

# A systematic review on the outcomes of correction of diastasis of the recti

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## Abstract

**Purpose** Diastasis or divarication of the rectus abdominus muscles describes the separation of the recti, usually as a result of the linea alba thinning and stretching. This review examines whether divaricated recti should be repaired and tries to establish if the inherent co-morbidity associated with surgical correction outweighs the benefits derived.

**Methods** EMBASE, MEDLINE and the Cochrane library were searched for ('divarication' OR 'diastasis') AND ('recti' OR 'rectus'). A standard data extraction form was used to extract data from each text. Due to the lack of randomised control trials, meta-analysis was not possible.

**Results** Seven studies report that patient satisfaction was high following surgery. The most common complication seen was the development of a seroma. Other common complications included haematomas, minor skin necrosis, wound infections, dehiscence, post-operative pain, nerve damage and recurrence, the rate of which may be as high as 40%.

**Conclusions** Further studies are required to compare laparoscopic and open abdominoplasty techniques. Patients and physicians should be advised that correction is largely cosmetic, and although divarications may be unsightly they do

not carry the same risks of actual herniation. Progressive techniques have resulted in risk reduction with no associated surgical mortality. However, the outcomes may be imperfect, with unsightly scarring, local sepsis and the possibility of recurrence.

**Keywords** Divarication · Recti · Review · Outcome

## Introduction

The abdominal wall is a muscular structure that serves to protect the abdominal viscera, maintaining their intra-abdominal position against changing gravitational forces and increases in compartmental pressures [1].

Diastasis or divarication of the rectus abdominus muscles describes the separation of the two muscles, usually as a result of the linea alba thinning and stretching (see Fig. 1). The extent of the divarication may be measured by the inter-recti distance (IRD) [2]. Once separated, the function of the anterior abdominal wall may become compromised.

Secondary divarication is an acquired phenomenon and may result from excessive exercise, significant weight loss, and most commonly following pregnancy [2, 3].

Divaricated recti are commonly mistaken for incisional or epigastric hernia during clinical examination. A hernia is defined as the protrusion of an organ, or part of an organ into a cavity into which it should not protrude [4]. Divarications may exist with or without the presence of protrusion of the abdominal contents. The abdominal bulge that results, however, is not a true hernia, with no recognisable risk of strangulation or incarceration of the contents [3].

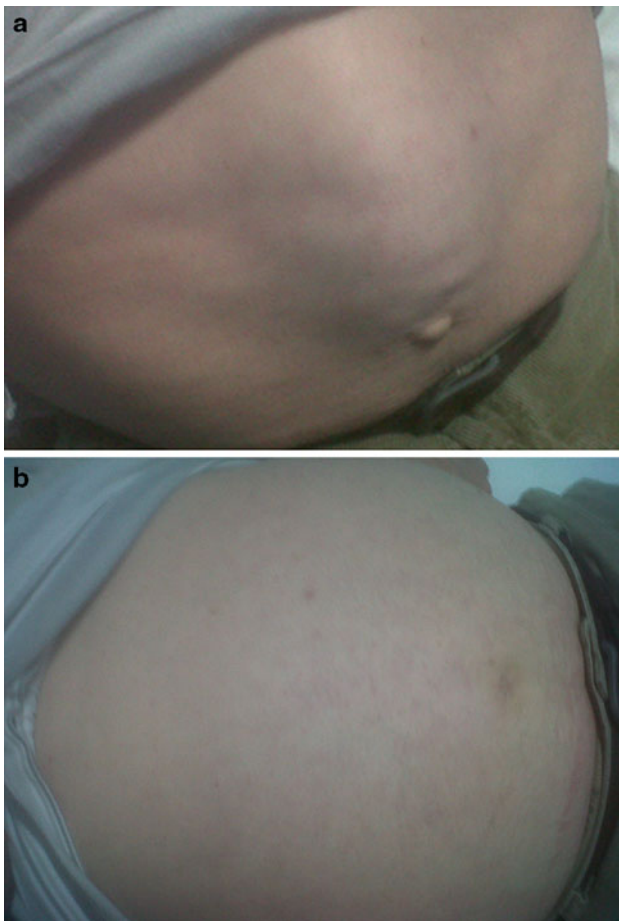
Abdominoplasty is a commonly employed technique by which divaricated recti are corrected [1]. There are a multitude

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**Fig. 1** **a** Contracted abdomen clearly demonstrating a divaricated rectus abdominus. **b** The same abdomen relaxed. Note the absence of divarication

of different procedures, which include the minimally invasive and the more traditional open approaches. Whichever approach is taken, however, in order for effective correction to be achieved plication of the rectus sheath is required. It is also necessary to establish whether the defect is congenital or acquired, as this determines whether it is necessary to plicate the posterior as well as the anterior sheath [5].

Surgical correction of divaricated recti remains a controversial subject. There are many complications associated with the procedure, including haematoma and seroma formation, wound infection, necrosis of the skin flaps, and hypertrophic scarring [6, 7]. Additionally, subsequent to plication of the rectus sheath, intra-abdominal pressure increases, decreasing venous return and increasing the risk of deep vein thrombosis (DVT) formation [8]. Despite appropriate and effective plication, recurrences may occur in 40% of cases [9].

This review examined studies that attempted to repair divaricated recti, in order to assess surgical outcomes and to establish whether the benefits of surgery outweigh the associated risk.

## Methods

This review included studies that were concerned with patients with divarication of the recti abdominus muscles as the primary complaint.

The types of intervention that were assessed included:

- Open abdominoplasty.
- Laparoscopic abdominoplasty.
- No intervention to determine if spontaneous resolution may occur.

All outcomes were considered. In the main, these included:

- Recurrence rates of divarication of the recti after abdominoplasty and surgical correction.
- Complications of surgery.
- Post-operative satisfaction.
- Spontaneous resolution.

This review assessed research studies, discussions and expert opinions related to treatment modalities of divarication of the recti. Published research studies included in this review comprise:

- Randomised control trials (RCTs).
- Observational studies without controls (cross-sectional studies and case series).

## Search strategy

An extensive search was performed of all published data appertaining to divaricated recti. Due to the limited volume of published work, broad search criteria were applied. EMBASE, MEDLINE and the Cochrane library were searched for ('divarication' OR 'diastasis') AND ('recti' OR 'rectus'). This was limited to and 'human studies', for the period of 1980 to the present day.

The bibliographies of all selected articles were hand searched, and further appropriate articles were identified until an exhaustive list of relevant studies was compiled.

A standard data extraction form was used to extract data from each text (see "Appendix"). Three reviewers performed data extraction independently. Disagreements were discussed and mutual agreement was reached. A relative lack of RCTs precluded meta-analysis and therefore a systematic review is presented.

## Results

The initial search identified 170 articles. After exclusion of duplicate articles, 99 remained. Of these 99 studies, 16 were deemed appropriate for inclusion. After hand searching the

bibliographies of these papers an additional study was included.

The 17 papers are summarised in Table 1. The total number of patients involved in these studies was 885.

The literature search retrieved a single RCT [10]. The remainder of the studies were case series, which lacked controls or statistical analysis.

The RCT [10] compared the laparoscopic approach to open abdominoplasty. Four of the studies describe a laparoscopic approach [3, 11–13], 12 were open abdominoplasties [5, 6, 9, 10, 14–21] and 1 study had no intervention [22]. The method of repair of the divarication differed between the studies with respect to the number of layers of sutures, the position of suture placement, the suture material used and the use of mesh. The number of participants in the studies ranged from 2 to 337, all of whom were adults. The largest study by Braumann et al. [18] did not explicitly state how many of the participants had divarication of the recti, and therefore conclusions from this study must be viewed with caution.

Seven of the studies claim that patient satisfaction was high [3, 7, 14, 18, 20, 21]; however, only two describe the use of a tool for measuring this by employing questionnaires or grading systems [9, 18]. The remainder, however, do not comment on patient satisfaction.

The most common complication was seroma formation [9, 12, 13]. The other common complications were haematomas, minor skin necrosis, wound infection, wound dehiscence, nerve damage, post-operative pain and, of great importance, recurrence.

Two studies assessed the long-term results following surgical correction of divaricated recti [9, 19]. Nahas et al. [19] report a 0% recurrence rate at an average of 81.2 months follow up, with 12 participants. However, van Uchelen et al. [9] evaluated the results of 63 patients, two-thirds of whom had a recurrence of their recti muscle separation at follow up; 16 of these were described as a recurrent divarication.

Zukowski et al. [12] present the only study to directly compare laparoscopic and open approaches. They demonstrated a lower rate of complications in the laparoscopic group (15%) compared to the open abdominoplasty group (24%). The nature of the complications differed greatly between the two groups. One patient returned to theatre in the laparoscopic cohort. This patient was dissatisfied with the cosmetic result and subsequently underwent revisional surgery. Four patients required operative re-intervention in the open abdominoplasty group for complications of wound healing and haematoma formation [12].

## Discussion

Divaricated recti are not true herniae. There is, therefore, no risk of strangulation of the contents and as such the decision to repair is largely cosmetic.

What is apparent from this literature review is that the evidence base on the topic of divarication is poor. Only one of the studies identified was an RCT [10]. The other papers were descriptive case reports without controls and lacked statistical analysis. Due to the relatively limited literature on diastasis recti, the databases were searched with broad terms. This inevitably retrieved studies that did not focus on the repair of diastasis, rather mentioning it only as a feature of syndromes, other conditions, or in other contexts. For this reason, these studies were excluded from the review. There were a limited number of studies remaining, which were of variable quality; however they all had a focus on the repair of diastasis. As there was only one RCT, it was deemed appropriate to include all the studies, but to make it explicit to the reader that the strength of evidence differed greatly between studies.

In comparison to previously published studies [10, 19], this paper directly compares the published literature comparing open and laparoscopic techniques and demonstrates a lower complication rate in the laparoscopic cohort. It also incorporates an overview of the reported complications, recurrences and degree of satisfaction following repair of diastasis. Due to the differences observed in measuring the degree of diastasis between studies, different rates of recurrence are observed. Newer techniques incorporating elements of day case surgery are under development, for example, surgery under local anaesthetic agents, which may have a role in the further reduction of peri-operative complications.

The overall research base remains poor and there is room for further studies (particularly RCTs) directly comparing the results and complications of open versus laparoscopic repair.

Despite the limited published data, however, some conclusions can be drawn from the data. Overall, patient satisfaction appears to be high post surgical correction of divarication of the recti; however, only two of the studies provided a means of assessing the level of satisfaction [9, 18].

The complication rate varied widely between studies—in part due to the different patients in each series, although the types of complication were consistent. No DVTs were reported, despite the hypothesis that plication of the rectus sheath leads to a rise in intra-abdominal pressure, reduction in venous return and subsequent increase in venous pooling [8]. Though the evidence for direct comparison is limited, it appears that the complication rate is significantly lower in laparoscopic repair than in open surgery [12].

**Table 1** Summary of studies on divarication of the recti. *IRD* Inter-recti distance, *DVT* deep vein thrombosis

| Study  | Authors               | Study type and Oxford level of evidence      | Number of patients | Procedure   | Control          | Outcome  | Statistical test and <i>P</i> value  |
|--|-----------------------|--|--------------------|---|------------------|--|--|
| Laparoscopic abdominoplasty for divarication of recti  | Bhanot [11]           | Case report series                           | 5                  | Laparoscopic abdominoplasty<br>One layer of sutures<br>Mesh applied                     | None             | All experienced significant post-op pain. Decrease in abdominal girth and increased abdominal tone at 1 year follow up   |  |
| Laparoscopic repair of diastasis recti using the 'Venetian blinds' technique of plication with prosthetic reinforcement: a retrospective study | Palanivelu et al. [3] | Level 4 study<br>Case report series          | 18                 | Laparoscopic abdominoplasty<br>One layer interrupted sutures<br>Mesh applied            | None             | IRD obliterated post-op, no recurrence at 48 months. Minor complications in 5 of 18—post op pain, chronic pain, pneumonia. Most patients noticed improved muscle tone, 2 patients did not see any improvement in muscle tone |  |
| Ambulatory abdominoplasty tailored to patients with an appropriate body mass index   | Williams et al. [14]  | Retrospective case series<br>Level 2 b study | 22                 | Open abdominoplasty—3 layer incision  | None             | Satisfaction and no complications of any patients at 3 months  |  |
| An efficient way to correct recurrent rectus diastasis   | Nahas et al. [5]      | Case report<br>Level 4 study                 | 2                  | Open abdominoplasty<br>Two layers of sutures<br>Posterior and anterior sheaths plicated | None             | Patient 1—complete correction at 30 months<br>Patient 2—complete correction at 6 months  |  |
| Nylon versus polydioxanone in the correction of rectus diastasis   | Nahas et al. [10]     | RCT<br>Level 1 study                         | 20                 | Open abdominoplasty<br>Two layers of sutures<br>One interrupted, one continuous         | 2-0 nylon suture | Correction of diastasis recti was achieved and maintained at 6 months with both suture materials. Five patients developed seromas, 3 in the polydioxanone group and 2 in the nylon group                                     | t-test, $P \leq 0.35$ for traction at superior level; $P \leq 0.45$ for traction at inferior level |
| Triangular mattress suture in abdominal diastasis to prevent epigastric bulging  | Ferreira et al. [15]  | Case report series                           | 56                 | Open abdominoplasty<br>One layer of interrupted triangular mattress sutures             | None             | Prevented epigastric bulging in all patients   |  |

Table 1 continued

| Study  | Authors             | Study type and Oxford level of evidence  | Number of patients | Procedure   | Control | Outcome   | Statistical test and P value |
|--|---------------------|--|--------------------|---|---------|---|------------------------------|
| Natural resolution of rectus abdominis diastasis. Two single case studies                | Hsia et al. [2]     | Case report series Level 4 study         | 2                  | None—IRD measured at 3 levels (superior border of umbilicus, 45 mm above umbilicus and 45 mm below umbilicus). Measurements taken at 36 weeks gestation and 12 weeks postpartum | None    | IRD persists at 12 weeks post partum  |                              |
| Progressive tension sutures: a technique to reduce local complications in abdominoplasty | Pollock et al. [6]  | Retrospective case series Level 2b study | 65                 | Open abdominoplasty<br>One layer of progressive tension sutures<br>Eliminate dead space, preventing fluid collection  | None    | No seromas, haematomas or skin necrosis. Ten revisions due to dog-ears or liposuction touch-ups.<br>One small area of localised drainage—due to liquefaction of an area of fat necrosis |                              |
| Should diastasis recti be corrected?   | Nahas et al. [16]   | Case report series Level 4 study         | 14                 | Open abdominoplasty—rectus diastasis corrected with two layers of sutures   | None    | Three seromas formed, all had complete correction of the divarication at 6 months   |                              |
| A simple technique for repair of rectus sheath defects                                   | Asaadi et al. [17]  | Case report series Level 4 study         | 39                 | Open abdominoplasty<br>Two running sutures<br>One from sternal edge and the other from supra-pubic region, both meeting and tied at umbilicus                                   | None    | At >25 months follow-up—no recurrence, no hernias, no discomfort  |                              |
| Liposuction abdominoplasty: an advanced body contouring technique                        | Brauman et al. [18] | Prospective case series Level 2 study    | 337                | Open abdominoplasty<br>If indicated, segmental diastasis repair was performed<br>Repairing only the site of greatest separation—not xiphoid to pubis.                           | None    | No deaths, no major complications of surgery or anaesthetic, no DVTs.<br>Five infections of seromas, six cases of minor tissue necrosis, patient satisfaction high                      |                              |

Table 1 continued

| Study  | Authors                | Study type and Oxford level of evidence | Number of patients | Procedure   | Control             | Outcome   | Statistical test and <i>P</i> value |
|--|------------------------|---|--------------------|---|---------------------|---|-------------------------------------|
| Endoscopic intracorporeal abdominoplasty: a review of 85 cases   | Zukowski et al. [12]   | Retrospective case series               | 90                 | Laparoscopic abdominoplasty   | Open abdominoplasty | Laparoscopic morbidity 15%—one case of epidermolysis, two cases of full-thickness skin loss, one wound infection, three cases of prolonged neuralgia and six seromas  |                                     |
|  |                        | Level 2 b study                         |                    |   |                     | Open morbidity 25%—postoperative ileus lasting 1 week, one full-thickness skin loss, one wound infection, one wound separation, one wound protuberance requiring operative revision, and one postoperative hematoma requiring surgical drainage |                                     |
| Rectus muscle diastasis in males: primary indication for endoscopically assisted abdominoplasty  | Lockwood [13]          | Case report series<br>Level 4 series    | 4                  | Endoscopically assisted abdominoplasty  | None                | Good to excellent results at 4–18 month follow ups. Complications—suture infection, seroma  |                                     |
| Long-term follow-up of correction of rectus diastasis  | Nahas et al. [19]      | Case report series<br>Level 4 series    | 12                 | Open abdominoplasty<br>Two layers of sutures<br>One interrupted, one continuous | None                | No recurrence at long term follow up—average 81.2 months, complications—one seroma  |                                     |
| The long-term durability of plication of the anterior rectus sheath assessed by ultrasonography  | van Uchelen et al. [9] | Case report series<br>Level 4 series    | 63                 | Open abdominoplasty<br>One layer of sutures<br>Continuous                       | None                | Complications: one DVT, 74 sensibility disorder of abdomen, 6 sensibility disorder of thigh, 10 wound complications. At follow up (40 patients) 2/3rds had separation of the recti, however only 40% were graded as diastasis recti             |                                     |
| Circumferential suction lipectomy of the trunk with anterior rectus fascia plication through a periumbilical incision: an alternative to conventional abdominoplasty | Dabb et al. [20]       | Case report series<br>Level 4 series    | 32                 | Open abdominoplasty—small periumbilical incision                                | None                | All patients satisfied. Two required small revisions, five developed seromas, one partial thickness subdermal burn  |                                     |
| Abdominoplasty and abdominal wall rehabilitation: a comprehensive approach   | Ramirez [21]           | Case report series<br>Levels 4 series   | 104                | Open abdominoplasty   | None                | High level of patient satisfaction. Three skin flap necrosis, two revisions, five seromas, one pseudobursa formation, one drain tract infection   |                                     |



A large discrepancy was demonstrated in the recurrence rate of divarication stated by the two papers concerned with long-term follow up: 0% [19] compared to 40% [7]. The technique used in the study by van Uchelen et al. [7] involved correcting the divarication by plicating further than the medial edge of the rectus muscles, which might result in excessive tension on the sutures with increased likelihood of failure [23]. Palanivelu et al. [3] also had a recurrence rate of 0% using their ‘venetian blinds’ technique; however, they state that recurrence was defined as a post-operative IRD measuring the same as the pre-operative distance [3]. There is potential, therefore, that there was separation of the recti in some patients that did not meet the ‘recurrence criteria’.

Newer techniques are currently being practised that enable the procedure to be performed under local anaesthesia with sedation, as a laparoscopic approach and in a day case setting. This largely eliminates the added complications that general anaesthesia incurs [14].

The main conclusion from this review is that further studies are needed to assess open abdominoplasty approaches, with strict definitions as to the extent of the pre-operative divarication and what qualifies as recurrence. Once these studies have been performed it may be possible to progress to comparing laparoscopic and open approaches by the means of randomised controlled trial. Statistical analysis is important to determine how significantly the complication rates differ between the two approaches with long-term follow up necessary to demonstrate the lifetime risk of recurrence. Any claims of patient satisfaction require methods and evidence to substantiate them.

The advice to patients and for referring physicians would be that surgical correction is a cosmetic procedure. Although divarications may be unsightly they do not carry the risks that true herniae do. Newer techniques have allowed safer surgery with, as yet, no documentation of post-operative mortality. However, corrective surgery may result in scarring and local complications such as sepsis with the possibility of recurrence in the future.

## Appendix

### Data extraction form

|   |
|---|
| Reference                                   |
| Objective                                   |
| Study design                                |
| Population                                  |
| Intervention                                |
| Control                                     |
| Outcome                                     |
| Statistical analysis (type, <i>P</i> value) |
| Comments                                    |

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