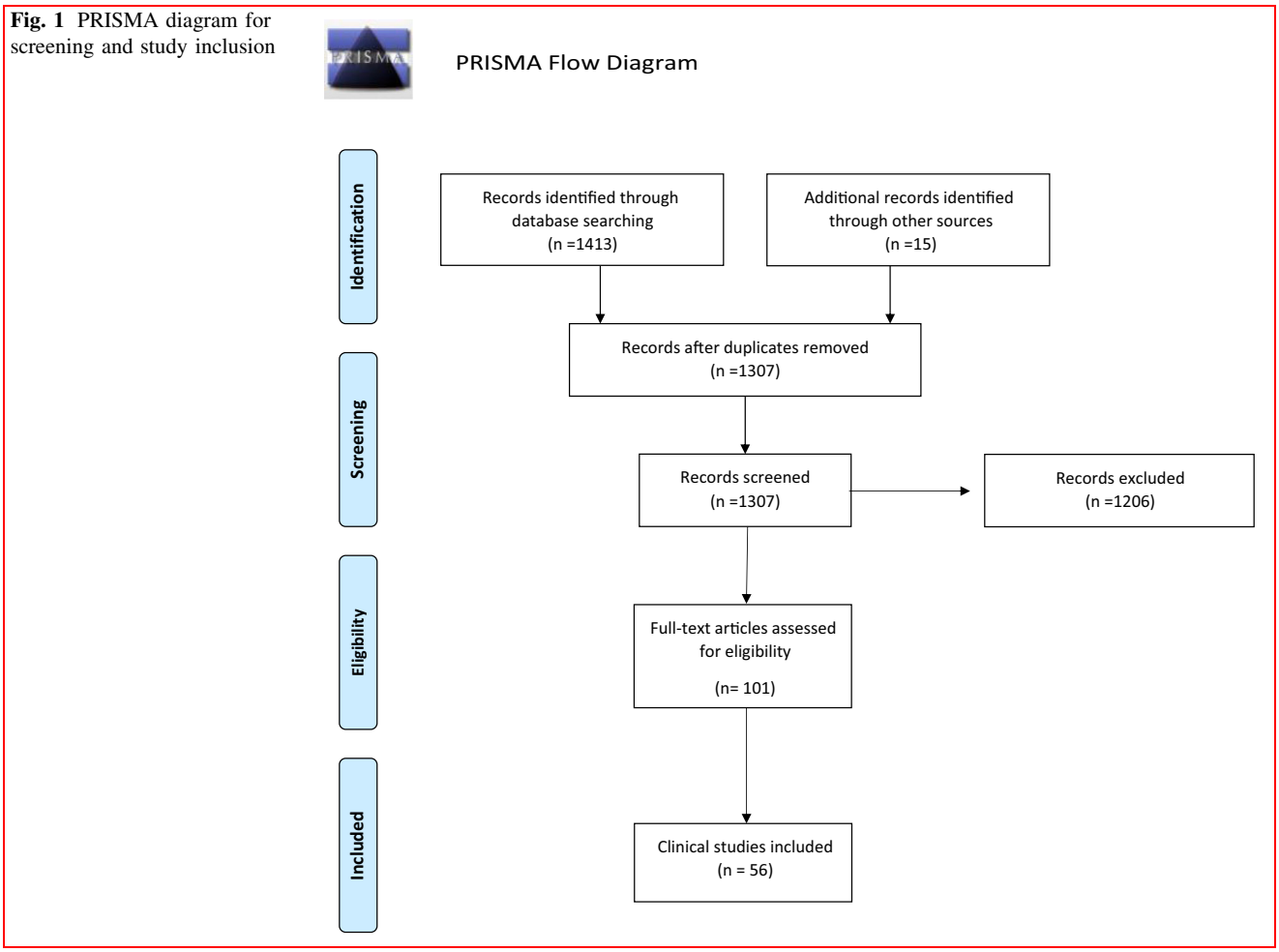

Fig. 1 PRISMA diagram for screening and study inclusion

The overwhelming majority of both open and laparoscopic RD repair techniques consisted of either single- or double-layer repair of the rectus aponeurosis. Both absorbable and non-absorbable sutures have been described as useful in RD repair. Specifically, of the 36 open techniques for which suture type was specified, 20 (55.6%) used non-absorbable sutures, 14 (38.9%) used absorbable sutures, one used both absorbable and non-absorbable (2.8%). and one used staples (2.8%). Similarly, of the 23 laparoscopic techniques for which suture type was reported, 13 (56.5%) used non-absorbable sutures while 10 (43.5%) used absorbable sutures. Furthermore, only 12 of the 39 (30.8%) open techniques described involve repair reinforcement with a mesh, while 24 of the 28 (85.7%) laparoscopic RD repair techniques involved mesh reinforcement. Mesh was reported to be placed either onlayed, inlayed, or sublayed.

A concurrent hernia repair was commonly performed in many of the included studies. Specifically, 10 of the 39 (25.6%) open RD repair techniques and 22 of the 28 (78.6%) laparoscopic RD repair techniques described a concomitant abdominal hernia repair. Weighted average duration of follow-up was comparable between patients who underwent laparoscopic (21.3 months) and open surgery (24.1 months; $p > 0.05$). Pooled analyses of RD recurrence and complications were stratified based on the presence of a concomitant hernia repair. A total of 2129 patients were included in the pooled analysis of recurrence rates. In patients who underwent both RD and hernia repair, there was no significant difference in recurrence rates between open repairs ($n = 4/463$; 0.86%) and laparoscopic repairs ($n = 11/684$; 1.6%) ($p > 0.05$). Similarly, in patients who underwent RD repair *without* herniorrhaphy, there was no significant difference in recurrence rates between open repairs ($n = 7/785$; 0.89%) and laparoscopic repairs ($n = 0/197$; 0%, $p > 0.05$). (Table 1).

A total of 2608 patients were included in the pooled analysis of complications. Approximately half of them ($n = 1{,}283$; 49.2%) underwent RD repair *with* concurrent herniorrhaphy while the remaining patients ($n = 1{,}325$; 50.8%) underwent RD repair *without* hernia repair. The most common complications reported were seroma, skin dehiscence, hematoma/post-operative bleeding, and

Table 1 Pooled analysis of recurrence rates of open and laparoscopic RD repair stratified based on the presence of a concomitant hernia repair

		Recurrence		
		Main surgical approach		
		Open	Laparoscopic	Significance
Associated hernia repair	Yes	0.86% (n = 463)	1.6% (n = 684)	$p > 0.05$
	No	0.89% (n = 785)	0% (n = 197)	$p > 0.05$

Chi squared tests were performed and reported as p values to compare recurrence rate between open and laparoscopic repairs after controlling for a concomitant hernia repair

infection. In patients who underwent RD repair with concurrent herniorrhaphy, there was no significant difference in total complication rates between those who underwent open repairs (13.3%) and their counterparts who underwent laparoscopic repairs (14.5%) ($p > 0.05$). With regards to specific complications, laparoscopic repairs were associated with a significantly higher rate of seromas compared to open repairs (7.2% vs. 2.3%, respectively; $p = 0.0007$). On the other hand, open compared to laparoscopic repairs were associated with higher rates of skin dehiscence (6.2% vs. 2.4%, respectively; $p = 0.0007$) and hematomas (4.2% vs. 1.4%, respectively; $p = 0.002$). There were no significant differences in the other types of complications (Table 2).

Similarly, in patients who underwent RD repair *without* herniorrhaphy, there was no significant difference in total complication rates between those who underwent open repairs (11.8%) and their counterparts who underwent laparoscopic repairs (16.2%) ($p > 0.05$). Moreover, there were no significant differences in the rate of *any specific* type of complication between open and laparoscopic RD repairs without hernia repairs ($p > 0.05$) (Table 3).

Other reported outcomes included hospital stay, surgical time, post-operative pain, and patient satisfaction. However, due to the heterogeneity in reporting of other outcomes, a pooled analysis was not feasible. Please refer to supplementary tables 1–2 for details.

Discussion

This systematic review and pooled analysis of outcomes demonstrates that both open and laparoscopic approaches are effective in repairing RD in patients with and without ventral hernia as evidenced by very low recurrence rates (approximately 1%) in both groups. Moreover, both approaches are safe as evidenced by low total complication rates and almost negligible major complication rates. There was no significant difference in recurrence or total complication rates between open and laparoscopic approaches.

Over time, there has been a general shift in abdominal surgery towards minimally invasive techniques [68]. While open techniques can sometimes allow for better visualization, previous studies have shown that minimally invasive surgery, in general, is associated with less post-operative

Table 2 Pooled-analysis of complication rates of open and laparoscopic Rectus Diastasis (RD) repair techniques *with* concurrent hernia repair

Main surgical approach	Open (n = 354) %	Laparoscopic (n = 929) %	Chi square	Significance
Rate of seroma	2.3	7.2	11.4	$p = 0.0007$
Rate of dehiscence/necrosis	6.2	2.4	11.5	$p = 0.0007$
Rate of bleeding/hematoma	4.2	1.4	9.67	$p = 0.002$
Rate of infection	0.0	1.2	N/A	N/A
Rate of chronic pain/neuralgia	0.0	0.8	N/A	N/A
Rate of thromboembolic events (DVT/PE)	0.0	0.0	N/A	$p = 1$
Rate of other complications*	0.6	1.6	2.16	$p = 0.142$
Total rate of complications	13.3	14.5	0.33	$p = 0.545$

(n = total number of patients included in pooled-analysis; DVT/PE: deep vein thrombosis/pulmonary embolism)

*Other complications include: scar revision, foreign body sensation, dog ears, granulomas, hyperpigmentation, bladder injury, pneumonia, subcutaneous emphysema, ecchymosis and epidermolysis

Table 3 Pooled-analysis of complication rates of open and laparoscopic Rectus Diastasis (RD) repair techniques *without* concurrent hernia repair

Main surgical approach	Open (n = 1040) %	Laparoscopic (n = 285) %	Chi square	Significance
Rate of seroma	4.4	5.6	0.71	p = 0.399
Rate of dehiscence/necrosis	1.1	1.4	0.24	p = 0.625
Rate of bleeding/hematoma	0.8	0.0	N/A	N/A
Rate of infection	1.5	0.4	0.58	p = 0.446
Rate of chronic pain/neuralgia	0.0	3.2	N/A	N/A
Rate of thromboembolic events (DVT/PE)	0.4	0.0	N/A	N/A
Rate of other complications*	3.7	5.6	2.20	p = 0.138
Total rate of complications	11.8	16.2	3.74	p = 0.053

(n = total number of patients included in pooled-analysis; DVT/PE: deep vein thrombosis/pulmonary embolism)

*Other complications include: scar revision, foreign body sensation, dog ears, granulomas, hyperpigmentation, bladder injury, pneumonia, subcutaneous emphysema, ecchymosis and epidermolysis

pain, shorter hospital duration, and fewer operative and non-operative complications [69]. Due to the heterogeneity of in pain reporting scales between different studies and paucity in data regarding length of hospital stay, we were unable to demonstrate their comparative efficacy with regards to the aforementioned factors. However, with regards to complications, our study showed no difference in total complications between open and laparoscopic RD repairs (after controlling for the presence of a herniorrhaphy).

One subset of minimally invasive surgeries are robotic surgeries. This emerging field has the advantage of preforming complex procedures with high precision and control, promising the potential of minizine tissue dissection and reducing morbidity. However, since its conception approximately two decades ago, it has faced some challenges that slowed down its implementation in various surgical domains [70]. Several recent papers compared robotic to open and laparoscopic hernia repair demonstrating a significant reduction in hospital stay associated with the former. However, robotic surgery was found to be associated with a significantly longer operative time [71, 72]. While we found no published peer reviewed studies in scientific literature that specifically describe outcomes of robotic rectus diastasis repair, it holds great promise for the future. Therefore, we hope that future studies assess its efficacy and safety profile compared to conventional open and laparoscopic RD repairs.

The current review demonstrates the wide array of surgical techniques for RD repair. One of the technical aspects that vary from one technique to another is the suture type used for the repair. Conventional wisdom stipulates that nonabsorbable sutures might provide a stronger more permanent repair. However, several previous studies have shown no difference in the repairs' strength between nonabsorbable and absorbable sutures and that strong reliable long-term stability is achieved by both [25, 27–29]. Another technical variation that is reported in the current review is the use of mesh. Mesh was commonly utilized in the setting of laparoscopic repair, while it was used sparingly by surgeons performing open repair. This is consistent with previous studies describing the tenuous ergonomics and higher recurrence rates of suture-only laparoscopic repairs [50]. However, in patients whose body habitus makes them a candidate for simultaneous abdominoplasty and RD repair, the archetypal patient seen in a plastic surgery practice, the open approach is preferred [73]. In this setting, a randomized, prospective clinical trial administered by Emanuelsson et al. [17] comparing absorbable suture reinforced with mesh to self-retaining sutures only found no difference in recurrence or complication rates.

This review has several limitations. Most importantly, the included studies were highly heterogeneous and were not amenable to a meta-analysis of outcomes (ex. length of hospital, post-operative pain etc.). Moreover, surgical indications and baseline patient characteristics varied between studies. However, this study fills an important void in the literature surrounding outcomes of RD repair controlled for concurrent herniorrhaphy. Importantly, the updated complication and recurrence rates published herein will allow surgeons to provide evidence-based information to their patients with the goal to improve the process of informed consent.

Conclusion

There is a multitude of surgical approaches described for the management of RD, which this paper serves to exhaustively report on. Both open and laparoscopic techniques are effective and safe in repairing RD as evidenced

by the low recurrence rate of approximately 1% and almost negligible major complication rates. With novel surgical techniques constantly being developed, there is a need to recursively review the literature to update these figures to continually provide the optimal care for our patients.

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