Circumferential Mesh in Abdominal Wall Reconstruction

Indications, Technical Notes and Case Report

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Abstract: The authors describe an original technique of abdominoplasty aiming at correcting ventral muscles, hypotonia, and relaxation, especially in formerly obese patients, pluriparae women, and patients with neuromuscular impairment. The technique encloses regular dermolipectomy, laparocele or hernia reduction (if existing), ventral fascia plication on the midline, and suprafascial application of a purposely built polypropylene mesh. The mesh consists of three continuos segments: two lateral, wider, rectangular segments to be fixed on the ventral area and one central and narrower (like a belt) segment to be inserted posteriorly into the deep subcutaneous tissue above the dorsal muscles and the spine. The vehicle of inserting circumferential mesh includes introducing a smooth, hollow rod through a small lateral skin access. Then, the two lateral segments are extended and criss-crossed over the abdominal muscles and are fixed to the iliac periosteum. This allows the dorsal and ventral muscles to be contained and supported by the mesh during prolonged standing and exercise.

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Abdominoplasty is a widespread surgical procedure, not only for cosmetic purposes but also for correction of ventral hernias,[1–3] laparocele,[4,5] recti muscles diastasis, or forward-protruding belly.[6–9]

However, an increasing number of morbidly obese patients who have previously undergone bariatric surgery require abdominal wall reduction during follow-up. One of the problems for the reconstructive surgeon during corrective procedures is the marked forward-projection of the abdomen and its intraperitoneal contents, caused by lumbar hyperlordosis and abdominal muscles hypotonia.[10]

Quite often, after a perfect cosmetic abdominoplasty, the patient reports an exceedingly protruding profile on ventral and lumbar projection. The attempts to close the linea alba by plicating the midline with a series of stitches do not definitely correct the prominence.

However, doctors advise regular physical activity to improve the abdominal muscle tone. Unfortunately, this advice is not regularly adhered to by unmotivated patients. Backache and sciatic pain are often common in the previous, present, and future medical histories of the patients. These problems are also related to body weight of the patient and the type daily work performed by the patient.

Therefore, we tried to evaluate whether a different surgical approach during abdominoplasty might provide a better physical appearance if attention was paid to the postural balance of posterior and anterior trunk muscles.

Some basic anatomic considerations regarding the thoraco-lumboabdominal fascia continuity that envelopes dorsal and ventral muscles lead us to conceive a circumferential (dorso-ventral) support mesh to strengthen this structure whenever its function is weakened.

The use of large polypropylene or other biocompatible mesh in the anterior repair of abdominal wall defects, laparocele, or hernias is a widespread surgical procedure. Unfortunately, it lacks anchorage to strong supporting structures on the dorsal surface.[11] Sometimes iliac periosteal or costicartilaginous stitches are applied, another mesh is simply stratified subcutaneously over the abdominal fascia, or, more often, it is buried preperitoneally under the ventral muscles after laparocele sac reduction. No attention is paid to a potentially active support of the abdominal wall, especially during strain or Valsalva maneuver by the mesh, which is considered a further layer passively overlapping and thickening the ventral area.

Therefore, we wanted to create a more functional plastic with a dorsally prolonged mesh, like the staves of a barrel, thus strengthening the thoracodorsolumbar fascia envelope during active and passive motion.

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MATERIALS AND METHODS

Our study was performed on 11 patients: eight females and three males aged between 44 and 70 years (Table 1).

Preoperative Evaluation

The patients were carefully interviewed about symptoms and informed consent was preliminary obtained. Standard and lateral spine x-rays were preoperatively performed, and NMR ruled out patients whose symptoms were suspicious of lumbo-sacral disk hernia, which was a formal contraindication to the "round mesh" operation. Lung function tests were also routinely investigated, and only patients with normal results were enrolled in the study.

TABLE 1.

Initials of the name	Sex	Age	Diagnosis
F.L.	M	70	relapsing abdominal wall schwannoma
G.M.	F	52	laparocele
			relapsing colon carcinoma infiltrating the abdominal wall
			obesity
			pain on standing and walking
R.L.	M	44	abdominal hernia
			subfascial lipoma
			dorsolumbar pain
			heavy work
L.S.	M	65	obesity
			ventral hernia
			recti muscle severe diastasis
			lumbar pain
N.B.	F	53	laparocele on pfannensitel
			abdominal muscle hypotonia
			lumbar pain
V.B.	F	48	laparocele
			abdominal muscle atrophy
			lumbar pain
R.S.M.	F	51	abdominal muscle hypotonia
			weight loss
			lumbar pain
S.L.	F	53	laparocele
			obesity
			diabetes
			lumbar pain
L.M.	F	58	laparocele
			urinary incontinence
			abdominal wall hypotonia
			lumbar pain
C.C.	F	62	weight loss
			abdominal wall ptosis
			muscle hypotonia
			lumbar pain
B.C.	F	56	obesity
			laparocele
			abdominal wall ptosis
			lipomatosis

Preoperative standing and effort (lifting weights of 5, 10, and 15 kg with the arms extended) lumbar pain, and ischialgia were evaluated in each patient by means of the Scott-Huskinson scale.

Finally, they underwent the laying–sitting-up test, according to the method of Clarkson and Gilewitch.[12] The test, purposely invented to evaluate the trunk muscles efficiency, is performed as follows: the patient is lying supine with the leg flexed and the feet fixed by one of the doctor's hands while the other hand is slightly palpating the abdomen of the patient on the midline. The arms are extended aside the trunk. Scores are rated as:

Score 0: the patient is unable to perform any movement and the doctor does not feel any abdominal muscle contraction
Score 1: no movement observed but muscle contraction detected
Score 2: the patient partially lifts the lumbar, cervical, and thoracic spine up to the area of scapular bones
Score 3: the patients slowly flexes the pelvis backwards, moving the lumbar spine and then the cervical and thoracic spines while holding the trunk with the arms extended over the flexed thighs
Score 4: the patient is able to sit with the arms flexed and crossed over the thorax
Score 5: the patient is able to sit with the hands touching the ears

This investigation supports very specific information about compartment dyssynergy of the ventral and dorsal muscles. Sitting up requires an effective abdominal muscle contraction and strong spine erector activity at the same time.

The length of the round mesh was individually measured as follows: the trunk circumference was wrapped with a Velcro-strap body-belt tensed enough to avoid breath discomfort during inspiration.

Circumference of the belt was then measured, and ultrasound evaluation of subcutaneous fat tissue was performed to calculate the deep subcutaneous (fascial) length of the trunk by simple geometrical evaluation:

Outer circumference divided by 6.28 = external circumference radius
External circumference radius - subcutaneous thickness = internal circumference (fascial) radius
Internal circumference - (radius x 6.28) = correct individually adjusted length of the round mesh

The round mesh was then built. It has an apron-like 30- x 30-cm (or wider) ventral surface, is prolonged on one side, has a 5-cm belt to be turned subcutaneously around the trunk and sutured on the opposite mesh edge in the ventral area, like a martingale (Fig. 1). The material used was polypropylene with fine thread size and tensile strength of 80 kg/cm.

Position and Anesthesia

All the patients underwent general anesthesia, and the sacral and dorsal areas were uplifted in supine position, 12 cm above the operating table. This way, a lumbar tunnel between the spine and table surface is created to easily shift the mesh belt across the dorsal subcutaneous area (Fig. 2A).

Surgical Technique

Regular anterior laparocele reduction and dermolipectomy (a la demande) are preliminary performed, preferably by means of intertrochanteric access and skin dissection up to the xiphoid area.

The ventral fascia is sutured when necessary or is plicated in the midline. Bilaterally on both flanks, the fat is smoothly undermined over the thoracodorsolumbar fascia to create access to the posterior mesh extension (Figs. 2B,C). A specifically designed polypropylene mesh is then used.

It is designed with three different segments: two lateral, wider, rectangular (45-cm long x 15-cm high) segments to be fixed on the ventral area and one central, narrower (29-cm long and 4-cm high) segment to be inserted posteriorly, like a belt, into the deep subcutaneous tissues above the dorsal muscles and the spine.

The mesh is inserted with a suitable device (Fig. 2D) through a lateral, small skin incision at the posterior axillary line. A specifically built introducer is then inserted into the newly formed skin access (Fig. 2E). The device is a smooth, hollow, cylindrical PVC shaft that is 2-cm in diameter and 80-cm long, with a smooth, conic plug on the tip containing the folded belt. It is similar to the axilla-femoral bypass dissector carrying the arterial prosthesis to be inserted.

The instrument is pushed blindly across the spine at the level of L2-L4 prevertebral space to exit on the contralateral flank in the previously undermined prefascial tunnel (Figs. 2F,G). Advancement of the instrument is performed gently in a rotating manner, taking care not to tear any lumbar vein or stromal bundles; instead, the instrument is slid over these, displacing them apart. This maneuver is usually safe and bloodless. Rarely, we choose to inspect the posterior tunnel with laparoscopic instruments. Eventually we clip some veins if any bleeding is observed from the lateral skin incision. With this kind of smooth dissector, the posterior mesh extension is well-layered around the trunk and extruded from the contralateral flank without twisting or folding.

When the two lateral segments have been extruded from the flank tunnels, they are well-extended, criss-crossed on the midline (Figs. 2H,I), and fixed on the periosteum of the iliac brim with 6 to 12 unabsorbable polypropylene stitches under moderate tension. The exceeding edges of the mesh are cut off to avoid folds or foreign material excess.

Two drains are then introduced. One is introduced anteroinferiorly and the other is introduced from the lateral access to the epigastric area, which remains in situ 48 hours.

Adequate dermolipectomy "a la demande" completes the operation, and 2% povidone iodine irrigation is provided before suturing.

The skin incision is closed with three absorbable layers (Fig. 2L) and a moderately tense elastic bandage is applied around the trunk to reduce the dead space and lymph discharge and to obtain good compressive hemostasis in the dorsal tunnel.

Postoperative Follow-up

Antibiotic and analgesic medication (cefazolin 1 g twice daily), tramadol (100 mg three times daily), and ketoprofen (100 mg twice daily) are regularly administered during the next 72 hours. Mobilization and walking start on the first postoperative day, as do respiratory exercises to optimize lung function after abdominal cavity reduction. All the patients were discharged between postoperative days 4 and 6.

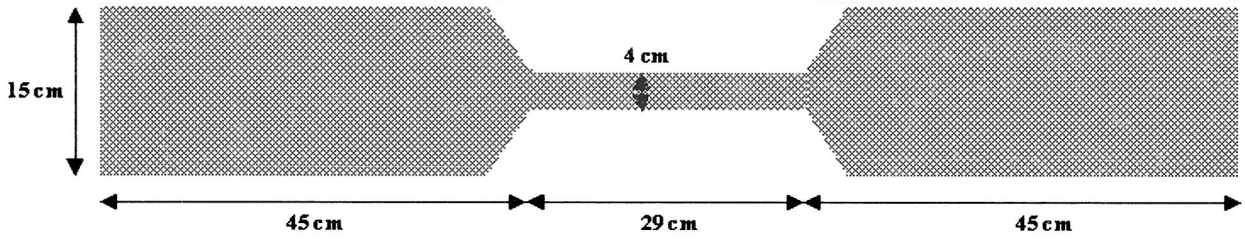
All the patients were reevaluated after 6 months and after 24 months with the same preoperative tests to investigate the potential benefit of round mesh surgery on their physical status. Furthermore, they were interviewed regarding the final cosmetic outcome of the procedure (Table 2).

RESULTS

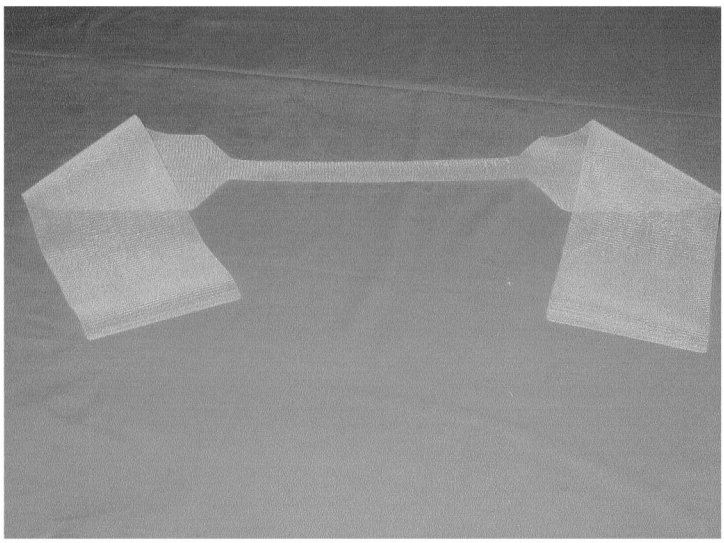
The surgical procedure required between 2 and 3 hours to be performed. No relevant complications were observed. In one patient, partial necrosis of the upper lip wound required a prolonged follow-up (medication twice per week). It healed uneventfully after 1 month, without damage or infection to the underlying mesh.

The patients were asked to perform physical activity and to lose some weight, if obese, by increasing their physical exercise. Only two of them accomplished this.

Follow-up between 6 months and 2 years (average 15 months) confirmed the good results of the round mesh procedure in terms of abdominal support during prolonged standing or physical strain, with specific improvement of lumbar pain in 80% of patients. The trunk profile was corrected satisfactorily in those patients who reported excessive lumbar hyperlordosis. Control x-rays confirmed the modification of vertebral curve (Fig. 3). Limitation in bending, flexing, or extending the spine were not observed during follow-up, nor were adverse effects or symptoms caused by the large surface of biomaterial implanted (Fig. 4).



A



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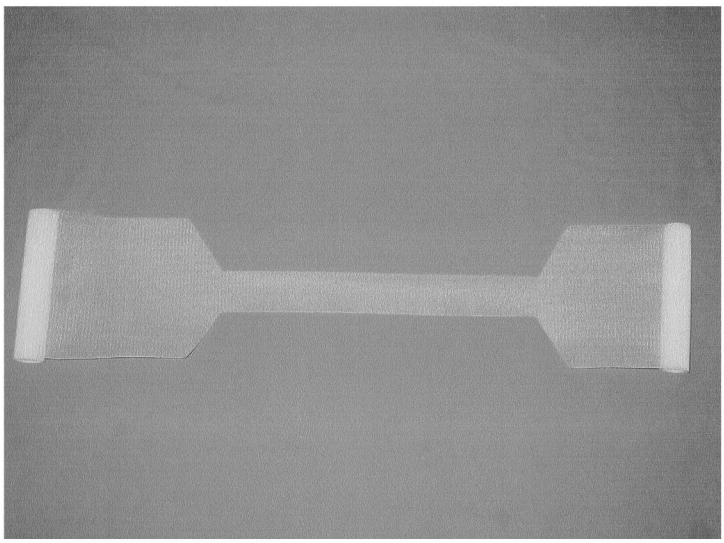

C

FIGURE 1. Drawing (*A*) and photos (*B, C*) of the polypropylene circumferential mesh with the specific cross-belt design.

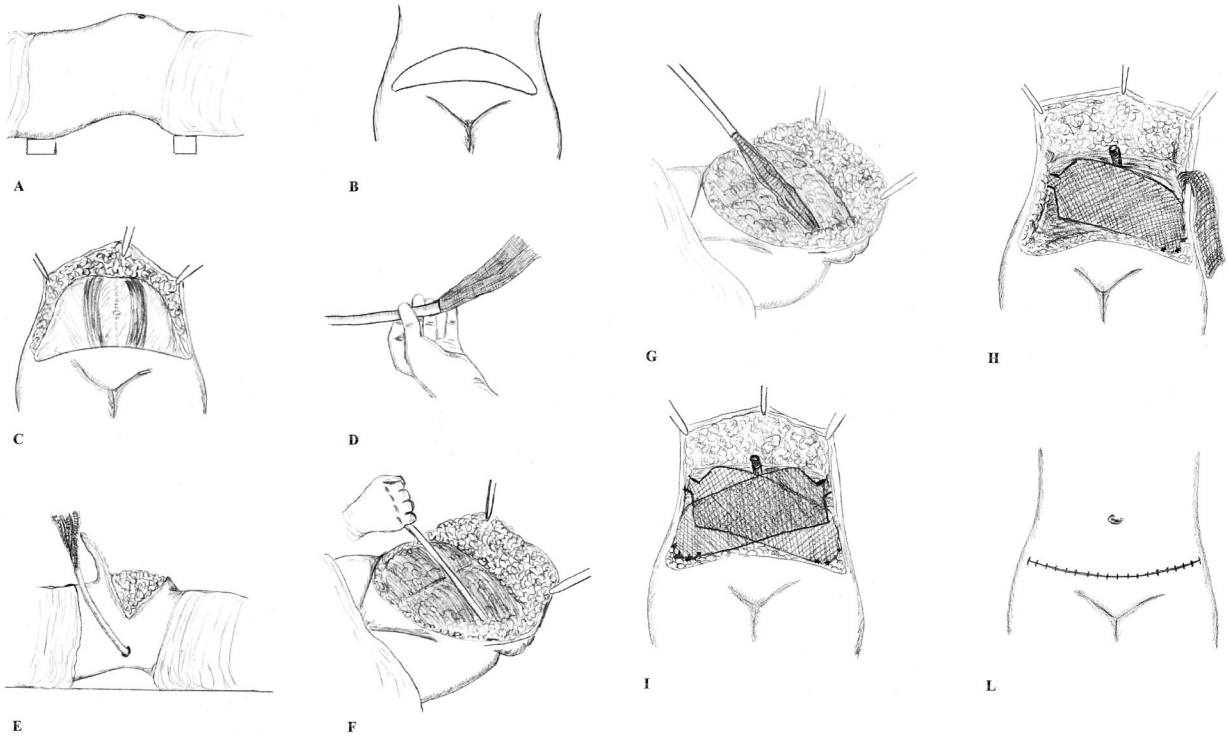

FIGURE 2. Intraoperative steps. (*A*) Lateral view of the patient on the operating table with sacrum and scapular uplifting. (*B*) Typical abdominoplasty skin incision. (*C*) Abdominal wall under the elevated upper skin flap. The linea alba has been sutured with nonabsorbable polypropylene stitches. (*D*) The circumferential mesh is plicated and inserted into the hollow cylinder with smooth conic tip used as the introducer. (*E*) The introducer is passed dorsally over the spine through a small cutaneous incision open in the flank. (*F, G*) The introducer is extracted anteriorly and contralaterally by the surgeon's hand. (*H*) The mesh arms are delivered from the flanks and crossed above the fascia. (*I*) The mesh is fixed with moderate tension to the iliac bone with nonabsorbable stitches. (*L*) Final appearance of the incision with reimplantation of the navel.

DISCUSSION

This second series of round mesh operations allowed to us to better standardize the steps of the procedure and to avoid any complications of the previous one.[13]

Regarding the proper indications for this method, we suggest it specifically for cosmetic or reconstructive (tumor, hernia, laparocele, recti muscle diastasis, or hypotonia) abdominoplasty in patients with excessive belly protrusion and lumbar hyperlordosis with pain.

Many obese people, after massive slimming caused by surgery or diet and medications, potentially will benefit from this operation, especially when the lean mass has been reduced together with the fat and when the abdominal wall is loose and hypotonic.

In a previous work,[13] we used two round meshes at different heights to better support the spine, thus applying two strong perpendicular vectors at the tips of the lordotic arch. In this group of patients, we preferred a single dorsal tunnel and a wider anterior abdominal mesh to simplify the procedure.

The anteroposterior continuity of the round mesh mimics the function of the trunk belt worn by professional weight lifters. It helps the abdominal muscles to effectively support the spine erector muscles during acute strain. During long-term movement or prolonged standing, when the ventral tone is reduced, the round mesh is helpful for endurance. This explains the improvement of lumbar pain in most of the operated patients. The dorsal anchorage of the implant by the belt is a very important step in stabilizing the spine, acting at the same time as a fulcrum of the mesh and supporting the ventral muscle strength.

Both these functions are not accomplished by the standard use of the exclusively ventral meshes that are overlapping or underlying fascia and muscles to close laparocele or recti diastasis. Their role in the postural and dynamic physiology of the vertebral column and anterior muscle compartment, especially after the fibrotic outcome, is quite passive like that of a turtle's shell.

For this reason, we definitely suggest implanting the round mesh, specifically in cases of anteroposterior abdomi-

TABLE 2.

	Objective symptoms						Subjective symptoms					
	Lasegue Test (degree of leg mobilization triggering pain) (10–90°)			Lifting of weights with the arms extended (pain threshold lifting up) (5, 10, 15 kg)			Clarkson-Gilewich Test (laying supine to sitting) (0–5)			Scott-Huskinson scale (on backache and sciatic pain) (0–100%)			Spine flexion tying shoes and wearing sockets (Yes/No)		
Name	preop	6 months	24 months	preop	6 months	24 months	preop	6 months	24 months	preop	6 months	24 months	preop	6 months	24 months
F.L.	30	50	70	5	5	5	0	1	1	100	90	30	No	No	No
G.M.	30	60	80	5	10	10	0	3	4	100	80	30	No	Yes	Yes
R.L.	50	60	90	5	10	15	0	3	5	100	80	30	No	Yes	Yes
L.S.	30	50	80	5	5	10	0	3	4	100	70	30	No	No	Yes
N.B.	40	50	80	5	5	10	1	3	5	100	80	30	No	No	Yes
V.B.	50	70	90	5	10	15	1	4	5	100	70	30	No	Yes	Yes
R.S.M.	30	40	70	5	5	5	0	0	1	100	90	30	No	No	No
S.L.	40	60	80	5	10	10	1	3	5	100	80	30	No	Yes	Yes
L.M.	30	50	70	5	5	10	0	3	4	100	80	30	No	No	Yes
C.C.	30	50	70	5	5	10	0	3	4	100	70	30	No	No	Yes
B.C.	40	60	80	5	10	10	1	3	5	100	70	30	No	Yes	Yes

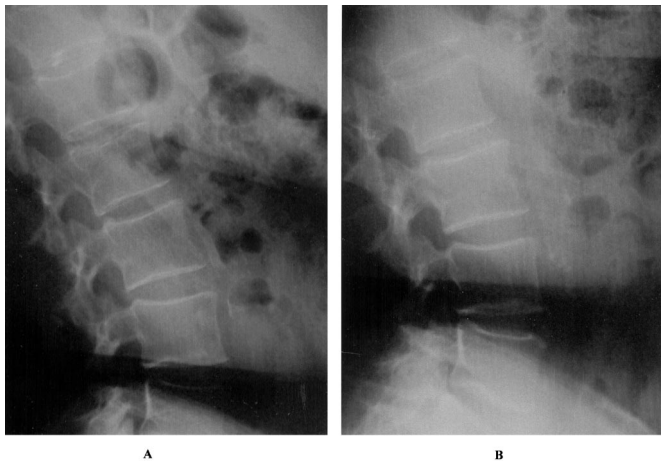

FIGURE 3. X-rays. Preoperative (*A*) and postoperative (*B*) images of lumbar spine posture. The round mesh improves hyperlordosis and corrects the L2-L3 intervertebral posterior pinching.

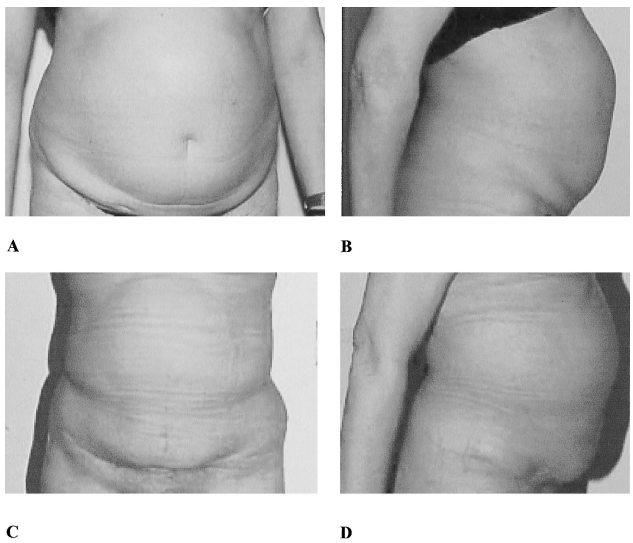

FIGURE 4. Preoperative front (*A*) and lateral views (*B*) of a professional weightlifter. Postoperative frontal (*C*) and lateral view (*D*) 8 months later. The patient increased her body weight 6 kg.

nal muscle compartment dyssynergy with abnormal muscle relaxation and lumbar pain.

A previous work of Toranto describes the original technique of wide abdominal rectus plication abdominoplasty (WARP),[14] aimed at reducing stress at the interverterbral joints and, subsequently, the lumbar pain. The action mechanism was explained in terms of improving the tension of the lumbodorsal fascia, thus increasing the dorsal muscle tone. Toranto was the first to investigate and define the role of ventral muscles in spine physiology, to perform a surgical

restorative method, and to validate a test predictive of the outcome of this operation.

However, the exciting results achieved by Toranto required a strong increase in abdominal pressure because of the shortening of the recti muscles on the midline. Twelve percent of postoperative complications were reported mainly as being lung function impairment caused by high pressure on the abdomen.

Our technique, however, is to be considered a low-tension procedure, enveloping and shortening the circumference of the trunk, thus improving the fascia and muscle function in stabilizing the spine.

The use of prosthetic material, rather than simple plication of recti, that is routinely performed by us whenever relaxation, diastasis, or hernia are detected offers passive, long-term support to the plastic shortening of the muscles. We are afraid that worsening of neurological and orthopaedic conditions of the aging patient, might, in the long-term, frustrate the effectiveness of WARP technique.

For this reason, Toranto performs a preventative, strong hypercorrection of trunk circumference, with observed increased pressure in the abdominal, thoracic, and lower-leg vein areas.

Even if the respiratory complication rate in his study is similar to that reported by Hunter et al,[15] we suppose that most plastic surgeons and their informed patients would be reluctant to accept such a dramatic postoperative risk.

Regarding technical improvement in posterior tunnelization caused by the introducer from a lateral access, this is to be considered a real advantage in terms of safety, speed, and accuracy.

The polypropylene mesh that we used showed optimal integration with the tissue. It did not involve infection or necrosis of the wound. It elicited a moderate collagenic response without any stiffness of the abdominal wall.

We trust that this procedure will be endorsed and practiced in the future by many abdominal and plastic surgeons because of its rational and functionally restorative potential.

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