



The encircling mesh in abdominal wall surgery: rationale and technical details of a dorso-ventral physiological restoration

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Summary We describe a new, functional surgical technique, known as 'encircling mesh', designed to address abdominal wall problems. The rationale of the procedure is to connect the anterior and posterior trunk muscle compartments by means of a purpose built polypropylene mesh that encloses a belt shifted posteriorly across the spine subcutaneously, through use of a disposable introducer. The technical details and a case presentation, with specific references to the cosmetic and functional outcomes are described.

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The human abdominal wall often develops surgical problems related to the weakening of its ventral muscles, the aetiology of which can involve many factors. Multiple congenital and acquired factors (aging, marked weight loss, dorso-lumbar neuropathy, surgical scars, increased intra-abdominal pressure) are often concurrently involved.

Whenever large herniae or laparocoeles have to be reduced, especially if rectus muscle diastasis or marked hypotonia are evident, the surgeon faces the task of strengthening the abdominal wall by employing a synthetic, usually non-absorbable, mesh, either buried in the retromuscular, preperitoneal space, or fixed over the ventral fascia with a series of stitches just to increase the abdominal wall strength.

In other types of abdominoplasty, the recti and lateral muscles are selectively plicated or shifted to the midline, through different procedures to tighten the trunk circumference (DiBello and Moore¹, Ramirez,² Nahas³).

Combining muscle plastic procedure and the use of overlying mesh is a further option, to thicken the ventral hemi-circumference with a biomaterial sheet and thus stiffen the abdominal wall without correcting the deformity of the profile. In fact, the forward projection of the abdomen due to lumbar hyperlordosis, is not effectively counteracted by any anchorage of the ventral fascia to the dorsal muscles (Marques et al.⁴).

Al Qattan⁵ investigated the 1-year follow-up of 20 multiparous women, with severe muscle relaxation; all patients had undergone classic abdominoplasty, with wide longitudinal plication by means of a n°1-/prolene running suture. Recurrence of musculoaponeurotic laxity was observed in all

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treated cases, and this was due to failure of the ventral muscle tone after plication, with further relaxation of the ventral part of the dorso-lumbar fascia—which was not posteriorly retained, according to the author.

The 'encircling mesh' procedure aims to connect the ventral and dorsal muscular fascia compartment in order to achieve a better ergonomic function to stabilise the column, and to effectively contain, with its posterior anchorage, the abdominal pressure.

Our technique, after linea alba closure, or laparocoele reduction, if required, continuously envelopes both the ventral and dorsal muscle compartments by means of a suitable polypropylene mesh designed in shape of a posterior belt (5 cm wide, 25–35 cm long) that is positioned subcutaneously across the spine and the dorsal muscles by means of a specific introducer. The belt is prolonged, anteriorly and on both sides, with two wider wings (20–30 cm wide, 40–80 cm long), that are crossed over the abdominal fascia on the midline and sutured to the ilio-pubic periosteum.

With the 'encircling mesh' we thus obtain a circumferential reinforcement of thoraco-lumbo-abdominal fascia, stabilising all the trunk muscles at once and allowing for a better synergistic tonic and phasic function of both the anterior and posterior compartments. In these cases, this strategy has been proven effective, not only as aesthetic procedure in the abdominal profile restoration, but particularly with laparocoele or large ventral hernias as improvement of lumbar symptoms caused by severe muscle hypotonia and vertebral instability.

Materials and methods

From January 1998 to June 2002, we selected 100 patients, 85 females and 15 males aged between 32 and 76 years to undergo the 'encircling mesh' abdominal wall reconstruction because of ventro-parietal problems and lumbar-lumbosciatalgic symptoms.

Admissions diagnoses were (Graphic 1)

- A Laparocoele: 25 cases;
- B Wide umbilical hernia and abdominal muscle weakening with previous unsuccessful classic abdominoplasty: two cases;
- C Abdominal and synchronous inguinal hernia in patients performing heavy works: two cases;
- D Abdominal wall metastatic tumor: two cases (one malignant schwannoma and one colon carcinoma with wide tissue loss);

- E Recti muscles diastasis and ventral hypotonia in pluriparous, overweight women: 12 cases (previous abdominoplasty had failed in three cases);
- F Severe weight loss and muscle relaxation after open or laparoscopic bariatric surgery: 18 cases;
- G Aesthetic abdominoplasty in multiparous (one or more caesarean sections) nonobese women with lumbar pain and marked forward protrusion of trunk profile, due to relaxation of ventral muscles, with skin folds, relapsing mycotic infection and impairment from increased intra-abdominal pressure: 39 cases.

Each patient had been preliminarily submitted to spine NMR in order to exclude frank disk hernia or major bone-medullary problems. Preoperative examinations included also spirometric function tests and abdominal echography with specific adjunctive reference to the subcutaneous fat thickness.

The Local Ethical Committee agreed to the trial as the mesh design did not meet the criterion of major innovation, being a modification of an existing surgical technique.

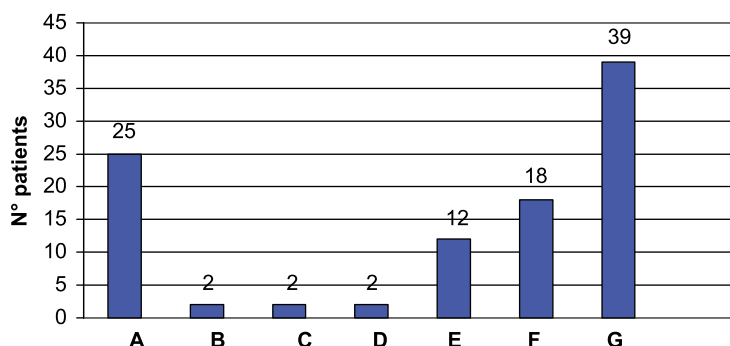
Each signed an informed consent for the 'encircling mesh' procedure rather than a simple abdominoplasty. In the former, more ergonomic restoration of the circumferential trunk muscles might be achieved, with eventual improvement of lumbar symptoms, and potentially better motility.

The percentage of lumbar symptoms recorded in a comprehensive analysis of the group were:

- A Lumbar pain on prolonged standing: 85%;
- B Impairment of squatting-uptilting movements: 12%;
- C Bilateral and unilateral lombosciatalgia: 28 and 12% respectively;
- D Pain due to trunk bending and rotating: 20%;
- E Pain due to arm lifting and tiptoeing walking: 13% (see Graphic 2).

Exclusion criteria were mainly lung, liver, kidney and cardiovascular insufficiency, severe diabetes and hypertension. On a five-patient sample, we performed a pre- and postoperative (8 weeks) gait analysis and postural examination, by an optoelectronic system (ELITE PLUS BTS Milano, Italy), with six cameras and two force plates (9286 A Kistler, Enschede, The Netherlands). Kinematic data were acquired at 50 Hz, and force plates data at 100 Hz. Twenty-one markers were placed on patient's body, in accordance with the Davis protocol marker set. The cases were matched with five comparable

ABDOMINAL WALL PROBLEMS



Graphic 1 Case selection for 'round mesh' procedure: (A) Laparocoele; (B) Wide umbilical hernia and abdominal muscle weakening with previous unsuccessful classic abdominoplasty; (C) Abdominal and synchronous inguinal hernia in patients performing heavy works; (D) Abdominal wall metastatic tumor; (E) Recti muscles diastasis and ventral hypotonia in pluriparous, overweight women; (F) Severe weight loss and muscle relaxation after open or laparoscopic bariatric surgery; (G) Aesthetic abdominoplasty in pluriparous (one or more caesarean sections) non-obese women.

(age, sex, weight) classic abdominoplasties with the same test.

Encircling mesh technique

Under general anaesthesia and in a supine position, with the dorsum and sacrum lifted 12 cm above the bed surface, a bridge across the spine in the lumbar area is created in order to simplify the posterior mesh introduction.

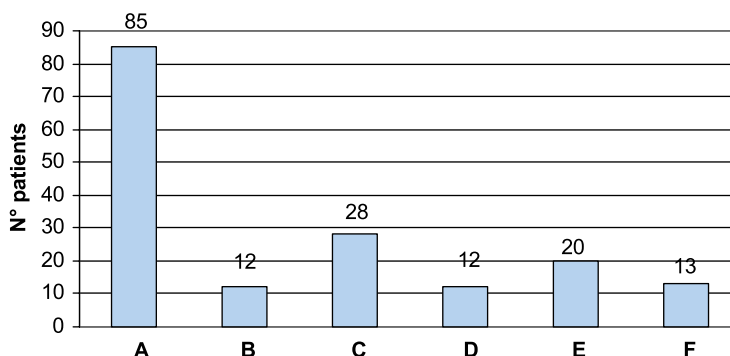
The skin incision is introduced either on the midline or intertrochanteric (as in cosmetic abdominoplasty) wide exposure of the bare abdominal fascia, with careful haemostasis, is achieved, followed by laparocoele or hernia reduction and, eventually, recti muscles plication on the midline. Lateral tunnelling on both sides is performed with the cautery, to extend the mesh without fold on the flanks.

The round mesh next is prepared by the scrub

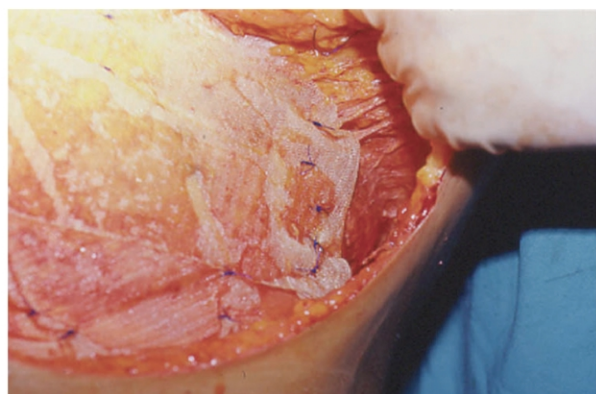
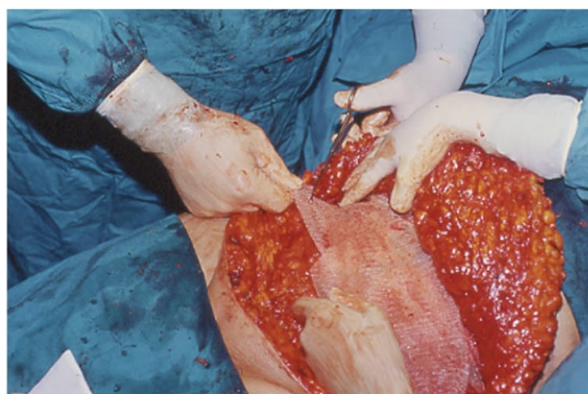
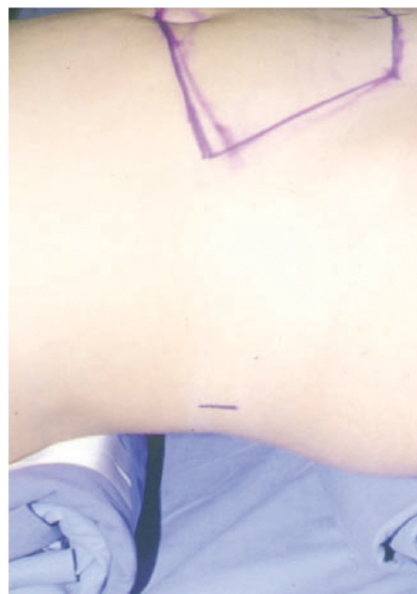
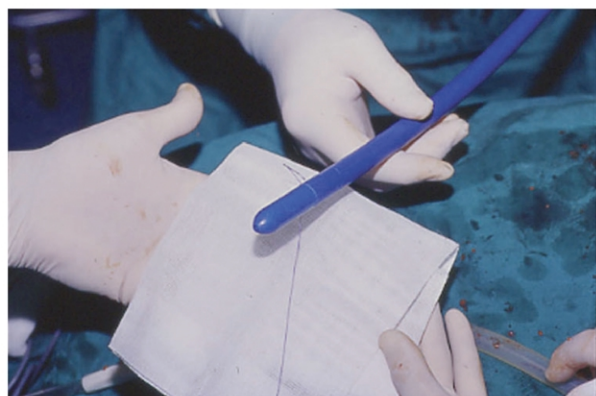
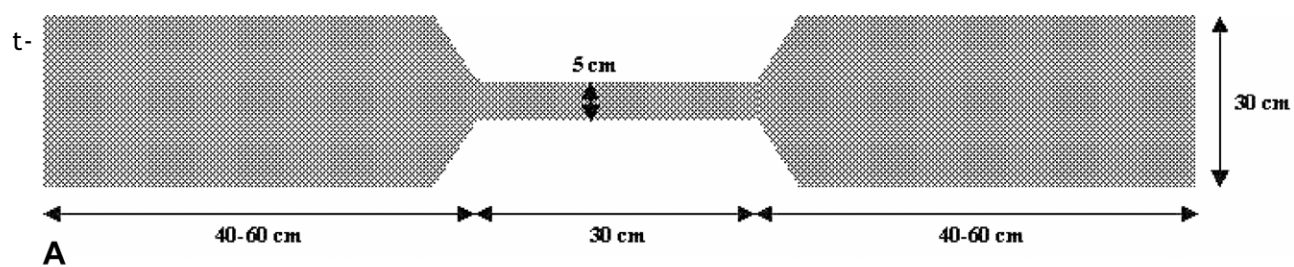
nurse. The mesh (supplied by Soveta Co. Milano, Italy) is a standard-sized 5 cm wide, 30 cm long polypropylene belt that expands bilaterally in two identical segments, each 30 cm wide and 40-60 cm long (Fig. 1(A)). These measures were chosen on the basis of previous clinical experiences as the safest and the most effective way to solve the ventral holding and dorsal anchorage. Specifically the height of posterior belt could not be more than 5 cm, in order to pass through and be extended across a bloodless tunnel avoiding to tear any of the lumbar veins.

The round mesh is carefully folded and partially inserted into the introducer, a hollow, smooth and semiflexible plastic rod 60 cm long, 1.5 cm in diameter and given a conical-shaped removable tip (Fig. 1(B)). The opposite end of the mesh is floating outside of the introducer. This introducer is available commercially for the axillo-femoral bypass tunnelling and fits adequately to secure

LUMBAR SYMPTOMS



Graphic 2 Main symptoms enclosed for 'round mesh' eligibility: (A) Lumbar pain on prolonged standing; (B) Impairment of squatting-uptilting movements; (C) Bilateral and (D) unilateral lombosciatalgia; (E) Pain due to trunk bending and rotating; (F) Pain due to arm lifting and tiptoeing walking.



he dorsal tunnel for the posterior belt of the round mesh.

A stab incision next is performed on one flank, 2 cm above the iliac bone (Fig. 1(C)), and the introducer is inserted subcutaneously and advanced carefully across the spine, at the 4th-5th lumbar space, along the transversal tunnel available over the patient's bridged back. With smooth, very delicate up-and-down and rotating movements, the tip is delivered to the opposite flank and slips over the fascia (Fig. 1(D)). The surgeon recovers it by hand, using gentle traction. Before withdrawing the introducer anteriorly, the surgeons checks if adequate space (5 cm wide) has been dissected during the tunnelling, up-and-down manoeuvre, to finally place the belt without twisting and folding its edges.

At this time, a thorough check for blood in the tunnel (due to inadvertent vessel tearing during the blind manoeuvre) is conducted. Coagulation and pressure-control of any bleeding spot is easily achieved.

The mesh segment in the contro-lateral area is delivered over the incised flank and the two rectangular terminal segments of the 'round mesh' are crossed ventrally on the midline, leaving a space for the umbilical stalk to exit.

The encircling mesh's final length is individually determined by cutting its ends (Fig. 1(E)) before affixing them to the pubo-iliac periosteum under moderate tension and with 0-prolene atraumatic stitches (Fig. 1(F)).

Two suction drainages are now inserted, one for the ventral area, the other for the posterior tunnel, exiting through a purse-string suture at the skin hole incised for the introducer. They are left in place until the output drops to 30-50 ml per day, usually around the 5th postoperative day.

Dermolipectomy and three-layer skin sutures complete the operation, which usually lasts not more than two-and-half hours.

Moderate elastocompressive dressing is mandatory to reduce the lymph pooling in the 'dead space', as we could demonstrate on the basis of exudate output in a group of 10 patients wrapped with loose bandages compared with 10 moderately tense elastic bandages. The antibiotic/anti-inflammatory and analgesic schedule (Cefazolin 2 g/die, Tramadol 100 mg \times 3 and Ketoprofen 100 mg \times 2) is administered for 72 h.

Respiration exercises and early mobilisation are part of the protocol, as well as low molecular-weight heparin prophylaxis for a duration of 3 weeks. Discharge from the hospital is usually between the 5th and the 8th postoperative day.

Results

No mortality or major morbidity is described in our case series, in particular no haemorrhages or excessive lymphorrhea, prosthesis infection, respiratory failure or thromboembolic disease. Two cases of partial skin necrosis of the wound flap were recorded, each requiring medications and healing in 1 and 3 months, respectively. The long-term follow-up was enclosed between 8 months and 2 years (15 months on average). During the final visit cosmetic and functional results were judged by independent doctors and the patients, comparing the outcome with preoperative pictures (Figs. 2 and 3), and preoperative records with physical tests (Tables 1 and 2; Figs. 3 and 4).

The abdominal analysis and postural examinations on the five sample cases showed a reduction in kyphosis (inner angle increased more than 16%), with increased pelvic bone antiversion and a forward shifting of the body's centre of gravity (Centre of Pressure or CoP) (Fig. 4). No variation was detected in the control patients submitted to abdominoplasty without circumferential mesh.

During the duration of the follow-up, we observed one case of median laparocoele sliding under the round mesh following 22 kg weight loss. The mesh had been introduced during a previous Mason gastropasty operation, and fast and severe loss of weight was assumed to be the cause of the pathology. The patient again underwent surgery; the 'encircling mesh' was removed and the reduction of laparocoele was followed by primary closure of the abdominal wall without further foreign material, because strong, newly formed fibrous tissue had thickened the fascia.

We therefore agreed as a rule to postpone the 'encircling mesh' implant for at least 1 year after gastroplastic procedures. As a result, we observed no further hernias or laparocoele. There were three cases of weight increase (3, 5 and 7 kg), but the fat was mainly stored in the subcutaneous tissue of the

Figure 1 Intraoperative steps: (A) drawing of the round mesh; (B) disposable introducer with removable tip: the mesh is plicated and introduced into the lumen, to be passed across the spine; (C) lateral view of the access for the mesh introduction; (D) introducer output into the operative field, contralaterally to the flank access; (E) criss-crossed expansion of the mesh above the ventral fascia; (F) periosteal unabsorbable stitches to fix anteriorly the 'round mesh'.

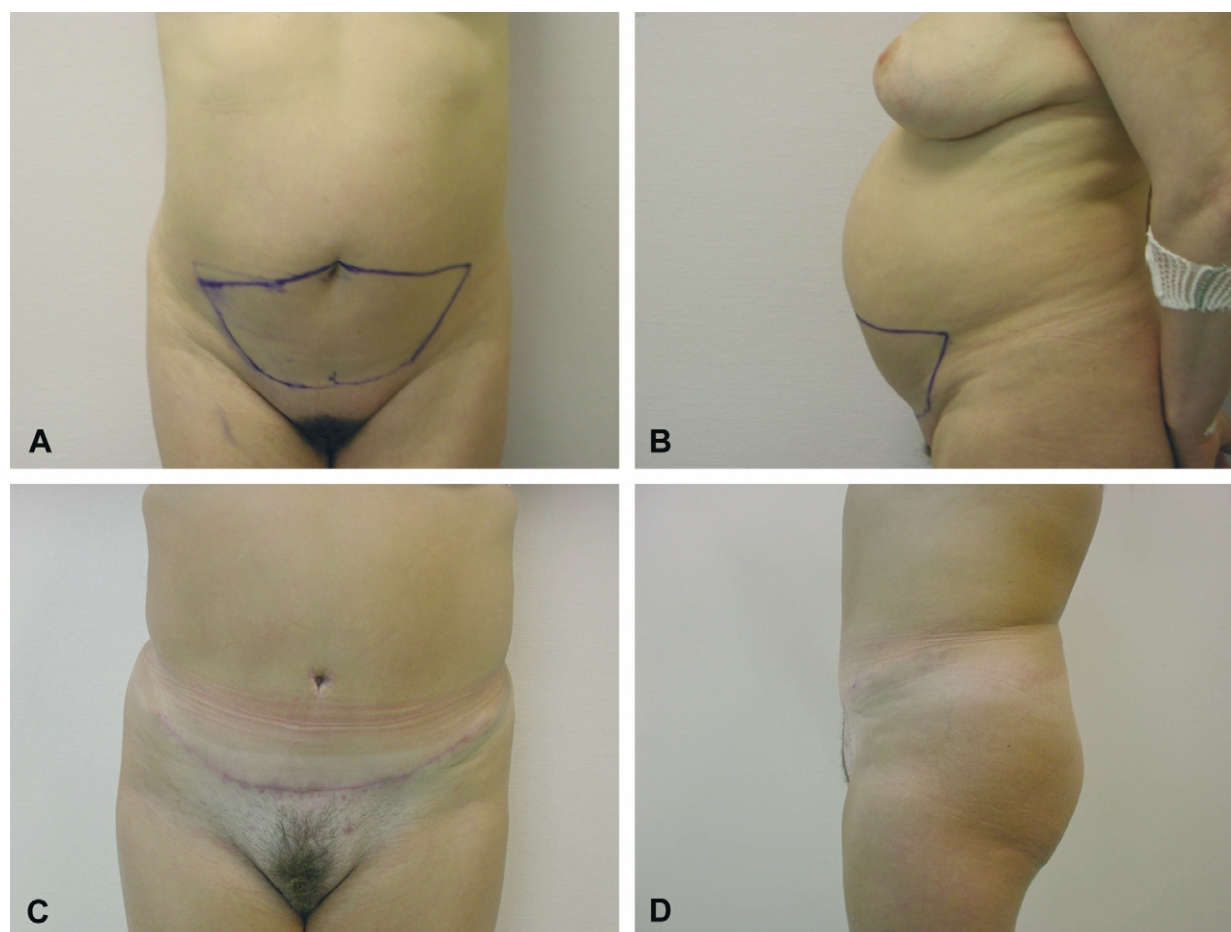


Figure 2 Pre (A and B) and post (C and D) frontal and lateral view of operated patients.

trunk, dorsum and thorax without any problem to the 'round mesh'.

The majority of the patients complied with the diet and behavioural prescription, and most of them acknowledged that the encircling mesh operation had tightened abdominal extensibility, thus preventing overfeeding and gastrectasia.

Discussion

The encircling mesh technique is a reconstructive

procedure for abdominal wall eventration, laparocoele, hernias or muscle hypotonia (recti muscles diastasis), usually joined with lumbar hyperlordosis and lumbar or lumbo-sciatic symptoms. It can also be applied during cosmetic abdominoplasty, particularly when one of the patient's main complaints is forward abdomen protrusion.

The rationale of the 'round mesh' has been recently supported by several researchers,⁶⁻¹⁰ who have stressed the positive ergonomic role of an abdominal orthopaedic belt in supporting the patient's trunk muscles as they stabilise the sacroiliac joints and spine erector muscles, whether the patient is sitting or standing.

Table 1 Functional results after 6 months

Functional results				
Excellent	Good	Fair	Poor	
78	15	5	2	Judged by the patients ^a
82	8	6	4	Judged by the doctors ^b

^a Pain symptoms, painkiller use, subjective motility, physical exercise.

^b Tilt-test, lasague, change of position from squatting to standing, pain in prolonged standing.

Table 2 Cosmetic results after 6 months

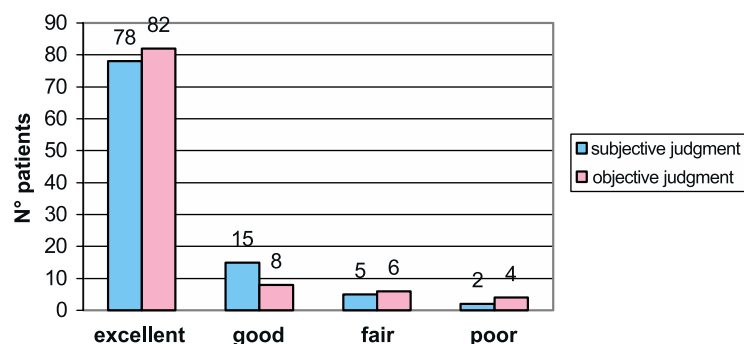
Cosmetic results ^a				
Excellent	Good	Fair	Poor	
84	12	2	2	Judged by the patients
75	16	7	2	Judged by the doctors

^a Cosmetic evaluation: ventral protrusion and laxity correction quality of the scar, symmetry, dog-ears.



Figure 3 Pre (A and B) and post (C and D) frontal and lateral view of operated patients.

FUNCTIONAL RESULTS



Graphic 3 Overlapping agreement between doctors and patients as to functional and cosmetic outcome of the 'round mesh'.

In fact, the ventral and dorsal muscles have been demonstrated to act synergistically during physical exercise (Hodges and Richardson,¹¹ Snijders et al.,¹² Souza et al.¹³), and the polypropylene encircling mesh enveloping both the anterior and posterior compartment tightens the muscle-fascial layer of the trunk, thus obtaining a better tone and phasic ergonomics.

In fact, a preliminary pre- and postoperative postural investigation on the five sample patients who received the round mesh showed an improved stability of the spine, due to the pelvic bone anteversion and reduced dorsal kyphosis.

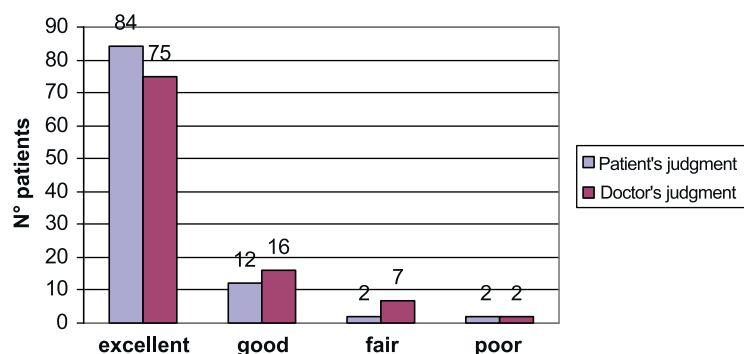
Some literature (Toranto, 1990;¹⁴ Marques et al., 1995;⁴ Ramirez, 2000²) describe back symptoms improvement after simple abdominoplasty. Specifically, Toranto¹⁴ performed first a wide abdominal rectal plication technique to increase intra-abdominal pressure, thus improving the spine stability. He reported that 24 of 25 patients sustained pain relief and had with few side effects.

We chose to avoid the high tension closure and intra-abdominal, strong and raised pressure of Toranto's method, and instead employ a continuous mesh that circumferentially overlaps to the thoraco-lumbo-abdominal fascia and thus stabilise under moderate tension the spine-erecting muscles with oblique and transverse ones.

The criss-cross mesh stitching on the pubo-iliac periosteum is an effective spine-stabilising method, as we could demonstrate with the postural examination: in fact the increased pelvic anteversion, with advancement centre of gravity pressure, suggests a more ergonomic balance of the body weight on the musculo-aponeurotic system.

The operation is simple and quick to perform. The posterior introduction of the mesh, by means of a suitable introducer, is achieved without vessel or nerve damage. The belt is well extended and strongly supports the apron-like ventral mesh segments and intra-abdominal pressure, particularly during strains.

COSMETIC RESULTS



Graphic 4 Overlapping agreement between doctors and patients as to functional and cosmetic outcome of the 'round mesh'.

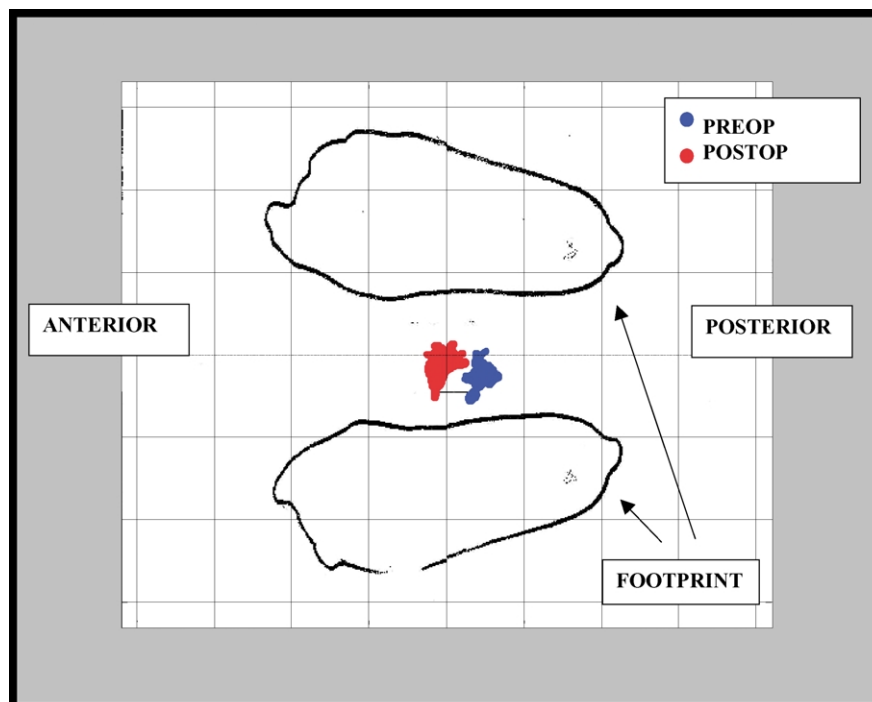


Figure 4 Sample of pre (blue) and postoperative (red) change of the 'Centre of Pressure' (CoP) measured by optoelectronic system: the gravity centre of the body is shifted forward.

Seromas due to fascia overlapping with polypropylene mesh has never been observed and collagen reaction never gave exceeding trunk stiffness or any adverse effects. Reoperation by laparotomy, if required, is easily performed by knife cutting the mesh during wall incision and resuturing it at the end of the operation.

The weight gain of the surgical patients in the long run does not compromise the function of the encircling mesh. As a matter of fact, the fat storage is observed in the subcutis or into the coelomic cavity, without respiratory failure or postural impairment.

We believe that the 'encircling mesh' operation opens new perspectives of integrated functional and cosmetic surgery in abdominal wall restoration.

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