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Effect of transversus abdominis release on core stability: Short-term results from a single institution

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ABSTRACT

Introduction: Transversus abdominis release is an increasingly used procedure in complex abdominal wall reconstruction. The transversus abdominis muscle is a primary stabilizer of the spine, yet little is known regarding the effect of transversus abdominis release on core stability, back pain, or hernia-specific quality of life. The purpose of our study was to investigate the effect of complex abdominal wall reconstruction using transversus abdominis release on patient quality of life and core stability function.

Methods: All patients undergoing complex abdominal wall reconstruction requiring transversus abdominis release from June 2016 through October 2016 at our institution were eligible for study inclusion. Back and hernia quality-of-life measures, including the Quebec Back Pain Scale and the Hernia Quality of Life Survey (HerQLes), in addition to patient core stability, as measured using the prone test and the Sahrmann Core Stability Test, were collected at the preoperative evaluation and at 6 months after surgery. Student's *t* test was used to determine the effect of complex abdominal wall reconstruction on quality of life and core stability.

Results: Twenty-one patients completed the preoperative and 6-month postoperative evaluations. Back pain scores significantly improved postoperatively overall and in each of the 6 subcategories measured using the Quebec Back Pain Scale ($P = .001$). There was also a statistically significant improvement in abdominal wall function as reflected by Hernia Quality of Life Survey scores ($P < .001$). There was no statistically significant difference in core stability as reflected in the average prone score ($P = .6$) or the Sahrmann Core Stability Test average score ($P = .4$).

Conclusion: Abdominal wall reconstruction with transversus abdominis release leads to improved back pain and hernia quality of life and does not appear to negatively affect core stability in the short term.

Introduction

More than 2 million laparotomies are performed annually in the United States, with upward of 30% of these patients going on to develop an incisional hernia.[1] After initial ventral hernia repair (VHR), 24% to 43% of patients will experience at least 1 ventral hernia recurrence.[1,2] With each subsequent VHR, the risk for increasing hernia complexity requiring abdominal wall reconstruction at the time of VHR rises.[3] Several techniques for myofascial separation of components have been reported for use in this setting. Although release of the external oblique aponeurosis has been used for decades, recent reports suggest that transversus abdominis release (TAR) may lead to a more durable hernia repair with less associated wound morbidity.[3–6]

One of the key tenants of complex abdominal wall reconstruction with separation of components is restoring the linea alba through reapproximation of the rectus muscles in the midline.[7] It has been assumed that restoring the linea alba will facilitate return of native abdominal wall function and improve core strength. Nevertheless, the potential donor site morbidity associated with separation of components, particularly the transversus abdominis release, has been largely overlooked until now. Some authors have raised concerns about the loss of lateral abdominal wall function as a result of a TAR procedure, although no objective evidence has supported these claims.[8] Core stability, which is controlled

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primarily by the transversus abdominis muscle, refers to the ability of the body to "control the whole range of motion of the lumbopelvic-hip unit so that there is no major deformity, neurological deficit, or incapacitating pain."[9] Although previous studies have reported the contribution of the transversus abdominis muscle to core stability, no study has directly compared the effect of VHR with TAR on both patient quality of life and core stability. Therefore, the purpose of our study was to investigate the effect of TAR VHR on these two outcomes at a single institution using patient-reported outcomes and standardized objective measures. We hypothesized that TAR VHR leads to improved patient quality of life and does not affect core stability.

Methods

After obtaining institutional review board approval, all patients undergoing complex abdominal wall reconstruction requiring TAR from June 2016 through October 2016 at our institution were eligible for study inclusion. Data on back pain disability and hernia quality-of-life measures, in addition to patient core stability, were collected at the preoperative evaluation, which occurred within 30 days of operative intervention and at 6 months after surgery. Paired *t* tests were used to determine the association between preoperative quality-of-life measures and core stability with postoperative quality of life measures and core stability.

Quality-of-life measures

Patients were asked to complete two quality-of-life questionnaires: the Quebec Back Pain Disability Scale (QBPDS) and the Hernia-Related Quality-of-Life Survey (HerQLes). The QBPDS is a standardized survey that includes 20 questions that measure functional disability as it relates to back pain within 6 different categories: resting, sitting/standing, ambulation, movement, bending, and handling of heavy objects.[10–12] Patients are asked to rate their level of difficulty performing these activities, with a score of 0 corresponding to not difficult at all and a score of 5 corresponding to unable to perform. The maximum total score is 100, with a maximum categorical score of 15 for resting, sitting/standing, ambulation, and movement and a maximum categorical score of 20 for bending and handling of heavy objects.[10–12] No change or a negative absolute change in a patient's overall QBPDS or categorical QBPDS score from the preoperative to the postoperative period correlated with a negative impact on back pain disability and quality of life. Because this test has a high test–retest probability and a high sensitivity, any change from a patient's preoperative score to their postoperative score was assumed to be due to the effect of the transversus abdominis release.[10–12]

The HerQLes questionnaire includes 12 questions related to abdominal wall function and quality of life.[13] Patients are asked whether they agree or disagree with each statement, with a score of 1 corresponding to strongly disagree and a score of 6 corresponding to strongly agree. Based on the original publication by Krpata et al,[13] to make any clinically meaningful conclusion from the HerQLes questionnaire, each patient's raw score (range: 6–72) must be converted to a standardized score (range: 0–100). No change or a negative absolute change in a patient's standardized HerQLes score from the preoperative to the postoperative period correlated with a negative impact on abdominal wall function and patient quality of life, and any change from a patient's preoperative score to their postoperative score was attributed to the effect of the complex abdominal wall reconstruction requiring transversus abdominis release.[13]

Measurement of core stability

Abdominal wall hollowing refers to the simultaneous contraction of the muscles responsible for core stability, including the transversus abdominis muscle.[9] To perform abdominal wall hollowing, a patient contracts and draws in the abdominal wall toward the spine without movement of the pelvis.[9] Previous studies have reported that transversus abdominis muscle activity is increased during abdominal wall hollowing.[14] Transversus abdominis activity should correlate with improved core stability, which can be indirectly measured using a biofeedback pressure gauge.[14] No change in pressure during abdominal wall hollowing is seen in patients with a stable core, whereas a change in pressure during abdominal wall hollowing is seen in patients with an unstable core.[9]

Two core stability tests were performed on each patient using the Stabilizer Pressure Bio-Feedback system (DJO, LLC, Vista, CA). Prior to completing either of these tests, patients were asked to watch a video of the senior author (M. J. R.) performing these tests. The first test that was performed was the prone test. This is performed with patients lying prone on an examination table with the biofeedback unit under them and at the level of the umbilicus. The pressure gauge is inflated to 70 mm Hg, after which patients are asked to perform abdominal wall hollowing.[15] If this is performed correctly, there should be a decrease in pressure to below 70 mm Hg.[16,17] Patients were asked to perform this maneuver 5 times, with redirection by the examiner if this maneuver was not being performed correctly as evidenced by an increase in pressure above 70 mm Hg. The average overall decrease in pressure was recorded for each patient. A recording of 0 corresponded to either no decrease in pressure or an increase in pressure and was interpreted as the patient having an unstable core. The prone test has been reported to have both high inter-observer variability and a high test–retest probability.[17] Therefore, the same member of the research team performed the prone test on all included subjects.

The second test that was performed was the Sahrmann Core Stability Test. This test is performed with patients in the supine position with the biofeedback unit under the lumbar spine. The pressure gauge is inflated to 40 mm Hg, and patients are asked to perform abdominal wall hollowing. If this is performed correctly, there should be no change in pressure.[15] After abdominal wall hollowing, there are 5 levels to the Sahrmann Test (Table 1).[18] To progress through the levels, core stability must be maintained, with no more than a 10 mm Hg increase or decrease in pressure.[15] As for the prone test, patients were asked to perform this test 5 times, and the highest level achieved was recorded for each patient. Patients received a score of 0 if they were unable to perform the first step of the test with more than a 10 mm Hg increase in pressure. Moreover, to minimize the risk of interuser variability, the same member of the research team who performed the prone test also performed the Sahrmann test on all included subjects.

Statistical analysis

Data were described using the mean ± standard deviation for continuous variables and counts and percentages for categorical variables. Paired Student *t* tests were used for statistical analysis, and all data were assumed to have a normal distribution. Four linear regressions were performed after data collection. First, preoperative QBPDS scores were compared with postoperative QBPDS scores. Second, preoperative standardized HerQLes scores were compared with postoperative standardized HerQLes scores. Next, preoperative prone test scores were compared with postoperative prone test scores. Finally, preoperative Sahrmann test scores were compared with postoperative Sahrmann test scores. All statistical analysis was performed using SAS 9.4 Software (SAS Institute, Cary,

Table 1
Sahrmann Core Stability Test.

Level	Action performed
1	One leg is raised to a 100° angle at the hip with the knee bent. The other leg is brought up to the same position.
2	One leg is brought down until the heel touches the ground. The leg is fully extended and returned to position 1. The other leg remains in position 1 throughout this level.
3	The same leg is fully extended while it is kept 12 cm above the ground and then returned to position 1. The other leg remains in position 1 throughout this level.
4	Level 2 is performed with both legs simultaneously.
5	Level 3 is performed with both legs simultaneously.

Table 2
Patient demographics.

Variable	*Outcome (N = 21)*
Age, y	58.5 ± 11.3
Female sex	7 (33%)
Body mass index, kg/m^2	33.2 ± 5.4
Hypertension	13 (62%)
Chronic obstructive pulmonary disease	1 (5%)
Diabetes	5 (24%)

*Values are expressed as the number (%) or mean ± SD.

Table 3
Hernia details and 30-day outcomes.

Variable	*Outcome (N = 21)*
Hernia width, cm	18 ± 6.3
Length of hospital stay, d	6 [5–7]
Surgical site infections	2 (9.5%)
Superficial	2 (100%)
Surgical site occurrence	2 (9.5%)
Nonhealing incisional wound	1
Infected hematoma	1
Surgical site occurrence requiring procedural intervention	3 (14.3%)
Wound opening	3 (100%)
Unplanned return to operating room	0
Unplanned hospital readmission	0

*Values are expressed as the mean ± SD, median [interquartile range], or number (%).

NC). P values $< .05$ were considered to indicate statistical significance.

Results

A total of 33 patients were enrolled in our study. Twenty-one patients (63.6%) completed the study through the follow-up period of 6 months; the remaining patients were lost to follow-up. Patient demographics for the group that completed the study are outlined in Table 2. A total of 11 (52.4%) patients underwent at least 1 prior ventral hernia repair (range: 1–4). Hernia-specific details and 30-day outcomes are outlined in Table 3. Postoperative wound events were classified based on the standardized definitions for postoperative wound events after VHR.[19] Of note, fascial closure was achieved in all 21 patients, and at least a 30 × 30-cm piece of synthetic mesh was placed into the retromuscular space.

Preoperative and postoperative QBPDS scores are outlined in Table 4. Statistically significant improvement was seen in QBPDS scores after transversus abdominis release for all measurable categories including resting, sitting/standing, ambulation, movement, bending, handling of heavy objects, and total score. Statistically significant improvement was also seen in HerQLes standardized scores after transversus abdominis release when comparing preoperative with postoperative scores (38.5 ± 9.6 vs 61.5 ± 9.7, $P < 0.001$). Interestingly, there was a significant correlation between the improvement in QBPDS and the standardized HerQLes scores ($r = 0.51$, $P = .02$). Finally, preoperative and postoperative core stability results for the prone test and the Sahrmann Core Stability Test are outlined in Table 5. No change in core stability was noted on either test after transversus abdominis release ($P = 0.6$ and 0.4, respectively).

Table 4
Quebec Back Pain Disability Scale scores: Preoperative versus postoperative ($N = 21$).

Score category	*Preoperative score*	*Postoperative score*	P *value*
Resting	3 ± 2.47*	1.81 ± 1.89	.04
Sitting/standing	3.29 ± 3.26	1.71 ± 2.17	.02
Ambulation	4.1 ± 4.06	1.67 ± 2.18	.004
Movement	5.52 ± 3.8	2.76 ± 3.28	.007
Bending	3.2 ± 3.34	1.29 ± 2.03	.01
Handling of heavy objects	6.19 ± 5.66	2.76 ± 4.84	.02
Total score	26.62 ± 19.49	12.05 ± 13.99	.001

* Mean ± SD.

Table 5
Core Stability Test results: Preoperative versus postoperative outcomes ($N = 21$).

Core stability test	*Preoperative score*	*Postoperative score*	P *value*
Prone test	−3.05 ± 3.77*	−3.43 ± 3.36	0.6
Sahrmann Core Stability Test	1.76 ± 2.14	2.19 ± 2.42	0.4

* Mean ± SD.

Discussion

Our study is the first to examine the direct clinical consequences of transversus abdominis release as it relates to core stability, the main function of the transversus abdominis muscle.[9] At the 6-month follow-up after transversus abdominis release, we found that there was no negative impact on core stability as measured by both the prone test and the Sahrmann Core Stability test. Also, importantly, there was a statistically significant improvement in both the QBPDS scores and the standardized HerQLes surveys. Furthermore, there was a moderate correlation between improvement in the QBPDS and the standardized HerQLes scores, indicating an association between abdominal wall and back quality of life, both of which are proposed to be influenced by a TAR.[9]

As recurrent hernias have continued to increase in incidence, surgeons have been left with the quandary as to which is the optimal repair technique.[1] One approach, originally described in plastic surgery literature by Ramirez et al,[4] is the external oblique, or anterior components separation, technique.[4] Prior to this description, large defects either were deemed not amenable to surgery, were repaired using bridged mesh, or otherwise required myocutaneous flaps or free tissue transfers for closure. As the concept of myofascial release diffused and became more accepted in the surgical community, novel improvements based on the same idea were developed, such as endoscopic components separation, periumbilical perforator-sparing components separation, and transversus abdominis release.[6,20–22] Transversus abdominis release has been reported to give similar advantages in terms of medialization of both the posterior and anterior components of the abdominal wall.[6] In

addition, TAR is purported to reduce wound morbidity and improve long-term durability over external oblique release by avoiding a large potential/dead space while also facilitating wide mesh overlap of the defect.[6] Generally speaking, the performance of myofascial components separation has improved the ability of surgeons to achieve approximation of the linea alba without undue tension, a concept that has long been held important but is little supported with objective evidence.[7,23]

Evidence notwithstanding, a general proliferation of publications surrounding the concept of myofascial components separation as an aid to closure of the linea alba has been seen over the past 30 years. Interestingly, with such techniques, very little consideration has been given to either the specific function of abdominal wall musculature or the unintended physiological consequences of dividing muscles to achieve fascial closure. The transversus abdominis muscle, along with the multifidus, attaches directly to the vertebrae and is a primary stabilizer of the spine, as it stabilizes but does not move the spine.[9] The external oblique, internal oblique, and quadratus lumborum are all considered to be secondary stabilizers of the spine, as they stabilize and move the spine.[9] As noted by Jorgensen et al,[24] few studies have evaluated abdominal muscle function in ventral incisional hernia. In addition, few studies have given consideration to abdominal wall function after myofascial separation of components. Although some studies have attempted to approach this concept obliquely, for instance with comparative use of computed tomography imaging before and after components separation to examine dimensional changes in the abdominal wall, exercise physiology literature would suggest that conventional radiologic testing is both insensitive and unreliable to make any generalizable conclusion regarding the function of the examined musculature.[9,25–27] For example, De Silva et al[26] did note what was thought to be compensatory hypertrophy of the rectus abdominus, external oblique, and internal oblique muscles on computed tomography imaging in a small group of patients who underwent TAR as compared with patients undergoing laparoscopic ventral hernia repair. Nevertheless, the clinical consequence of this observation remains unclear. On the other hand, Zarzaur et al[28] attempted to replace quality-of-life survey instruments as a replacement for physical functional evaluation after abdominal wall reconstruction. However, in this case, there is the obvious limitation of subjective reporting compounded by the specific patient population examined, in which a high prevalence of post-traumatic stress disorder and depression was noted, thereby lending additional bias.

Importantly, our study is the first to seek out objective evidence regarding the change in function of the transversus abdominis muscle via core stability tests after TAR with reconstruction of the linea alba. Jensen et al[29] examined truncal function and quality of life after endoscopic anterior components separation versus routine colorectal surgery by using truncal flexion and extension strength, hand grip strength, leg extension power, and quality-of-life instruments. Criss et al[7] examined isokinetic and isometric measurements of the rectus abdominus muscles after restoration of the linea alba utilizing TAR. However, this study did not specifically determine the function of the transversus abdominis muscle before or after intervention.[29] Surprisingly, we found that release of the transversus abdominis muscle had no discernible impact on core stability in the early postoperative period. Additionally, we noted marked improvement in both back pain disability scores and hernia-specific quality-of-life scores.

Our findings of preserved core stability and overall improvement in back pain disability and hernia-specific quality-of-life scores were surprising. Although there is no clear objective explanation for these findings, we do have some theories. First, the transversus abdominis release itself involves dividing the muscle just proximal to its distal insertion as opposed to its origin, which involves the internal surfaces of the 7th to 12th costal cartilages, thoracolumbar fascia, anterior three fourths of the iliac crest, and lateral third of the inguinal ligament.[30] It may be that the point of muscle division relates to the amount of dysfunction (in this case none), which is observed as a consequence. Next, there is the potential that simply dividing the muscle and exploiting the retroperitoneal plane would indeed render the muscle less functional than its baseline, whereas the reinforcement with mesh allows for tissue ingrowth and artificial restabilization of the muscle. In the absence of a control arm without mesh, we were unable to verify this hypothesis. Finally, there is the potential that the multifidus muscle group, the other primary stabilizer of the spine, may be improved after TAR through compensatory hypertrophy, just as compensatory hypertrophy of the rectus abdominus, external obliques, and internal obliques is thought to occur based on computed tomography imaging.[26] Further studies are needed to elucidate the reason for these findings.

Although the initial findings of our study are encouraging, there are some limitations that must be taken into consideration. First, there are additional factors, including reduction of hernia contents and mesh placement, which may be contributing to the changes in core stability and patient quality-of-life measures after TAR VHR. Second, the QBPDS and HerQLes scores reflect patient reported outcomes. As such, recall bias and the inability to accurately compare preoperative and postoperative quality of life are possible. Next, as the current study is from a single institution that reports short-term outcomes, it may be underpowered to detect significant change in core stability after TAR. In addition, the follow-up time frame is relatively short with respect to relevant hernia outcomes, such as hernia recurrence and also long-term quality of life, back pain, and abdominal wall function. Longer follow-up will be necessary to confirm our findings. Nevertheless, these early results are encouraging that transversus abdominis release does not cause early postural instability.

Conclusion

Our study is the first to prospectively investigate the direct downstream effects of transversus abdominis release with respect to core stability, muscular function, and quality of life. Our findings, although encouraging, are still preliminary and should be interpreted with caution. Further study is needed with larger patient groups and longer follow-up to confirm our findings.

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