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Minimally Invasive Robotic Abdominoplasty

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Abstract

The author introduces the use of Robots, da Vinci Surgical System for muscle aponeurotic rectus plication in abdominoplasty. Pioneer in endoscopic plastic surgery, in 1992 the author developed a set of instruments for adapting endoscopic methods to the subcutaneous territory to perform minimally invasive muscle aponeurotic rectus plication. With 25 years of experience in using endoscopic methods (subcutaneous copy) for treating small and median size abdominal wall deformities like rectus diastasis, ventral hernias, and umbilical hernias, with a representative number of patients up to 20 years follow-up presenting with successful results and a series of secondary surgeries for repairing unsuccessful cases. The author presents his personal experience as well as a bibliographic review of the different methods of plication with the use of different sutures materials, abdominal wall CT Scan and linear ultrasound in long-term evaluation of the efficacy and longevity of the muscle aponeurotic plication. Since 2014, he started with great enthusiasm dedicating to bring the minimally invasive abdominal wall muscle aponeurotic plication and endoscopic Abdominoplasty to the next level by a key-hole high tech, Robotic Abdominoplasty, using daVinci Surgical System Robotic Surgery. So far he has already delivered 5 cases of Robotic rectus plication and designed some new instruments to facilitate the method.

It is already possible to say that robotic surgery brings important advantages comparing with endoscopic methods, by improving precision, reducing operating and anaesthesia time, reducing surgeon fatigue.

Introduction

In a comfortable ergonomic position makes the surgery much easier more precise and less stressful.

It is very user friendly to perform sutures in deep cavities, that is why I became interested in using it [1]. In selected cases it is not necessary to remove any skin in the lower abdomen when performing mini-abdominoplasty. In many cases the complaint of our patients is not the cosmetic aspect of the skin, but the bulging stomach that is the result of a rectus diastasis [Figure 1-5, 6].

They complain that despite working hard at losing weight, having a strict and rigorous work out regime, they cannot get rid of that bulging stomach. The weakening of the muscle aponeurotic abdominal wall due to congenital conditions, weight variation, aging or pregnancy is a frequent cause of rectus diastasis and/or umbilical hernia that can alter the cosmetic aspect of the abdomen [1-4]. The rectus abdominal muscle plays an important role, not only in the cosmetic appearance of the abdomen, but also in the stability of the spine. Depending of the degree of the rectus diastasis, it can lead to a vicious posture, spine problems, back pain, slipped disc, etc. Rectus plication can effectively restore function providing a balance between the anterior and posterior muscle of the abdominal wall and improve the cosmetic appearance of the abdomen [1, 3, 5].]. The long-term evaluation by ultrasonography and CT-scan of the plication of the anterior rectus sheath [4, 5] as well as our long term clinic follow-up [Figure 1] has shown the efficiency of the recti plication when properly performed.

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Since 1989, I changed my concept and my way of doing mini-abdominoplasty. Using the previous C-section scar, with the aid of light-source retractors and long needle holders for performing the rectus plication, not limited to the lower abdomen or just above the umbilicus but all the way from pubis to xyphoid process, treating lower abdomen lipodystrophy by doing lipectomy, avoiding removing any skin in the lower abdomen and counting with the capacity of the skin to retract, without adding or increasing the scars length [Figure 2].

The great improvement in the quality of the results of my Minimal Scar Abdominoplasty technique comparing with my Mini-abdominoplasty gave me the idea of adapting endoscopy to the subcutaneous tissue to treat patients without previous C-sections scars.

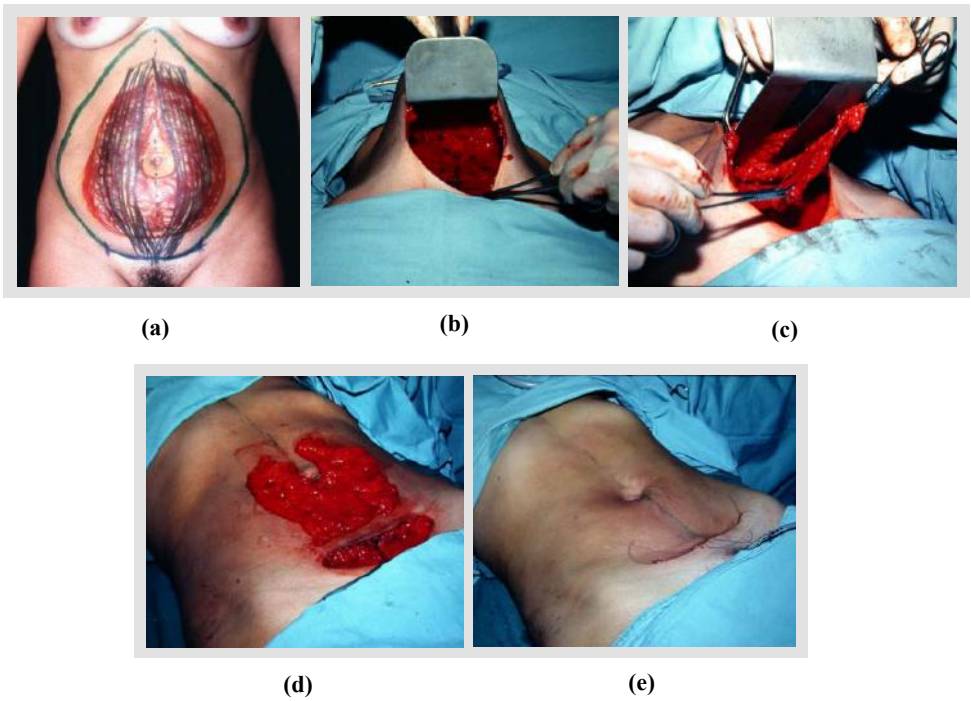
From 1992, I started using endoscopy working through incisions as small as 4 to 5 cm hidden in the pubic hair-bearing area and inside the umbilical area [2, 3, 8-10]. Some of our patients with follow-up for more than 20 years shown the effectiveness of the technique and the beauty of restoring the original anatomy leaving minimal and inconspicuous scars [Figure 3, 5].

Attentive to the evolution surgical methods, tools and machines that can help us to improve our results, and facilitate the execution and benefit our patient; in 2014 I started my studies and training in robotic surgery. It is the "Gold standard" of the minimally invasive surgery in many surgical fields.

The Robotic high definition 3-dimentional view and the amplification of images gives us a much better depth sensation of the surgical field than the 2-D endoscopic view; and it is even better than our naked eyes. Laparoscopic instruments have a limited range of motion; the robot Endowrist range of movements is comparable to the human wrist. The surgeon's hands tremors are transmitted through the rigid laparoscopic instrument and this limitation makes

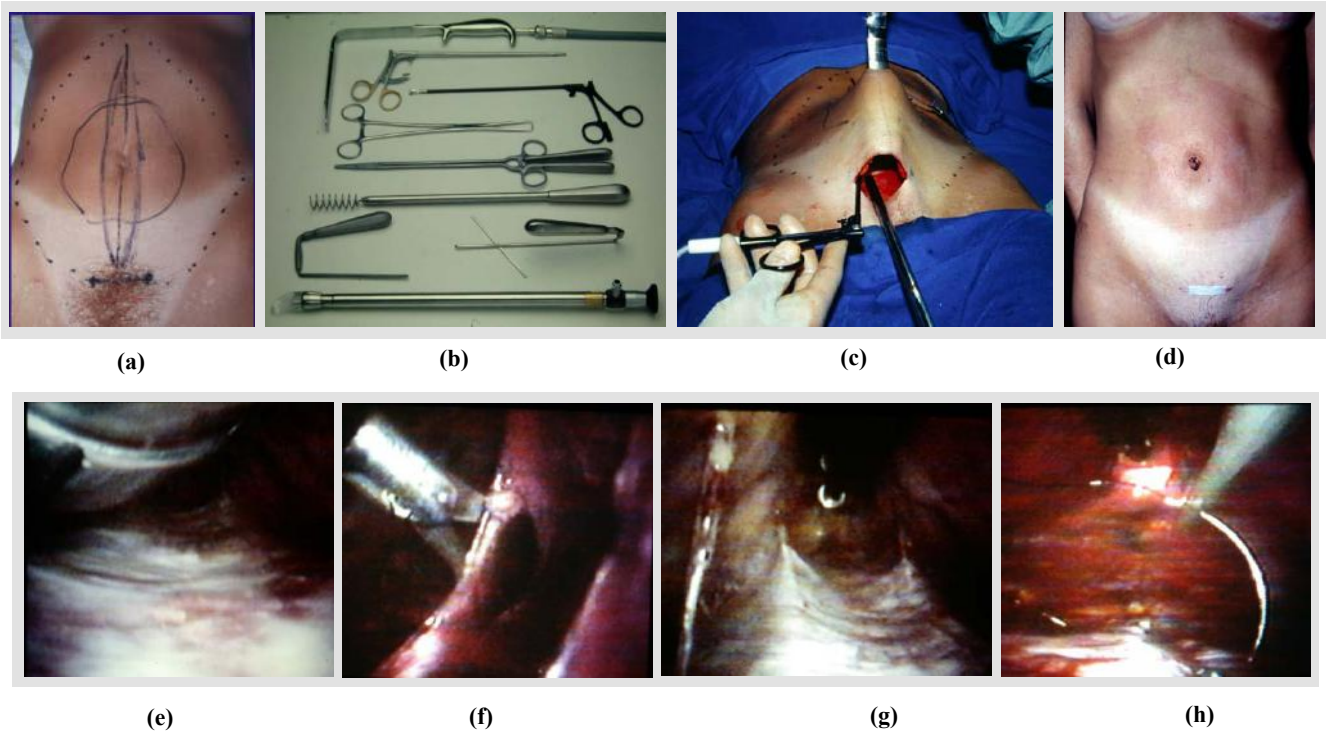
Figure 1: Endoscopic abdominoplasty 20 years follow up showing the maintenance of the result of the rectus plication even after patient aging 20 years and put on 8kg.

Figure: 2 Minimal Incision Abdominoplasty technique 1989.



2. a- Surgical plan
2. b- Ampla undermining and plication from pubic bone till xyphoid
2. c- Sub Scarpa fascia open lipectomy
2. d- Observe the amount of fat removed from the lower abdomen and peri-umbilical area
2. e- Wound closure without removing any skin.

Figure 3: Endoscopic abdominoplasty technique scars hidden inside the navel/umbilical and inside the pubic hair bearing area



3.a- pre op plan
3.b- set of instrument developed
3.c- trans-op showing the inscisions, retractor, scope and endoscopic hemostasis
3.d- 4th post op day
3.e - endoscopic undermaining using the subcutaneous-tomoscope
3.f - cutting and cauterazing vessels using endoscopic scissors
3.g- dissection completed, clean fascia free of fat tissue, rectus diastasis seen
3.h- plication been performed

delicate procedures more difficult. The superb precision and stability of the robot arms, surgical field and instruments, all controlled by the surgeon seated at the console.

In reconstructive plastic surgery, it has already been used for the harvesting of Latissimus Dorsi in breast reconstruction, super microsurgery, hand surgery [6, 7, 11] and hair transplant.

So far I didn't find in the literature any report of other applications of Robotics in Aesthetic Plastic Surgery.

As a Cosmetic Plastic Surgeon, I feel it is very interesting that there is a fast growing trend for the use of Robot for performing transaxillary robotic thyroidectomy and robot retro-auricular submandibular gland resection [12, 13], procedures that are improved or tweaked to minimize visible scars or even relocate scars to other body areas that could be hidden. Yet little is done in the area of Aesthetic Plastic Surgery, where scarring is of an important concern for patients [1].

Materials & Methods

Patient Selection

Minimally Invasive methods in abdominoplasty are indicated for the the treatment of patients presenting with no redundant folds of skin, good skin elasticity, and moderate degree of lipodystrophy and presenting with rectus diastasis [1, 2, 3, 8-10]. We exam the patient in standing position, seating position and supine position to evaluate the amount of skin as well as function of the rectus and the degree of diastasis. We advise the patient that the procedure will not improve the tonus or the elasticity of the skin but the function of the core muscles. The best candidates are patients presenting with small and median post gestational deformities or male and female patients that lost weight after been 10 to 15 kg overweight for a while. The cosmetic appearance of the abdomen is one of the most popular concerns in the modern society. We are seeing an increasing number of male and female patients coming to our clinics asking for minimal invasive procedures that can effectively improve the functional and aesthetic aspects of the abdomen by leaving minimal and inconspicuous scars [1].

To be a Robotic surgeon

The daVinci Surgical System is a high tech surgical machine presenting with many features and is mandatory a formal training to operate the machine. There is a pathway training and exam to Certify as Robotic Surgeon. Starting from a foundational understanding of the da Vinci

Figure 4: The before photo showing patient had abdominal deformities after delivery twins and 4kg over weight. 1 year follow up after patient cut down 8kg. After 5 years post op, patient put back 2kg. We observe the long term maintenance of the result.

Before **After 1 year** **After 5 year**

Surgical System, Technology Training [Product Training], working with simulators and with the real console to develop skills, using dry lab and wet lab, observing robotic surgeons from different specialities performing robotic cases, and a final exam testing our skills in live surgery in pigs. Continuing Advanced da Vinci training in multiple specialties is available through selective training centres as well as online.

Surgical Robots:

The daVinci Surgical System is the equipment that we are using. It consists of three components [Figure 7C] the console where the surgeon sits to operate the robotic arms; (a) The patient site robotic cart with 3 or 4 arms; [b] The high-definition 3D vision system.

Every single movement is operated and controlled by the surgeon. The robot system does not have autonomy to do anything by its own. It is the surgeon that operates. The surgeon seats at the console, uses the joysticks, drives the robot arms and Endowrist instrument, operating very precise miniaturized tools [Figure 8]. With the feet, the surgeon controls the camera, zoom-in zoom-out, monopolar, bipolar cut and cauterization, as well as switching use of the second and the third robot-working arms. There are a few different robot models presenting with different features, we are using the da Vinci S and the da Vinci SI. The daVinci XI still not available in my practice but is more versatile.

Anaesthesia

I prefer to work under general anesthesia because once we dock in the patient side cart, the patient should not be in a state where she could move as a reaction to pain or other stimuli –in other words, to be completely still. There is a so called "remote centre" in the trocar that must stay in place to avoid tearing the skin. All the movement of the robot arms are around a fixed rotating point.

Infiltration

To facilitate dissection and reduce bleeding, the incisions areas and the region between the fat tissue and the muscular aponeurosis are infiltrated with 500ml of saline solution and epinephrine [1:500,000].

Incisions

If patient presents with previous scars from caesarean sections or other abdominal surgery [Figure 4], the surgeon assesses the need to repair the scars as well as the possibility of using them for access [4, 7].

In our original Endoscopic Abdominoplasty Technique if there is no previous C-section scar, a 5cm incision is made at the pubic hair bearing area and another one inside the umbilical scar. [Figure 3, 5, 9].

Figure 5: Before and after endoscopic abdominoplasty performed through one 4cm incision hidden inside the pubic hair bearing area and a Y-shaped incision located inside the umbilical skin

(a)

(b)

(c)

In our Robot technique the docking points of the robotic arm are 8 to 10 cm far from each other to avoid instrumental collision. The incision for the camera arm is at the midline of the patient's abdomen, inside the pubic hair bearing area at the pubic bone level, 3cm above the vaginal furcula, measuring 2- 3 cm. Docking incisions for the two instruments arms should have a distance of 16 to 20 cm over the bikini line area, each incision measuring 0.8cm [Figure 6, 10]. A 4th incision is made within the umbilical scar [Figure 6, 9]. The

umbilical port is used for the introduction of retractors for tenting the abdominal flap, for supplying sutures and gauze into the operative field, and for the surgical assistant also to help with laparoscopic instruments if necessary. Additional 0.5 cm incisions can be made at the iliac crest level each on bilateral sides, in cases of lipo-abdominoplasty when the lower back needs to be treated. These incisions can also be used as an extra port for the surgical assistant [1].

The skin of the umbilical scar is detached from its stalk. The umbilical stalk is then transfixed using a 3-0 PDS suture. The suture is not cut short. Instead, the spare suture is left at its full length with the needle attached for further reinsertion of the skin flaps in their original site, deep inside the plication [3]. If there is redundant skin at the navel a Y-shaped or cross-shaped incision is made generating 3 or 4 triangular flaps [Figure 9], the closure of it will leave inconspicuous converging scars, following Avelar original idea [14]. By resecting part of these triangular flaps we treat the redundant skin.

Figure 6: The incisions: at the bikini line 3 incisions one at the mid line 2.5cm for the robot endoscope and 2 at the bikini line 0,7cm length distant 12 to 16cm from each other for the robot arms and 1 at the navel for passing the sutures, gaze, suction and helper instruments. Additional 0.5 cm incisions can be made at the iliac crest level each on bilateral sides, in cases of lipo-abdominoplasty when the lower back needs to be treated. These incisions can also be used extra port for the surgical assistant.

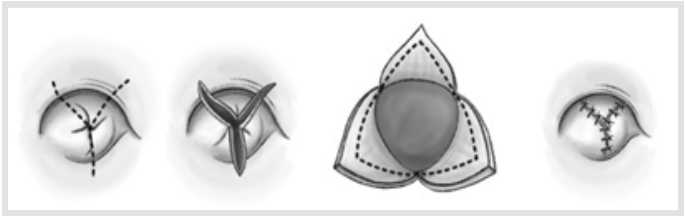
Figure 7: Da Vinci Xi System

7.a - patient side cart
7.b - 3D vision recorder
7.c - surgeon control console

Figure 8: Surgeon manipulate the joysticks operating the endowrist instrum-instruments that has a range of motion comparable to the human risk motion. The two lens robotic scopes that provide a fantastic High Definition 3 Dimensional view

Figure 9: The surgical sequence of umbilicoplasty technique is as follows:

- Intraumbilical Y-shaped incision
- Three triangular flaps and a wide entrance port
- Partial resection of these flaps to treat flabbiness
- Closure leaving inconspicuous converging scars



Dissection and Elevation of the Abdominal Flap

The undermining starts from the umbilicus progressing downwards through the midline towards the pubis and from the pubic incision upwards, or vice-versa, to meet each other. The procedure begins with the use of traditional methods with conventional instruments as far as our eyes, fingers, and instruments allow us to work safely and comfortably. With the aid of a 4 or 7mm 30^0 degree endoscope, retractors and the "subcutaneous tomoscope" [3] and electrocautery we progress dissecting a tunnel from the pubic bone to the xiphoid process [Figure 2, 3, 11, 12, 14] up to the outer borders of the rectus abdominal muscles to create the optical cavity. The undermining can be done endoscopically or with the aid of the robot system. If further undermining is necessary for a proper redistribution of the abdominal flap, we do a blunt dissection, creating tunnels, preserving vessels and nerves. Tunnelling preserves the sensitive innervation of the abdominal wall and provides faster recovery with earlier reduction of the oedema [3], [Figure 3, 11, 12] .

Figure 10: The surgeon positioning the robot arms and camera

Figure 11: Surgeon undermining the dermoadiposous abdominal flap from the muscle aponeurotic fascia, preparing for robitic rectus aponeurotic plication

Figure 12: Robot arms and camera docked in and positioned ready to start the rectus plication

Liposuction

If there is any area that requires liposuction, the liposuction will be performed after the rectus plication. I perfom the liposuction after plication for a few reasons: to have a clean muscle aponeurotic fascia free from fat tissue in order to properly perform an accurate plication. I observed in many cases of secondary abdominoplasty with failure of the plication and diastasis recurrence that there was lots of fat growing igrowing inside the plication. Only after the plication we can properly evaluate the abdominal areas to be aspirated and to treat any tissue tissue accumulation in the midline due to the plication. Liposuction should not be used for flap undermining because it can rupture the Scarpa fascia and aspirating the superficial layer of the fat causing skin uneven surface. We aspirate only the deep surface of the derma-adipose flap. In the undermined areas we use the cannula with the holes facing up aspirating / shaving off, only the deep layer. In the non-undermined areas we use the cannula with the holes facing down in the traditional way, liposuction of the deep fat tissue area, creating tunnels preserving vessels creating a closed vascular system like described by Avelar [15].

Rectiplication

We identify the rectus diastasis [Figure 14A] and with a small cotton bud tinted with methylene blue, we demarcate the inner border of the rectus abdominal muscle aponeurosis to be plicated [Figure 14B] Plication of the anterior rectus sheath is performed in two layers, the first layer using 2-0 or 3-0 nylon buried stiches 1.0 cm distant from each other [Figure 14C], and the second layer of two continuous sutures using V-loc 3-0 [Figure 14D]: one starting from the xiphoid process running till just above the umbilical stalk; another continuous running suture starting from just below the umbilical stalk to the pubic bone [3]. Based in my own experience and other author's reports [1-5, 16, 17] two layers of plication combining first layer of non absorbable interruptive stitches with a second layer of continuous over and over suture with absorbable or non-absorbable sutures is effective and long lasting method.

Supra-umbilical or peri-umbilical flabbiness is frequent finding [Figure 15A]. This deformity occurs during pregnancy when the abdominal muscles stretch and the subcutaneous fatty tissue attached to them is pulled away, creating a gap with skin flabbiness in the region. This subcutaneous fat gap is repaired by suturing the two edges of the fat tissue together with 4-0 monocryl interrupted sutures [Figure 15 B, C]. A small hole is left between the edges to permit these small triangular umbilical skin flaps to pass through it for the reinsertion into the umbilical stalk, which was previously secured by the spare suture mentioned earlier [1, 3].

Complications

So far, in 6 Robotic cases already done we didn't have any complication. We anticipate that complications would be similar to those encountered in endoscopic abdominoplasty or other types of surgery. Seroma was the most common one in endoscopic abdominoplasty. We manage to reduce the incidence of seroma by reducing as much as possible the undermining area, tunnelling to help redistribute the flap, stitching the dermo-adiposous flap to the muscle fascia as preconized by Baroudi, and suction drainage would have to be maintained minimal for 2 or 3 days or until the drainage over 24 hrs is not more than 30 cc [1-3].

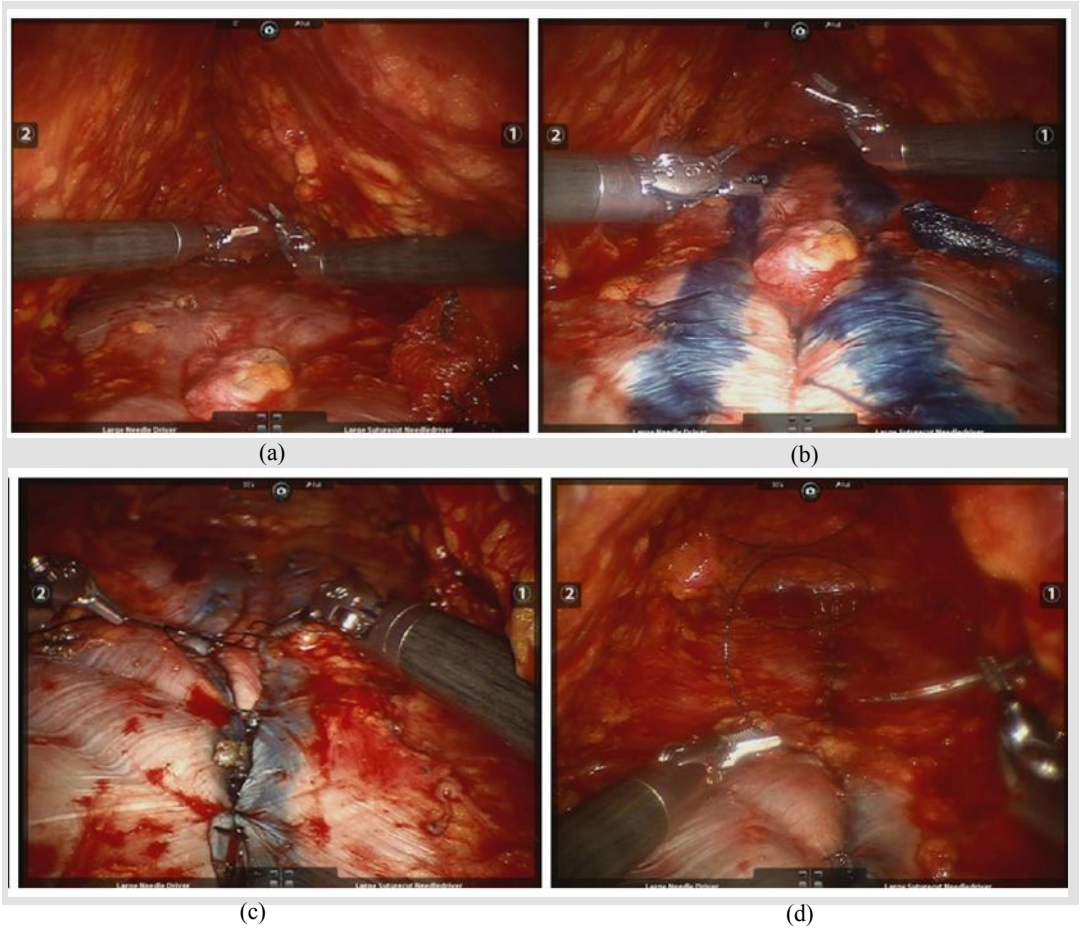
Results

Da Vinci Robotic system was used in 5 cases of minimally invasive mini abdominoplasty, similar to approximately 300 cases of endoscopic abdominoplasty.

The best results are obtained when you operate patients with BMI within 18-23. The normal age of our patients is between 30 to 50 years old. Age is not what matters but the quality of the skin elasticity and not having over redundant skin. The operation time is between

Figure 13: Surgeon seated at the robot console distant about 4 to 5 meters from the patient, operating the robot arms and camera with joysticks and pedals.

Figure 14: Robot rectus aponeurotic plication. Surgeon's HD 3D view in the console



14.a - Identify the rectus diastasis
14.b - Drawing the inner border of the rectus abdominalis using a small cotton bud
14.c - Plication starts using 2-0 nylon interruptive stiches 1cm distant from each other
14.d - A second layer of plication by using a 2-0 V-loc nylon running suture

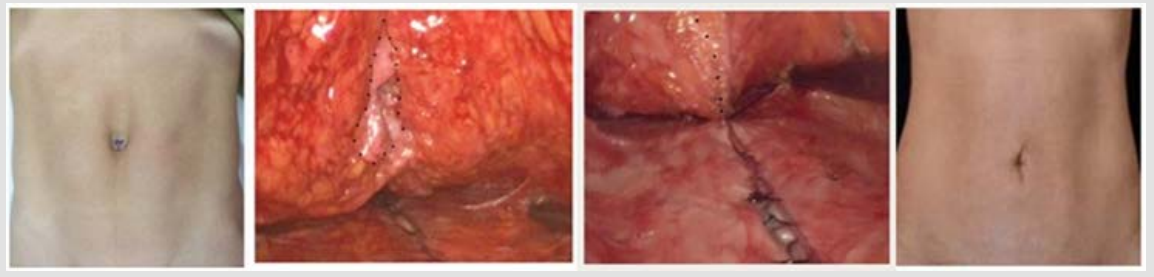
Figure : 15

15.a - Pre op showing the rectus and peri-umbilical fat diastasis

15.b - Intra operation, a view of repaired rectus diastasis and the mark of the edges of the subcutaneous fat gap to be repair

15.c - Intra op view of the rectus diastasis repaired and subcutaneous fat gap repaired

15.d - Immediate post operation result



2.5 to 3.5 hrs. When using the previous C-section scar that allows a faster undermining, it reduces the surgical time, when the patient do not have previous C-section scar and we want to perform the operation using keyhole incisions the undermining time takes slightly longer. Normally we do not remove any skin as the indication of the procedure and it is for patients without excessive skin, but to treat rectus diastasis. If there is any lipodystrophy we treat it by liposuction.

5 cases female, BMI range from 18-23, surgery plan: robotic application with liposuction, no complications so far.

Discussion

Minimally Invasive Surgery presents many advantages compared to open methods, like fast recovery, less pain, lower risk of infection and minimal scars that are our goals in cosmetic surgery. But there are a number of limitations even though minimally invasive surgery appears attractive. The few most obvious limitations include loss of haptic feedback (force and tactile), natural hand-eye coordination and dexterity. The da Vinci System proves to be superior in compensating these aspects of limitations. Conventional endoscopy presents with a 2D image view whereas the da Vinci system presents with a high definition precise 3D image that compensates the loss of haptic feedback. There is a learning curve and an investment of time and money to be a robotic surgeon. There is also an extra cost for using the robot, but it is partially compensated by the reducing the operative time in at least 1 hr if comparing with a endoscopic abdominoplasty.

Conclusion

Robotics in aesthetic plastic surgery is still at its infancy stage, but it is very promising considering its many advantages of minimally invasive surgery associated with high technology that helps us work through minimal scars with incisions at remotes sites, leaving inconspicuous scars that are the hallmark of plastic surgery. Over the the past 20 years we are seeing an increasing number of female and male patients coming for the treatment of small and medium- size abdominal deformities. Many of them are presenting with rectus diastasis, no redundant folds of skin, good skin elasticity, with or without abdominal lipodystrophy. They demand for scarless procedures that can effectively correct it. Liposuction alone will not be effective enough in many cases. The long term evaluation of midline aponeurotic rectus plication, when properly performed, has proved its efficiency. Plastic Surgeons are always looking for tools and instruments that can help us to better perform our procedures with more precision, efficacy, less trauma, faster recovery of patients and leaving minimal scars. Since 1991, I started using endoscopic methods for the treatment of the described deformities. The efficacy of the method in patients with more than 20 years follow-up gives me the enthusiasm of going for the next level. The “Gold standard” of the minimal invasive video surgery, the use of Robot “daVinci Surgery System” for the Plication of the Rectus diastasis. In many areas of application like urology, gynaecology, general surgery, neurosurgery, and heart surgery, robot surgery has proved to have many advantages over conventional endoscopic methods due to the Robot high definition 3-dimentional surgical view and amplification of images that makes it much more accurate than the 2-D view provided by the conventional endoscopic methods, the superb precision and a much larger range of motion of the robot endowrist instruments that are comparable to the human wrist and the stability of the surgical field, camera and instruments, all controlled by the surgeon seated at the console in a comfortable position. Is time now for plastic surgeons embarking in the new era of high tech minimally invasive surgery incorporating Robots to our practice?

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