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Is release of the posterior lamella enough? A cadaveric exploration of posterior component separation techniques

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A B S T R A C T

Background: As posterior component separation techniques continue to gain popularity there is uncertainty regarding the degree of fascial advancement afforded by the various techniques. Our study seeks to compare the degree anterior rectus sheath translation seen in full transversus abdominus release compared to simple release of the posterior lamella of the rectus sheath.
Methods: Ten hemi-abdomens in five fresh cadavers were dissected. One hemi-abdomen underwent external oblique release. The contralateral hemi-abdomen underwent retrorectus dissection and initial release of the internal lamella of the internal oblique, followed by full transversus abdominus release. A 4 kg weight was suspended from the fascia and excursion was measured after 1) external oblique separation, 2) posterior lamella of the internal oblique separation, and 3) transversus abdominis separation.
Results: Average unilateral hemifascial translation after release of the external oblique provided an average unilateral hemi-fascial translation of 3.38 cm (+/- 0.69). Release of the posterior lamella of the internal oblique provided 3.98 cm (+/- 0.94). After transversus release the average translation increased to 4.31 cm (+/- 0.89).
Conclusions: In this cadaveric study, the majority (92%) of fascial advancement afforded by posterior component separation was achieved by an intermediate step in the transversus abdominus release operation: division of the posterior lamella of the internal oblique.

Introduction

Complex abdominal wall defects may arise from myriad etiologies ranging from primary and multiply recurrent hernias, to large defects following oncologic extirpation. Repair of these defects continues to present challenges to both general and plastic surgeons, and is an active area of surgical innovation and research.[1–3] Hernia repair is one of the most commonly performed procedures in the US, and retromuscular techniques are gaining popularity. A novel technique for abdominal wall reconstruction which is an elaboration on the well known Rives-Stoppa repair, known as the Transversus Abdominus Release (TAR), has emerged and is gaining popularity.[3,4]

The most well known procedure for fascial translation was first described by Ramirez et al., in 1990. The Anterior Component Separation (ACS) involves division of the external oblique muscle for midline translation of the rectus sheath. Ramirez described fascial advancement of up to 10 cm per side and the procedure ushered in a new era in abdominal wall reconstruction.[5] The anterior component separation has proven to be a long-enduring and easily performed intervention for robust fascial translation of the abdominal wall.[5,6] However, division of the external oblique typically necessitates raising large lipocutaneous flaps, which can lead to considerable morbidity.[6–9] In the last 17 years much work has been done to either limit or avoid this morbidity all together. Methods which seek to avoid these broad lipocutaneous flaps include endoscopic external oblique release, laparoscopic transversus fascia release, and an innovation of the retro-muscular approach to the abdominal wall: transversus abdominus release.[1–3]

What follows is an analysis in cadavers, quantifying fascial translation achieved in posterior lamella release (PLR) compared to TAR and to external oblique release (EOR). In addition, we have

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performed sub-group analysis to quantify how much of the final fascial advancement afforded by TAR can be achieved by simple PLR alone. PLR is an intermediate step in the TAR procedure, and if its execution serves to significantly advance the fascia without completing TAR, then this would add a novel tool to the abdominal wall surgeon's armamentarium. One that may theoretically improve morbidity inherent in raising broad retromuscular planes to the psoas muscle and under the costal margin.

Methods

Ten hemi-abdomens in five fresh cadavers were dissected. Exclusion criteria included: BMI >35, scaring of the abdominal wall indicating history of major abdominal surgery, trauma, or hernia repair.

A 'chalk line' was created by running thread between pins placed at the xiphoid process, and at the symphysis pubis marking midline. The distance from xiphoid to symphysis was evenly divided into 3 equidistant points that were labeled: middle, upper, and, lower abdomen. The midline was then divided from xyphoid to symphysis, taking great care to divide the fascia in the midline. One hemi-abdomen was randomly selected to undergo anterior component separation, and the converse to undergo posterior component separation (Fig. 1).

External oblique release was carried out by dissecting a plane between the anterior sheath and the adipose of the abdominal wall to 4 cm lateral to the semilunar line from the inguinal ligament caudally and to the costal margin cephalically. The external oblique was then divided from the inguinal ligament to the costal margin (Fig. 1).

Posterior component separation was achieved in standard fashion as described by Novitsky et al.[3,4] The posterior sheath was entered just laterally to the linea alba on its deep surface and the plane was dissected laterally. The posterior lamella of the internal oblique fascia was incised 1 cm medial to the perforating neurovascular bundles, revealing the underlying transversus muscle and transversus aponeurosis (Figs. 1 and 2). Cephalically, the transversus muscle belly was divided taking care to spare the transversalis fascia. As the transversus receded caudally, great care was taken to divide the transversus aponeurosis to the inguinal ligament. Blunt dissection was then used to create a plane between the transversus and transversalis with peritoneum laterally to the psoas, caudally to the round lig or spermatic cord, and subcostally to the level of the xiphoid (Figs. 1 and 2).

A Kocher clamp was applied to each of the anterior sheath fascial measurement points on the linea alba (upper, middle, lower) and a 4 kg weight was applied by a tether to each point. Fascial translation past midline, as determined by the aforementioned 'chalk line', was measured. Each of the fascial points were weighted and measured individually. EOR was measured after division of the external oblique. On the contralateral side PLR excursion was measured after division of the posterior lamella, and TAR excursion measured after division of the posterior lamella as well as transversus muscle and aponeurosis with a plane carried to the psoas laterally. To account for theoretical impact of tissue temperature on translation, care was taken to measure ACS and PLR translation after both dissections had been completed. Subsequently TAR dissection was undertaken and immediately measured to minimize

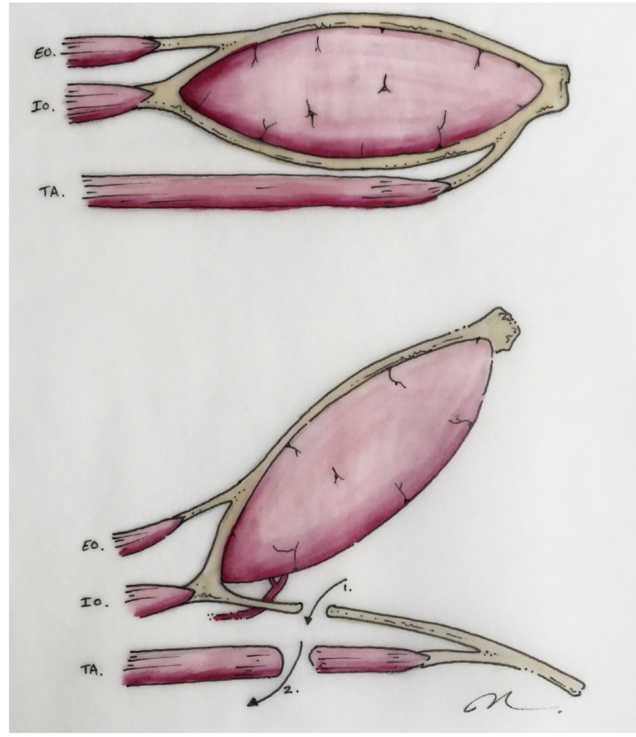

Fig. 2. Cross sectional anatomy of the rectus sheath. (*Above*) The transversus muscle extends further medially in most cases than is classically depicted. (*Below*) The anterior sheath and rectus are elevated, while the posterior sheath is retracted inferiorly. 1. Posterior lamella internal oblique incision. 2. Transversus abdominis incision.

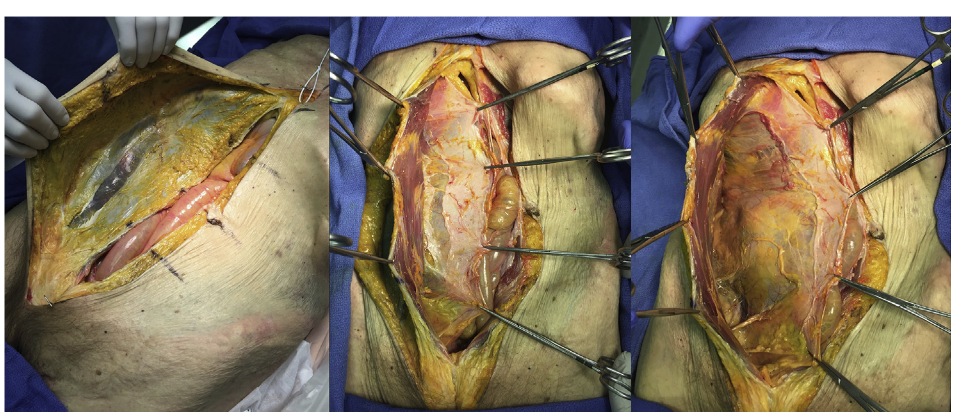

Fig. 1. Left: External Oblique Release. Middle: Posterior Lamella Release: the posterior aspect of the rectus is seen reflected laterally, the posterior lamella is divided and transversus m & transversus fascia is visible below. Right: Transversus Abdominis Release.

the effect of tissue temperature on our result.

For statistical analysis between interventions we utilized the paired *t*-test, with a p value of <0.05 denoting statistical significance.

Results

Comparing EOR to TAR, we found a statistically significant difference in average fascial translation for the midpoint (3.62 cm ACS vs. 4.94 cm TAR p = 0.008), and for the lower fascial measurement (3.50 cm ACS vs. 4.38 cm TAR p = 0.026). At the upper fascial measurement, we did not find a statistically significant difference (3.02 cm ACS vs 3.62 cm TAR p = 0.209) (Tables 1 and 2).

We then averaged the fascial translation for all points in a given intervention group (EOR, TAR, PLR) to create an impression of total hemi-fascial translation. We again found a statistically significant difference between anterior component separation and TAR (3.38 cm EOR vs 4.31 cm TAR p = 0.0061) (Table 2).

Analysis comparing EOR to PLR was performed. In this comparison we did not observe a statistically significant difference at any point: upper (3.02 cm EOR vs 3.46 cm PLR p = 0.37), middle (3.62 cm EOR vs 4.70 cm PLR p = 0.071), and lower (3.50 cm EOR vs 3.80 cm PLR p = 0.30) (Tables 1 and 2). We again took the average of all measurement points, combining upper, middle and lower groups for each fascial intervention to give an impression of total hemi-fascial translation but this did not achieve statistical significance (3.38 cm EOR vs 3.98 cm PLR p = 0.067) (Table 2).

We compared PLR to TAR. Comparison of these groups addresses whether simple PLR can provide comparable fascial advancement to complete TAR. We did not find statistically significant difference at any of the individual measurement points: upper (3.46 cm PLR vs 3.62 cm TAR p = 0.39), middle (4.70 cm PLR vs 4.94 cm TAR p = 0.08), lower (3.80 cm PLR vs 4.38 cm TAR p = 0.11) (Table 2).

In this cadaveric analysis, PLR achieved 92% of the facial excursion provided by the TAR.

Discussion

Our findings reflect a statistically significant difference between EOR and TAR in the middle and the lower abdomen, and for overall fascial translation. We did not appreciate a statistically significant difference in the upper abdomen, which is consistent with the findings of other authors.[10]

Our data demonstrate that in terms of overall averaged hemi-fascial translation, PLR achieves the vast majority of the excursion achieved by TAR (92%). There are undoubtedly benefits to the very broad pre-peritoneal plane afforded by TAR as it allows placement of large fascial reinforcements which may allow mesh coverage of the entire abdominal wall en-mass (supra-xiphoid to sub pubis, and psoas to psoas laterally). Our data, however, beg the question of TAR's universal applicability in retro-muscular hernia repair in cases where less broad mesh coverage may suffice.[3,4,6] In these cases, we would advocate that perhaps the surgeon could assess fascial translation after posterior lamella release, and if sufficient to achieve midline closure stop the dissection there.

In a recent publication by Majumder et al., a comprehensive analysis of the steps of the TAR procedure has been described. Their study is similar to ours in that a cadaveric analysis of fascial excursion has been undertaken.[11] A key difference between the two studies is that we found that 92% of total fascial excursion can be achieved with release of the posterior lamella of the rectus sheath, a step which precedes division of the transversus muscle. Majumder et al. have shown that the bulk of the fascial advancement is the result of elevation of the plane between the peritoneum and the transversus muscle, the step after PLR. The difference in the two findings could be the related to technique, or perhaps to variable characteristics of the cadaveric tissues. Regardless, when performing hernia repair with components separation, it is worth assessing fascial advancement after each step in the process. PLR alone may offer sufficient fascial translation and minimize the need for dissection of large pre-peritoneal planes.

We found that PLR, which is a relatively minor addition to the Rives-Stoppa repair proved at least as effective as ACS. We feel that demonstrating the efficacy of PLR as an independent fascial intervention adds a novel tool to the abdominal-wall surgeon's armamentarium, one with theoretically less morbidity than either ACS or TAR in terms of seroma, hematoma or inadvertent bowl injury associated with raising broad pre-peritoneal or pre-fascial planes.[6,8]

Our study was limited by the small number of cadavers that were available for dissection, however because of the bilateral and symmetric nature of the procedures, the number of hemi-

Table 1
The individual fascial measurements are recorded. Mean: the averaged fascial excursion for each point is recorded with standard deviation for the 5 cadavers. Combined: total, averaged hemifascial translation is recoded with standard deviation.

	EOR			TAR			PLR		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
1	1.9 cm	3.9 cm	3.0 cm	3.2 cm	5.0 cm	4.7 cm	3.5 cm	4.7 cm	3.7 cm
2	3.5 cm	4.0 cm	3.1 cm	3.7 cm	5.4 cm	3.2 cm	3.4 cm	4.8 cm	3.0 cm
3	2.1 cm	3.2 cm	3.4 cm	3.3 cm	3.8 cm	4.4 cm	2.6 cm	3.8 cm	2.9 cm
4	3.7 cm	X	4.4 cm	4.8 cm	6.0 cm	5.1 cm	4.8 cm	5.8 cm	5.1 cm
5	3.9 cm	3.4 cm	3.6 cm	3.1 cm	4.5 cm	4.5 cm	3.0 cm	4.4 cm	4.3 cm
Mean	3.02 cm ± *0.94*	3.62 cm ± *0.38*	3.50 cm ± *0.69*	3.62 cm ± *0.69*	4.94 cm ± *0.84*	4.38 cm ± *0.71*	3.46 cm ± *0.82*	4.70 cm ± *0.72*	3.80 cm ± *0.92*
Combined		3.38 cm ± *0.69*			4.31 cm ± *0.89*			3.98 cm ± *0.94*	

Table 2
Mean fascial translation for each point, and total averaged hemifascial translation are compared between interventions.

	EOR vs TAR	EOR vs PLR	PLR vs TAR
Upper	3.02 vs 3.62 cm (*p 0.209*)	3.02 vs 3.46 cm (*p 0.373*)	3.46 vs 3.62 cm (*p 0.390*)
Middle	3.62 vs 4.94 cm (*p 0.008*)	3.62 vs 4.70 cm (*p 0.071*)	4.70 vs 4.94 cm (*p 0.080*)
Lower	3.50 vs 4.38 cm (*p 0.026*)	3.50 vs 3.80 cm (*p 0.301*)	3.80 vs 4.38 cm (*p 0.113*)
Combined	3.38 vs 4.31 cm (*p 0.006*)	3.38 vs 3.98 cm (*p 0.067*)	3.98 vs 4.31 cm (*p 0.014*)

abdomens allowed for a greater sample size (n = 10 hemi-abdomens). Furthermore, the elasticity of cadaveric tissue cannot be expected to mirror that of living tissue and there may be differences in terms of absolute excursion from cadaver to cadaver or between different studies, and therefore we do not imply facial advancement in terms of centimeters to clinical practice. Rather, it is the advancement achieved by each intervention relative to the others that bears significance and it is noteworthy that our results are consistent in this regard.

Furthermore, in our analysis we left the linea alba intact (attached to the xiphoid and pubis), and have not made and transverse incisions in the fascia. One could argue that complete dissection of the abdominal wall from the pelvis and rib cage would best isolate the change in compliance seen after a fascial intervention, however, we felt that leaving the linea alba intact best mirrored the procedures as carried out in the operating room. It is important to note that we cannot account for the tension inherent in the linea alba. In clinical practice hernias attenuate and may stretch the linea alba thereby augmenting its length and affecting fascial excursion. Until a cadaveric analysis can be performed only in specimens that have large hernias, this is a problem that cannot be avoided. Procedurally we have utilized a single weight, and measured once, to avoid confounding our measurements by serially stretching the tissue and to only measure the effect that division of each fascial plane would have on abdominal wall elasticity. Serially stretching the cadaveric tissue has the potential to confound the results as cadaveric tissue may lose its elasticity and consistency with live human patients with increased time from death and affect the tissue viscoelasticity and shear modulus.[12]

Due to the aforementioned shortcomings, it is difficult to conclude that TAR will provide more clinically translatable fascial advancement than ACS in our patients. Nevertheless, the observed trends are noteworthy, and we conclude that in our cadaveric sample TAR provided greater fascial advancement compared to ACS in the lower and middle abdomen as well as in terms of overall averaged fascial translation. We also conclude that PLR was at least no worse than ACS. Furthermore, we feel that PLR may be viewed as an independent fascial intervention, much like ACS or TAR, rather than as an intermediate step in the TAR procedure. When surgeons are performing retromuscular hernia repair, we would encourage them to assess fascial excursion after release of the posterior lamella of the internal oblique in case this intervention alone provides the excursion needed for midline re-approximation, thereby obviating the need for more challenging dissection through and under the transversus muscle.

Conflicts of interest

Neal Moores MD has no conflict of interest to report. Hannah Conway BA has no conflict of interest to report. Daniel Donato MD has no conflict of interest to report. Barbu Gociman MD PhD has no conflict of interest to report. Christopher Pannucci MD has no relevant conflict of interest to report. Jay Agarwal MD has no relevant conflict of interest to report.

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