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Rectus sheath plication in abdominoplasty: Assessment of its longevity and a review of the literature☆

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Summary *Background:* Correction of rectus diastasis during abdominoplasty is controversial. Few published studies have investigated the long-term value of plication. This prospective study aims to assess the long-term durability of plication of the rectus sheath in abdominoplasty using ultrasound.

Methods: A total of 28 consecutive abdominoplasty patients underwent rectus plication by the senior author (FSF) since 2006, using a 0/0 looped nylon suture. Rectus diastasis was measured preoperatively and postoperatively at 3, 6 and 12 month's intervals using a standardised ultrasound (7.5 MHz) probe, by the single senior radiologist (GJD). Diastasis of the recti was assessed at three fixed points: at the umbilicus, 6 cm above and 6 cm below the umbilicus. Diastasis was categorised using the Beer classification.

Results: All patients were female with a mean age of 36 years and average of body mass index (BMI) 26 kg m^{-2}. The majority of subjects had previous abdominal surgery including caesarean sections (82%, $n = 23$) and had at least one previous pregnancy (87%), with only two patients (8.7%) in the study being nulliparous. Correction of diastasis was maintained in all patients despite previous pregnancies and abdominal surgery.

Postoperative follow-up time averaged 28 months (range 12–43 months). According to the Beer classification, there was no recurrence of rectus diastasis at the 12-month postoperative ultrasound measurements. A significant reduction in the mean distance between rectus

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muscles before surgery and 12 months postoperatively was noted. Previous surgery did not have a statistically significant affect on preoperative rectus distance.
Conclusions: Vertical rectus plication with a non-absorbable suture demonstrates long-term durable results without any suture-related complications. Patient factors such as extent of preoperative rectus diastases and previous abdominal surgery did not appear to have a significant effect on the durability of the corrected diastasis.

Introduction

Rectus plication, commonly performed during abdominoplasty, aims to relocate the rectus muscles to the midline and restore abdominal contour. The classic Pitanguy technique described in 1967 plicates the fascia in the midline using a non-absorbable suture.[1] Since then, various techniques and suture types have been used for correction of rectus diastasis.

Constant forces such as muscular contraction and increased intra-abdominal pressure, as well as tissue elasticity, act on the sutured aponeurosis, affecting the durability of the correction.[2] The majority of studies have demonstrated the efficacy of rectus plication either with retrospective methodology or with a short period of follow-up.[3,4] There is paucity of published articles prospectively evaluating the durability of rectus plication with a long-term follow—up.[2]

The aim of this study was to prospectively evaluate the long-term durability of standard vertical plication of the anterior rectus sheath with a non-absorbable suture, using ultrasound measurements at specific points along the rectus sheath.

Patients and methods

Between January 2007 and December 2009, 28 patients undergoing abdominoplasty with rectus plication by the senior author were recruited into the study. Abdominoplasty was performed through a transverse suprapubic incision that was extended laterally to the anterior superior iliac spines. The abdominal cutaneous flap was dissected from the aponeurosis up to the xiphoid process centrally and to the costal margins laterally. The excess flap was resected and the umbilicus repositioned. The diastasis was corrected with two loop 0 nylon sutures on a round-bodied needle (Ethicon™) in a continuous single layer: the first from the umbilicus to the xiphisternum and the second from the umbilicus to the symphysis pubis.

Ultrasound, performed by a single, senior radiologist using a standardised probe was used to measure rectus diastasis. All patients were scanned preoperatively and postoperatively at 3, 6, 12 months at three fixed points: at the umbilicus, 6 cm above and 6 cm below the umbilicus.

Data were collected prospectively on demographics, risk factors, surgical outcomes and ultrasound measurements of the distance between the rectus muscles. Rectus diastasis was defined using the classification by Beer et al.[5] (Table 1).

Table 1 Beer classification.[5]

Level	Normal width of the linea alba	
	Age < 45 years (mm)	Age > 45 years (mm)
At the level of the xiphoid	10	15
3 cm above the umbilicus	27	27
2 cm below the umbilicus	9	14

Statistical analysis

The widths of rectus diastasis obtained preoperatively and postoperatively using ultrasound were noted. Using these measurements, the mean of the widths at equivalent points was calculated and statistically analysed using the Student's *t*-test.

Results

The mean age of the 28 recruited patients was 36 years (range 23—47 years) with an average BMI of 26 kg m^{-2} (range 21—37 kg m^{-2}). Smoking (33%) was the commonest risk factor, while other recorded risk factors included hypertension (17%), respiratory disease such as asthma or chronic obstructive pulmonary disease (COPD) (14%), diabetes (11%) and ischaemic heart disease (4%). The majority of subjects had previous abdominal surgery including caesarean sections (82%, $n = 23$) (Table 2) and had at least one previous pregnancy (87%), with only two patients (8.7%) in the study being nulliparous (Table 3). The average weight of the resected abdominal tissue was 920 g (range 320—2900 g).

Table 2 Previous abdominal surgery.

Abdominal surgery	
No previous surgery	18% ($n = 5$)
Previous abdominal surgery	82% ($n = 23$)
C-sections only	36% ($n = 10$)
Other open procedures	25% ($n = 7$)
Laparoscopic procedures only	21% ($n = 6$)

Table 3 Number of pregnancies.

Parity	Number
None	7% ($n = 2$)
1 pregnancy	18% ($n = 5$)
2 pregnancies	46% ($n = 13$)
3 pregnancies	18% ($n = 5$)
4 pregnancies	11% ($n = 3$)

Postoperative follow-up time averaged 28 months (range 12—43 months). There was one major postoperative complication with a patient suffering a pulmonary embolism 1 day after the abdominoplasty despite prophylaxis against thrombo-embolism. The patient made a full recovery after treatment. Minor complications included dog ears ($n = 6$) that required revision and small area of wound breakdown ($n = 1$) that was treated conservatively. No cases of stitch palpability or extrusion were noted in the series.

Measurements of the rectus diastasis were categorised using the Beer classification,[5] as shown in Table 1. According to this classification, none of the patients in the study had recurrent diastasis and all ultrasound measurements at the 12-month postoperative period were within those defined by Beer. A significant reduction in the mean distance was noted in the mean distance between rectus muscles before plication and 12 months after surgery (Table 4). Previous surgery did not have a statistically significant affect on the preoperative rectus distance (Table 5). Both multiparous women and those with previous abdominal surgery maintained correction of laxity at 12 months' follow-up.

Discussion

Rectus plication has become an integral part of the abdominoplasty procedure to correct musculoaponeurotic laxity and improve the definition of the waistline. Several techniques of fascial plasty of the anterior abdominal wall have been described to improve abdominal contour. Plication can be performed from a transverse to vertical orientation, at single or multiple sites using absorbable or non-absorbable sutures.[3,4,6] However, approximation of the muscle fascia vertically in the midline using a non-absorbable suture has remained the most popular method of reducing musculoaponeurotic laxity.[1]

Currently, there is no consensus in opinion regarding the normal width of the linea alba or the feasible distance between the rectus muscles and only a couple of studies have attempted to define and classify rectus diastasis.[5,7] Rath studied the linea alba in 40 fresh cadavers and 40 abdominopelvic computed tomography (CT) scans and defined parameters for patients above and below the age of 45 years.[7] However, they investigated patients of both sexes (16 females and 24 males) with a broad range of ages (mean 83 years, range 62—99 years) and variable BMI and fail to disclose information regarding the number of pregnancies in the women. The non-homogeneous patient population precluded the use of the Rath classification in our assessment. By contrast, Beer at al.[5] evaluated the normal width of the linea alba in 150 nulliparous women between 20 and 45 years of age with a BMI less than 30 kg m^{-2} using ultrasound at three reference points: the origin at the xiphoid and 3 cm above and 2 cm below the umbilicus. They defined the 'normal' width of the linea alba as up to 15 mm at the xiphoid, up to 22 mm at 3 cm above the umbilicus and up to 16 mm at 2 cm below the umbilicus (Table 1). The large sample size and standardisation of patients provide a more accurate assessment of rectus diastasis and it was therefore used in this study. However, further extensive studies are needed to provide a definitive definition and classification of rectus diastasis.

Table 4 Reduction in the mean distance between rectus muscles before surgery and 12 months after plication.

Level	Mean pre-operative distance (mm)	Mean post-operative distance (mm)
Above umbilicus	32	9
At umbilicus	30	10
Below umbilicus	22	6

Table 5 Affect of previous surgery on pre-operative rectus distance.

Level	Mean preoperative rectus distance		*P*-value
	Previous surgery ($n = 23$)	No previous surgery ($n = 5$)	
Above umbilicus	25.6	21.8	0.53
At umbilicus	20.5	9	0.12
Below umbilicus	21	24.6	0.49

The durability of plication has been evaluated by a number of studies but the use of retrospective methodology, small sample size and a short-term follow-up have been limiting factors.[4,6,8] Al-Qattan[9] corrected severe musculoaponeurotic laxity in 20 multiparous women with a midline vertical plication using interrupted non-absorbable (1/0 prolene) sutures. A partial return of musculoaponeurotic laxity was reported in all patients after a follow-up time of 1 year based on clinical assessment alone, without any objective methodology. Despite the lack of objective assessment of preoperative and postoperative diastasis, they attributed the recurrence of musculoaponeurotic laxity to the high-risk patients, who were multiparous (five or more pregnancies) and morbidly obese. This study questions the durability of plication and considers whether a reinforcing mesh repair or modified plication would be more effective.

Long-term prospective data analysing rectus plication with a non-absorbable suture is limited, with only a single study with a small sample size published to date. Nahas et al.[2] in a prospective study with 12 female patients performed two-layer vertical plication with a 2/0 Nylon suture. CT scan was used to assess the rectus sheath at 3 cm above and 2 cm below umbilicus preoperatively and postoperatively at 3 weeks and at a long-term period (76—84 months) at the same levels. On long-term CT scan, no recurrence of diastasis and no residual distance between the rectus muscles were noted at either level. Despite their

findings, a physiological distance where the linea alba is located exists between the two rectus muscles.[5] Beer and colleagues argue that such close approximation of the recti may be unnecessary and may be detrimental, leading to symptoms of abdominal discomfort.[5] Comparatively, our series is larger ($n = 28$) than the published studies of Nahas and colleagues. Although the follow-up time is shorter, 12 months was felt to be a sufficient period for the formation of scar tissue, at which point rectus correction should be stable. At 12 months, the distances between the rectus muscles were within the classification specified by Beer and demonstrating that good long-term results are achievable and maintained with a non-absorbable suture. Although the majority of women had previous pregnancies and had undergone previous abdominal surgery, correction of laxity was maintained at 12 months follow-up.

There has been considerable debate on the efficacy of absorbable and non-absorbable sutures. Although, absorbable sutures may be preferable on the basis that they are less palpable through the skin with less risk of stitch granulomas, extrusion or infection, the long-term durability of rectus correction with absorbable sutures is questionable. In a recent prospective study, 12 patients underwent rectus plication with 2/0 polydioxanone (PDS) with no recurrence of diastasis on CT at long-term follow-up.[10] Nahas et al. in an earlier study randomly allocated 20 patients to a two-layer suture plication with either PDS or Nylon group.[3] CT assessment was performed 3 cm above and 2 cm below the umbilicus (at fixed bony points) preoperatively and postoperatively at 3 weeks and 6 months. Correction of diastasis was maintained at 6 months in both groups but the small patient numbers in each group ($n = 10$) and short-term follow-up were significant drawbacks of this study. Birdsell et al.[8] also compared absorbable (polyglycolic acid and polyglactin 910) versus non-absorbable (nylon) material and also reported equivalent results with both suture types. However, the small number of patients ($n = 15$), a follow-up time of just 6 months and the non-validated method for recurrent diastasis measurement using metal clips and serial radiographs are major weaknesses to this study, leading to questionable results. By contrast, a retrospective study by van Uchelen et al.[4] reported a 32- to 109-month follow-up on the long-term durability of standard plication of the anterior rectus sheath with Vicryl in 40 patients with ultrasonography. According to the Rath classification, 40% of the patients had residual or recurrent diastasis. However, the variable Vicryl suture size used, the multiple operators and the retrospective nature of the study limit its validity. Furthermore, preoperative ultrasound scans were not performed to determine the degree of diastasis prior to correction. In our series, the senior author (FSF) used two non-absorbable (loop 0 nylon) sutures to plicate the sheath and placed the suture knots in the xiphisternum and the umbilicus to minimise palpability. No suture-related complications were noted on follow-up. The longevity of plication with absorbable and non-absorbable suture remains controversial and larger, prospective studies with long-term follow-up are needed to give definitive results.

The actual technique used for vertical midline rectus plication is often overlooked and has not been formally assessed or compared in literature. In this study, a continuous, single-layer plication with a non-absorbable suture was performed, whereas Nahas and colleagues used a double-layer plication in which the first layer was undertaken with interrupted buried sutures (approximately 0.4 mm apart) and then the second layer with a continuous suture.[2,3,10] Comparing these studies, both single- and double-layer plication are effective and demonstrate durable, long-term results. However, single-layer plication has the benefit of less suture material, thereby reducing the risk of suture-related problems and in addition, is less time-consuming and more cost-effective. Other, less commonly used techniques have been adopted by some authors, such as the paramedian vertical and transverse plication.[4,6] Randomised trials are needed to enable direct comparison of single- and double-layer vertical midline plication techniques with standardised sutures and offers scope for future research.

Investigation of the rectus sheath has been performed with both CT and ultrasound by different authors. Although CT has the advantage of using bony points for measurement, ultrasound has been shown to be a valid method of examining the anterior abdominal wall that is non-invasive, inexpensive and repeatable without any exposure to radiation.[2,5,11] Mendes et al.[11] compared rectus diastasis preoperatively and intra-operatively in 20 females and found ultrasonography to be an accurate method of measurement above the umbilicus and at the umbilical level. However, below the umbilicus, these values differed significantly, showing smaller values in the imaging evaluation. They explained this difference below the umbilicus as a result of fibrosis from previous caesarean sections, which 95% of the patients had previously undergone. The fibrosis may have led to difficulties in visualising the rectus muscles inferior to the umbilicus. A single highly skilled senior radiologist (GJD) performed the scans in all cases in our study to provide accurate measurements and minimise subjective variations.

In summary, this is one of the very few prospective studies that addresses the controversial issue of the value and durability of plication in abdominoplasty with a large number of patients and long-term follow-up. The results demonstrate that midline vertical rectus plication with a non-absorbable suture achieves long-term durable results without any suture-related complications. Correction of diastasis was maintained despite the majority of patients having previous pregnancies and abdominal surgery.

Conflict of interest

None declared.

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