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Original Article

Biomechanical assessment of the preperitoneal hernial repair by a bipedicled external oblique aponeurotic flap: mobility of the floor of the inguinal canal

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Abstract

Introduction

Development of indirect inguinal hernias through the inguinal canal is usually prevented by the shutter and the sphincteric mechanisms, which are known to be destroyed by almost all anterior herniorrhaphies.

Objective

A new preperitoneal repair, which uses a bipedicled external oblique oponeurotic flap, has been recently introduced and was suggested to change the mechanics of this area. In this hernia repaires, the biomechanics of the inguinal region were assessed in healthy individuals and in patients with hernia after new repair and after other conventional anterior hernial repairs.

Methods

The study included 20 patients with inguinal hernias and 5 non-hernia control cases (group A). Ten of the hernia cases were repaired by the new preperitoneal repair (group B) wheareas the other 10 were repaired by convemtional anterior repair (modified Bassini) (group C). The 5 control cases were selected from patients without hernia, who were scheduled for inguinal surgery for excision of symptomatic varicoceles. During surgery in all cases, two ligaclips were inserted into the ileopubic tract. After sound healing, all cases were radiographed to detect any change in the position of the ligaclips, on contraction of the external oblique muscle. Any displacement of the inserted ligaclips was considered in this study as a sort of mobility at the floor of the inguinal canal, induced by the contracted muscle.

Results

The study showed that contraction of the external oblique muscle induced, in all cases, a degree of an upward displacement of the floor of the inguinal canal, which could be called a reversed shutter movement. The magnitude of this reversed shutter mobility was nearly identical in normal controls and in cases that underwent conventional anterior hernial repairs.

Conclusion

The new preperitoneal repair, with the bipedicled external oblique oponeurotic flap, was found to augment this reversed shutter movement significantly. The possible explanation and the forces that possibly induced this reversed shutter mechanism are herein presented and discussed.

Keywords: Biomechanical assessment, inguinal canal, reversed shutter mechanism

Introduction

The inguinal canal is a 4-cm natural tunnel through the anterior abdominal musculature. It begins at the internal and ends at the external inguinal openings. In female individuals, it transmits the round ligament from the abdomen to be inserted into the labia majora. In male individuals, it is the pathway for the testis with its spermatic cord from the abdomen to the scrotum. In

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humans, development of hernias through this canal is prevented by efficient mechanisms. Of these protective mechanisms, two were identified long ago. They are the shutter and the sphincteric mechanisms. The shutter mechanism is induced by the contraction of the lower arching fibers of the internal oblique and transversus abdominis muscles. This contraction leads to the straightening of their muscular arch in the region of the inguinal canal causing consequent descent of its roof and strengthening of its posterior wall. The sphincter mechanism is induced by contraction of the transversus abdominis muscle, which is attached to the internal abdominal ring by a transversalis fascial sling. Thus, on the contraction of this muscle, the sling is pulled superiorly and laterally leading to the closure of the internal ring around the cord [1]. Most of the open hernial repairs aim at strengthening the walls of the inguinal canal by either suturing of local tissues to the inguinal ligament or by inserting a synthetic mesh. In almost all hernial repairs, the two known protective mechanisms are destroyed, and the integrity of the canal becomes entirely dependent on the formation of a stable, immobile fibrous tissue [2]. However, in 1997, Moneer [3] presented a new preperitoneal repair. In this repair, a bipedicled viable external oblique aponeurotic flap was fashioned and rerouted into the preperitoneal space, after a preperitoneal herniotomy, to be sutured with the fascia transversalis to the ileopubic tract. The author observed that after this new repair, patients showed tensing of the operated inguinal region on the contraction of the ipsilateral external oblique muscle. According to this observation, the present study was designed to assess the biomechanics of the inguinal region after this new repair and after other conventional anterior herniorrhaphies, in comparison with that of healthy individuals.

Patients and methods

The study included 25 male patients who gave their consent to participate in this study. They were allocated to three groups. Group A included five patients who did not have any hernias or weakness of the inguinal regions, but they underwent inguinal surgery for treatment of symptomatic varicoceles. In patients of this group, the external oblique aponeurosis was just incised, and the cremasteric veins were dissected and ligated *in situ*, without disturbing the inguinal musculature. Patients of this group were analyzed and evaluated in this study as normal controls. Group B included ten patients with inguinal hernias that were repaired with the new preperitoneal repair described by Moneer (Fig. 1). In these patients, the external oblique aponeurosis was transversely incised after a transverse inguinal skin incision (Fig. 1a). The upper flap of the incised external oblique aponeurosis was fashioned as a bipedicled flap by a superior transverse incision. The preperitoneal space was entered by splitting both the internal oblique and transversus abdominis muscles, approximately 5 cm superior to the inguinal ligament (Fig. 1b). Through this preperitoneal approach, herniotomy was accomplished (Fig. 1c), and the bipedicled flap was rerouted into the preperitoneal space and sutured with the fascia transversalis to the ileopubic tract (Fig. 1d). Before

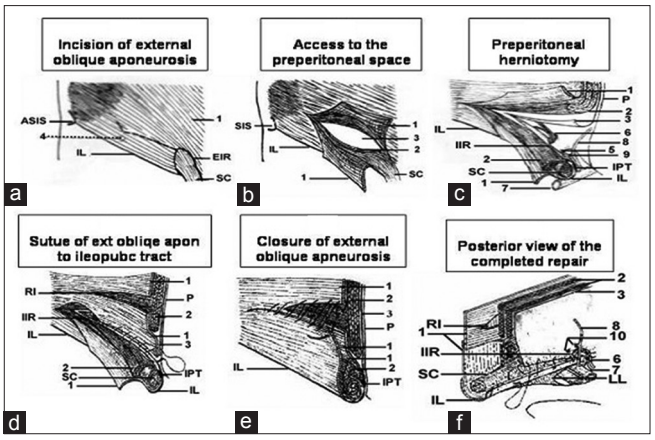

Figure 1: (a–f) Operative technique. 1, external oblique aponeurosis; 2, lower arching fibers of internal oblique and transversus abdominis muscles; 3, fascia transversalis; 4, proposed position of IIR; 5, hernial sac; 6, vascular and testicular vessels; 7, external iliac artery; 8, inferior epigastric artery; 9, cremasteric artery; 10, divided cremasteric artery; ASIS, anterior superior iliac spine; EIR, external inguinal ring; IIR, internal inguinal ring; IL, inguinal ligament; IPT, ileopubic tract; LL, lacunar ligament; P, peritoneum; RI, release incision; SC, spermatic cord.

closing the skin, the lower external oblique aponeurosis was sutured to the upper edge of the release incision which was performed in the transpositioned upper flap (Fig. 1e). Group C also included ten patients with inguinal hernias, but they were repaired by an anterior herniorrhaphy [5-7] (modified Bassini repair). In these cases, the fascia transversalis was plicated, and the internal inguinal ring was narrowed, when indicated. During the closure of these cases, the incised edges of the external oblique aponeurosis were overlapped to simulate the studied repair of group B patients. All patients of the three groups underwent surgery under general anesthesia [8,9]. Moreover, we inserted ligaclips at the ileopubic tract in all patients; synthetic nonabsorbable sutures were used for performance all hernial repairs and aponeurotic closures.

Three months after surgery, selected patients were evaluated clinically to ascertain sound healing and absence of hernias [10,11] After that, they were evaluated radiologically to verify displacement of the previously inserted ligaclips under specific muscular actions. The radiological examinations were in the form of two consecutive plain radiographs of the pelvic region in the supine position with the pelvis fixed to the radiographic table by straps. The first film was taken with the patient relaxing his abdominal muscles, whereas the second film was taken with the patient contracting his ipsilateral external oblique muscle without moving the fixed pelvis (flexing and rotating the trunk). The two films were to be superimposed on each other to ascertain accurate projection of the skeleton in the two films. If the skeletal projection was not exact, the films were not accepted for evaluation and were repeated with better fixation of the patient's pelvis. In the evaluable films, the position of the radiopaque ligaclips in the relaxed films was identified, and any observed displacement on the contraction of the external oblique muscle was measured. The displacement

of the clips away from their original position in the relaxed film was considered, in this study, as a quantitative measure for mobility of the ileopubic tract on the contraction of the external oblique muscle. Because photocopying of double-layered radiographic films is expected to be blurred and lose fine details, a high-quality digital camera (Sony DSC10 Sony manufacturing company, Tokyo, Japan) was used, and photographs were edited by a computer image-processing program (PSP, version 7.02). With this program, pictures were changed to grayscale images. Moreover, illumination and contrast were regionally modified until the fine details of the ligaclips became clear.

Results

All patients presented for evaluation in this study were clinically free of hernial recurrence and showed sound healing [12]. Radiological examination revealed that on the contraction of external oblique muscles, the inserted ligaclips in the ileopubic tract of normal control cases (group A) showed an upward displacement ranging from 7 to 12 mm with mean upward displacement of 9.6 mm (Fig. 2). In cases of group C (patients with hernias treated by a modified Bassini), the displacement of the inserted ligaclips, on the contraction of the anterior abdominal muscles, was also upward. It ranged from 8 to 14 mm. With a mean of 10.1 mm (Fig. 3). In patients of group B (patients with hernias treated by the new preperitoneal repair described by Moneer), contraction of the external oblique muscles induced an upward displacement of the inserted ligaclips at the ileopubic tract. However, this displacement ranged from 18 to 27 mm, with a mean of 23.7 mm. The difference in the displacement of the clips in cases of groups B and C was statistically significant ($P < 0.01$). Fig. 4 shows this discrepancy in one patient with bilateral hernias, which were treated on the right side by a modified Bassini repair and the left side by the new preperitoneal repair.

Discussion

The present study is one of the unique studies that tried to assess for possible mobility at the floor of the inguinal canal. Although the observed upward displacement of the ileopubic tract on the contraction of the anterior abdominal musculature was not wide, it is undoubtedly an unpreceded observation. It denotes that there are some active or passive forces that move the stretched inguinal ligament and ileopubic tract, hence caused an upward displacement of the floor of the inguinal canal. This upward movement, which decreased the vertical diameter of this intramuscular canal, could be described as a reversed shutter mechanism and could be considered as the third protective mechanism for the inguinal canal. With the available evidence in the present study, the underlying forces were not verified precisely.

However, some known anatomical fact about the inguinal region could give a reasonable expectation of the factors that possibly induced this reversed shutter movement. It is known that the inguinal ligament is the part of the external oblique aponeurosis that stretches between the anterior superior iliac spine and the pubic tubercle and the ileopubic tract is its curved thickened posterior edge, which is attached to the fascia

Figure 2: Upward displacement of the ileopubic tract on the contraction of the external oblique muscle in cases with varicocele.

Figure 3: Upward displacement of the ileopubic tract on the contraction of the external oblique muscle in cases with anterior herniorrhaphy.

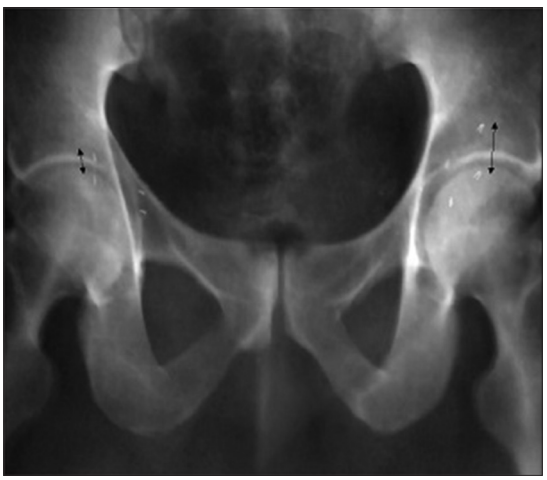

Figure 4: Upward displacement of the ileopubic tract on the contraction of the external oblique muscle in cases with anterior herniorrhaphy (right side) and posterior preperitoneal repair by a transpositioned external oblique aponeurotic flap (left side).

transversalis. The inguinal ligament is known to be immobile on the contraction of the external oblique muscle because its fibers are parallel to the direction of pull of this muscle [4].

On the extension of the thigh, this ligament is known to be thrown into a downward convexity owing to the stretch of the fascia lata, which is attached to it. Given these anatomical facts, one could postulate that although contraction of the external oblique muscle could not move the inguinal ligament, it could at least stretch it and make it tense. The increased tension in this structure could passively antagonize the downward stretch of the attached fascia lata. Thus, its downward convexity is decreased, and an apparent upward displacement could be observed.

Moreover, the attachment of the lower arching fibers of the internal oblique and transversus abdominis muscles to the lateral part of the inguinal ligament and the medial part of the ileopubic tract might give an active upward pull to the floor of this canal [13-16]. Whether this observed upward displacement of the floor of the inguinal canal was induced by the passive recoil of the stretched inguinal ligament or by an active pull of its two lateral ends or combination of both or by other forces, this upward mobility has been documented in this study for further assessment. There is near similarity of the observed displacement of the inserted ligaclips after an anterior hernial repair (group C cases), to those of healthy control (group A cases). This denotes that the newly described reversed shutter mechanism is not destroyed or affected by this type of hernial repair, which is known to disturb and destroy the shutter and sphincteric mechanisms.

The significantly increased displacement of the inserted ligaclips in group B patients denotes an amble-free reversed shutter mobility after applying the new hernial repair described by Moneer. The explanation of this significant augmentation of the reversed shutter mechanism is difficult to explain. However, the probable operating factor for this augmentation is probably the sutured bipedicled external oblique aponeurotic flap to the ileopubic tract. This flap is viable and is still connected to its parent functioning muscle. Thus, contraction of the muscle fibers of the transpositioned flap (as part of contraction of the whole muscle) causes a specific new active pulling force on the ileopubic tract. The direction of this pulling force is expected to be upward and laterally (the direction of pull of the external oblique muscle), as shown in this study. Thus, the preperitoneal hernial repair of Moneer is quite distinguished functionally. It adds a new viable tissue to the posterior wall of the inguinal canal at its weakest area, inferior to the arching conjoint muscles, and so long as this new tissue is not sutured to the conjoint muscle, the shutter mechanism is expected to be undisturbed. Moreover, according to the findings of the present study, this repair seemed to add a further insertion to the external oblique muscle into the ileopubic tract. This new posterior insertion allows this muscle to pull up the inferior wall of the inguinal canal and further augments a newly described reversed shutter mechanism.

Conclusion

Contraction of the external oblique muscle causes tensioning of the inguinal ligament and recoil of its downward pull by the fascia lata. This recoil raises the floor of the inguinal canal in a reversed shutter movement. This reversed shutter mechanism could be considered a third normal protective mechanism additional to the well-known shutter and sphincteric mechanisms of the inguinal canal, which prevent the development of indirect inguinal hernias. Although the shutter mechanisms are known to get disturbed by almost all open anterior herniorrhaphies, the newly described reversed shutter mechanism is not affected by these herniorrhaphies. The preperitoneal hernial repair described by Moneer is a new efficient repair. It not only preserves the shutter mechanism but it also augments the newly described reversed shutter mechanisms by the powerful pull of the bipedicled external oblique aponeurotic flap on the floor of the inguinal canal.

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Conflicts of interest

There are no conflicts of interest.

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