FÁSCIA DE SCARPA

ESTUDO MORFOLÓGICO E APLICAÇÃO EM CIRURGIA DA PAREDE ABDOMINAL

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Part of the scientific work present in this thesis resulted in the publication in peer-reviewed international scientific journals of the following manuscripts:

1. Costa-Ferreira A., Rebelo M., Vásconez L.O., Amarante J. Scarpa fascia preservation during abdominoplasty: a prospective study. Plast Reconstr Surg 125: 1232-1239, 2010 (Surgery; impact factor: 3.535, ranking 13/198; quartile: Q1)

2. Costa J., Costa-Ferreira A., Rebelo M., Valença-Filipe R., Reis J., Silva A., Amarante J. Scarpa fascia preservation during abdominoplasty: what´s the point. Plast Reconstr Surg 128 (4S): 61-62, 2011. Presented in the Annual Meeting of the American Society of Plastic Surgery - Plastic Surgery 2011, Denver, USA. (Surgery; impact factor: 3.535, ranking 13/198; quartile: Q1)

3. Costa-Ferreira A., Rebelo M., Vásconez L.O., Amarante J. Scarpa fascia preservation during abdominoplasty: a prospective study. Plast Reconstr Surg, 130 (5S): 82S-85S, 2012. Selected by the editorial staff for reprint from original publication 1, to be included in a Special Issue. *In: Updates in Aesthetic Surgery II: Plastic and Reconstructive Surgery Cosmetic Supplement* (Editors: Rohrich R., Gruber R., Guyron B., Hammond D., Matarasso A., Carruthers D.). (Surgery; impact factor: 3.535, ranking 13/198; quartile: Q1)

4. Costa-Ferreira A., Rebelo M., Silva A., Vásconez L.O., Amarante J. Scarpa fascia preservation during abdominoplasty: randomized clinical study of efficacy and safety. Plast Reconstr Surg 131: 644-651, 2013. Presented in the ISAPS (International Society of Aesthetic Plastic Surgery) World Meeting, held in Geneve, Switzerland, 2012, and awarded the International Prize by the BODY CONTOURING RESEARCH FOUNDATION FUNDED PRIZE (5000 US dollars) for the best presentation of clinical results (Surgery; impact factor: 3.535, ranking 13/198; quartile: Q1)

5. Costa-Ferreira A., Vásconez L.O., Amarante J. Reply: Scarpa fascia preservation during abdominoplasty: randomized clinical study of efficacy and safety. Plast Reconstr Surg 132: 873e-874e, 2013. (Surgery; impact factor: 3.535, ranking 13/198; quartile: Q1)

6. Costa-Ferreira A, Rodrigues-Pereira P, Rebelo M, Vásconez L, Amarante J. Morphometric study (macro and microscopic) of the lower abdominal wall. Plast Reconstr Surg 134: 1313-1322, 2014. (Surgery; impact factor: 3.535, ranking 13/198; quartile: Q1).

ABSTRACT

The subcutaneous tissue has deserved a growing interest due to the generalization of bariatric surgery and the popularity of body contour surgery. It has been the object of few scientific studies and some doubts still persist about its structure. Previous studies described a trilaminar structure (superficial and deep fat compartments separated by Scarpa fascia) in the lower abdominal wall. Contradictory perspectives do exist regarding the relative compartment dominance and changes with increasing adiposity. The presence, extension and structure of Scarpa fascia are other issues surrounded by considerable controversy since its original description in the XIX century by Antonio Scarpa. A clearer understanding of these issues will have a positive impact in body contour surgery.

The surgical procedures for body contour of the abdominal region, usually known as abdominoplasty, are among the most frequently performed for either aesthetic or reconstructive purposes. Since the classical descriptions of the abdominoplasty technique published in the 60s, there has been a continuous effort to develop modifications with the aim of improving results and lower complications. Nevertheless, abdominoplasty continues to be a surgical technique that implies a considerable risk of complications along with a high secondary surgical revision rate. Scarpa fascia is usually ignored in the classical descriptions of the abdominoplasty surgical technique but it has been suggested that it may have an important role in this type of surgery, namely reducing the most frequent complication: seroma. There are no objective data that validate this statement, more specifically prospective clinical studies.

Chapter I is a general introduction to this work. The concepts and current knowledge on abdominoplasty are presented as well as on the anatomy of the subcutaneous tissue of the abdominal wall and on the level of dissection used during an abdominoplasty. The aim of this bibliographic revision is to contextualize the scope of this work and understand its purpose. The objectives, general and specific, are defined.

In **Chapter II**, a clinical prospective comparative study with 208 patients to investigate the effects of preserving Scarpa fascia during a full abdominoplasty in the immediate postoperative period is presented. The outcomes were: time to suction drain removal, total volume of drain output, length of hospital stay.

In **Chapter III**, the effects of preserving Scarpa fascia during a full abdominoplasty on results and complications, in the immediate and late postoperative periods, were studied by means of a clinical prospective randomized study (Randomized Controlled Trial) with 160 patients. The study was designed according to the guidelines from the Consolidated Standards of Reporting Trials Group (CONSORT). The outcomes of this study were: time to drain removal, daily and total volume of drain output, length of hospital stay, systemic complications (need for blood transfusion, pulmonary fat embolus syndrome, thromboembolic complications, death), local complications (seroma, hematoma/bleeding, wound infection, healing problems/wound dehiscence without necrosis, skin necrosis), emergency department visit, second admission to the hospital, secondary surgical revision and aesthetic result (evaluated separately by the patient and also by the care provider).

In **Chapter IV** an anatomic study is presented that was performed with the surgical specimens from 41 patients submitted to a classical abdominoplasty with umbilical transposition. Two different approaches were used: gross morphometric and histologic analysis of fresh surgical specimens. For that, the thickness of the two adipose layers was assessed in predetermined location points followed by microscopic evaluation of the surgical specimens to verify the presence and structure of Scarpa fascia and to study the organization of the adipose tissue.

In **Chapter V** two additional publications on the subject of this thesis are presented. One is an abstract of an oral communication presented in the Annual Meeting of the American Society of Plastic Surgery (Plastic Surgery 2011 held in Denver, United States of America) and the other is a letter to the editor. The former briefly presents the results of the prospective study detailed in Chapter II. The latter presents a discussion on the experimental design of the study from Chapter III as well as a state of the art summary of dual plane abdominoplasties.

In **Chapter VI** a brief synopsis of the key findings of the anatomic and clinical trials is presented along with a comparison with other published studies. A discussion is presented about the mechanisms and possible explanations of the results, limitations of the studies, clinical and research implications of the results as well as their external validity and applicability. Finally, the main conclusions of this thesis are presented.

RESUMO

O tecido celular subcutâneo tem sido alvo de um interesse crescente devido, entre outras razões, à generalização da cirurgia bariátrica bem como à popularidade da cirurgia de contorno corporal. Foi objeto de poucos estudos científicos, persistindo algumas dúvidas quanto à sua estrutura. Estudos prévios descrevem uma estrutura trilaminar (dois compartimentos adiposos, superficial e profundo, separados pela fáscia de Scarpa) na parede abdominal inferior. Existem perspetivas contraditórias sobre a dominância relativa dos compartimentos adiposos e também quanto à sua modificação com variações do grau de adiposidade. A presença, extensão e estrutura da fáscia de Scarpa são outros assuntos rodeados por alguma controvérsia desde a sua descrição original no século XIX por António Scarpa. O esclarecimento destas questões terá certamente um impacto positivo sobre as cirurgias de contorno corporal.

Os procedimentos de contorno corporal da região abdominal, vulgarmente designados por abdominoplastia, são dos mais frequentemente efetuados, quer em cirurgia estética quer reconstrutiva. Desde as descrições clássicas da técnica de abdominoplastia nos anos 60, tem-se assistido a um esforço constante no sentido de desenvolver modificações que se traduzam em melhores resultados com menos complicações. De qualquer forma, continua a ser uma técnica que implica um risco considerável de complicações a par de uma necessidade de correção cirúrgica secundária elevada. A fáscia de Scarpa é ignorada nas descrições clássicas da técnica cirúrgica de abdominoplastia mas foi sugerido que poderá ter um papel importante neste tipo de cirurgias, nomeadamente na redução da complicação mais frequente: o seroma. Não há dados objetivos que validem esta constatação, mais concretamente estudos clínicos prospetivos.

O **Capitulo I** é uma introdução geral a este trabalho. Apresentam-se os conceitos e conhecimentos existentes sobre abdominoplastia, sobre a anatomia do tecido celular subcutâneo da parede abdominal e sobre o nível anatómico de disseção usado durante uma abdominoplastia. Pretende-se com esta revisão bibliográfica contextualizar o âmbito deste trabalho e perceber o seu propósito. Os objetivos, gerais e específicos, são definidos.

No **Capitulo II** apresenta-se um estudo clinico prospetivo comparativo efetuado em 208 doentes para investigar os efeitos pós-operatórios imediatos da preservação da fáscia de Scarpa durante uma abdominoplastia completa. Os resultados foram: duração de uso de dreno aspirativo, volume total drenado, duração do internamento hospitalar.

No **Capitulo III** estudaram-se os resultados e complicações, efeitos pós-operatórios imediatos e tardios, da preservação da fáscia de Scarpa durante uma abdominoplastia completa através de um estudo prospetivo randomizado (Randomized Controled Trial) efetuado em 160 doentes. O estudo em questão foi estruturado de acordo com as indicações do Consolidated Standards of Reporting Trials Group (CONSORT). Os resultados foram: duração de uso de dreno aspirativo, volume total drenado, volume diário drenado, duração do internamento hospitalar, complicações sistémicas (necessidade de transfusão sanguínea, síndrome de embolia pulmonar gorda, complicações tromboembólicas, morte), complicações locais (seroma, hematoma/hemorragia, infeção da ferida operatória, problemas de cicatrização/deiscência de sutura sem necrose, necrose cutânea), necessidade de ida ao serviço de urgência, segunda admissão hospitalar, revisão cirúrgica secundária e resultado estético (avaliado separadamente pelo doente e pelo médico).

No **Capitulo IV** descreve-se um estudo anatómico realizado em peças operatórias provenientes de 41 doentes submetidos a abdominoplastia clássica com transposição umbilical. Esta investigação foi realizada com duas abordagens distintas: estudo morfométrico macroscópico da parede abdominal na peça fresca e estudo histológico. Para isso, a espessura dos dois compartimentos adiposos foi avaliada em pontos pré-definidos seguida por avaliação microscópica das peças operatórias para verificar a presença e estrutura da fáscia de Scarpa e para estudar a organização do tecido adiposo.

O **Capitulo V** apresenta duas publicações adicionais efetuadas no âmbito deste trabalho. Uma refere-se a um resumo de uma comunicação oral apresentada na Reunião Anual da Sociedade Americana de Cirurgia Plástica (Plastic Surgery 2011, realizada em Denver, Estados Unidos da América) e outra trata-se de uma carta ao editor. A primeira apresenta de forma sucinta os resultados do estudo prospetivo do Capitulo II. A segunda apresenta uma discussão sobre a metodologia experimental do trabalho apresentado de forma detalhada no Capitulo III, assim como um breve resumo sobre o estado da arte da utilização de planos duplos em abdominoplastia.

No **Capitulo VI** são resumidos os resultados mais relevantes dos ensaios clínicos e anatómico e são comparados com outros estudos publicados. Discutem-se os mecanismos e explicações possíveis para os resultados obtidos, principais limitações, implicações clinicas e de investigação futura, assim como a validade externa e a aplicabilidade dos resultados dos ensaios efetuados. Finalmente apresentam-se as principais conclusões desta tese.

CHAPTER I

General Introduction

GENERAL INTRODUCTION

The surgical procedures for contour of the abdomen, commonly known as abdominoplasty, are among the most frequently performed for either reconstructive or aesthetic purposes. Abdominoplasty ranks sixth on the 2012 top ten surgical cosmetic procedures from the American Society of Plastic Surgeons, with a total number of 106,628 procedures (1). The demand for this technique has been increasing which is clearly demonstrated by a 70 % rise from 62,713 procedures in 2000 (fig. 1)(1). According to the American Society for Aesthetic Plastic Surgery Cosmetic Surgery National Data Bank, the number of abdominoplasty procedures performed has increased approximately 333% since 1997 (2). Such a major increase has many possible causes, namely the recent increase in bariatric surgery and also the popularity of cosmetic surgery. The very good results obtained with this technique, with a positive impact on patient´s self-image and quality of life (3-6), can also explain the above mentioned trend.

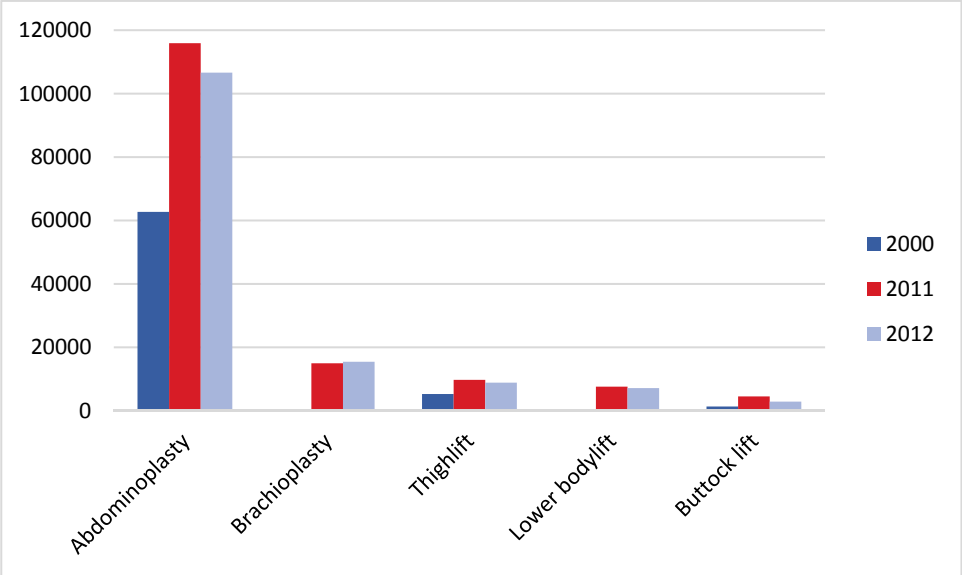

Fig 1. Statistics from the American Society of Plastic Surgeons describing trends in body contour surgical procedures from 2000 to 2012 (1).

This is not exclusive to the United States as abdominoplasty continues to be one of the most popular surgeries performed by plastic surgeons throughout the world. The International Society of Aesthetic Plastic Surgeons issued an invitation to participate in a study to

approximately 20,000 plastic surgeons. Based on this International Survey on Aesthetic/Cosmetic procedures performed in 2011, abdominoplasty ranks fourth on the number of world-wide surgical procedures performed by plastic surgeons, after lipoplasty, breast augmentation and blepharoplasty (Table 1, 2) (7).

Table 1. Trends in world-wide surgical procedures performed by plastic surgeons in 2011*.

Rank in 2011	Surgical procedure	Total	Total (%)	Rank in 2010
1	Lipoplasty	1,268,287	19.9	1
2	Breast augmentation	1,205,251	18.9	2
3	Blepharoplasty	703,610	11.0	3
4	Abdominoplasty	553,399	8.7	4
5	Rhinoplasty	478,023	7.5	5
6	Breast lift	444,222	7.0	6
7	Breast reduction	428,129	6.7	7
8	Face lift	308,926	4.8	8
9	Gynecomastia	174,806	2.7	10
10	Otoplasty	167,772	2.6	9

*Adapted from the ISAPS International Survey on Aesthetic/Cosmetic Procedures performed in 2011 (7).

Table 2. Countries performing abdominoplasty in 2011*.

Rank in 2011	Country	Total	Total (%)	Rank in 2010
1	U.S.A.	114,062	20.6	1
2	Brazil	95,004	17.2	2
3	China	31,780	5.7	4
4	Mexico	30,208	5.5	5
5	Japan	28,142	5.1	**

*Adapted from the ISAPS International Survey on Aesthetic/Cosmetic Procedures performed in 2011 (7).
** Did not place in top five for 2010. India fell from top five due to new estimated plastic surgeon counts.

The anterior abdominal wall is one of the body areas most affected by aging, body weight variations, undisciplined life style, inadequate diet, lack of physical exercise, adipose tissue anomalous accumulations, loss of skin elasticity, celiotomies and pregnancies. Abdominoplasty corrects anterior abdominal wall deformity by acting on its three main elements: skin, fat and musculoaponeurotic layer. It is indicated for patients presenting with abdominal deformities marked by excess abdominal skin, excess adipose tissue and muscle laxity (Psillakis types IV and V (8) or Matarasso types III and IV (9)). The purpose of abdominoplasty is not merely cosmetic improvement but also and even more important structural reconstruction. In patients who present morbid obesity or those who have massive losses of body weight following bariatric surgery, abdominoplasty represents a repairing procedure of the function of each affected tissue. Actually the reconstructive component includes recreation of the original fascial and muscular anatomy as well as the restoration of any other anatomical deformations which may be present in order to achieve functional relief of pain, cutaneous irritation and intertrigo under the skin folds, postural disturbances, hampered movements, sexual difficulty and emotional disturbances (10). Nevertheless the aesthetic goals of an abdominoplasty must be considered as they are also important and should include: improvement in abdominal wall contour, reduction of the volume of the abdomen, improvement of the lateral contour, elimination of the excess sagging skin, reconstruction of a natural appearing umbilicus, optimal placement and quality of the resulting abdominal scar (11). Many surgical treatments have been proposed for the correction of the different types of alterations of the abdominal contour, emphasizing the priority of maintaining the function added to the improvement of form and searching for more and more refined results.

One of the first publications on abdominal wall contour surgery dates from 1880 when Demars and Marx (12, 13), in France, described the ample resection of skin and fat of the abdominal wall. In 1899 Kellie (2, 12) used a large horizontal elliptical midabdominal incision to correct excess abdominal skin and fat (the umbilicus was resected simultaneously). This author reported a resection of a panniculus weighing over 7000 g (2). In 1901, Peters (12, 14) described a surgery in which he resected 7450 g of a patient, including the umbilicus, without undermining. In 1905 Gaudet and Morestin (13) performed a resection of significant excess skin and underlying fat, repair of a large umbilical hernia and umbilical preservation. Thorek (2), in 1924, was the first to describe an abdominal procedure with a low transverse incision that preserved the umbilicus. This author removed the umbilicus with the tissue specimen and then replanted it as a graft in a new location. He also described a method of circumscribing the

umbilicus and leaving it attached by its stalk to the abdominal wall, bringing it through the skin at the end of the procedure (13). All these techniques involved resection of the skin and fat with little or no undermining of the abdominal wall and established the principles used in modern techniques with transversal low incisions.

In 1957, Vernon (15) published a version of abdominoplasty that represents an important landmark in the evolution of this technique. It combined a transversal incision, similar to the one described by Thorek, with two important contributions to abdominoplasty: the undermining of the superior abdominal wall and the transposition of the umbilicus (15). Callia (12), in 1965, introduces a new kind of incision: the median part is placed over the pubis and its lateral extensions parallel the crural arcades. In 1967, Pitanguy (16) supported the horizontal incision just above the pubis curving laterally downwards with intense undermining and transposition of the umbilicus. His great contribution was the plicature of the straight abdominal muscle without opening the aponeurosis (16). Regnault (17) described in 1972 the W shaped technique which involved resection of the upper hair bearing mons with lateral incisions along the inguinal folds. Grazer (18) in 1973 suggested an incision similar to the one presented by Pitanguy but with a lateral extension corresponding to the anterosuperior iliac spine. Baroudi (19) published his significant experience in 1974 and 1975 drawing particular attention to the importance of an aesthetic appearance of the umbilicus. Since then several modifications of incision placement, incision design and variations of musculofascial repair have been reported in an effort to improve the technique. Nevertheless, the classical descriptions of a full abdominoplasty are the ones from the sixties and seventies (16-20) which defined its surgical principles: a low-transverse abdominal incision, wide undermining of the skin and subcutaneous tissue to the costal margins on the plane of the muscular fascia, tightening of the abdominal musculature with correction of rectus muscle diastasis, resection of redundant abdominal skin and subcutaneous tissue, umbilical repositioning and skin closure. These principles are still used today and define a traditional or classical abdominoplasty. The addition of liposuction in the 1990´s allowed a further evolution of abdominoplasty procedures serving as a complement in many occasions (21, 22). Continuous improvement in abdominoplasty techniques has been observed since the very first procedures were performed more than 100 years ago. Overall abdominoplasty is considered to be a safe and efficacious procedure (23).

Despite the good results obtained with a classical full abdominoplasty a significant complication and secondary surgical revision rates are still reported (Table 3) (3, 4, 23-34).

Grazer and Goldwyn (3) in 1977 surveyed 958 plastic surgeons, who had collectively performed 10,490 procedures, and found an overall complication rate of 15 %. Mohammad (32) in 1998 performed a prospective study with 80 patients submitted to a classical full abdominoplasty and reported a complication rate of 52 % and a seroma rate of 43 %. Chaouat (24) presented a 22% complication rate based on 258 female patients submitted to a full abdominoplasty. Hensel (4) reported a 32 % complication rate from 199 patients but higher values in smokers (52 %) and patients with diabetes and/or hypertension (58 %). Van Uchelen (25) found a 37 % complication rate and 14 % seroma rate, in a clinical series with 86 patients. Hafezi (33) in 2002 presented a 38 % seroma rate on a series of 86 patients. Stewart (26) reported an 18 % early complication rate, a 25 % late complication rate and a 24% surgical revision rate from a series of 278 patients. Kim (34) performed a retrospective study which was published in 2006 with 118 patients and found a 38 % seroma rate. Matarasso (27) surveyed 497 plastic surgeons who had performed 11,016 full abdominoplasties and found a local complication rate of 26 %. Neaman (29) presented a clinical series of 206 consecutive patients submitted to abdominoplasty with an overall complication rate of 37 % and a seroma rate of 17 %. Fraccalvieri (28) in a series of 117 patients (previously submitted to bariatric surgery) found a complication rate of 50 %. Andrades (30) in 2007 published a Randomized Controlled Trial (RCT) with 60 patients to investigate the effect of progressive tension sutures to reduce seroma after abdominoplasty. A complication rate of 69 % and seroma incidence of 35 % were reported (30). Khan (35) presented a series of 96 patients submitted to a classical full abdominoplasty and reported a seroma incidence of 26 %. In 2011 Najera (31) published a retrospective cohort study of 200 patients who underwent abdominoplasty with or without flank liposuction. A total complication rate of 50 % and a seroma rate of 26 % were found. The seroma rate was significantly higher in the group submitted to abdominoplasty with flank liposuction (31 %) when compared to the abdominoplasty without flank liposuction (16%). The total complication rate in the abdominoplasty-only group was 55 % and in the abdominoplasty with flank liposuction group was 45 % (31). Neaman (23) recently published a retrospective study of 1008 patients submitted to a full abdominoplasty by six different surgeons, all working at a single center, and reported a total complication rate of 33 %, a secondary surgical revision rate of 36 % and a seroma rate of 15 %. The six surgeons did not use the same surgical procedure as differences were present regarding the method of dissection (scalpel versus electrosurgery), the association of liposuction of the upper abdominal flap, the number of drains used, the extension of undermining, the criteria used for drain removal. The seroma rate was different between surgeons and varied from 7.4 % for surgeon E to 26.7 % for surgeon A (this difference was statistically significant).

Table 3. Studies about full-abdominoplasty complications including seroma.

Authors	Year	Type of study	Sample size	Complication (%)	Seroma (%)
Grazer (3)	1977	Survey (958)	10,490	15	—
Mohammad (32)	1998	Prospective	80	52	43
Chaouat (24)	2000	Retrospective	258	22	11
Hensel (4)	2001	Retrospective	199	32	14
Van Uchelen (25)	2001	Retrospective	86	37	14
Hafezi (33)	2002	Retrospective	86	—	38
Stewart (26)	2006	Retrospective	278	43	5
Kim (34)	2006	Retrospective	118	—	38
Matarasso (27)	2006	Survey (497)	11,016	26	—
Neaman (29)	2007	Retrospective	206	37	17
Fraccalvieri (28)	2007	Retrospective	117	50	17
Andrades (30)	2007	Prospective(RCT)	60	69	35
Khan (35)	2008	Retrospective	96	—	26
Najera (31)	2011	Retrospective	200	50	26
Neaman (23)	2013	Retrospective	1008	33	15

Multiple surgical strategies have been described to lower the complication rate of a traditional full abdominoplasty, such as lipoabdominoplasty (36-39), selective undermining by reducing width and extension (37, 39, 40), closed suction drains (30, 41), internal fixation techniques (35, 42-47), avoidance of electrocautery (48, 49), use of pressure dressings (50), sclerotherapy (51, 52) use of fibrin glue (53-55) and delayed mobilization (56). None of them as proved to be totally effective. The fact is that overall complication rates as high as 30% have been recently reported after a full abdominoplasty (23, 26, 29, 39). Seroma alone is still reported with frequencies as high as 40 % (30-35) and is the most frequent complication following an abdominoplasty procedure. Although seromas usually resolve uneventfully with multiple percutaneous aspirations, some can persist and lead to the development of a pseudobursa. Progression to this chronic state generally justifies a second surgery for successful management, usually surgical exploration and capsulectomy. Seromas are benign in nature but cause discomfort and anxiety in patients, generating frequent office visits, procedures for treatment and increase postoperative costs. Prevention seems to be the best strategy. One of the most accepted and universal method of seroma prevention is the use of closed suction drains (30). Most surgeons use suction drains after a full abdominoplasty, most prefer to place at least two drains with their orientation and exit points varying according to

surgeon preference (57). The drains are usually removed when there is less than 30 cc of aspirate collected in each drain over a 24 hour period but this criteria may also be different among surgeons (57). Another possible strategy that has been gaining increase interest is the use of internal fixation techniques, which refer to the placement of sutures between the upper flap and the fascia at periodic intervals. Mladick (47) was the first author to refer briefly to this subject but a more detailed description was made by Baroudi and Ferreira (42) who used "quilting sutures" associated to suction drains to reduce dead space and shearing forces. Pollock and Pollock (43, 45) introduced the concept of "progressive tension sutures" which had a double role: reduce dead space and tension-free advancement of the abdominal flap. This solution is effective for seroma prevention (30, 58). Its efficacy may avoid the use of drains (46). As stated above, Andrades (30) performed a randomized controlled trial with 60 patients, submitted to full abdominoplasty, to investigate the role of drains and progressive tension sutures for prevention of seroma. The use of progressive tension sutures resulted in significantly longer surgical time and lower drain outputs, however the overall incidence of seroma did not differ between any of the cohorts studied. It is important to recall that the control group (no drains or progressive tension sutures) was interrupted after 10 patients due to large volume seromas. The incidence of seromas in the control group was 50 %. The conclusion of this study was that at least one of this methods (drains/quilting sutures) should be incorporated by surgeons performing abdominoplasty and the association does not provide advantages. Both techniques are not synergistic as the association of progressive tension sutures with drains does not reduce seroma development or improve results. Drains, progressive tension sutures or both have the same seroma incidence, overall complication rate and aesthetic outcome (30). Nevertheless, drains are easier to use than progressive tension sutures and do not extend the surgical time. The use of suction drains is still the most accepted method of seroma prevention (30, 57). This was fully confirmed in Matarasso´s survey of 497 plastic surgeons who had performed 11,016 full abdominoplasties: 98 % of the surgeons used suction drains after a full abdominoplasty and the average length of time until drain removal was 8 days (27). The objective data available on this subject is still not significant enough to change one´s practice by adding progressive tension sutures and eliminating drains.

ANATOMY

There are few studies on the structure of the subcutaneous tissue of the abdominal region, the majority are based on cadaver dissection or imaging analysis. Many suffer from small sample sizes. Nevertheless this subject is very relevant to clinical medicine, to body contour surgery in particular.

Previous anatomical and imaging studies described two different fat compartments in the lower abdominal wall, superficial and deep, separated by a layer of membranous tissue known as Scarpa fascia (fig.2) (59-69).

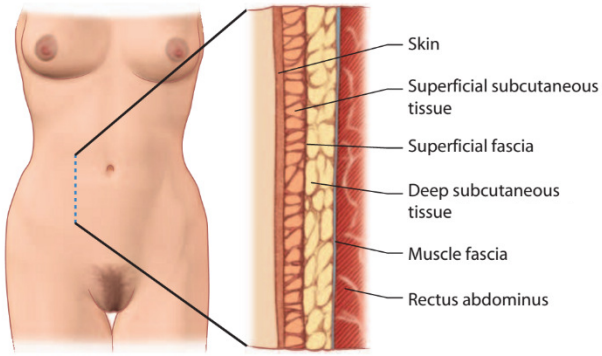

Fig 2. The superficial structures of the abdominal wall from superficial to deep, include the skin, superficial fat, superficial fascia (Scarpa fascia), deep fat; adapted from Hunstad (69).

The first description of a membranous layer on the deep aspect of the subcutaneous tissue of the lower abdominal wall was made by Antonio Scarpa (70) in the XIX century in a paper about abdominal hernia. But his description is vague as the main subject of the publication was anatomy and surgery of hernias. In 1854, Struthers (66) published a detailed study about that structure, confirmed its existence and suggested the designation of Scarpa fascia. We should pay attention to the fact that this author did not extend his dissections superiorly but limited them to the inguinal region assuming that Scarpa fascia did continue in that direction.

During the 200 years that separate us from the original descriptions, Scarpa fascia was involved in controversy in which concerns its extension but also its existence. This problematic is very well summarized by Chopra (63) and by Abu-Hijleh (62). Actually some authors

defended in the past the existence of a single layer of fat in the abdominal wall (70, 71) on a different perspective from the one that nowadays seems more consensual: subcutaneous tissue is divided in two layers, one superficial and the other deep, with different characteristics, separated by Scarpa fascia.

Johnson (61), Wendell-Smith (72) and Abu-Hijleh (62) previously pointed out that the classical descriptions of the subcutaneous tissue are confusing and the terminology is variable. Different descriptions of the fascia do exist in the literature and various terms are presently used to define the same structure (72, 73). Besides that, the same terminology can be used with clearly different meanings. This idea is confirmed by older descriptions of the subcutaneous tissue of the anterior abdominal wall which described two layers, a superficial fatty layer (termed *Camper´s fascia* or areolar layer) and a deeper membranous layer (termed *Scarpa´s fascia* or lamellar layer) (59, 61, 74) (fig. 3). It is of particular interest the observation by Martin (75) on a publication on Scarpa fascia: "although the superficial fatty layer is sometimes referred to as fascia of Camper, these authors found no reference to this layer in any of Camper´s publications ".The use of terms *Scarpa fascia* and *Camper fascia* with no definition of these terms contribute to this confusion and should be avoided. Johnson (61) inclusively proposed that this eponymous terms should be forgotten. The same applies to the designations areolar and lamellar layers. The terminology used to describe the different components of the abdominal wall subcutaneous tissue needs to be clarified.

Chopra (63) pointed out that the concept of a three-layer-structure in the subcutaneous tissue of the lower anterior abdominal wall has not yet found its place in anatomical text books. Forster (76) in 1937 had already verified the same and wrote that "Scarpa fascia is daily seen and recognized by surgeons in the operating theatre but it is not found to conform to the orthodox anatomical description which is generally being taught". This last author observed that "glancing at the cut edge of the structures divided by a simple incision exposing the aponeurosis" in the anterior abdominal wall "one recognizes successively (1) skin; (2) a fat-bearing layer; (3) a fibrous, tough membrane (fascia of Scarpa); (4) another layer of fat, less thick than the similar and more superficial layer; (5) deep fascia which covers the external oblique muscle and its aponeurosis. Thus interpreted, Scarpa´s fascia is therefore sandwiched in between two layers of fat" (76). More than seventy years separate this two observations but the fact is that the context remained the same. Nevertheless there is sufficient scientific information to validate the concept of three distinct layers in the subcutaneous tissue of the abdominal region. The trilaminar structure and the different organization of the superficial and

deep fat compartments were first described by Markman (59), Avelar (60) and Lockwood (59, 60, 77). Nakajima (64) recognized a more solid structure to the superficial compartment and a more mobile nature to the deep one. Abu-Hijleh (62) and Chopra (62, 63) presented data confirming that this trilaminar structure is also present in the subcutaneous tissue of other regions of the body and not only in the lower abdomen.

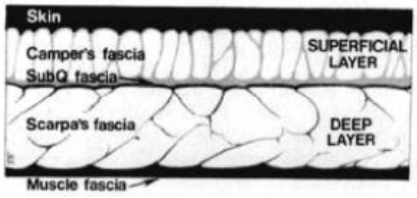

Fig 3. Typical gross anatomy of the subcutaneous adipose tissue in the trunk; adapted from Markman and Barton (59).

Markman and Barton (59) studied the subcutaneous tissue by dissecting 8 fresh and 10 embalmed cadavers (total of 36 hemidissections) and analyzing CT scans. Observations were made throughout the span of each region (trunk and lower extremity) and measurements were taken at predetermined locations. Samples were collected at the points of measurement for histologic study. This authors identified the superficial fascia as a discrete layer separating the superficial and deep fat on much of the trunk and lower extremities. They also verified that the "superficial adipose layer extended from the subcutaneous fascia to the dermis and consisted of small fat lobules packed tightly between secondary fibrous septa oriented perpendicular to the skin" and that "beneath the subcutaneous fascia lay a deep adipose layer consisting of large lobules of fat loosely packed within widely spaced fibrous septa " (fig. 3). In the abdomen of 8 cadavers the thickness of the fat layers was measured at a point 7 cm lateral to the umbilicus (59). The superficial fat layer present with relatively constant thickness while the deep fat compartment had a major contribution to the overall thickness of the abdominal subcutaneous tissue and overall body contour, being the dominant compartment (fig. 4) (59). The profile of this population was not presented, namely age, gender, height, weight or body mass index.

Adipose Layer Thickness, Superficial/Deep (mm)

Abdomen	Paralumbar	Gluteal	Thigh
9/17	12/41	13/20	7/20
10/17	14/58	18/35	16/22
12/16	14/47	20/34	18/32
12/20	15/50	18/37	20/39
13/26	15/65	24/48	22/40
15/24	18/55	25/40	25/38
20/20	25/78	30/45	27/43
↓47/42	↓64/95	↓30/47	↓48/49
Thickness range			
Superficial layer:			
↕ 9–47	↕12–64	↕13–30	↕ 7–48
Deep layer:			
↑17–42	↑41–95	↑20–47	↑20–49

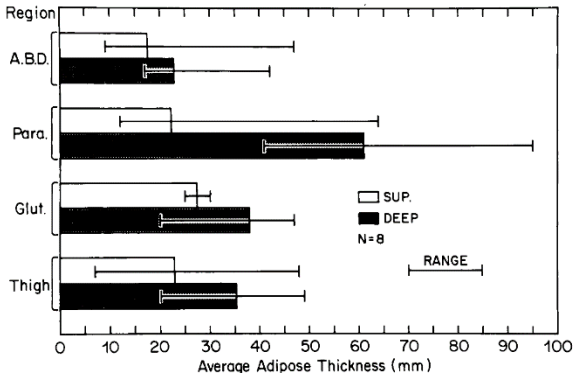

Fig 4. Thickness of the subcutaneous tissue in different anatomical regions (n=8); adapted from Markman and Barton (59).

Avelar (60, 78) devoted considerable attention to the anatomy of the subcutaneous tissue by performing anatomical dissections on corpses. This author described measurements of the subcutaneous layers in several areas, verified that the thicker region of the abdomen corresponds to the anterior projection of the rectus abdominis muscle and that the thickness of the deep layer progressively decreases on the lateral regions (60, 78). Avelar (60) was the first to publish on the structural changes of the subcutaneous tissue with increasing adiposity. Studying the same region in fat and thin people, Avelar found great anatomical differences. According to this author, thin patients have dominant superficial compartments while in fat patients the deep fat compartments from the "odd regions" (medial regions: epigastric, umbilical and hypogastric) (fig. 5) increase their thickness much more than the superficial fat compartments and become dominant (Table 4). The deep layer in the "odd regins" is more susceptible to increase in thickness in cases of obesity than the superficial compartment (Fig. 6). The "even regions" (hypochondriac, lumbar and inguinal) in fat patients preserve the same proportion between the superficial and deep fat compartments observed in thin patients (60).

This author also observed that the subcutaneous fascia consists of several layers which become separated by adipose tissue with increasing adiposity (fig. 6) (60). In thin patients the Scarpa fascia is thin but very visible and easily recognizable but in fat people it becomes vestigial (78). Avelar concluded that Scarpa fascia and the deep layer in fat patients increase the thickness much more than the superficial layer (60, 78).

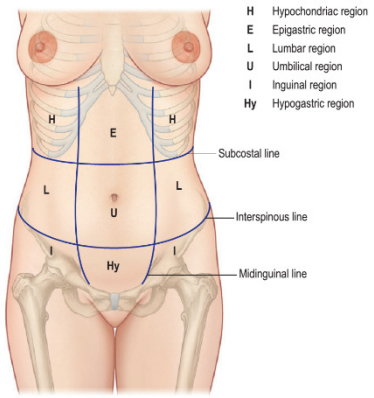

Fig 5. Drawing showing the 9 regions of the abdomen: 3 odd - epigastric, umbilical and hypogastric; 3 even - hypochondriac, flank and inguinal; adapted from Avelar (60).

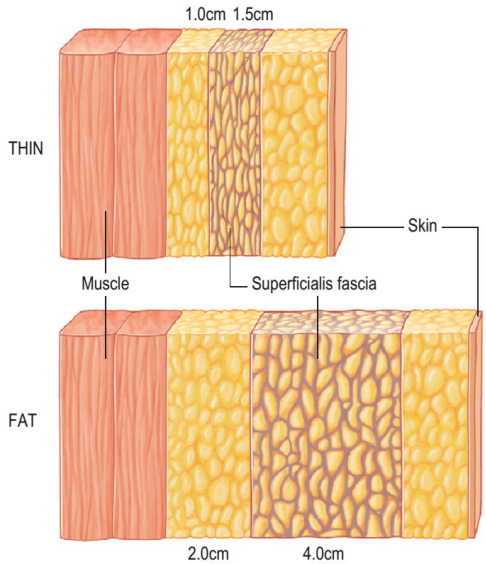

Fig 6. Schemes comparing the subcutaneous panniculus of a thin and a fat person according to Avelar. In fat people, the Scarpa fascia (here called superficialis fascia) and the deep fat compartment increase in thickness much more than the superficial compartment. The difference between Scarpa fascia of a thin and a fat person can be appreciated; adapted from Avelar (60).

Table 4. Results of Avelar study (78) on fat compartments thickness on the anterior abdominal wall; thickness of the abdominal wall layers of two groups of adult cadavers presenting similar weight and height*.

	Group A (Thin)	Group B (Fat)
Height	1.65 m	1.65 m
Weight	58 kg	85 kg
BMI	21 kg/m^2	31 kg/m^2
Thickness of the:	All regions	Odd regions
Superficial layer	From 0.8 to 1.2 cm	From 1.4 to 2.0 cm
Deep layer	Up to 0.5 cm	From 3.2 to 4.5 cm

Lockwood (77) based on a study of 12 fresh and embalmed cadavers and 20 body-contour patients, also described the same structure of the subcutaneous fascia, i. e. multilayered and the same alterations with increasing adiposity as reported by Avelar. Lockwood (77) proposed the concept of superficial fascial system (SFS) which corresponds to all the connective tissue located between the dermis and muscle fascia with the function of supporting the skin and fat of the body. It consists primarily of one to several thin horizontal membranous sheets separated by varying amounts of fat with interconnecting vertical or oblique fibrous septae. “In addition extensions of the superficial fascial system connect with the overlying dermis, tightly encasing the superficial fat in vertically oriented compartments. Similar collagenous extensions connect the entire superficial fascial system with the underlying musculoskeletal system.” (77). He recognized a protective and supportive role to the skin, superficial fat and superficial fascial system. According to this author, these structures provide a protective cushion or carpet over the musculoskeletal framework and allow sliding of soft tissues over that framework with dynamic activities. Lockwood also stated that in the lower anterior trunk the superficial fascial system consists of a well-defined single membranous sheet called Scarpa fascia. According to this author the anatomy of the superficial fascia varies significantly as the level of adiposity changes. He pointed out that there is a significant amount of fat separating the layers of the superficial fascia even in the nonobese individual. Obesity further separates the superficial fascia layers until they become indistinct and are not easily recognizable. According to this author this has confused both anatomists and surgeons regarding the existence of the superficial fascia.

Alexander (79) used ultrasound to investigate the subcutaneous fat of the abdominal wall from 17 women attending a weight control group over a 12 month period. This author measured the thickness of the superficial and deep fat compartments 3 cm below the umbilicus. The probe was moved from the midline to the left until the maximal thickness of the rectus muscle could be seen and the thickness was measured at this site. This author concluded that the thickness of the superficial layer remained relatively constant over a wide range of body fatness and nearly all changes in the subcutaneous adipose tissue were due to changes in the deep layer. The measurements showed the proportion of thickness of the deep fat to the superficial fat to be almost 4:1 (79).

Recent publications presented data suggesting a completely different structural organization of the abdominal wall, in contradiction to the results of the above mentioned studies. A minor role to the deep fat compartment on the lower abdominal contour was described by several authors along with constant presence of Scarpa fascia with increasing adiposity (61, 65, 66, 80).

Johnson (61, 80) performed CT scans on 20 female patients and measured the thickness of the adipose compartments at the level of the umbilicus 5 cm from the midline and verified a dominance of the superficial compartments: 67 % to 37 % (% of total fat thickness occupied by respectively superficial and deep fat compartments) (61). The subcutaneous fascia was easily identified in a wide range of adiposity (80).

Worseg (66) performed anatomical dissections of 27 fresh cadaver specimens, CT and ultrasound studies in 13 healthy volunteers and 3 cadavers. This author also did histologic examination of Scarpa fascia and he concluded that it was identical in obese and non-obese patients. Thickness measurements of the superficial and deep fatty tissue were performed in CT scans (n=16) and confirmed a predominance of the superficial compartments in the anterior abdominal wall (66).

Harley and Pickford (65) published their work based on CT analysis of fat distribution in the mid and lower abdomen in 69 women. The measurements were taken immediately superior to the umbilical dimple and at the superior margin of the mons pubis. The relative thickness of the superficial and deep fat compartments demonstrated a predominance of the former. At mid and lower levels, the superficial layer was thicker than the deep layer but a greater contribution from the deep layer was seen in the mid abdomen (43 % total thickness) than in the lower (19%) (65). In the lower abdomen, as the overall thickness increases, the

contribution from the superficial layer increased at a higher rate than that of the deep layer. In the mid-abdomen the increase rate was identical for both compartments. The deep fat compartment was never the dominant and Scarpa fascia did not become vestigial with increasing adiposity.

The contribution of the two fat compartments, superficial and deep, to abdominal wall thickness along with their variation with increasing adiposity is still a question surrounded my considerable controversy. The fact is that contradictory descriptions have been published. Some authors, namely Markman (59), Avelar (60), Lockwood (77) and Alexander (79), argue that the deep fat compartment is dominant in the lower abdomen and that it contributes significantly to the total abdominal wall thickness. Others like Johnson (61, 80), Worseg (66) and Harley (65), defend a minor role of the deep fat compartment. Previous studies by Markman (59), Lockwood (77) and Avelar (60) postulate that increasing adiposity correlates with increasing thickness of both the deep fat compartment and Scarpa fascia, so that the latter becomes a vestigial structure. This point of view has been contradicted by other authors, namely Worseg (66) and Johnson (80), who found Scarpa fascia to be identical in obese and non-obese patients.

We lack more detailed descriptions of the subcutaneous tissue which will provide answer to these questions and eventually reconcile the conflicting reports. Understanding the anatomy of the subcutaneous tissue and the changes that occur with adiposity will allow a new perspective in body contour plastic surgical procedures.

LEVEL OF DISSECTION

The classical technique of abdominoplasty is performed using a premuscular plane which means that all the dissection is performed on top of the deep fascia over rectus abdominis and external obliqus muscles. A different approach from the classical technique of abdominoplasty was proposed by Claude Le Louarn (81) in 1992, who suggested that the abdominal flap should be elevated on two different surgical planes: in the supraumbilical region a premuscular plane as in a traditional abdominoplasty and in the infraumbilical region a more superficial plane adjacent to Scarpa fascia, more precisely on its deep side (Fig. 7). The author named this technique partial subfascial abdominoplasty.

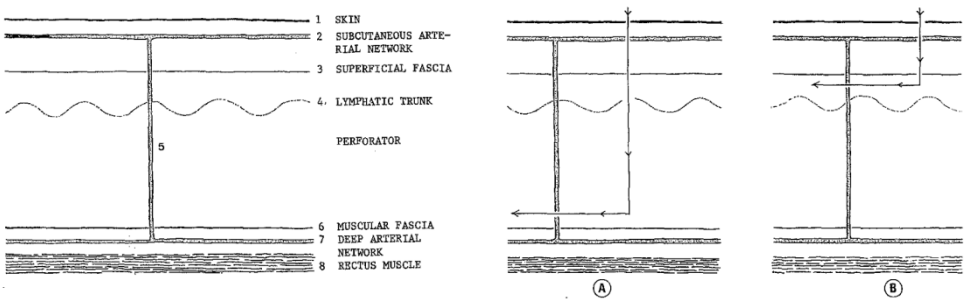

Fig 7. On the left anatomy of the abdominal wall. On the right: traditional (A) versus new (B) dissection planes (subumbilical part of the flap); adapted from Le Louarn (81).

The main goal of this modification was to lower the seroma rate. The author presented a clinical series of 36 patients submitted to a full abdominoplasty with liposuction of the infraumbilical area (essentially the deep fat) followed by dissection on the described two different surgical planes. The dissection on the deep side of the superficial fascia was done with scissors. The change between the two surgical planes was made at the umbilicus level. If diastasis of the muscles was present then the deep fat anterior to it was removed to facilitate the muscle plication. The author highlights that on this medial location this specific treatment does not injure any of the lymphatic trunks. Seroma was totally eliminated with this technique. Other advantages were avoidance of cutaneous necrosis and depressed scars. The author interpretation of his results was that a safer vascularization of the skin and fat as well as a better preservation of the lymphatic system was obtained with this modification (81). Actually Le Louarn wrote that partial subfascial abdominoplasty respects the anatomy of the abdominal wall better than the classical technique (81). His interpretations were based on previous anatomical studies that suggested that the abdominal wall lymphatic structures seem to be preferentially located in the area deep to Scarpa fascia and that two distinct areas of lymph drainage could be defined and divided by the umbilicus: the epigastric regions drain to the axilla and the hypogastric area drains to the inguinal area (fig 8). Le Louarn considered that the classical suprapubic incision involving all abdominal wall layers from skin to the muscular aponevrosis necessarily cuts the lymphatic trunks which predisposes to the development of secondary seroma. On the contrary the dual dissection plane better respects the lymphatic drainage pattern either in the infraumbilical area, where the surgical plane is located on the deep side of the superficial fascia, but also in the supraumbilical area where the dissection plane is pre-aponevrotic. The author believes that the supraumbilical part keeps its lymphatic trunks, which ensure drainage to the axillary nodes, in a similar manner to the infraumbilical area. The change of plane at the umbilical level was justified by the need to avoid edema of the supra-umbilical part of the flap.

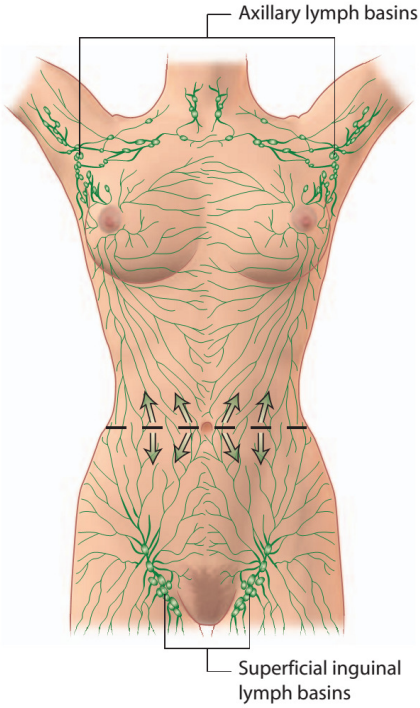

Fig 8. The abdominal soft-tissue lymphatics drain largely into the axillary and superficial inguinal lymph basins. The lymphatic network is located within the soft tissue apron, with the umbilicus serving as a watershed point. The soft tissue-tissue lymphatics above the umbilicus drain primarily into the axillary lymph basin while those below the umbilicus drain primarily into the superficial inguinal lymph basin; adapted from Hunstad (69).

A similar concept had been previously suggested by Regnault in 1975 (17) and by Guerreosantos in 1980 (82). Actually, Regnault highlighted that full abdominoplasty undermining should be performed in such a way that "the flap is raised superficial to the fascia leaving a fine cellular layer of tissue to cover the aponeurosis (this is important to facilitate the postoperative resorption of any possible fluid collection)" (17). Guerrerosantos used a dual plane abdominoplasty: skin in lower lateral abdominal wall, hip and upper thigh was dissected very superficially as in a face lift; in the rest of the abdominal wall dissection extends deep down to bottom of fat superficial to deep fascia (82). The reason for this modification was to preserve vessels and lymphatics. The fact is that this concept of a dual plane of dissection with the aim of preserving lymphatics was not further explored or reported by these or by other authors until the above mentioned publication by Claude Le Louarn in 1992. The latter was the first to report a retrospective clinical series of patients treated according to the principle of a more superficial plane of dissection during an abdominoplasty (81). This author later on updated his experience with his technique, reporting no seroma formation and shorter

hospitalization in a series of 65 patients (83). This second publication presented a similar technique to the one reported on the first paper.

Other authors further developed this principle of using two different levels of dissection during an abdominoplasty. Gardner and Vasconez (84) in 1996 published on a technique of abdominoplasty performed superficial to Scarpa fascia in the infraumbilical region and associated with abdominal liposuction. These authors used an avulsion technique that maintained the proper plane of dissection in the infraumbilical area on top of Scarpa fascia. The edge of the flap was grasped laterally and avulsed in a single motion, without using scalpel or electrosurgery. The authors observed no seroma or hematoma which was attributed to leaving the Scarpa fascia intact (84). Another important advantage of this technique was avoidance of the contour deformity sometimes seen at the junction of the inferior skin and fat with the superior flap. Leaving Scarpa fascia with the underlying fat softens this transition and gives a smooth contour. Actually it is not unusual to have a flattening or even a depression in the hypogastrum at the junction of the mons and superior flap after a full abdominoplasty. According to the authors, this step-off can be prevented by preserving Scarpa fascia (84).

Saldanha (36, 37) presented a modification of the traditional abdominoplasty that was popularized as lipoabdominoplasty. This technique had three major distinctive components: limited and selective undermining, total abdominal liposuction along with preservation of Scarpa fascia and sub-Scarpa fat in the infraumbilical region. The first publication on this technique was based on a clinical series of 28 female patients (36). The resection involved all the infraumbilical skin with preservation of Scarpa fascia and the deep fat compartment with its connective tissue, lymphatic vessels, arteries and veins. When necessary complementary lipoplasty was performed in this area to remove the excess fat. When there was an indication for rectus abdominis muscle plication adipose tissue was removed from the site of plication at the lower abdomen and a conventional plication was done. According to the authors the "procedure resulted in an improved body shape, better accommodation of the abdominal flap and a more youthful appearance of the abdomen with less scarring and no incidence of dog-ears or major complications" (36). There was a seroma incidence of 3.6 % (1 case in 28 patients). There were no cases of hematoma, suture rupture, skin slough or infection. Lipoabdominoplasty enhanced the aesthetic results with fewer complications than the classical abdominoplasty (36). In 2003 Saldanha (37) updated his experience and published a clinical series of 125 patients submitted to lipoabdominoplasty. Again the deep fatty layer with its connective tissue, lymphatic vessels arteries and veins was preserved beneath Scarpa fascia.

There was a seroma incidence of 1.6 % (two cases in 125 patients) and again no cases of hematoma, suture rupture, skin slough or infection. The authors concluded that lipoabdominoplasty is a safer way to treat the abdominal region than the classical abdominoplasty producing more harmonious results with fewer complications (37). Saldanha (85) in a personal communication presented eight reasons for preserving Scarpa fascia during an abdominoplasty: reduction of bleeding, greater infra-umbilical uniformity, smaller scar because it forms a dermic belt, maintenance of the lymphatic vessels, support for the thin superior flap, greater adhesion in the immediate post-operative, smaller possibility of dehiscence, smaller incidence of seroma and haematoma.

In 2006 Vasconez (38) published a retrospective study based on 60 patients submitted to abdominoplasty plus total abdominal liposuction, Scarpa fascia preservation and no upper flap undermining. All the patients enrolled in this study had been previously submitted to bariatric surgery and experienced massive weight loss. Suctioning rather than resection of the deep fat compartment allowed preservation of lymphatics and the resection of the pannus at a more superficial level. A complication rate of 22 % was found and a seroma rate of 3.3 %. Suture rupture in 10.0 %, skin necrosis in 5.0 %, infection in 3.3 %. No patient required a blood transfusion and the median in-hospital stay was 1 day, with 42 % of the patients treated as outpatients (38).

Heller (39) was the first to report a retrospective cohort study with 114 patients to evaluate and compare the outcomes between abdominal liposuction alone (n=20), classical abdominoplasty (n=33), abdominoplasty with Scarpa fascia preservation (n=30) and lipoabdominoplasty, also with Scarpa fascia preservation (n=31). All the participants in this study were operated by the same surgeon. Two suction drains were used and removed when serum drainage was less than 15 cc per 24 hours. No compression garments were worn until drains were removed, which usually happened 10 to 14 days after surgery. There were no statistically significant differences among the four groups in terms of mean age, mean body mass index, presence of abdominal scars and smoking history. The groups with Scarpa fascia preservation had a significantly lower complication rate when compared to the group submitted to classical abdominoplasty. The complication rates were 5% for the liposuction group, 42 % for the classical abdominoplasty, 17 % for the group with abdominoplasty with Scarpa fascia preservation and 9 % for the lipoabdominoplasty group (39). Considering specifically the seroma rate it was 0 % for the liposuction group, 15 % for the classical abdominoplasty group, 7 % for the group with abdominoplasty with Scarpa fascia preservation

and 3 % for the lipoabdominoplasty group (39). The group submitted to lipoabdominoplasty had a significantly lower dissatisfaction rate when compared to the other type of abdominoplasties. The dissatisfaction rate was 10 % for the liposuction group, 42 % for the classical abdominoplasty group, 37 % for the group with abdominoplasty with Scarpa fascia preservation and 3 % for the lipoabdominoplasty group (39).

Table 5. Studies on dual plane abdominoplasty.

	Year	Type of study	Level of evidence*	Number cases	Complication (%)	Seroma (%)
Le Louarn (81)	1992	Case series	IV	36	—	0
Le Louarn (83)	1996	Case series	IV	65	—	0
Gardner (84)	1996	Expert opinion	V	—	—	0
Saldanha (36)	2001	Case series	IV	28	—	3.6
Saldanha (37)	2003	Case series	IV	125	3.0	1.6
Vasconez (38)	2006	Case series	IV	60	22.0	3.3
Heller (39)	2008	Retrospective	III	114	17.0	7.0

*According to the American Society of Plastic Surgeons Rating Levels of Evidence and Grading Recommendations (Level III: retrospective cohort or comparative study; case-control study; or systematic review of these studies; Level IV: case series with pre/post test; or only post test; Level V: expert opinion developed via consensus process; case report or clinical example; or evidence based on physiology, bench research or “first principals”)

The publications from Le Louarn, Vasconez, Saldanha and Heller suggest that using a more superficial plane of dissection in the lower abdomen during a full abdominoplasty can reduce complications, mainly seroma. Objective evidence regarding this strategy is lacking as it is mainly based on publications with level of evidence IV and V (table 5). Higher level of evidence studies are needed to confirm this and to investigate other potential advantages of using a dual plane of dissection during abdominoplasty.

OBJECTIVES:

This investigation has two main purposes: to contribute to a better understanding of the anatomy of the subcutaneous tissue of the lower abdominal wall and simultaneously to evaluate the clinical effects of using a more superficial plane of dissection (with preservation of Scarpa fascia) during a full abdominoplasty.

The specific objectives were:

1. Morphometric study (macroscopic) of the subcutaneous tissue of the lower abdominal wall in fresh surgical specimens (from patients submitted to a classical full abdominoplasty) with particular emphasis on studying adipose compartment dominance in different anatomical locations and the variations with increasing adiposity.

2. Morphometric study (microscopic) of the subcutaneous tissue of the lower abdominal wall with particular emphasis on Scarpa fascia (presence and structure).

3. Prospective comparative clinical study on the effects of Scarpa fascia preservation during a full abdominoplasty in the immediate postoperative period.

4. Randomized controlled trial to investigate the effects Scarpa fascia preservation during a full abdominoplasty in the immediate and late postoperative periods.

CHAPTER II

Scarpa fascia preservation during abdominoplasty: a prospective study

Scarpa Fascia Preservation during Abdominoplasty: A Prospective Study

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Background: Preservation of the Scarpa fascia has been suggested as a way of lowering complications associated with conventional abdominoplasty. Objective evidence regarding this strategy is lacking. The purpose of this investigation was to evaluate the effect of preserving the Scarpa fascia in the infraumbilical area during a full abdominoplasty.
Methods: A prospective study was performed at a single center from November of 2005 to November of 2007 of the patients submitted to abdominoplasty with umbilical transposition. Two groups were identified: group A, classic full abdominoplasty; and group B, full abdominoplasty with preservation of infraumbilical Scarpa fascia. Several variables were determined: age, body mass index, previous surgical procedures, comorbid conditions, specimen weight, time to suction drain removal, total volume of drain output, and length of hospital stay.
Results: A total of 208 full abdominoplasties were performed (group A, 143 patients; group B, 65 patients). There was no statistically significant difference between groups with respect to body mass index, previous abdominal operations, comorbid medical conditions, or weight of the surgical specimen ($p > 0.05$). The group with preservation of the Scarpa fascia had an average reduction of the total amount of drain output of more than 50 percent ($p < 0001$). This group also had an average reduction of 2.0 days until the time to drain removal ($p < 0.001$) and 1.9 days of the hospital stay ($p < 0.001$).
Conclusion: Preservation of the Scarpa fascia during abdominoplasty has a beneficial effect on patient recovery, as it reduces the total drain output, time to drain removal, and length of hospital stay. (*Plast. Reconstr. Surg.* 125: 1232, 2010.)

Abdominoplasty is a very popular body-contouring procedure. It ranks fifth among the 2007 top five surgical cosmetic procedures from the American Society of Plastic Surgeons, with a total number of 148,410 procedures. The demand for this technique has been increasing, which is clearly demonstrated by a 133 percent rise from 62,713 procedures in 2000 to 146,240 in 2006.[1] Such a major increase has many possible causes, namely, the recent increase in bariatric surgery and the popularity of cosmetic surgery. The very good results obtained with this technique, with a positive impact on the patient's self-image and quality of life, can also explain the above-mentioned trend.

Despite the good results obtained with a full abdominoplasty, significant complication and secondary surgical revision rates are still reported.[2–9] Multiple surgical strategies have been described to lower the complication rate, such as lipoabdominoplasty,[10–12] selective undermining,[12–14] internal fixation techniques,[15–19] avoidance of electrocautery, use of pressure dressings, and use of fibrin glue. The fact is that overall complication rates as high as 30 percent have been recently reported.[4,6,20] Seroma alone is still reported with frequencies as high as 30 percent.[9,21]

Previous anatomical and imaging studies described two different fat compartments in the lower abdominal wall: a superficial compartment

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and a deep compartment separated by a fascial plane known as the Scarpa fascia or superficial fascia.[22–27] Le Louarn,[28–30] Vásconez and de la Torre,[10,31] and Saldanha et al.[12] proposed a different approach from the classic technique of abdominoplasty by suggesting that the abdominal flap should be elevated on two different surgical planes: in the supraumbilical region, a premuscular plane as in a traditional abdominoplasty; and in the infraumbilical region, a pre–Scarpa fascia plane. The goal of the surgical modification proposed by Le Louarn, Vásconez and de la Torre, and Saldanha et al. was to decrease complications (i.e., seroma). Objective evidence regarding this strategy is lacking. The purpose of this investigation was to evaluate the effect on full abdominoplasty of preserving the Scarpa fascia in the infraumbilical region in the immediate postoperative period.

PATIENTS AND METHODS

A prospective study was performed. Patients submitted to full abdominoplasty with umbilical transposition between November of 2005 and November of 2007 at the Department of Plastic Reconstructive Aesthetic and Maxillofacial Surgery, São João Hospital/Porto Medical School formed the study population. These patients presented with abdominal deformities marked by excess abdominal skin and adipose tissue with muscle laxity: Psillakis types III and IV[32] and Matarasso types III and IV.[33,34] Two patient groups were identified: group A, patients who underwent a classic abdominoplasty with umbilical transposition[35]; and group B, patients who underwent a similar type of abdominoplasty except for preservation of the Scarpa fascia and the deep fat compartment in the infraumbilical area. The two groups were representative of two different surgical teams whose standard approach to the abdominal procedure differed only with respect to the preservation of the Scarpa fascia. The patients were allocated to each surgeon according to the department policy of patient distribution among the plastic surgeons. A total of six surgeons were involved in the study. All of the surgeons were fully trained. The group that preserved the Scarpa fascia (group B) had a total of two surgeons, and the group that did not preserve the Scarpa fascia (group A) had four surgeons. The following variables were analyzed: age of the patient, body mass index, previous surgical procedures in the abdomen, previous bariatric surgery, comorbid medical conditions, specimen weight, time to drain removal, total volume of drain output, and length of hospital stay. This study was approved by the Ethical Committee (Comissão de Ética para a Saúde) of São João University Hospital. All patients accepted to enroll in this study signed informed consent documents.

Surgical Methods

Preoperative enoxaparin (40 mg subcutaneously daily during the hospital stay starting at least 2 hours before surgery) and broad-spectrum intravenous antibiotics were routinely administered to all patients. All patients included in this study were submitted to a full abdominoplasty with umbilical transposition and rectus abdominis muscle plication. The preoperative markings and the surgical technique of the abdominoplasty are well described elsewhere and are well known.[35] The surgical technique began with preparing and draping the patient under general anesthesia. In group A, the abdominal flap was dissected in a preaponeurotic (premuscular) plane as traditionally described, to the level of the subcostal margin. In group B, the abdominal flap was dissected in two different planes: presuperficial fascia (pre–Scarpa fascia) in the lower abdomen and preaponeurotic (premuscular) in the epigastric region and infraumbilical midline (Figs. 1 and 2). First, the skin was incised with a scalpel along the preoperative markings. Sharp Mayo scissors were used to complete the incision to the Scarpa fascia (Fig. 3, *above, left*). Each end of the skin paddle was grasped with two clamps and the segment was avulsed along the plane of the Scarpa fascia (Fig.

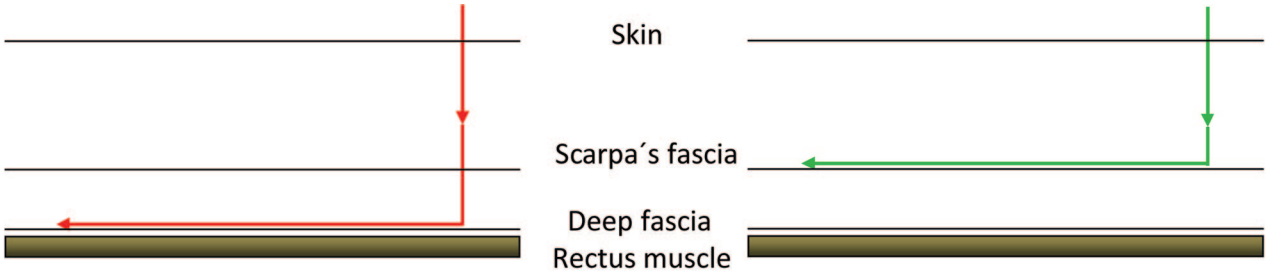

Fig. 1. Dissection planes in the infraumbilical area: traditional (*red line*) versus Scarpa fascia preservation (*green line*).

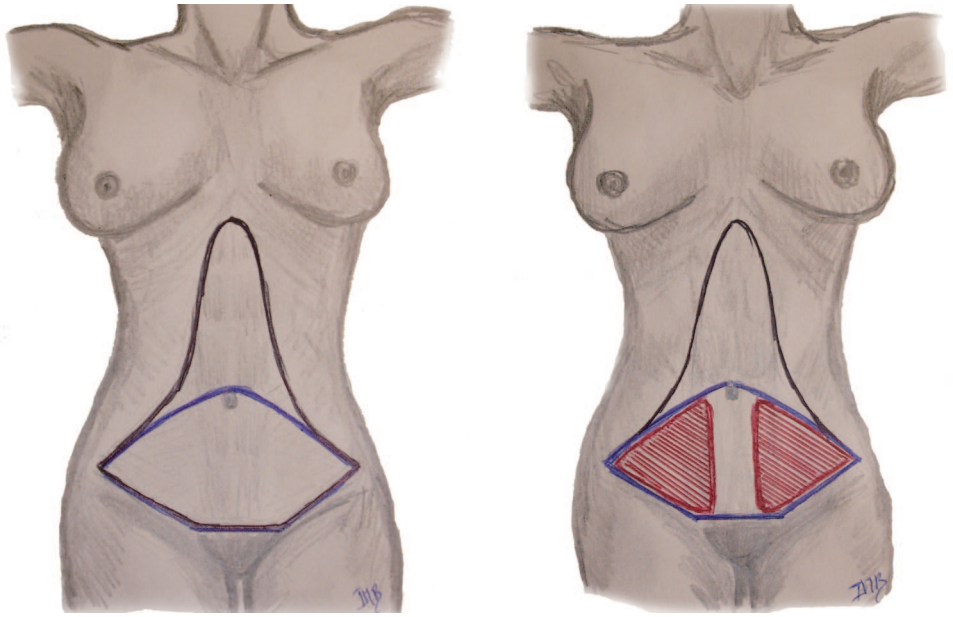

Fig. 2. Dissection planes in the traditional abdominoplasty (*left*) versus abdominoplasty with Scarpa fascia preservation (*right*). The *blue line* represents the skin resection pattern. The *black line* limits the area to be undermined. (*Left*) The dissection is performed on the plane of the deep fascia. (*Right*) The dissection is performed on the plane of the deep fascia except for the areas within the *red line*, which correspond to dissection on the plane of the Scarpa fascia.

3, *above, right* and *center, left*).[31] This maneuver is simplified if the assistant uses both hands to apply downward pressure while the surgeon applies vertical traction. The avulsion maneuver stopped a few centimeters from the midline bilaterally so that a small central strip of the Scarpa fascia could be incised and removed along with the underlying deep fat (Fig. 3, *center, right* and *below*). This was done to expose the muscular fascia plane to simplify the xiphopubic muscular plication. Then, the dissection was extended to the level of the subcostal margin on a premuscular plane. The procedure did not differ in any other aspects between the groups. Two closed-suction drains were used in all patients. Compression garments were used routinely and applied in the operating room. Drains were removed routinely when the patient was ambulatory and the drain output per day was less than or equal to 30 cc collected over 24 hours (on each drain). Regardless of the amount of fluid, the drains were never removed during the first 24 hours. The patients were motivated to ambulate on the first postoperative day, and compression garments were used for at least 6 weeks after surgery. Patients were instructed to avoid strenuous activity for a full 6 weeks postoperatively.

Statistical Analysis

Statistical analysis was performed using SPSS for Windows version 17.0 (SPSS, Inc., Chicago, Ill.). The *t* test and Mann-Whitney *U* test were used to analyze continuous variables. The chi-square test was applied to analyze categorical variables.

RESULTS

A total of 208 full abdominoplasties were performed in women. In 143 patients (group A), a classic full abdominoplasty without preservation of the Scarpa fascia was performed. In 65 patients (group B), a full abdominoplasty was performed with preservation of the infraumbilical Scarpa fascia. The general characteristics of the two groups are summarized on Table 1 and were identical except for age.

In group A, the average age was 41.10 ± 8.96 years (range, 24.0 to 65.0 years), the average body mass index was 27.89 ± 4.19 kg/m^2 (range, 19.1 to 39.3 kg/m^2), 93 patients (65 percent) had previous abdominal surgical procedures, 11 patients (7.7 percent) had previous bariatric surgery, 22 patients (15.4 percent) had comorbid medical conditions (hypertension was present in 11 patients, diabetes mellitus in eight patients, asthma in two patients, rheumatoid arthritis in two pa-

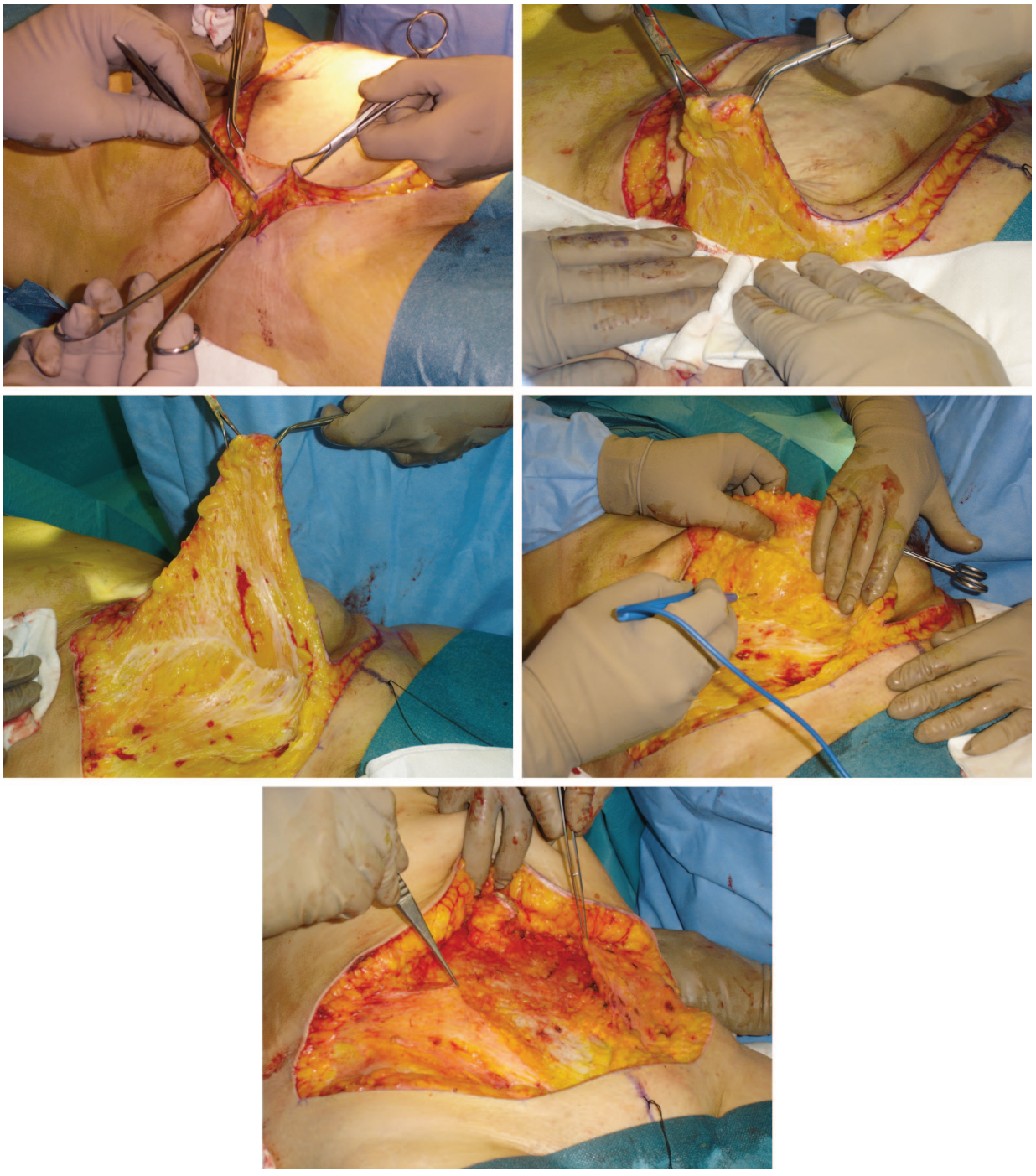

Fig. 3. (*Above, left*) Exposure of the plane of the Scarpa fascia. (*Above, right*) Detail of the avulsion maneuver. (*Center, left*) Aspect after avulsion of the lateral segment of the skin paddle along the plane of the Scarpa fascia. (*Center, right*) Removal of the deep fat in the proximity of the midline. (*Below*) View after removal of the skin paddle with lateral preservation of the Scarpa fascia and the deep fat compartment. On the midline, the dissection was performed on the muscular fascia plane. The forceps indicate the Scarpa fascia.

tients, pulmonary thromboembolism in one patient, chronic hepatitis type C in one patient, systemic lupus in one patient, and two comorbid medical conditions in four patients), and the average weight of the surgical specimen was 1250.4 ± 636.5 g (range, 190.0 to 3050.0 g).

In group B, the average age was 37.82 ± 6.87 years (range, 22.0 to 54.0 years), the average body

Table 1. General Characteristics and Results of Both Groups (*n* = 208)*

	Group A (*n* = 143)	Group B (*n* = 65)	*p*
Age, years			
Mean ± SD	41.10 ± 8.96	37.82 ± 6.87	0.009
Range	24.0–65.0	22.0–54.0	
BMI, kg/m^2			
Mean ± SD	27.89 ± 4.19	26.63 ± 4.72	NS
Range	19.1–39.3	19.7–43.0	
Total no. of previous abdominal operations (%)	93 (65.0)	42 (64.6)	NS
Total no. of previous bariatric operations (%)	11 (7.7)	6 (9.2)	NS
Total no. of medical comorbidities (%)	22 (15.4)	9 (13.8)	NS
Weight specimen, g			
Mean ± SD	1250.4 ± 636.5	1153.0 ± 873.2	NS
Range	190.0–3050.0	250.0–6000.0	
Time until drain removal, days			
Mean ± SD	5.14 ± 3.08	3.17 ± 1.42	<0.001
Range	2.0–22.0	2.0–9.0	
Drain output, cc			
Mean ± SD	523.11 ± 521.61	214.85 ± 201.75	<0.001
Range	80.0–3615.0	5.0–1225.0	
Length of hospital stay, days			
Mean ± SD	6.80 ± 3.24	4.91 ± 1.70	<0.001
Range	3.0–26.0	3.0–11.0	

BMI, body mass index; NS, not significant ($p > 0.05$).

*Group A, no preservation of the Scarpa fascia ($n = 143$); group B, preservation of the Scarpa fascia ($n = 65$). The incidence of previous operations, previous bariatric surgery, and comorbid medical conditions was compared between the groups using the χ^2 test. Time to drain removal and duration of hospital stay were compared between both groups using the Mann-Whitney *U* test. The other variables were compared using the *t* test.

mass index was 26.63 ± 4.72 kg/m^2 (range, 19.7 to 43.0 kg/m^2), 42 patients (64.6 percent) had previous abdominal surgical procedures, six patients (9.2 percent) had previous bariatric surgery, nine patients (13.8 percent) had comorbid medical conditions (hypertension was present in six patients, diabetes mellitus in two patients, asthma in one patient, thyroid disease in one patient, sarcoidosis in one patient, and two comorbid medical conditions in two patients), and the average weight of the surgical specimen was 1153.0 ± 873.2 g (range, 250.0 to 6000.0 g).

There was no statistical difference regarding body mass index, previous abdominal operations, previous bariatric surgery, comorbid medical conditions, and weight of the surgical specimen between the groups. The results of both groups concerning the time to drain removal, total drain output, and duration of hospital stay are summarized in Table 1 and were not identical.

In group A, average time to drain removal was 5.14 ± 3.08 days (range, 2.0 to 22.0 days), average total volume drained was 523.11 ± 521.61 ml (range, 80.0 to 3615.0 ml), and average hospital stay was 6.80 ± 3.24 days (range, 3.0 to 26.0 days). In group B, average time to drain removal was 3.17 ± 1.42 days (range, 2.0 to 9.0 days), average total volume drained was 214.85 ± 201.75 ml (range, 5.0 to 1225.0 ml), and average hospital stay was 4.91 ± 1.70 days (range, 3.0 to 11.0 days). There was a statistically significant difference between the groups concerning the time to drain removal ($p < 0.001$), total volume of drain output ($p < 0.001$), and duration of hospital stay ($p < 0.001$).

DISCUSSION

Abdominoplasty techniques were introduced in the 1960s but have undergone a continuous process of evolution to provide better and safer results. The potential role for preserving the Scarpa fascia and/or the deep fat compartment during an abdominoplasty has been pointed out by some authors as a way of lowering the complication rate.[10–12,28,29] Several possible reasons for preservation of the Scarpa fascia may include decrease in seroma formation, decrease in abdominal necrosis, allowance for safer liposuction at the same time as limited abdominoplasty, decrease in swelling of the lower abdominal flap, and avoidance of discrepancy in flap thickness (between the pubic flap and the abdominoplasty flap). Objective data based on prospective studies are needed to validate these advantages.

Le Louarn proposed liposuction behind the abdominal superficial fascia followed by dissection first located at the deep side of this fascia and then changing plane at the level of the umbilicus to reach the premuscle fascia plane.[28] This author updated his experience with his technique, reporting no se-

roma formation and shorter hospitalization in a clinical series of 65 patients.[29] Other authors further developed this principle.[36,37] Saldanha et al. proposed limited and selective undermining and total abdominal liposuction along with preservation of the Scarpa fascia.[11,12] Espinosa-de-los-Monteros et al. proposed total abdominal liposuction performed with abdominoplasty with preservation of the lymphatic vessels below the Scarpa fascia without upper flap undermining.[10]

A procedure has been used in our department applying the same principle: preservation of the Scarpa fascia and the deep fat compartment in the infraumbilical region, with the difference that no abdominal liposuction was performed. The Scarpa fascia was preserved mainly laterally, as a central strip was excised along with the deep fat compartment located underneath, to facilitate the midline plication inferior to the umbilicus. The two groups of the current study were similar in terms of body mass index, previous abdominal operations, and weight of the surgical specimen. These factors were analyzed because they are known to influence adversely the surgical outcome and complications of abdominoplasty, especially the weight of the pannus[10] and body mass index.[20,38]

One possible explanation for the results presented is that Scarpa fascia preservation on the infraumbilical area better respects the physiology of the abdominal wall, as it also implies the preservation of the deep fatty layer along with its connective tissue, lymphatic vessels, arteries, and veins. There is a possibility that the deep subcutaneous compartment rather than the Scarpa fascia is the key structure to preserve. Previous anatomical studies show that the abdominal wall lymphatic structures seem to be preferentially located in the area deep to the Scarpa fascia and that two distinct areas of lymph drainage can be defined and divided by the umbilicus: the epigastric region drains to the axilla and the hypogastric area drains to the inguinal area.[24,30,31,39,40] We should also pay attention to the differences in the suprapubic incision between both groups: in group B, it does not involve the full thickness of the subcutaneous tissue, whereas in group A, it does. Assuming that the hypogastric area drains into the inguinal area, the incision used in group B will have a lower potential to interfere with the lymph drainage of the abdominal wall. The change from one dissection plane to the other was performed at the umbilical level, respecting the transition areas of lymph drainage. The explanation for the more favorable postoperative behavior in group B regarding total drain output, length of time to drain removal, and length of hospital stay is probably related to a lower interference with the abdominal wall lymphatic system.

Another possible explanation for our results is better tissue healing and adhesion. This can be the result of two healing surfaces with better vascularization than the ones that are opposed after a traditional abdominoplasty, which is known to produce a profound devascularization of the abdominal wall.[41] One can raise the possibility that the avulsion maneuver used in group B to dissect the infraumbilical region can cause less injury to the raw surfaces.

Seroma is a very frequent complication of abdominoplasty, and suction drainage is one of the most accepted and universal methods of prevention.[9] The drains are usually removed when the patient is ambulatory and the drainage subsides to 30 cc of aspirate collected in each drain over a 24-hour period. The use of drains for extended periods is not advisable, as they are a source of retrograde bacterial migration and can increase patient discomfort and reduce patient mobility, which in turn can contribute to a higher incidence of morbidities such as local infections and thromboembolic accidents.[2,42] This last aspect assumes particular importance in abdominoplasty, as it is considered to be the plastic surgery cosmetic procedure with the highest incidence of thromboembolic accidents.[31,43–46] However, the fact is that suction drainage is used more frequently than any other seroma preventive measure.[9,36,46] Surgeons must be aware of the importance of shortening the period of use of suction drains and the options available to do so.

The length of hospital stay can be influenced by several factors. It is well known that hospitalization is different in different countries. The policy in our department is to discharge patients only after drain removal; consequently, the length of time to drain removal influenced the length of hospital stay. Reduction of costs, minimization of patient discomfort, and reduction of infections are well known advantages of shortening the hospital stay.[47] Abdominoplasty can be safely performed as an ambulatory procedure in selected patients.[10,46] Even in this different clinical setting, a reduction of the total volume of drainage and a reduction of the length of time to drain removal are obviously advantageous. As with all elective procedures, minimizing morbidity and postoperative disability is very important.

The different plane of dissection that was used in group B is more difficult to access and not so

"clean." One can easily disrupt the Scarpa fascia if care is not taken. Previous superficial liposuction is said to facilitate dissection of the Scarpa fascia. Liposuction of the infraumbilical superficial and deep fat compartments was routinely performed by the authors who first suggested and reported the preservation of the infraumbilical deep fat compartment. In our clinical series, no liposuction of the infraumbilical area was performed. The thickness of the deep fat compartment was not modified, as most of the abdominal fat was found superficial to the Scarpa fascia, and this did not interfere with the final aesthetic result. A satisfying abdominal contour was obtained in all patients regardless of which group was considered. In our clinical series, the preservation of the deep compartment in group B was not an obstacle to attaining a good aesthetic result.

Creating a study that eliminates all the independent variables is desirable but often impossible. Different surgical teams can be a factor that influenced the results of our study; nevertheless, we think these data are interesting and deserve to be shared with the plastic surgery community.

CONCLUSIONS

This prospective study provides evidence for some of the potential advantages of preserving the Scarpa fascia during a full abdominoplasty, namely, a significant reduction of the total volume of fluid drained, a reduction of the period the patient has to use suction drains, and a reduction of the length of hospital stay. Patient recovery is thus improved.

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CHAPTER III

Scarpa fascia preservation during abdominoplasty: a randomized clinical study of efficacy and safety

Scarpa Fascia Preservation during Abdominoplasty: Randomized Clinical Study of Efficacy and Safety

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Background: Scarpa fascia preservation has been suggested as a way of reducing complications associated with conventional abdominoplasty. A prospective randomized study was conducted to evaluate the effect on results and complications of preserving the Scarpa fascia during a full abdominoplasty.

Methods: This was a single-center study conducted from August of 2009 to February of 2011. Patients were assigned randomly to one of two procedures: classic full abdominoplasty (group A) or a similar type of abdominoplasty except for the preservation of the Scarpa fascia and the deep fat compartment in the infraumbilical area (group B). Four surgeons were involved in the study. Several variables were determined: general characteristics, time to suction drain removal, total volume of drain output, length of hospital stay, systemic complications, local complications, and aesthetic result.

Results: A total of 160 full abdominoplasties were performed in women (group A, 80 patients; group B, 80 patients) equally divided by the four involved surgeons. There were no statistically significant differences between groups with respect to general characteristics, complications (except for the seroma rate), and aesthetic result. The Scarpa fascia preservation group had a highly significant reduction of 65.5 percent on the total drain output, 3 days on the time to drain removal, and 86.7 percent on the seroma rate.

Conclusion: Preservation of the Scarpa fascia during an abdominoplasty had a beneficial effect on patient recovery, as it reduced the total drain output, time to drain removal, and seroma rate without compromising the aesthetic result. (*Plast. Reconstr. Surg.* 131: 644, 2013.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, I.

Scarpa fascia preservation during abdominoplasty is not a new concept. It has been suggested by Le Louarn as a way of reducing complications associated with conventional abdominoplasty, mainly seroma.[1–3] Other authors further argued in favor of this point of view.[4–8] Objective data supporting this surgical strategy are lacking. The question is very pertinent, as seroma is still the most frequent complication following an abdominoplasty procedure, with a reported incidence from 5 to 50 percent.[9–16] Although seromas usually resolve uneventfully with multiple percutaneous aspirations, some can persist and lead to the development of a pseudobursa. Progression to this chronic state generally justifies a second operation for successful management. Other potential advantages of preserving the Scarpa fascia during an abdominoplasty have been suggested: elimination of the suprapubic depression,[4] reduction of the total drain output,[17] reduction of the time to drain removal,[17–19] and use as a lifting layer to improve thigh contour.[20,21]

A prospective randomized study was conducted to evaluate the effect on results and complications of preserving the Scarpa fascia in the infraumbilical area during a full abdominoplasty. To our knowledge, a randomized controlled trial

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comparing the two techniques has not been performed yet.

PATIENTS AND METHODS

This was a single-center, randomized, parallel-group study conducted in Porto, Portugal, at the Department of Plastic Surgery at São João Hospital, Porto Medical School, from August of 2009 to February of 2011. This study was approved by the Ethical Committee of São João Hospital, Porto Medical School. The study was compiled according to the guidelines from the Consolidated Standards of Reporting Trials Group, which provides evidence-based recommendations for reporting randomized controlled clinical trials.

The method of participant recruitment was referral from the primary care provider. One hundred sixty consecutive patients who came to the outpatient unit were selected. Eligible participants were all the female patients who presented with abdominal deformities marked by excess abdominal skin and adipose tissue with muscle laxity and who met the criteria for a full abdominoplasty with umbilical transposition (Psillakis types III and IV and Matarasso types III and IV).[22,23] Exclusion criteria were significantly elevated operative health risks, bariatric patients without weight stabilization for at least 6 months, patients who anticipate future pregnancy, and patients with a body mass index over 30 kg/m^2 except for the ones with previous bariatric surgery.

Four surgeons (fully trained) were involved in the study. The patients were allocated equally and sequentially to each surgeon, respecting the Department of Plastic Surgery policy for patient distribution. Each surgeon performed a total of 40 surgical procedures. Patients were assigned randomly to one of two surgical procedures: classic full abdominoplasty (group A) or a similar type of abdominoplasty except for preservation of the Scarpa fascia and the deep fat compartment in the infraumbilical area (group B). For allocation of the participants, a computer-generated list of random numbers was used. Active smokers were instructed to stop smoking or to reduce smoking to three cigarettes per day 6 weeks before surgery (these participants were considered to be active smokers).

Surgical Methods

Preoperative enoxaparin (40 mg/day subcutaneously during the hospital stay starting at least 2 hours before surgery) and broad-spectrum intravenous antibiotics were administered routinely to all patients. All of the patients included in this study were submitted to a full abdominoplasty with umbilical transposition and rectus abdominis muscle plication. The preoperative markings and the surgical technique of the abdominoplasty are well described elsewhere and are well known.[24] The surgical technique began with preparing and draping the patient under general anesthesia. In group A, the abdominal flap was dissected in a premuscular plane as traditionally described, to the level of the subcostal margin. In group B, the abdominal flap was dissected in two different planes: pre–Scarpa fascia in the lower abdomen and premuscular in the epigastric region and infraumbilical midline. The procedure used in group B is well described in a previous publication.[17] First, the skin was incised with a scalpel along the preoperative markings. Sharp Mayo scissors or a scalpel was used to complete the incision to the Scarpa fascia. Each end of the skin paddle was grasped with two clamps and the segment was avulsed along the plane of the Scarpa fascia. The avulsion maneuver stopped a few centimeters from the midline bilaterally so that a small central strip of Scarpa fascia could be incised and removed along with the underlying deep fat. Then, the dissection was extended to the level of the subcostal margin on a premuscular plane. The procedure did not differ in any other aspects between both groups. Liposuction was limited to the flanks, and no quilting sutures were used. Two closed-suction drains were used in all patients. Compression garments were routinely used and applied in the operating room. No additional procedures were performed. Drains were routinely removed when the patient was ambulatory and the drain output per day was less than or equal to 30 ml collected over 24 hours (on each drain) but were never removed during the first 24 hours. The patients were motivated to ambulate on the first postoperative day. For at least 6 weeks after surgery, compression garments were used and strenuous activity was avoided.

Outcomes

The outcomes measured in this study included time to drain removal, daily and total volume of drain output, length of hospital stay, incidence of systemic complications, incidence of local complications, emergency department visit, second admission to the hospital, secondary surgical procedure (excluding scar revision), and aesthetic result (evaluated by the patient and by the care provider). Drain output volume was registered daily at the same time by a nurse (7 AM) who was not aware of the type of procedure. After hospital

discharge, patients were observed by one of the four surgeons enrolled on the trial at 2 weeks, 1 month, and 6 months after surgery. The complications were defined as local or systemic. Systemic complications were defined as need for blood transfusion, pulmonary fat embolus syndrome, thromboembolic complications (deep vein thrombosis/pulmonary thromboembolism), and death. Local complications were defined as seroma, hematoma/bleeding, wound infection, healing problems/wound dehiscence without necrosis, and skin necrosis. Seroma was defined as a subcutaneous abdominal wall fluid collection evident on physical examination after drain removal that was successfully aspirated at least once (nonhematic clear fluid). Hematoma was defined as a subcutaneous abdominal wall fluid collection (hematic) evident on physical examination that was successfully aspirated at least once.

The aesthetic result was evaluated by both the patient (by telephone interview) and the surgeon at 6 months after surgery, considering the overall contour, volume of subcutaneous tissue, and excess skin. The patients were not aware of which procedure they received. The quality of the scar was not considered for the purpose of the aesthetic result because of the short follow-up period. The aesthetic evaluation was performed using a Likert scale with five levels (1 = very bad and 5 = very good).

Sample Size

Sample size was determined based on the following outcomes: time to drain removal and total volume of drain output. To detect a reduction in time to drain removal of 2 days, which is in agreement with the study of Costa-Ferreira et al.[17] with a two-tailed 5 percent significance level and a power of 80 percent, a sample size of 60 patients per group was necessary. To detect a reduction in total drain output of 250 ml, which is in agreement with the study of Costa-Ferreira et al.[17] with a two-tailed 5 percent significance level and a power of 80 percent, a sample size of 42 patients per group was necessary.

Statistical Analysis

Statistical analysis was performed with the program SPSS for Windows version 20.0 (SPSS, Inc., Chicago, Ill.). The *t* test and Mann-Whitney *U* test were used to analyze continuous variables. The chi-square test was applied to analyze categorical variables.

For the dependent variables seroma rate, total drain output, and time to drain removal, the effect of the two independent variables (effect of the procedure and effect of the surgeon) was evaluated, using the chi-square test for seroma rate and the Kruskal-Wallis test for the total drain output and time to drain removal. For all of them, the surgeon's effect was not statistically significant; thus, all other variables were analyzed independent of the surgeon assuming that findings are consistent with different surgeons.

RESULTS

A total of 160 full abdominoplasties were performed in women (group A, 80 patients; group B, 80 patients). Patient characteristics are summarized in Table 1 and did not differ significantly between group A and group B. Outcomes are summarized in Table 2.

The daily evolution of drain output is presented in Figure 1. The daily drain outputs were

Table 1. General Characteristics of Both Groups (*n* = 160)*

	Group A	Group B	*p*
Age, yr			NS
Mean ± SD	38.50 ± 9.27	40.64 ± 8.31	
Range	23–61	21–68	
BMI, kg/m^2			NS
Mean ± SD	25.38 ± 2.93	26.32 ± 2.94	
Range	19.1–33.7	19.5–33.7	
Smoker, total no. (%)	16 (20.0)	20 (25.0)	NS
Previous abdominal operations, total no. (%)	56 (70.0)	54 (67.5)	NS
Previous bariatric surgery, total no. (%)	12 (15.0)	9 (11.3)	NS
Medical comorbidities, total no. (%)	17 (21.3)	14 (17.5)	NS
Weight specimen, g			NS
Mean ± SD	1087.47 ± 500.44	1025.37 ± 431.07	
Range	330.0–2700.0	330.0–2800.0	

NS, not significant ($p > 0.05$).

*Group A, no preservation of the Scarpa fascia ($n = 80$); group B, preservation of the Scarpa fascia ($n = 80$). The incidence of previous operations, previous bariatric surgery, smoking habits, and comorbid medical conditions was compared between both groups using the χ^2 test. The other variables were compared using the *t* test.

Table 2. Outcomes of Both Groups ($n = 160$)*

	Group A	Group B	p
Time until drain removal, days			<0.0001
Mean ± SD	6.24 ± 3.44	3.29 ± 1.34	
Range	2.0–21.0	2.0–10.0	
Drain output, ml			<0.0001
Mean ± SD	609.25 ± 460.21	210.13 ± 152.80	
Range	90.0–2925.0	20.0–735.0	
Hospital stay, days			<0.0001
Mean ± SD	6.69 ± 3.19	3.69 ± 1.36	
Range	2.0–20.0	2.0–10.0	
Emergency department visit, total no. (%)	5 (6.3)	1 (1.3)	NS
Readmission, total no. (%)	2 (2.5)	1 (1.3)	NS
Reoperation, total no. (%)	1 (1.3)	0 (0)	NS

NS, not significant ($p > 0.05$).
*Group A, no preservation of the Scarpa fascia ($n = 80$); group B, preservation of the Scarpa fascia ($n = 80$). The time until drain removal and hospital stay were compared between both groups using the Mann-Whitney U test. The drain output was compared using the t test. The other variables were compared using the χ^2 test.

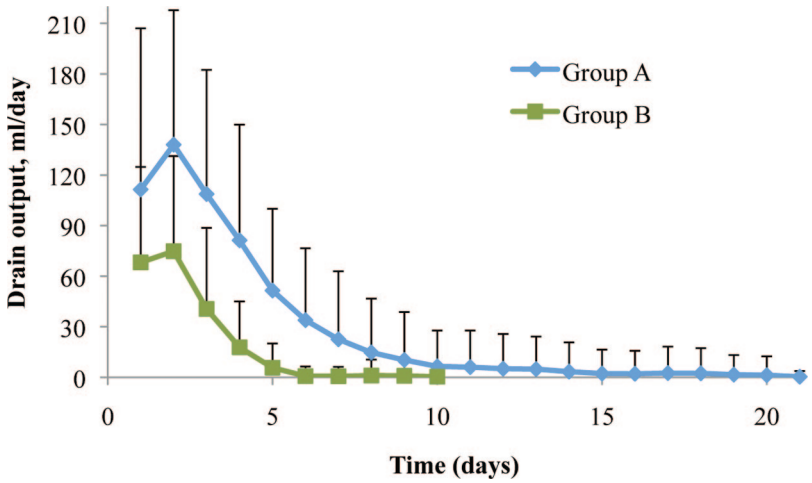

Fig. 1. Average daily drain output (mean ± SD) from group A (no preservation of the Scarpa fascia, $n = 80$), and from group B (preservation of the Scarpa fascia, $n = 80$). Drain outputs were significantly lower in group B from day 1 to day 8 ($p < 0.0000$), day 9 ($p < 0.001$), and day 10 ($p < 0.006$, t test).

significantly lower when the Scarpa fascia was preserved relative to the classic abdominoplasty. This difference was statistically significant on every day from day 1 to day 10. There was a statistically significant difference between group A and group B concerning the time to drain removal (3-day reduction in group B), the total volume of drain output (65.5 percent reduction in group B), and the duration of hospital stay (3-day reduction in group B). The other variables did not differ significantly between groups. A trend was found for a higher incidence of unscheduled hospital visits (emergency room visit), hospital readmission, and reoperation for group A.

Using a more superficial plane of dissection eliminated long periods with suction drains: in group A, 26 patients (32.5 percent) had to use drains for more than 6 days. In group B, only one patient (1.2 percent) had to use drains for more than 6 days (Fig. 2). The systemic and local complications of both groups are summarized in Table 3.

There was a statistically significant difference between group A and group B concerning the seroma incidence. Group B had an 86.7 percent reduction of seroma incidence compared with group A, from 15 occurrences to two ($p = 0.001$). The other variables did not differ significantly between groups, although there was a trend for a higher incidence of complications in group A, namely, blood transfusion, hematoma/bleeding, and infection. Preserving the Scarpa fascia in group B reduced hematoma/bleeding by 80 percent and infection by 83.3 percent. There was also a trend for a higher incidence of healing problems/suture rupture and necrosis in group B.

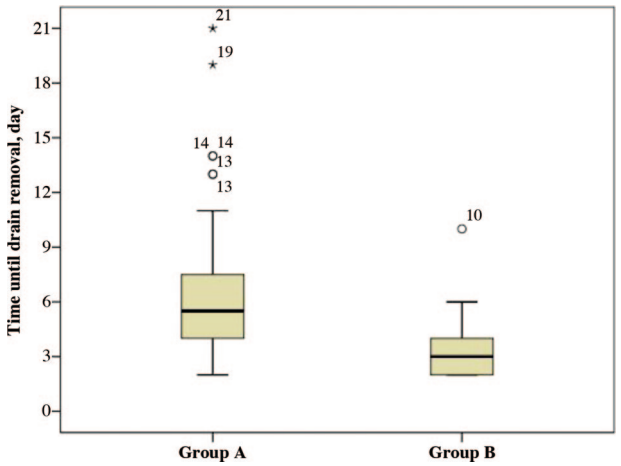

Fig. 2. Box-whisker plot of time until drain removal from group A (no preservation of the Scarpa fascia, $n = 80$), and from group B (preservation of the Scarpa fascia, $n = 80$). The *lower and upper boundaries* of the box indicate the 25th percentile (4 and 2 days for groups A and B, respectively) and 75th percentile (7.75 and 4 days for groups A and B, respectively), the *unbroken line* marks the median, and the *error bars* above and below the box indicate the U1 + 1.5 × IQ and L1 + 1.5 × IQ (where U1 is upper quartile, L1 is lower quartile, and IQ is interquartile range). *Circles* and *asterisks* denote the extreme values. Patients from group B met criteria for closed suction drain removal 3 days earlier than group A ($p < 0.0001$) (Mann-Whitney *U* test). Not significant ($p > 0.05$).

Table 3. Outcomes: Systemic and Local Complications of Both Groups ($n = 160$)*

	Total No. (%)		
	Group A (%)	Group B (%)	*p*
No. of patients	80	80	
Seroma	15 (18.8)	2 (2.5)	0.001
Hematoma/bleeding	5 (6.3)	1 (1.3)	NS
Infection	6 (7.5)	(1.3)	NS
Healing problems/ suture rupture without necrosis	8 (10)	15 (18.8)	NS
Necrosis	0 (0)	2 (2.5)	NS
Blood transfusion	1 (1.3)	0 (0)	NS
Fat embolism	0 (0)	0 (0)	—
DVT/PE	0 (0)	1 (1.3)	NS
Death	0 (0)	0 (0)	—

DVT, deep venous thrombosis; PE, pulmonary thromboembolism; NS, not significant ($p > 0.05$).
*Group A, no preservation of the Scarpa fascia ($n = 80$); group B, preservation of the Scarpa fascia ($n = 80$). The variables were compared between both groups using the χ^2 test.

The majority of complications were managed by observation or treatment in the office and did not require operative intervention. A single case of reoperation occurred, and the reason was an infected seroma in a group A patient. Three patients had to be readmitted to the hospital: two from group A with seromas and one from group B with deep venous thrombosis/pulmonary thromboembolism. Six patients needed unscheduled visits (emergency room): five from group A (four because of seroma, one for infection) and one from group B (deep venous thrombosis/pulmonary thromboembolism). Group A presents a trend for a higher incidence of seromas demanding unscheduled visits, hospital readmission, and ultimately reoperation. It is clinically significant that group B patients did not have any case of fluid collection demanding unscheduled visits, readmission, or reoperation.

The aesthetic evaluations, by the patient and by the physician, are summarized in Table 4. The evaluations were performed in 78 patients from group A and 75 patients from group B (seven patients were lost to follow-up) and did not differ significantly between them.

The aesthetic result evaluated by the patient in group A was as follows: level 1 in zero cases (0 percent), level 2 in zero cases (0 percent), level 3 in six cases (7.7 percent), level 4 in 24 cases (30.8 percent), and level 5 in 48 cases (61.5 percent). The aesthetic result evaluated by the patient in group B was as follows: level 1 in one case (1.3 percent), level 2 in one case (1.3 percent), level 3 in five cases (6.7 percent), level 4 in 23 cases (30.7 percent), and level 5 in 45 cases (60.0 percent).

The aesthetic result evaluated by the physician in group A was as follows: level 1 in zero cases (0 percent), level 2 in one case (1.3 percent), level 3 in three cases (3.9 percent), level 4 in 36 cases (46.2 percent), and level 5 in 38 cases (48.7 percent). The aesthetic result evaluated by the physician in group B was as follows: level 1 in zero cases (0 percent), level 2 in two cases (2.7 percent), level 3 in seven cases (9.3 percent), level 4 in 21 cases (28.0 percent), and level 5 in 45 cases (60 percent).

Table 4. Outcomes: Aesthetic Evaluation of Both Groups ($n = 153$)*

	Group A	Group B	*p*
No. of patients	78	75	
Patient satisfaction, total no. (%)			NS
Level 5	48 (61.5)	45 (60.0)	
Other levels	30 (38.5)	30 (40.0)	
Physician satisfaction, total no. (%)			NS
Level 5	38 (48.7)	45 (60.0)	
Other levels	40 (51.3)	30 (40.0)	

NS, not significant ($p > 0.05$).
*Group A, no preservation of the Scarpa fascia ($n = 78$); group B, preservation of the Scarpa fascia ($n = 75$). The variables were compared between both groups using the χ^2 test.

DISCUSSION

This randomized controlled trial provides evidence that elevating the abdominal flap at the Scarpa fascia level has four clinically important and statistically significant effects, regardless of the surgeon:

1. Drain output is reduced (65.5 percent reduction).
2. Suction drains can be safely removed earlier (3 days earlier).
3. Long periods with suction drains are eliminated (longer than 6 days).
4. Seroma rate is reduced (86.7 percent reduction).

The aesthetic result is not compromised by using this more superficial level of dissection and preserving the deep fat compartment. The other complications did not have statistically significant differences between the groups, but some had clinically important differences, namely, a fivefold higher incidence of hematoma/bleeding and a sixfold higher incidence of infection when the Scarpa fascia is not preserved in group A. There is a trend for a lower incidence of hematoma/bleeding (80.0 percent reduction) and infection (83.3 percent reduction) when the Scarpa fascia is preserved.

The structure of the subcutaneous tissue of the abdominal wall comprises two distinct fat compartments, superficial and deep, separated by the Scarpa fascia.[25–29] The patients from group B had preservation of the Scarpa fascia but also of the deep fat compartment along with its connective tissue, lymphatic vessels, arteries, and veins. This compartment was not modified in group B patients, as opposed to group A patients, in whom it was totally excised. This compartment is probably a key structure to preserve along with the Scarpa fascia, as it is the dominant one that concerns vessels and lymphatics.[3,27] The abdominal wall is considered to have two distinct areas of lymph drainage, defined and divided by a horizontal plane at the level of the umbilicus: the epigastric area drains to the axilla and the hypogastric area drains to the inguinal area.[3,8,27,30] The incision used in group B does not disrupt the connections of the deep fat compartment with the inguinal area. The incision used in group A disrupts all the connections between the two compartments. Another issue to consider is that preservation of the Scarpa fascia may improve the blood supply, as one preserves the superficial epigastric system of blood vessels in the majority of cases. The superficial inferior epigastric artery is known to travel just superficial to the Scarpa fascia and to release small branches to a fascial vascular network contained within the fascia.[31]

From the above, it can be inferred that Scarpa fascia preservation on the infraumbilical area better respects the structure and physiology of the abdominal wall when compared with the classic technique of abdominoplasty. A better capacity to deal with surgical trauma and to eliminate fluid can be expected; however, further studies are needed to corroborate this.

Another aspect to consider is the fact that the physical properties of the opposing healing surfaces are different between both techniques. This may imply a difference in the healing and adhesion process between the surfaces. Apparently, healing and adhesion are facilitated when the Scarpa fascia is preserved. The Scarpa fascia plane of dissection is more difficult to access and not so "clean" when compared with the classic plane of dissection. The Scarpa fascia can easily be disrupted during surgical dissection and, in fact, a surface is created where fascia alternates with fat. This surface will be the foundation for the upper skin flap and globally presents as a well-vascularized tissue. When using the classic technique, the rectus fascia serves as the foundation for the upper skin flap and presents as a glistering white surface. In contrast, the more flexible nature of the deep fat compartment, when compared with the more rigid rectus fascia, may justify a higher resistance to the shearing movements and thus a faster and more efficient adherence and healing. Consequently, we think there are two important points to consider when analyzing possible explanations for the results we obtained: (1) preservation of lymphatic drainage and blood supply of the abdominal wall, and (2) better adhesion between surfaces.

Interestingly, the aesthetic results obtained with both techniques were identical. We expected a worse abdominal contour in the Scarpa fascia preservation group, as the deep fat compartment was preserved, but this was not the case. It must be recalled that there was no volume reduction of the deep fat compartment in our population. The fat deep to the Scarpa fascia is usually thinner than the one superficial to it. The deep fat compartment probably has a minimal contribution to the total abdominal thickness.[32] This can explain a minimal impact of preserving the deep fat compartment on the final abdominal contour and the aesthetic result, but further morphologic studies of the abdominal subcutaneous tissues are needed.

Recent publications provided objective data on the advantages of using a more superficial

Table 5. Studies on Scarpa Fascia Preservation and Abdominoplasty*

	Saldanha et al., 2009[7]	Fang et al., 2010[18]	Costa-Ferreira et al., 2010[17]	Koller and Hintringer, 2012[19]	Present Study
Type of study	Retrospective	Retrospective	Prospective	Prospective	Randomized clinical
Total no. of patients	940	202	208	50	160
No. of patients with Scarpa fascia preservation	446	103	65	25	80
No. of patients with classic abdominoplasty	494	99	143	25	80
Drain volume reduction	NA	NA	58.9% decrease†	Decrease†	65.5% decrease‡
Earlier drain removal	NA	3 days‡	2 days†	Identical (NS)	3 days‡
Seroma	59.6% decrease‡	Decrease (NS)	NA	Decrease†	86.7% decrease†

NS, not significant ($p > 0.05$); NA, not available.
*The criteria for drain removal were the same in all the studies except the one from Saldanha et al. (i.e., 30 ml of aspirate collected in each drain over a 24-hr period).
†$p < 0.001$.
‡$p < 0.0001$.

plane during abdominoplasty. Clinically and statistically significant advantages are presented and summarized in Table 5. More information is needed to clarify the best plane of dissection: the Scarpa fascia level or another one in the thickness of the deep fat compartment.

The present study is the first randomized controlled trial on the subject and presents several clinical and research implications. A modification of the classic plane of dissection of abdominoplasty proved to have a major impact on patient recovery and complications. It is easily introduced into one's practice without interfering with the surgical time or the general principles of the classic abdominoplasty. Scarpa fascia preservation will probably be of additional interest for specific high-risk patients, namely, men,[11] obese patients,[33] and patients with massive weight loss.[15] Further studies are needed to clarify the physiology underlying our findings, namely, the mechanism of the decreased fluid collection. Lymphatic drainage studies on abdominoplasty patients will probably answer the question. As the structure of the subcutaneous tissue seems to be identical in other areas of the body,[29] one wonders whether using a more superficial plane for the dissection in other areas such as the arms or thighs will have the same advantages.

CONCLUSIONS

Based on a randomized prospective trial, our results suggest that preserving the Scarpa fascia during abdominoplasty decreases the time required for suction drains, the total drain output, and the seroma rate when compared with conventional abdominoplasty. The aesthetic result is not compromised by the more superficial plane of dissection.

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Instructions for Authors—*Update*

Ethical Approval of Studies/Informed Consent

Authors of manuscripts that describe experimental studies on either humans or animals must supply to the Editor a statement that the study was approved by an institutional review committee or ethics committee and that all human subjects gave informed consent. Such approval should be described in the Methods section of the manuscript. For studies conducted with human subjects, the method by which informed consent was obtained from the participants (i.e., verbal or written) also needs to be stated in the Methods section.

In those situations where a formal institutional review board process is not available, the authors must indicate that the principles outlined in the Declaration of Helsinki have been followed. More information regarding the Declaration of Helsinki can be found at http://www.wma.net/en/30publications/10policies/b3/index.html (Web site last accessed on September 30, 2010).

CHAPTER IV

Morphometric study (macro and microscopic) of the lower abdominal wall

Morphometric Study (Macroscopic and Microscopic) of the Lower Abdominal Wall

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Background: Abdominoplasty using a more superficial plane of dissection has several advantages. Previous studies described a trilaminar structure (superficial and deep fat compartments separated by the Scarpa fascia) in the lower abdominal wall. This study aimed to gain a clearer understanding of compartment dominance and changes with increasing adiposity.

Methods: The study was performed on the surgical specimens of 41 female patients submitted to a full abdominoplasty. A morphometric study was performed on 82 sides to evaluate the thickness of the fat layers at predetermined locations (point A over the external oblique muscle and point B over the rectus abdominis muscle). A histologic study was performed in 31 samples to analyze the structure of the fat compartments and Scarpa fascia.

Results: A trilaminar structure was always present, and the Scarpa fascia did not become vestigial with increasing adiposity. Total thickness at point B was significantly higher than that at point A; this difference was mainly attributable to the superficial compartment. The deep fat compartment was always thinner than the superficial, corresponding to 25 percent of total thickness in point A and 23 percent in point B. It was less susceptible to an increase in thickness in cases of obesity. Histologic analysis demonstrated constant morphology, with an average Scarpa fascia thickness of 0.29 mm (point A) and 0.28 mm (point B).

Conclusions: This study demonstrates a trilaminar structure with superficial compartment dominance and Scarpa fascia presence irrespective of adiposity in the lower abdominal wall. The deep fat compartment has a minor contribution to the lower abdominal wall thickness. (*Plast. Reconstr. Surg.* 134: 1313, 2014.)

Abdominoplasty is performed with increasing frequency and has undergone a continuous process of evolution to provide better and safer results. Previous anatomical and imaging studies described a trilaminar structure in the abdominal wall: two different fat compartments, superficial and deep, separated by a fascial plane known as the Scarpa fascia.[1–9] Using a more superficial plane of dissection in the infraumbilical area is a recent trend in abdominoplasty and an alternative to the classical plane over rectus fascia. Le Louarn[10] was the first to suggest this possibility with the goal of reducing the seroma rate, but other significant advantages have been recently described,[11] namely, reducing both the total drain output and time to drain removal, eliminating drain usage longer than 6 days.[12–20] Two options are still being considered regarding how to manage the deep fat compartment: to reduce it by liposuction[21] and/or direct fat excision,[14] or simply not to change it.[13,15,17]

Knowledge regarding the contribution of the two fat compartments to abdominal wall thickness along with their variation with increasing adiposity would be useful for defining and validating the best surgical strategy. The fact is that little attention has been paid to the quantitative distribution of fat between the superficial and deep compartments within the subcutaneous tissue of the abdomen. Considerable controversy still surrounds this issue, as contradictory descriptions have been

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published. Some authors argue that the deep fat compartment is dominant in the lower abdomen and that it contributes significantly to the total abdominal wall thickness.[1,2,22] Others defend a minor role of the deep fat compartment.[3,7,23] Previous studies postulate that increasing adiposity correlates with increasing thickness of both the deep fat compartment and the Scarpa fascia, so that the latter becomes a vestigial structure.[1,2] This point of view has been contradicted by other authors who found the Scarpa fascia to be identical in obese and nonobese patients.[8,23] We lack more detailed descriptions of the subcutaneous tissue that will provide answer to these questions and eventually reconcile the conflicting reports.

The present study endeavors to gain a clearer understanding on the topography of the abdominal wall fatty layers in the infraumbilical region and includes two different approaches: gross morphometric analysis and histologic analysis of fresh surgical specimens. For that, the thickness of the two adipose layers is assessed, followed by microscopic evaluation of the surgical specimens to confirm the presence and structure of the Scarpa fascia and to study the organization of the adipose tissue.

PATIENTS AND METHODS

This study was conducted in at the Plastic Surgery Department, São João Hospital-Porto Medical School, Porto, Portugal, from September of 2009 to February of 2012 and was approved by the Ethical Committee of São João Hospital-Porto Medical School. The anatomical study was performed in 82 sides from the surgical specimens of 41 female patients submitted to a classic standard full abdominoplasty (Fig. 1) under general anesthesia (without infiltration or liposuction of the infraumbilical area).

The method of participant recruitment was referral from the primary care provider or direct referral from bariatric consultation. Forty-one consecutive patients who came to the outpatient unit were selected. Eligible participants were all the female patients who presented with abdominal deformities marked by excess abdominal skin and adipose tissue with muscle laxity, who met the criteria for a full abdominoplasty with umbilical transposition (Psillakis types IV and V; Matarasso types III and IV).[24,25] Exclusion criteria were as follows: significantly elevated operative health risks, bariatric patients without weight stabilization for at least 6 months, patients who anticipate future pregnancy, and patients with a body mass index

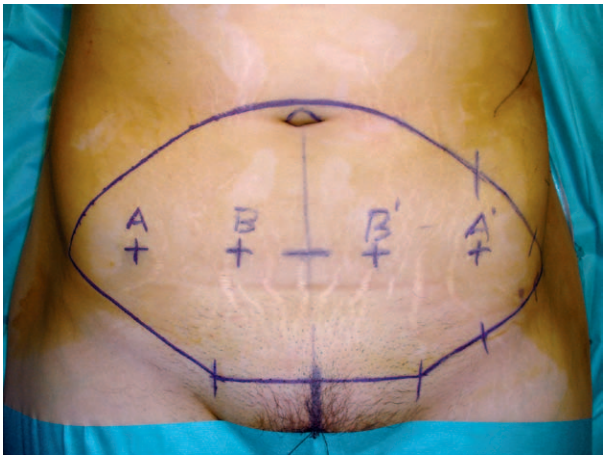

Fig. 1. Detail of the surgical markings and points A, A′, B, and B′.

greater than 30 kg/m^2 except for the ones who had previously undergone bariatric surgery.

The specimens were dissected in the operating room just after the end of the surgical procedure, by the first (A.C.F.) or third author (M.R.). The fat layer thickness was measured at predetermined locations to ensure their correspondence among the specimens. For this purpose, two points were considered: point A and point B (Figs. 1 and 2). Both were located on a horizontal line midway between the umbilicus and the lower pole of the surgical specimen. Point A was located on the junction of the middle to the lateral third of the surgical specimen, corresponding to the anterior projection of the external oblique muscle ("even region") by Avelar[2]; and point B was located 4 cm from the midline, corresponding to the anterior projection of the rectus abdominis muscle ("odd region") by Avelar.[2] Two similar points were considered and marked on the contralateral halve of the specimen and named A′ and B′. Vertical incisions were

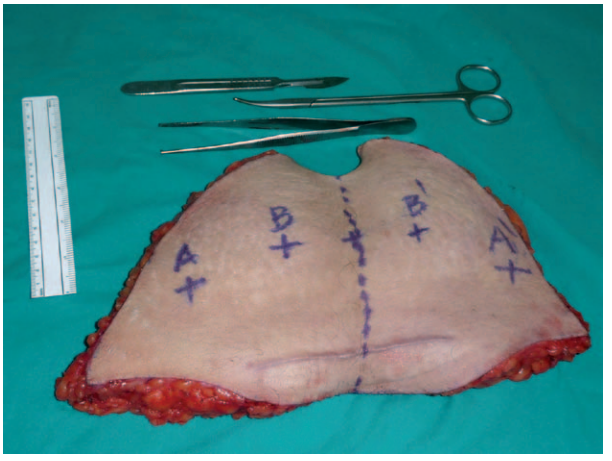

Fig. 2. Surgical specimen and instruments used for the dissection.

Fig. 3. Dissection to expose the Scarpa fascia.

made through the skin and subcutaneous tissue, including each of the four points, and the Scarpa fascia was identified (Figs. 3 and 4). The deep fat compartment was sectioned along the vertical lines (Fig. 5). The layers of fat above and below this fascia were measured at the four predefined locations (A, B, A′, and B′) (Figs. 6 and 7). For the histologic study, two samples of tissue were collected from each surgical specimen ($n = 31$) at points A and B. First specimens were excluded because of the lack of skin, which was essential for the correct anatomical orientation and to maintain the aggregation of each specimen during histologic processing. The tissue samples were 3 × 3 cm and included skin and the total thickness of the abdominal wall. The samples were fixed with 10% buffered formalin and embedded in paraffin. Sections were stained with hematoxylin and eosin and evaluated histologically with the following goals:

1. Evaluate the presence of the Scarpa fascia, defined as a continuous fascial layer in between the subcutaneous fat, with an orientation parallel to the skin surface.
2. Describe the architecture of the fascial layer as lax (split, splintered, with adipose tissue) or compact (well-organized regular structure with no/few/scarce adipose tissue).
3. Measure the thickness of the fascial layer (on a single field, consider the maximum and minimum thickness on a segment with parallel collagen bundles without fat tissue or blood vessels).
4. Verify the classical description of the subcutaneous fat structural organization[1,2] (superficial compartment presenting with fat lobules, small and ovoid contained within organized compact fascial septa oriented perpendicular to the skin; deep compartment presenting with larger fat lobules loosely contained by less organized and more widely spaced fascial septa).

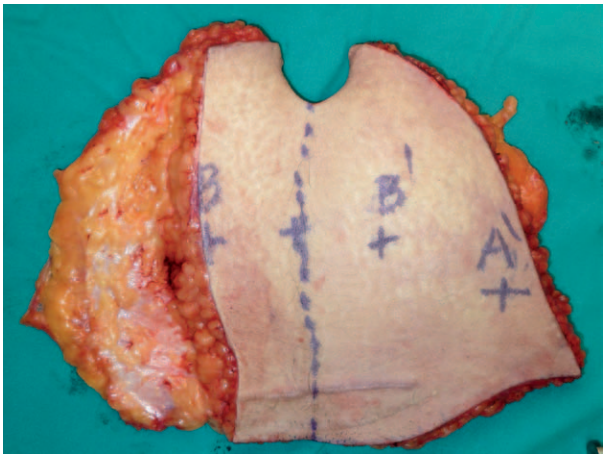

Fig. 4. The Scarpa fascia is exposed.

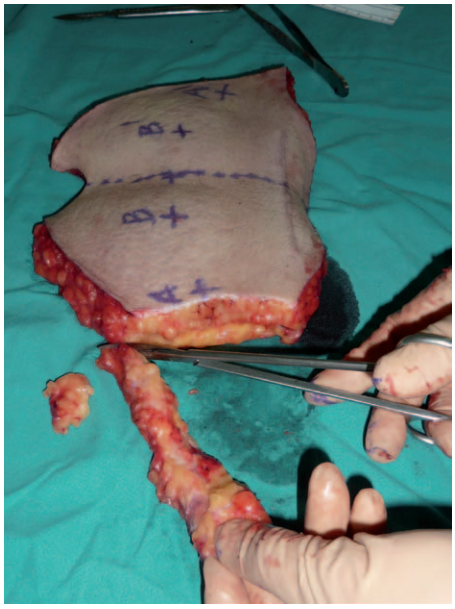

Fig. 5. Section of the deep fat compartment along the vertical line passing through point A.

Statistical Analysis

Statistical analysis was performed using IBM SPSS for Windows Version 21.0 (IBM Corp., Armonk, N.Y.). Descriptive statistical analysis was applied and its normal distribution and homogeneity of variances were checked. The t test was used to compare point A versus point B. One-way analysis of variance, followed by the Tukey multiple range test, was used to test significant differences ($p < 0.05$) among measurements of anterior abdominal wall thickness according to

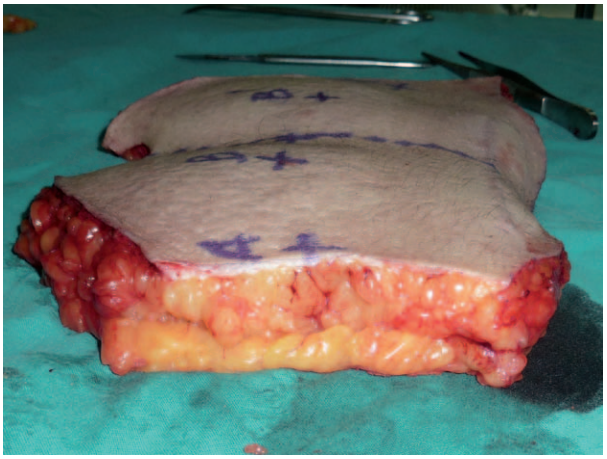

Fig. 6. The superficial and deep fat compartments are visible.

the patient's body mass index. Linear regression analyses were performed to fit total abdominal wall thickness and superficial or deep layer thickness; *t* tests were performed to compare the slopes of the regression equations.

RESULTS

Morphometric Study

The general characteristics of the 41 female patients submitted to full abdominoplasty are summarized in Table 1.

Gross dissection of the subcutaneous adipose tissue of the surgical specimens from the lower abdominal wall demonstrated a prominent continuous fascial plane parallel to the skin (Scarpa fascia) which separated the fat into two distinct layers: a superficial and a deep layer. This fascial plane was present on all the dissected points and was well organized macroscopically. It could be followed as a dissection plane on the full width of the surgical specimen (Fig. 4). This was also true for the specimens from higher adiposity patients.

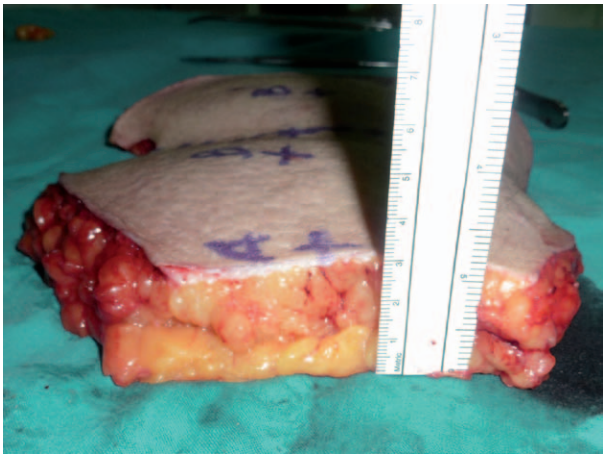

Fig. 7. Measurement of superficial and deep fat compartment thickness at point A.

Table 1. General Characteristics*

Characteristic	Value (%)
Age, yr	
Mean ± SD	41.8 ± 7.4
Range	26–58
BMI, kg/m^2	
Mean ± SD	26.4 ± 3.0
Range	21.0–32.9
No. of previous abdominal operations	35 (85.4)
No. of previous bariatric operations	11 (26.8)
No. of medical comorbidities	9 (22.0)
Weight specimen, g	
Mean ± SD	1167.8 ± 584.1
Range	330.0–2700.0

BMI, body mass index.
*n = 41.

The comparison of the measurements at points A and B is summarized in Table 2. The total thickness at point B was significantly higher than at point A, and this difference was mainly attributable to the superficial compartment, as no statistical differences were observed in the deep compartment thickness between points A and B (Table 2 and Fig. 8). The deep fat compartment had a more uniform thickness than the superficial compartment when both points were considered. The thicker region of the lower

Table 2. Comparison of Measurements of Anterior Abdominal Wall Thickness between Points A and B*

	Point A†	Point B‡	*p*
Full thickness, mm			
Mean ± SD	25.6 ± 8.5	31.1 ± 8.0	<0.001
Range	7.0–41.0	10.0–47.0	
Superficial thickness, mm			
Mean ± SD	19.1 ± 6.6	23.8 ± 6.1	<0.001
Range	6.0–31.0	7.0–35.0	
Deep thickness, mm			
Mean ± SD	6.5 ± 3.0	7.3 ± 3.0	NS
Range	1.0–15.0	2.0–17.0	
Total thickness relative contributions, %			
Superficial			
Mean ± SD	74.8 ± 7.6	76.9 ± 5.9	NS
Range	53.1–90.9	57.9–88.2	
Deep			
Mean ± SD	25.2 ± 7.6	23.1 ± 5.9	NS
Range	9.1–46.9	11.8–42.1	

NS, not significant at $p > 0.05$.
*n = 82. Variables were compared using the *t* test.
†Located at the junction of the middle to the lateral third of the surgical specimen (corresponding to the anterior projection of the external oblique muscle).
‡Located 4 cm from the midline (corresponding to the anterior projection of the rectus abdominis muscle); both points were located on a horizontal line midway between the umbilicus and the lower pole of the surgical specimen.

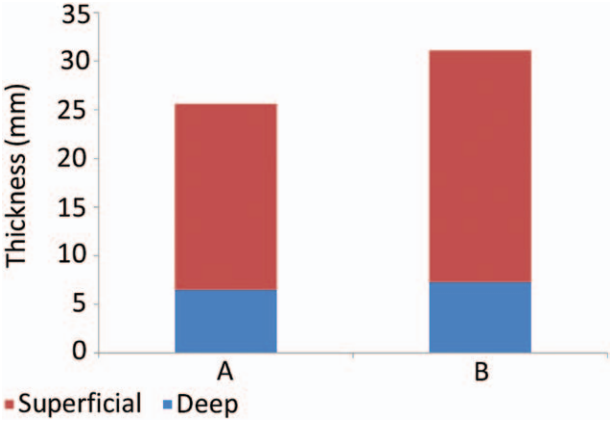

Fig. 8. Representation of mean abdominal wall thickness (in millimeters) and relative contribution (in millimeters) of superficial and deep fat compartments at points A and B ($n = 82$).

anterior abdominal wall was the one over the rectus abdominis muscle, corresponding to point B.

The superficial fat compartment contributed greatly to the overall thickness of the subcutaneous tissue, whereas the deep fat compartment had a minor contribution (Fig. 8). Indeed, the deep fat compartment was always thinner than the superficial fat compartment, corresponding to 25 percent of the total thickness at point A and 23 percent at point B, whereas the superficial fat compartment contributed to 75 percent of the total thickness of the abdominal wall at point A and 77 percent at point B (Table 2).

Table 3 presents our results divided into three groups according to body mass index: normal (<25 kg/m^2), overweight (≥25 and <30 kg/m^2), and obese (≥30 kg/m^2). At point A, the full,

Table 3. Comparison of Measurements of Anterior Abdominal Wall Thickness According to the Patient's Body Mass Index*

	BMI			
	<25	≥25 and <30	≥30	*p*
No.	32	40	10	
BMI				
Mean ± SD	23.4 ± 1.2[a]	27.5 ± 1.3[b]	31.6 ± 0.9[c]	<0.001
Range	21.0–24.8	25.0–29.4	30.2–32.9	
Point A				
Full thickness, mm				
Mean ± SD	18.1 ± 7.7[a]	29.6 ± 4.9[b]	33.5 ± 3.0[b]	<0.001
Range	7.0–35.0	20.0–41.0	28–37	
Superficial thickness, mm				
Mean ± SD	13.7 ± 6.0[a]	22.2 ± 4.6[b]	24.3 ± 3.4[b]	<0.001
Range	6.0–27.0	15.0–31.0	20.0–30.0	
Deep thickness, mm				
Mean ± SD	4.4 ± 2.3[a]	7.5 ± 2.6[b]	9.2 ± 2.3[b]	<0.001
Range	1.0–10.0	3.0–15.0	7.0–14.0	
Total thickness relative contributions, %				
Superficial				
Mean ± SD	75.8 ± 7.8[a]	74.5 ± 7.9[a]	72.4 ± 6.3[a]	NS
Range	56.3–88.5	53.1–90.9	61.1–81.1	
Deep				
Mean ± SD	24.2 ± 7.8[a]	25.5 ± 7.9[a]	27.6 ± 6.3[a]	NS
Range	11.5–43.8	9.1–46.9	18.9–38.9	
Point B				
Full thickness, mm				
Mean ± SD	24.1 ± 6.8[a]	34.7 ± 5.1[b]	39.0 ± 4.0[b]	<0.001
Range	10.0–40.0	21.0–45.0	31.0–47.0	
Superficial thickness, mm				
Mean ± SD	18.7 ± 5.1[a]	26.7 ± 4.5[b]	28.6 ± 2.2[b]	<0.001
Range	7.0–30.0	16.0–35.0	25.0–32.0	
Deep thickness, mm				
Mean ± SD	5.5 ± 2.3[a]	8.0 ± 2.4[b]	10.4 ± 3.6[c]	<0.001
Range	2.0–10.0	4.0–16.0	6.0–17.0	
Total thickness relative contributions, %				
Superficial				
Mean ± SD	77.7 ± 5.4[a]	77.0 ± 5.9[a]	73.8 ± 6.7[a]	NS
Range	67.7–88.2	57.9–87.9	63.8–81.1	
Deep				
Mean ± SD	22.3 ± 5.4[a]	23.0 ± 5.9[a]	26.2 ± 6.7[a]	NS
Range	11.8–32.3	12.1–42.1	18.9–36.2	

BMI, body mass index; NS, not significant at $p > 0.05$.
*$n = 82$. Means in the same row with different superscript letters are significantly different (one-way analysis of variance).

superficial, and deep thicknesses of the overweight and obese were significantly higher than those with normal weight, but the relative contributions were identical. The same applies for point B except for deep fat thickness that significantly increased with the increase of body mass index. All of the patients with a body mass index greater than or equal to 30 had undergone previous bariatric surgery (gastric band or laparoscopic gastric bypass).

A linear regression analysis of individual layer thickness against overall thickness at points A and B is presented in Figure 9. With increasing overall abdominal wall thickness, there was a linear increase of both the superficial and deep fat layer thicknesses. For each point, A or B, the *t* test was used to compare the slope of the two regression lines, indicating that regression slopes of superficial or deep layer thickness versus total thickness were significantly different ($p < 0.001$). This difference in slopes is interpreted as difference in the rate of change (i.e., irrespective of the total thickness of the abdominal wall, the superficial fat compartment thickness will always be higher than that of the deep fat compartment).

Histologic Study

The general characteristics of the 31 female patients submitted to full abdominoplasty that provided the surgical specimens for the histologic study are summarized in Table 4 and the results of the histologic study are presented in Table 5. Similar morphology of the subcutaneous tissue was observed independent of the body mass index (Fig. 10).

Scarpa fascia was not identified in one patient in point A (body mass index, 21; specimen weight,

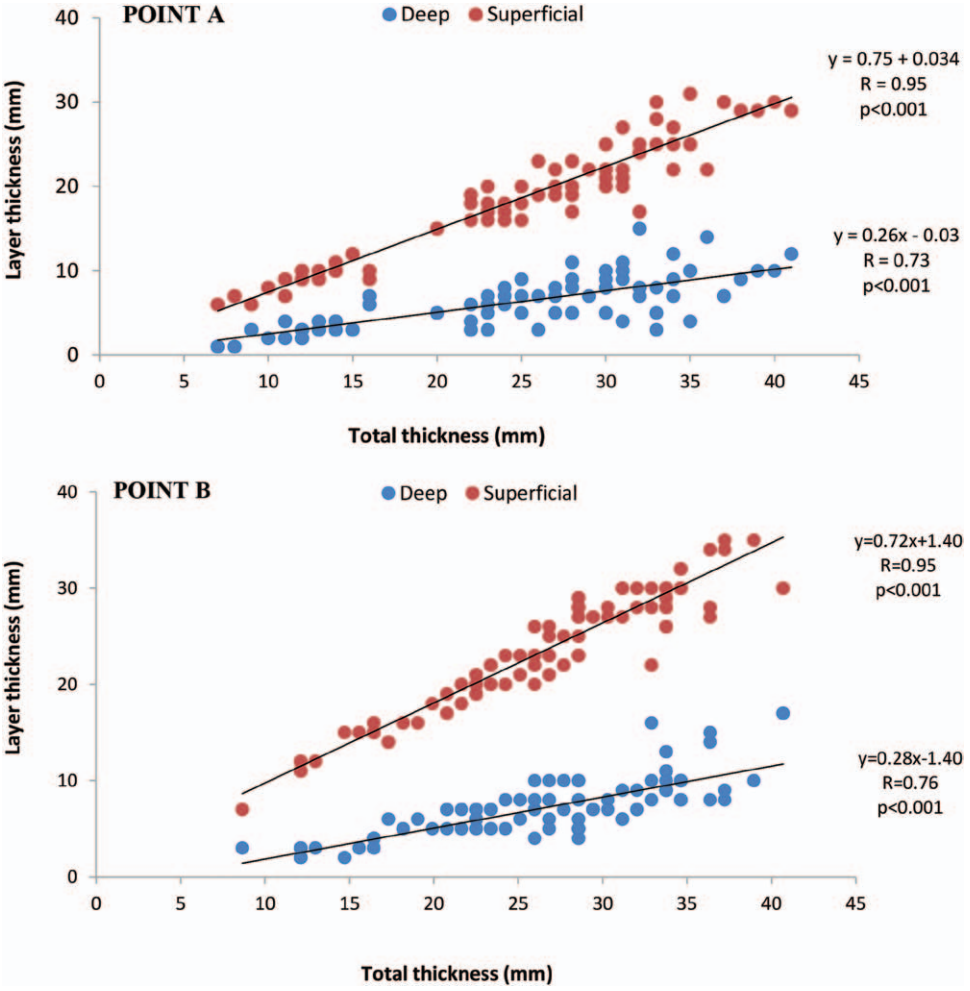

Fig. 9. Linear regression plots of total thickness (in millimeters) versus each layer thickness (in millimeters) at point A ($n = 82$) and point B ($n = 82$). The *t* test was used to compare the two regression lines of each plot, indicating that regression slopes were significantly different ($p < 0.001$). All data in the plot are derived from the present study. Regardless of the total thickness of the abdominal wall, the superficial fat compartment will always be thicker than the deep fat compartment.

Table 4. General Characteristics of Microscopy Study Group*

Characteristic	Value (%)
Age, yr	
Mean ± SD	41.2 ± 7.1
Range	26–57
BMI, kg/m²	
Mean ± SD	25.8 ± 2.9
Range	21.0–32.9
No. of previous abdominal operations	26 (83.9)
No. of previous bariatric operations	7 (22.6)
No. of medical comorbidities	8 (25.8)
Weight specimen, g	
Mean ± SD	1038.7 ± 501.8
Range	330.0–2300.0

BMI, body mass index.
*$n = 31$.

Table 5. Histologic Evaluation of the Surgical Specimens*

	Point A (%)	Point B (%)
Total no. with Scarpa fascia	30 (96.8)	28 (90.3)
Fascia type		
Compact	18 (60.0)	14 (50.0)
Lax	11 (36.7)	12 (42.9)
Mixed	1 (3.3)	2 (7.1)
Fascia thickness, mm		
Mean ± SD	0.29 ± 0.11	0.28 ± 0.11
Range	0.10–0.50	0.10–0.50
No. with classical subcutaneous structure	29 (96.7)	27 (96.4)

*$n = 31$.

620 g) and in three patients in point B (body mass index, 26.9, 24.1, and 23.2; specimen weight, 1010, 700, and 330 g). All of these patients were submitted to previous abdominal surgery and none was from the group with higher body mass index or heavier specimens. In all of these cases, it was possible to identify the Scarpa fascia macroscopically and to measure the superficial and deep fat compartments. The Scarpa fascia with compact morphology was the most frequent, averaging 55 percent of the total cases. The average Scarpa thickness was 0.29 mm for point A and 0.28 mm for point B. The classic description by Markman and Barton[1] and Avelar[2] was confirmed except for the cases previously mentioned and another one (body mass index, 26.1; specimen weight, 1300 g).

DISCUSSION

It has been proposed that by elevating the abdominal flap on two different surgical planes, the Scarpa fascia and the deep fat compartment can be preserved in the infraumbilical area and complications that arise during conventional abdominoplasty can be reduced.[10,17] Further advantages have been reported, but there is no agreement on the best way to deal with the deep fat compartment (i.

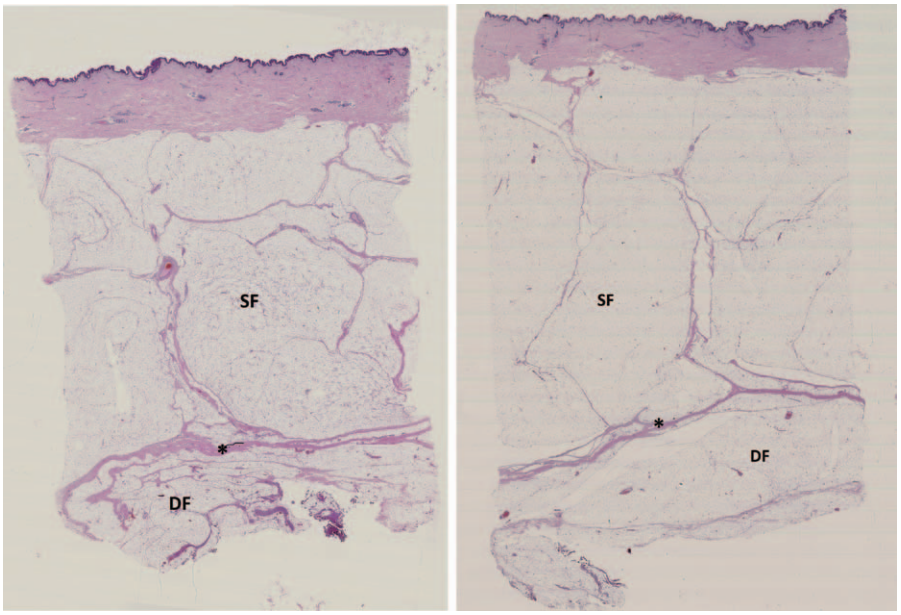

Fig. 10. Histologic image of a cross-section of the lower abdominal wall (hematoxylin and eosin, original magnification ×0.25) from (*left*) a normal patient (body mass index, 24; surgical specimen weight, 640 g; compact fascia with 0.4 mm thickness) and (*right*) an overweight patient (body mass index, 29; surgical specimen weight, 1050 g; fascia of mixed morphology with 0.3-mm thickness). *SF*, superficial fat; *DF*, deep fat; *asterisk*, Scarpa fascia.

e., to reduce it or not). This morphometric study of the subcutaneous tissue from the lower abdominal wall provides evidence that:

1. A trilaminar structure is always present.
2. The thicker region is the one over the rectus abdominis muscle and the difference is mainly attributable to the superficial compartment.
3. The deep fat compartment has a minor contribution to the overall thickness, less than 25 percent of the total thickness.
4. The deep fat compartment is less susceptible to increase in thickness in cases of overweight/obesity compared with the superficial compartment.
5. The Scarpa fascia is always present and does not become vestigial with increasing adiposity.

There are few studies on the structure of the subcutaneous tissue of the abdominal region, and the most are based on cadaver dissection or imaging analysis. Our study is the first to be based on fresh surgical specimens from a full abdominoplasty, adding a different type of data. The trilaminar structure and the different organization of the superficial and deep fat compartments were found to be in accordance with the classic descriptions by Markman and Barton, Avelar, and Lockwood.[1,2,26] Some differences were noted concerning compartment dominance and changes with increasing adiposity. Markman and Barton studied the subcutaneous tissue by dissecting eight fresh and 10 embalmed cadavers and analyzing computed tomographic scans. In the abdomen, the thickness of the fat layers was measured (n = 8) at a point 7 cm lateral to the umbilicus.[1] The deep fat compartment had a major contribution to the overall thickness of the abdominal subcutaneous tissue and overall body contour, being the dominant compartment.[1] The profile of this population was not presented, namely, age, sex, height, weight, or body mass index. Avelar was the first to publish information regarding the structural changes of the subcutaneous tissue with increasing adiposity.[2,17] According to this author, thin patients have dominant superficial compartments, whereas in fat patients, the deep fat compartments from the odd regions (medial regions: epigastric, umbilical, and hypogastric) increase their thickness much more than the superficial fat compartments and become dominant. The even regions (hypochondriac, lumbar, and inguinal) in fat patients preserve the same proportion observed in thin patients.[2] This author also observed that the subcutaneous fascia consists of several layers that become separated by adipose tissue with increasing adiposity.[2] Lockwood, based on a study of 12 fresh and embalmed cadavers, also described the same structure of the subcutaneous fascia (i.e., multilayered) and the same alterations with increasing adiposity.[26] Alexander and Dugdale used ultrasound to investigate the subcutaneous fat of the abdominal wall from 17 women attending a weight-control group over a 12-month period.[22] They concluded that the thickness of the superficial layer remained relatively constant over a wide range of body adiposity, and nearly all changes in the subcutaneous adipose tissue were caused by changes in the deep layer. The measurements showed the proportion of thickness of the deep fat to the superficial fat to be almost 4:1.[22] No data were presented on the general characteristics of the population (i.e., body mass index).

Recent publications presented data suggesting a minor role for the deep fat compartment on the lower abdominal contour, in accordance with our findings.[3,7,8,23] Johnson et al. performed computed tomographic scanning on 20 female patients and measured the thickness of the adipose compartments at the level of the umbilicus 5 cm from the midline[3,23] and verified a dominance of the superficial compartments: 67 to 37 percent (percentage of total fat thickness occupied by superficial and deep fat compartments, respectively).[3] The subcutaneous fascia was easily identified in a wide range of adiposity.[23] Worseg et al. performed anatomical dissections of 27 fresh cadaver specimens and computed tomographic and ultrasound studies in 13 healthy volunteers and three cadavers. They also conducted histologic examination of Scarpa fascia and concluded that it was identical in obese and nonobese patients. Thickness measurements of the superficial and deep fatty tissue were performed on computed tomographic scans (n = 16) and confirmed a predominance of the superficial compartments in the anterior abdominal wall.[8] Harley and Pickford published their work based on computed tomographic analysis of fat distribution in the mid and lower abdomen in 69 women.[7] The measurements were taken immediately superior to the umbilical dimple and at the superior margin of the mons pubis. The relative thickness of the superficial and deep fat compartments demonstrated a predominance of the former. At mid and lower levels, the superficial layer was thicker than the deep layer, but a greater contribution from the deep layer was seen in the mid (43 percent total thickness) than in the lower

(19 percent) abdomen.[7] In the lower abdomen, as the overall thickness increases, the contribution from the superficial layer increased at a higher rate than that of the deep layer. In the mid abdomen, the increase rate was identical for both compartments. The deep fat compartment was never dominant and the Scarpa fascia did not become vestigial with increasing adiposity. When we consider our results along with the ones from Harley and Pickford, it seems that superficial compartment dominance is accentuated from the umbilicus to the mons pubis.

The present recommendations for the infraumbilical dissection on a full abdominoplasty are to avoid the classic plane over the rectus fascia and to use a more superficial dissection over the Scarpa fascia.[11,27,28] This study provides evidence that, regardless of body mass index, the superficial fat compartment is largely dominant, indicating that leaving the Scarpa fascia and the deep fat compartment intact during an abdominoplasty will probably have a minimal impact on the abdominal contour. This is a relevant finding, as it is another argument in favor of surgical options directed to fully preserve both structures.

Further investigation of the physical properties of the Scarpa fascia is needed, namely, tensile strength. The population of our study did not accurately represent obese patients (body mass index ≥30), as the latter had all been submitted to previous bariatric surgery known to modify the structure of the subcutaneous tissue.[29,30] It would be interesting to study the structure of the subcutaneous tissue in obese persons (without previous bariatric surgery) and in male patients. Our study was conducted in female patients and thus the findings apply to women. Similar structure may be found in male patients, but we do not have data to validate that statement. Male patients,[31] obese patients,[32] and patients with massive weight loss are known to be high-risk patients for abdominoplasty; thus, knowing its specific structural characteristics would be important.

CONCLUSIONS

The results of this morphometric study demonstrate a trilaminar structure with superficial compartment dominance and Scarpa fascia presence irrespective of the adiposity degree in the lower abdominal wall. The deep fat compartment has a minor contribution to the lower abdominal wall thickness. Based on this evidence, the authors recommend that surgeons consider performing abdominoplasties using a more superficial plane of dissection in the infraumbilical area, with total preservation of the Scarpa fascia and the deep fat compartment.

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CHAPTER V

Other Publications

Scarpa Fascia Preservation During Abdominoplasty: What's the Point?

Joana Costa, MD; António Costa-Ferreira, MD; Marco Rebelo, MD; Rita Valença-Filipe, MD; Jorge Reis, MD; Álvaro Silva, MD; Jose Amarante, MD PhD.

INTRODUCTION: Abdominoplasty is one of the most popular body-contouring procedures. Previous studies described a superficial and deep compartment in the lower abdominal wall separated by Scarpa fascia.[1,2] Preservation of this fascial plane has been suggested as a way to lower the complication rate associated with conventional abdominoplasty.[3,4] The purpose of this study was to evaluate the effect of preservating Scarpa Fascia during a full abdominoplasty.

METHODS: A prospective study was perfomed, between November 2005 and November 2007, involving patients submitted to abdominoplasty, at the Department of Plastic Surgery of São João Hospital, Porto Medical School. Two groups of patients were created: classical full abdominoplasty (group A) and full abdominoplasty with preservation of Scarpa fascia in the infra-umbilical region (group B) (Figure 1)[4]. The variables analyzed were: age, body mass index (BMI), previous abdominal surgery, comorbid medical conditions, specimen weight, time to suction drain removal, total volume of drain output and length of hospital stay. T-student and Mann-Whitney test and $\chi 2$ test were used.

RESULTS: A total of 208 full abdominoplasties were performed (group A, 143 patients; group B, 65 patients). There were no statistically differences between groups respecting BMI, previous abdominal surgeries, comorbid medical conditions or surgical specimen weight ($p>0.05$). There were statistically significant differences respecting total volume of drain output ($p<0.001$), time to drain removal ($p<0.001$) and hospital stay duration ($p<0.001$) (Table 1). The group with preservation of Scarpa fascia had an average reduction of the amount of drain output of more than 50% and an average reduction of 2.0 days on time to drain reduction and 1.9 days on hospital stay, when compared to the other group.

CONCLUSION: Preservation of Scarpa fascia during abdominoplasty has a beneficial effect on patient recovery, reducing total drain output, time to drain removal and hospital stay.

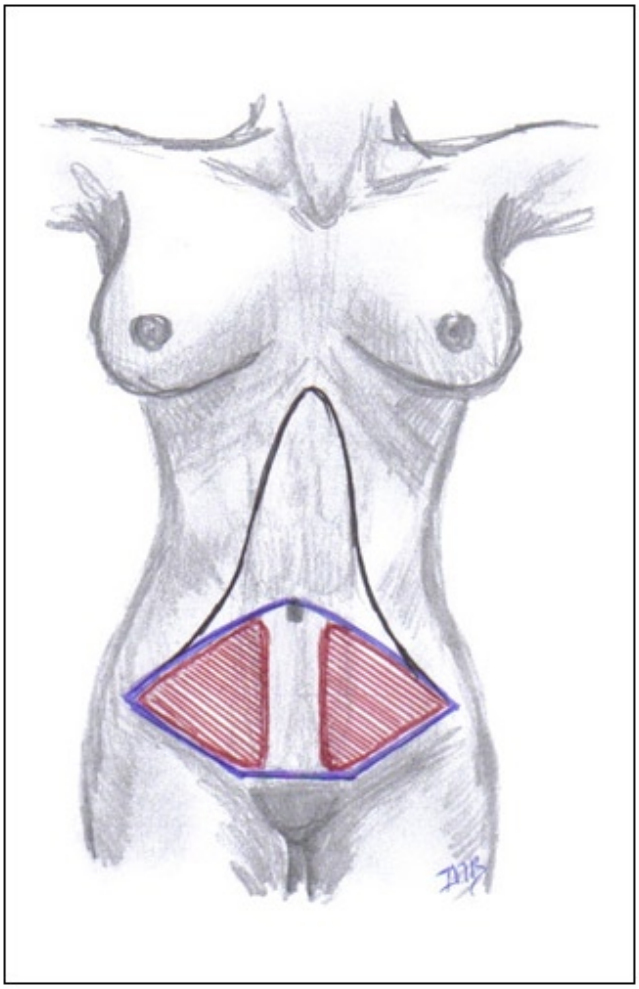

Figure 1. Dissection planes in abdominoplasty with Scarpa fascia preservation. The *blue line* represents the skin resection pattern. The *black line* limits the area to be undermined. The dissection is performed on the plane of the deep fascia except for the areas within the *red line*, which correspond to dissection on the plane of the Scarpa fascia.

	Group A (n=143)	Group B (n=65)	p-value
Age, years Mean (Range)	41.1 ± 8,96 (24.0 - 65.0)	37.8 ± 6,87 (22.0 - 54.0)	0.009
Body mass index, Kg/m2 Mean (Range)	27.89 ± 4,19 (19.1 - 39.3)	26.63 ± 4,72 (19.7 - 43.0)	NS p>0.05
Previous abdominal surgeries Total number (%)	93 (65%)	42 (64.6%)	NS p>0.05
Specimen weight, gr Mean (Range)	1250.4 ± 636,5 (190-3050)	1153.0 ± 873,2 (250-6000)	NS p>0.05
Time to drain removal, day Mean (Range)	5.14 ± 3,08 (2.0 - 22.0)	3.17 ± 1,42 (2.0 - 9.0)	< 0.001
Drain output, cc Mean (Range)	523.11 ± 521,61 (80 - 3615)	214.85 ± 201,75 (5 - 1225)	< 0.001
Hospital stay, day Mean (Range)	6.8 ± 3,24 (3.0 - 26.0)	4.91 ± 1,70 (3.0 - 11.0)	< 0.001

Table 1. General characteristics and results of both groups, n=208. (NS: Not significant)

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Quill™ Barbed Suture in Body Contouring Surgery: A Six Year Comparison Study with Running Absorbable Braided Sutures

Dennis J. Hurwitz, MD, FACS; Brian Reuben, MD

INTRODUCTION: Expecting superior performance and speed (1, 2), a University of Pittsburgh plastic surgeon started in 2007 to close body contouring wounds with Quill™ barbed suture. Improved technique and inclusion of Monoderm reduced complications and improve retention (3). A contrary view has been published (4).

METHODS: This single surgeon six year clinical review compares two similar groups of body contouring patients' suture closed with two layers with the deep layer absorbable barbed (Quill™, Angiotech, Vancouver, Canada) or braided running sutures (Polysorb™, Covidien, Mansfield, Massachusetts). Relevant information was acquired from operative reports, clinical notes and photographic achieves of 360 consecutive patients. Total operative times were compared. The healing complications were documented as complications per suture line. Severity of complications was progressively graded 1, 2 and 3.

RESULTS: There were a total of 950 procedures with 1,590 suture lines at risk for wound related complications in 360 patients. (Table 1) 132 patients were closed with a deep running layer of Polysorb and 228 patients were closed with a deep running layer of PDO Quill. There were less overall wound complications in the Quill™ group when compared to the running Polysorb™ group ($p<0.05$). Evaluation of the differences in complications by multivariable logistical regression controlling for ancillary surgical procedures, Quill™ was associated with significantly less complications. Total minor, moderate and severe wound complications between our sub-groups of massive weight loss versus non-massive weight loss patients were more for the massive weight loss ($p<0.05$). Dividing the total operative time by the number of suture lines for Quill™ the time was 72.45 minutes and Polysorb™ the time was 68.58. There was no difference between the times ($p=0.63$).

account for an increased propensity for wound healing problems.[1] A deep fascial repair is needed to anchor the flap inferiorly and prevent upward migration of the scar and the hair-bearing mons pubis (Fig. 1). The key to patient satisfaction is not the length of the scar but its vertical level. If the scar is kept within the bikini line, patients report low rates of scar dissatisfaction (4.3 percent).[3] A flexed position of the operating table (not so much "beach chair" as "jackknife") is essential to allow a secure deep fascial repair and keep the scar low.

Seromas can be a source of frustration for the patient and surgeon. The remedy is not particularly difficult but does involve changing a surgical habit. Reducing the need for seroma treatment would seem to justify such a change. There is no need to adopt a different dissection plane that creates aesthetic compromises. The goal is to reduce the risk of complications while maintaining an optimal aesthetic result.

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DISCLOSURE

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Reply: Scarpa Fascia Preservation during Abdominoplasty: Randomized Clinical Study of Efficacy and Safety

Sir:

We appreciate the letter by Dr. Swanson and would like to thank him for his comments and criticisms on our article.[1] First, we would like to clarify that our randomized controlled trial provided more than one statistically significant conclusion. When Scarpa fascia was preserved during an abdominoplasty, (1) the seroma rate and drain output were reduced (86.7 percent and 65.5 percent reduction, respectively); (2) suction drains could be safely removed earlier (3 days earlier, using the criteria of 30 ml collected over a 24-hour period on each drain); and (3) long periods with suction drains were eliminated (longer than 6 days).

The aesthetic result was not compromised by using this more superficial plane of dissection. We reported a prospective quantitative evaluation (using Likert scales) of the aesthetic results of both groups with regard to the following: overall contour, volume of subcutaneous tissue, and excess of skin (the scar quality was not considered). This evaluation was performed by both physicians and patients, 6 months after surgery. Our randomized controlled trial clearly demonstrates that "stacking the fascial layers" did not result in any significant aesthetic difference between the groups. There is no reason to expect that preserving Scarpa fascia may create aesthetic compromises. Before-and-after photographs would not add new data to this evaluation but would probably make the article more "appealing." The *Journal*'s space constraints limited the data and images we could include in our article. Interestingly, Dr. Swanson did not include any before-and-after photographs in his article on abdominoplasty,[2] possibly due to the same space constraints.

We consider that Dr. Swanson does not perform a traditional abdominoplasty for the following reasons: use of a vasoconstrictive solution, liposuction of the upper abdominal flap, and use of a more superficial plane of dissection. In his article, Dr. Swanson describes "scalpel dissection, preserving an areolar tissue layer and some fat on the abdominal wall."[2] These deviations from the traditional technique could explain his low seroma rate of 5.8 percent.

Dr. Swanson's seroma rate must be considered with caution. His study survey was based on the patient's own assessment of outcomes and complications. Our prospective randomized outcome study was performed by physicians who examined and evaluated each patient. A measurement bias is probable. Patients are not trained to self-diagnose seromas, and subclinical seromas could have been missed. The latter will only be diagnosed by a focused physical examination performed by a surgeon, as was the case in our randomized controlled trial. This hypothesis is supported by Dr. Swanson's statement in his article, "Patients reported only four seromas. However, there were in fact nine seromas, all after lipoabdominoplasty or abdominoplasty."[2]

We should continue pursuing validation studies with high levels of evidence with the objective of making abdominoplasty a safer procedure. The method used for undermining (scalpel versus electrocautery) has been implicated in the seroma rate. To the best of our knowledge, strong scientific evidence in favor of

either option during abdominoplasty is still needed. Dr. Swanson believes that greater electrodissection during flap elevation increases the seroma rate and that this is sufficient to explain the results of our study. A reference was presented but it does not validate this idea.[3] Actually, the cited article provides valuable information on the association of flank liposuction and abdominoplasty but none on blade/electrodissection.

Changing the level of dissection to a more superficial plane has also been suggested as a way to lower the seroma rate after an abdominoplasty. Claude Le Louarn was the first to suggest this,[4] but other authors further applied this principle and published their clinical experience[5–9] or prospective studies.[10,11] Some differences do exist among the cited authors, on the surgical plane used (Scarpa level or in the middle of the deep fat compartment) and on the surgical manipulation of the deep fat compartment (with or without liposuction). A question still remains: what is the best plane of dissection in the infraumbilical area? Is it over Scarpa fascia, or is it another one in the thickness of the deep fat compartment (like the one Dr Swanson used)? Certainly, it is not the one over the rectus fascia used on a classical abdominoplasty. Scarpa fascia and the deep fat compartment are not superfluous tissues, as their preservation during abdominoplasty carries several advantages. Lower drain volumes, faster drain removal, and avoidance of "long drainers" are probably clinically very significant advantages besides a lower seroma rate. There are enough scientific data to recommend a more superficial plane of dissection during abdominoplasty.

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DISCLOSURE

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The Influence of Procedure Delay on Resource Use: A National Study of Patients with Open Tibial Fracture

Sir:

We read with interest Sears et al.'s work on the influence of procedure delay in patients with open tibial injuries in the United States.[1] The authors are to be commended regarding the large sample size of their study, which included 7029 patients from 332 hospitals in the United States. Their study is one of the first to quantify how more timely initiation of care for open tibial fractures lowers cost and shortens length of stay.

However, we were surprised that the authors did not cite or comment on the first major work on early microsurgical reconstruction of the extremities by Marko Godina.[2] This study has served as the basis for much of the philosophies of complex lower limb management. Godina reviewed 532 lower limb injuries that underwent microsurgical reconstruction. He divided the procedure delay into three groups for the purpose of his analysis. Group 1 (early) underwent débridement and flap transfer in 72 hours; in group 2 (delayed), between 72 hours and 3 months of injury; and finally in group 3 (late), between 3 months and 12.6 years. The groups were evaluated by the following criteria: "free flap failure rate, postoperative infections,

CHAPTER VI

General Discussion and Conclusions

General Discussion and Conclusions

Scarpa fascia is ignored in the classical descriptions of the abdominoplasty surgical technique (15-20). The simple suture of Scarpa fascia during the closure of an abdominal operative wound seems to be advantageous but is normally ignored (76, 77, 86). Lockwood (77) presented three important advantages from repair of Scarpa fascia prior to skin closure during an abdominoplasty: superior displacement of the pubic hair is prevented; tension on the skin flap closure is reduced which may help decrease skin necrosis; late suprapubic scar depression is eliminated. Another role for Scarpa fascia during a full abdominoplasty has been suggested by Le Louarn (81, 83, 87), Vásconez (38, 84, 88) and Saldanha (37). These authors proposed a different approach from the classical abdominoplasty technique by suggesting that the abdominal flap should be elevated on two different surgical planes: in the supraumbilical region, a premuscular plane as in a traditional abdominoplasty; in the infraumbilical region, a more superficial plane which preserves Scarpa fascia and/or the deep fat compartment. The main argument for this dual plane abdominoplasty was a reduction of seroma rate. Objective evidence regarding the advantages of this strategy is lacking. One of the main goals of this investigation was to perform prospective clinical studies on this subject. Another goal was to gain a clearer understanding of the anatomy of the subcutaneous tissue of the lower abdominal wall, more specifically, investigate compartment dominance and changes with increasing adiposity. The controversy surrounding this issues needs to be clarified as this will have a positive impact on body contour surgery of the abdomen.

ANATOMICAL STUDIES (OBJECTIVES 1 AND 2)

The morphometric study (objectives 1 and 2) of the subcutaneous tissue from the lower abdominal wall provides evidence that:

1. A trilaminar structure is always present (two different fat compartments separated by Scarpa fascia)
2. The thicker region is the one over the rectus abdominis muscle and the difference is mainly due to the superficial compartment (Chapter IV, fig 8)
3. The deep fat compartment has a minor contribution to the overall thickness, less than 25% of the total thickness

4. Irrespectively of the total thickness of the abdominal wall the superficial compartment thickness is always higher than the deep fat compartment (Chapter IV, fig 9)
5. As the overall thickness of the abdominal wall increases, the contribution from the superficial layer increases at a higher rate than that of the deep layer (Chapter IV, fig 9)
6. The deep fat compartment is less susceptible to increase in thickness in cases of overweight/obesity when compared to the superficial compartment (Chapter IV, table 3)
7. Scarpa fascia is always present and does not become vestigial with increasing adiposity.
8. Scarpa fascia has a predominant compact morphology (well organized regular structure with no/few/scarse adipose tissue) mainly in point A
9. Scarpa fascia average thickness is 0.29 mm in Point A and 0.28 mm in Point B.
10. The classical description of the subcutaneous tissue structure is present in more than 96 % of the cases:
    a. The superficial compartment presents with fat lobules contained within organized compact fascial septa orientated perpendicular to the skin
    b. The deep fat compartment presents with fat lobules loosely contained by less organized and more widely spaced fascial septa.

This was the first study addressing the anatomy of the subcutaneous tissue of the lower abdominal wall that is based on fresh surgical specimens from abdominoplasty. One should also consider the high number of enrolled patients and the precise knowledge of their clinical profile as important advantages of this study. The anatomical study was performed in 82 sides from the surgical specimens of 41 female patients. Both sides were studied following the same methodology used by other authors who also performed anatomic and/or imaging studies in the abdominal wall (59, 61, 68, 79, 89). The histologic study was done from the surgical specimens of 31 patients. The first cases were not included due to difficulties in tissue processing for histological study. From the first samples we verified that it was essential to include the skin along with the total thickness of the subcutaneous tissue. The presence of skin was essential for the correct anatomical orientation and to maintain the aggregation of each specimen during histological processing.

The trilaminar structure and the different structural organization of the superficial and deep fat compartments were found to be in accordance with the classical descriptions by Markman, Avelar and Lockwood (59, 60, 77, 78). Nevertheless, some differences were noted concerning compartment dominance and changes with increasing adiposity which are in contradiction to the results reported before 1992 by Markman (59), Avelar (60, 78) Lockwood (77) and Alexander (79). These studies presented deep fat compartment dominance and vestigial Scarpa fascia with increasing adiposity but enrolled a small number of cases, employed different experimental designs and included study populations without a known clinical profile. The fact is that weight, height, body mass index, gender, age, previous surgeries or medical comorbidities were not known. Consequently comparing the results of these studies is difficult. Considering the study by Markman (59), abdominal subcutaneous compartment dominance was evaluated in 8 cadavers in a different area of the abdominal wall when compared to our study. Thickness measurements were made on the mid-abdomen, more precisely 7 cm lateral to the umbilicus and the profile of this study population was not presented. The more relevant data would be the body mass index and this was not available. A similar problem exists on the studies by Avelar (60, 78), i. e. small sample size, insufficient data on the study population, no definition on the location of the measurement points. Nevertheless Avelar devoted considerable time to investigate the subcutaneous tissue changes with adiposity. This author was the first to publish on this subject and presented the concept of deep fat compartment dominance with increasing adiposity in the odd regions of the abdomen. The study population data on which Avelar based his concepts was not presented with sufficient detail for us to compare the results (60, 78). Avelar (78) performed cadaver dissections on 18 adults from which he considered two groups presenting similar height, more specifically 1,65 m (table 4): Group A (thin) presented weight of 58 Kg, body mass index of 21, superficial compartment thickness of 8 to 12 mm, deep fat compartment thickness up to 5 mm; Group B (fat) presented weight of 85 Kg, body mass index of 31, and the relative thicknesses - from the odd regions - were for the superficial compartment 14 to 20 mm and for the deep compartment from 32 to 45 mm. The total number of adult cadavers included in either group A or group B was not presented. The thickness values presented for either group are very different from the ones found in our investigation. Another important aspect to consider is that our study population has a considerable small amount of patients in the obese range. We studied 10 sides from 5 patients with body mass index ≥ 30. These 5 patients had all been submitted to bariatric surgery and had experienced a massive weight loss: 1 patient had been submitted to gastric bypass and had lost 31 Kg; 4 patients had been submitted to gastric band and had lost respectively 22, 23, 31 and 38 Kg. Our study population does not represent accurately patients with body mass index ≥ 30 without bariatric

surgery. Our results are not sufficient to question the Avelar concept of changes in the subcutaneous structure in the odd regions verified in obese patients. Nevertheless our results suggest a tendency for deep fat compartment thickness increase in point B in obese patients that is not present in point A, but this was not sufficient to achieve deep fat compartment dominance as postulated by Avelar.

According to the studies and publications by Avelar (60, 78) and by Lockwood (77), the anatomy of the superficial fascia varies significantly as the level of adiposity increases.

On the contrary, studies published after 1992 by Johnson (61, 80), Worseg (66) and Harley (65), are in accordance with our results suggesting superficial compartment dominance, minor role to the deep fat compartment on the lower abdominal contour and no changes in Scarpa fascia structure with increasing adiposity. It is a fact that this studies also present different experimental designs when compared to ours as they are based on image analysis, cadaver dissections or both. Nevertheless, these more recent studies enrolled high numbers of patients and used detailed experimental designs. The investigation conducted by Worseg (66) was very comprehensive as it included image studies, cadaver dissection and inclusively histologic studies. Johnson (61, 80) and Harley (65) published the results of very well designed image studies performed in CT scans of female patients. All together, these studies provide considerable scientific information in favor of superficial compartment dominance in the lower abdomen and identical Scarpa fascia structure on a wide range of adiposity. The deep fat compartment was never dominant and Scarpa fascia did not become vestigial with increasing adiposity.

Looking specifically at the results of the studies by Johnson (61, 80), Harley (65) and ours we can say that the superficial compartment dominance is accentuated from the umbilicus to the mons pubis (fig. 9). In the mid-abdomen, more precisely at the level of the umbilicus, the superficial compartment responds for 67 % of the total thickness (5 cm from the midline) in the studies by Johnson (61, 80) and 57 % (in the midline) in the studies by Harley (65). In our study we found a superficial compartment dominance, in the mid-level between the umbilicus and the mons pubis, corresponding to 77 % at 4 cm from the midline over rectus muscle and 75 % over the external obliqus muscle. The studies by Harley (65) presented a superficial compartment dominance in the inferior abdomen at the level of the mons pubis corresponding to 81 % measured on the mid-line.

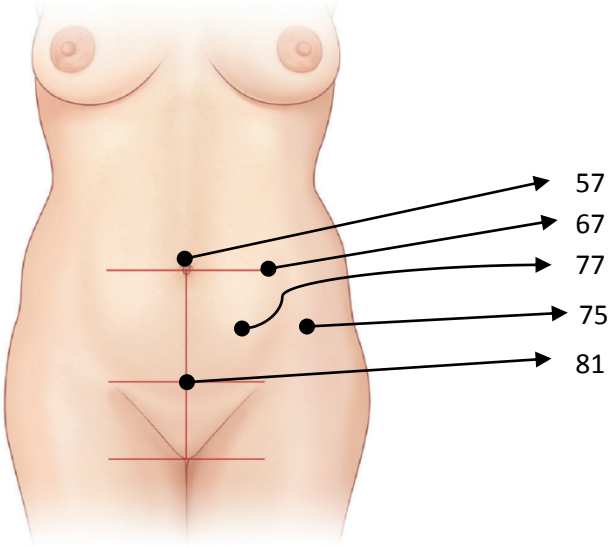

Fig 9. Superficial compartment dominance in the lower abdomen. The values represent the superficial compartment contribution (%) to the total abdominal thickness. Data from the studies by Johnson (61,, 80), Harley (65) and ours.

One of the conclusions of our study is the constant presence of Scarpa fascia irrespective the adiposity or BMI. Further clarification on the cases without Scarpa identification in the histological study is needed. Scarpa fascia was not identified in the histologic study of four cases. All this four cases had been previously submitted to surgery, presented low BMI, and the weight of the surgical specimen was always low and inferior to the average value found in our population (1038.7 gr) (Table 6). None of them had been previously submitted to bariatric surgery or experienced massive weight loss. New histological sections were performed in all this four cases and whenever possible we returned to the surgical specimen to harvest new tissue samples. Nevertheless the criteria of a continuous fascial plane parallel to the skin was not totally fulfilled in these situations. All these cases were interpreted as having sequels of previous surgeries as generalized fibrosis was found, the fascial layer was disorganized, presented thickened areas and was focally discontinuous. In all these cases it was possible to identify Scarpa fascia macroscopically and to measure the superficial and deep fat compartments. These cases should not be interpreted as absence of Scarpa fascia due to changes secondary to high adiposity.

Table 6. Profile of the patients without identification of Scarpa fascia on the histologic examination.

Patient	BMI (kg/m^2)	Specimen weight (g)	Prev. surgery	Point
14	24.1	700	c-section	B
18	23.2	330	2 c-sections	B
25	26.9	1010	hernia	B
31	21.0	620	Apendicectomy + 2 c-sections	A

BMI: Body mass index

The data published on the physical properties of Scarpa fascia is very scarce. In which concerns its thickness, two reports have been published that present data on this subject: one by Abu-Hijleh in 2006 (62)and other by Lancerotto in 2011 (68). Abu-Hijleh (62) investigated the existence of a membranous layer, classically described as confined to the lower anterior abdominal wall, elsewhere in the body by means of dissection of six embalmed adult cadavers along with ultrasound imaging of four living subjects. In all six cadavers a continuous membranous layer was found consistently in all the dissected regions of the body. This was fully confirmed by ultrasonography. The author also performed thickness measurements of the fascia. The average results were: for male 116.20 μm and for female 133.93 μm. The difference was not statistically significant. These values are lower than the ones found in our investigation. The difference is probably explained by the fact that Abu-Hijleh study was done in embalmed cadavers. Lancerotto (68) published the results of his investigation in ten fresh cadavers of differing physical constitution (four men and six women) and in vivo CT images of ten subjects. This author evaluated Scarpa fascia thickness by means of two different methodologies: (1) histologic preparation and image analysis software; (2) in vivo CT images of the abdomen of ten subjects. The results present a great discrepancy between the mean thickness measured on histological sections (847.4 μm) and on CT images (2310.0 μm). The author raises the possibility of underestimation of the former values due to tissue dehydration during histological preparation. He also considers the possibility of overestimation of the second values due to the low resolution of the method of measurement on the CT images. Nevertheless either values are quite different from the results of our study. We recall that our results are based on a study population of 31 females while the study by Lancerotto was based in 4 men and 6 women. Other data on the general characteristics of his population were not presented.

The findings of this morphometric study have several important clinical implications. This study demonstrated that irrespectively the body mass index, the superficial fat compartment is largely dominant. This means that the deep fat compartment is usually thin in comparison to the fat superficial to it, rendering it inconsequential to the final abdominal contour. Most of the fat is located above Scarpa fascia. Leaving Scarpa fascia and the deep fat compartment intact during an abdominoplasty will probably have a minimal impact on the abdominal contour. The first authors to propose a more superficial plane of dissection during an abdominoplasty included liposuction of the deep fat compartment to reduce its bulk (37, 38, 81, 83, 84, 88). This is probably unnecessary as our results show that the average thickness of the deep fat compartment was 6.5 mm in point A (range 1.0-15.0) and 7.3 mm in point B (range 2.0-17.0). This concern on the excessive bulk of the deep fat compartment still persists (90) but cannot be sustained due to lack of scientific basis. Another relevant clinical implication is related to abdominal liposuction which, in the lower abdominal wall, should be done superficially, i. e. directed to the superficial fat compartment where there is more fat.

The constant presence of Scarpa fascia, the high percentage of compact morphology (particularly in point A), the measured thickness, make it a possible candidate for donor area for fascia grafts. The latter have several clinical applications such as tissue augmentation, coverage of vital structures, dead space elimination, reconstruction of ligamentar structures (91). More specifically, there are reports about the utilization of fascia grafts for the surgical correction of facial paralysis (92, 93), paralytic lagophthalmos (94), congenital unilateral lower lip palsy (95), reconstruction of ruptured Achilles tendon (96), dural reconstruction (97-101), palpebral ptosis surgery - frontal suspension (102), correction of complex tissue defects of the face (103) and reconstruction of the palatal aponeurosis (104) . The abdomen is not considered to be a traditional donor area for fascia grafts (92, 93, 95-97, 100-104). This role belongs to fascia lata as this is the most common donor site for nonvascularized fascia (91, 105). The physical properties of fascia lata are well known namely its specific gravity, tensil strength and its variations with aging (106-108). The morbidity from harvesting fascia lata is not significant for grafts with 10 to 15 mm width. For larger grafts there is a considerable risk of muscular hernia (91, 105). In this situation the abdomen may have potential to be an alternative to fascia lata. As we have already mentioned, the knowledge on the physical properties of Scarpa fascia is scarce. Lancerotto (68) studied its resistance to traction in 10 fresh cadavers (4 men and 6 women) and reported the following values: 2.8 kg in a transversal direction and 5.5 kg in cranio-caudal direction. The reconstructive potential of Scarpa fascia has been previously pointed out by Worseg (66). The latter published very comprehensive studies about the structure (macro

and microscopic) of Scarpa fascia and inclusively published his clinical experience using Scarpa fascia flaps for reconstructive purposes, either as pedicled or free flaps (66). Combining our results with the ones from Worseg and Lancerotto one can consider the possibility of using Scarpa fascia as a donor area for fascia grafts due to its constant presence and morphology, at least for patients presenting with body mass index lower than 30. To validate this possibility further investigation on the physical properties of Scarpa fascia is needed.

Considering the applicability of this study, it is important to recall that it was done in females and thus the findings apply to women. Similar structure may be found in male patients but we do not have data to validate that statement. It is an open area of investigation as we lack more detailed descriptions of the anatomy of the subcutaneous tissue in male patients. Other aspects must be considered besides gender when analyzing external validity of this study. The fact is that the results of the morphometric study are based on a study population that has general characteristics and clinical profile of the typical candidate for a full abdominoplasty: female, fourth decade of life, no significant operative health risks, previous pregnancies, previous abdominal surgery (mostly c-section and Pfannenstiel incision), presenting with excess abdominal skin and adipose tissue and muscle laxity. We recall that patients with body mass index over 30 kg/m^2 were excluded except for the ones previously submitted to bariatric surgery. Consequently the findings of the morphometric study apply to the usual candidate for a full abdominoplasty. The anatomy of the subcutaneous tissue needs to be further studied in obese patients, i. e. patients with body mass index over 30 kg/m^2 (without previous bariatric surgery).

CLINICAL TRIALS

To investigate the possible role of using a more superficial plane of dissection during an abdominoplasty two prospective comparative studies were done. The main technical details of the surgical procedure that applies the dual plane abdominoplasty concept are detailed in Chapter II and are:

- Preservation of the deep fat compartment and Scarpa fascia in the infraumbilical region except for a central strip where both structures are removed to expose the rectus fascia (Chapter II fig 2; fig 10).

- Avulsion technique (manual distraction) as described by Vásconez (84, 88) (Chapter II fig 3)

- Supraumbilical dissection on the plane of the deep fascia
- No liposuction of the abdominal flap
- Two suction drains
- Criteria for drain removal: 30 cc in each drain during 24 hours
- Compression garment used for at least 6 weeks.

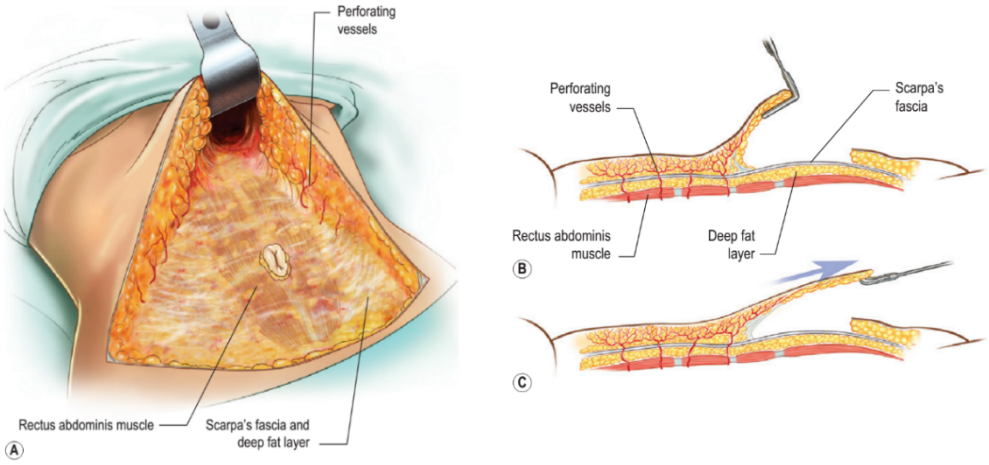

Fig 10 A and B. Anatomical details of abdominoplasty with Scarpa fascia preservation. C, Superior flap advancement over Scarpa fascia and the deep fat compartment; adapted from Saldanha (85).

A prospective study (objective 3) was performed at a single center with 208 patients to evaluate the effect of preserving Scarpa fascia in the infraumbilical area during a full abdominoplasty in the immediate postoperative period. The outcomes were: time to suction drain removal, total volume of drain output, length of hospital stay.

A randomized controlled clinical trial (objective 4) was designed according to the guidelines from the Consolidated Standards of Reporting Trials Group and performed at a single center with 160 patients to evaluate the effect of preserving Scarpa fascia in the infraumbilical area during a full abdominoplasty on results and complications, in the immediate and late postoperative periods. The outcomes of this study were: time to drain removal, daily and total volume of drain output, length of hospital stay, systemic complications (need for blood transfusion, pulmonary fat embolus syndrome, thromboembolic complications, death), local complications (seroma, hematoma/bleeding, wound infection, healing problems/wound

dehiscence without necrosis, skin necrosis), emergency department visit, second admission to the hospital, secondary surgical revision and aesthetic result (evaluated separately by the patient and also by the care provider).

PROSPECTIVE STUDY (OBJECTIVE 3)

The clinical study (objective 3) on the effects of Scarpa fascia preservation during a full abdominoplasty in the immediate postoperative period is the first prospective and comparative study of the two techniques, i. e. classical abdominoplasty and dual plane abdominoplasty. This study presents new advantages of using a dual plane abdominoplasty that can improve patient recovery. It provides evidence that elevating the abdominal flap at the Scarpa fascia level has three clinically important and statistically significant effects:

1. total drain output is reduced (58.9 % reduction)
2. time to drain removal is reduced (2.0 days reduction)
3. hospital stay is reduced (1.9 days reduction).

The major reduction in drain output observed explains that the criteria for suction drain removal (30 cc of aspirate collected in each drain over a 24-hour period) is achieved earlier. The possibility of removing drains earlier may improve patient comfort and mobility which will allow a faster recovery. The relevance of this effect is high as suction drains are one of the most accepted and universal methods of seroma prevention (27, 30, 57, 109).

Another important conclusion is obtained when analyzing the time to drain removal, more specifically its maximum value which was 22 days for the classical abdominoplasty group and 9 days for the Scarpa fascia preservation group. The patients submitted to classical abdominoplasty had to use drains for more than 5 days in 28.7 % of the cases while in the Scarpa fascia preservation group this only happened in 3.1 % of the cases. Consequently we can say that long periods with suction drains were eliminated when abdominoplasty was performed with Scarpa fascia preservation. This is a very important and relevant finding. Several authors published clinical series of full abdominoplasty using suction drains and it is relatively frequent to find patients using drains for long periods of time (23, 27, 34, 39). The study by Neaman is a good example of this and it is the largest retrospective study about abdominoplasty ever published (23). It is an analysis of 1008 patients submitted to a full abdominoplasty by six

different surgeons. The reported values for drain duration in days were (mean ± SD): surgeon A = 10.6 ± 2.3; Surgeon B = 11.7 ± 1.5; Surgeon C = 17.3 ± 1.9; Surgeon D = 9.8 ± 1.2; Surgeon E = 17.3 ± 2.6; Surgeon F = 14.3 ± 1.8. Surgeon A performed a total of 210 full abdominoplasties and the other surgeons performed respectively 213, 119, 203, 176 and 87 surgeries (23). Considering this scenario, technical strategies to reduce the duration of suction drain usage are very important.

The length of hospital stay can be influenced by several factors. It is well known that hospitalization is different in different countries. The policy in our department is to discharge patients after drain removal. A consequence of this is that, in this study, the length of time to drain removal influenced the length of hospital stay. Shortening the hospital stay has several advantages: reduction of costs, minimization of patient discomfort, reduction of infections (110). Nevertheless abdominoplasty can be safely performed as an ambulatory procedure (27, 38). If this is the case then reducing the total drain output and the time to drain removal are still relevant advantages.

There are two points to consider when analyzing possible mechanisms and explanations for our results: (1) preservation of lymphatic drainage and blood supply of the abdominal wall, (2) better adhesion between the surfaces. These two different explanations can be named, respectively functional model and adhesive model. They have already been discussed in detail in Chapters II and III, nevertheless some additional considerations should be made.

Regarding the functional model, previous anatomical studies show that the abdominal wall lymphatic structures are preferentially located deep to Scarpa fascia and two distinct areas of lymph drainage can be defined and divided by the umbilicus: the epigastric region drains into the axilla and the hypogastric area drains to the inguinal area (60, 69, 88, 111, 112). When abdominoplasty is performed with Scarpa fascia preservation, lymphatic vessels, arteries, veins and nerves of the deep fat compartment of the infraumbilical area are preserved along with their peripheral connections with the inguinal area. Apparently there is a lower interference with the lymphatic system of the abdominal wall when a more superficial plane of dissection is used as opposed to the classical abdominoplasty. In the latter, the deep fat compartment is totally excised. This compartment is probably a key structure to preserve along with Scarpa fascia as it is the dominant one, in which concerns vessels and lymphatics (60, 112-114).

Still regarding the functional model, the blood supply of the abdominal wall must be brought into discussion as it may be relevant to explain the mechanisms underlying our results.

One should consider the possibility that Scarpa fascia preservation may improve blood supply of the healing surfaces due to the fact that the superficial epigastric system of blood vessels is preserved in the majority of cases as opposed to what happens in a classical abdominoplasty. Actually, the superficial inferior epigastric artery is known to travel just superficial to the Scarpa fascia and to release small branches to a fascial vascular network contained within the fascia (66).

Another vascular system that may play a role in the mechanisms underlying the results of the present study is the deep inferior epigastric. One should also consider the perforators from the deep inferior epigastric vessels, more specifically their course after they pierce the rectus fascia. According to the studies by El-Mrakby and Milner (113, 114) there are two different courses for this musculocutaneous perforators in the subcutaneous fat depending on the diameter of the vessels: the large perforators (> 0.5 mm) have a straight direction toward the skin and at a level superficial to Scarpa fascia they course parallel to the skin and their branches contribute to the subdermal plexus; the small musculocutaneous perforators (<0.5 mm) terminate immediately at the deep subcutaneous fat contributing to its blood supply (113, 115). There is a horizontal axis of vessels on the deep fat compartment in relation to Scarpa fascia similar to the subdermal plexus but with much smaller vessels (115, 116). Consequently, when Scarpa fascia and the deep fat compartment are preserved during an abdominoplasty, a bed of well vascularized tissue is created that is the foundation for the upper abdominal flap. From the above, it can be inferred that Scarpa fascia preservation on the infraumbilical area better respects the structure and physiology of the abdominal wall when compared to the classical technique of abdominoplasty, which will probably result in preservation of lymphatic drainage and blood supply of the abdominal wall. A better capacity to deal with surgical trauma and to eliminate fluid can be expected.

Considering the adhesive model, a different structure of the superficial and deep fat compartments has been recognized by several authors and fully confirmed in the present morphometric study (objective 2). The flexible nature of the deep fat compartment has been previously pointed out by Nakajima (64). This author published in 2004 the results of a study performed in 20 fresh and embalmed cadavers to investigate the subcutaneous adipofascial tissue over the entire body. One of the specific goals of this study was to evaluate the mechanical characteristics of the components of the subcutaneous tissue. Nakajima concluded that the superficial fat layer was immobile and solid while the deep fat compartment was extremely mobile and that it joined loosely to the superficial and deep fascia. Another author who

presented data on the physical properties of the two fat compartments was Lancerotto (68). This author performed macroscopic dissection, compression tests on the two fat compartments and traction tests on Scarpa fascia by using 10 fresh cadavers, neither embalmed nor frozen prior to examination. Lancerotto verified the high structural stability and elastic properties of the superficial fat compartment and also the high lateral displacement and mobility of the deep fat compartment. These data are very relevant facts to the adhesive model which considers that the more flexible nature of the deep fat compartment (64, 68) when compared with the rigid rectus fascia may justify a higher resistance to the shearing movements and thus result in a faster and more efficient adherence and healing.

Another issue to consider in the adhesive model is that the avulsion maneuver used during dissection in Scarpa fascia preservation abdominoplasty, may also have an influence on the results on the account of less damage to the healing surfaces. The fact is that this technique does not use neither blade nor electrosurgery to perform the infraumbilical dissection but uses manual distraction. The method used for dissection and/or undermining (scalpel, electrosurgery or harmonic scalpel) has been implicated on the seroma rate (30, 48, 117, 118). To the best of our knowledge strong scientific evidence in favor of either option is still needed, specially well-designed prospective comparative randomized studies.

Different surgical teams can be a factor that influenced the results of this study. The two groups were representative of two different surgical teams whose standard approach to the abdominal procedure differed only with respect to the preservation of Scarpa fascia. Similar standards were used in both groups except for the plane of dissection. The surgical methodology was identical except for this difference on the plane of dissection. The general characteristics of both groups were identical. This is the first prospective study comparing the classical abdominoplasty technique with a dual plane abdominoplasty. Although valuable information can be obtained from a retrospective evaluation, this method has important inherent flaws that can include incomplete or inconsistent data collection and patient dropouts. Prospective studies provide more valuable information.

RCT STUDY (OBJECTIVE 4)

The randomized controlled trial (objective 4) provides evidence that elevating the abdominal flap at the Scarpa fascia level has six clinically important and statistically significant effects, regardless of the surgeon:

1. Total drain output is reduced (65.5 percent reduction)
2. Daily drain output is reduced on every day
3. Suction drains can be safely removed earlier (3 days earlier)
4. Hospital stay is reduced (3 days reduction)
5. Long periods with suction drains are eliminated (longer than 6 days)
6. Seroma rate is reduced (86.7 percent reduction).

Another very relevant conclusion of this trial was that the aesthetic result is not compromised by using this more superficial level of dissection and preserving the deep fat compartment. This was true for either patient evaluation or care provider evaluation.

The daily drain output was quite different between the two study groups in which concerns absolute values. When Scarpa fascia was preserved, it was significantly lower from day 1 to day 10 (Chapter III fig 1). The difference was statistically significant on every day. Despite these differences the fact is that the temporal evolution was similar: maximum value on the first day after surgery and progressive reduction until drain removal. The maximum value on the first day after surgery is coincident with the beginning of ambulation. This increase in daily drain volume on the first day after surgery was observed in both groups but it presented higher magnitude in the classical abdominoplasty group.

Reducing the time to drain removal was an important finding of this study which is in accordance with the first clinical trial (objective 3). The same can be said about the elimination of long drainers. As we have already pointed out, sometimes patients have to use suction drains for long periods of time after a classical abdominoplasty, mainly if the criteria used for drain removal is 30 cc in each drain during 24 hours. There are clinical series published presenting a time to drain removal with average values equal or superior to 8 days (23, 27, 34, 39) and maximum values superior to 20 days (34). Removing drains without respecting the criteria of

30 cc in 24 hours can result in another complication named lymphorreia. Chaouat (24) found a 10.9 % incidence of lymphorreia in a retrospective study of 258 patients submitted to abdominal dermolipectomies, with a maximum of 60 days duration. Other authors have presented even higher lymphorreia rates (119). Our results show that by using a more superficial plane of dissection long drainers are eliminated: 26 patients from the classical abdominoplasty group (32.5 %) had to use drains for more than 6 days while only 1 of patient from Scarpa fascia preservation group (1.2 %) did (Chapter III figure 2).

There was a trend for a higher incidence of unscheduled hospital visits (emergency room visit), hospital readmission and reoperation for the classical abdominoplasty group, the majority of these cases due to large volume seromas. It is clinically significant that patients from the Scarpa fascia preservation group did not have any case of fluid collection demanding unscheduled visit, readmission or reoperation.

Besides the seroma, the other complications did not have statistically significant differences between the groups, but some had clinically important differences, namely a fivefold higher incidence of hematoma/bleeding and a six fold higher incidence of infection with the classical abdominoplasty. Actually, there is a trend for a lower incidence of hematoma/bleeding (80.0 percent reduction) and infection (83.3 percent reduction) when Scarpa fascia is preserved. The only complication that was more frequent in the Scarpa preservation abdominoplasty group was healing problems and/or suture rupture without tissue necrosis. The difference was not statistically significant. The explanation for the higher incidence of this complication is probably related to the fact that the classical abdominoplasty group had 3 patients with hypertension or diabetes while the Scarpa preservation group had 10 patients. These two chronic diseases have been associated with a higher risk of minor complications with the surgical wound (4, 120). It is also of clinical relevance that 4 of the 8 patients from classical abdominoplasty group and 7 out of 15 patients from Scarpa fascia preservation group were active smokers that did not reduce the tobacco load. Smokers as well as patients with diabetes and hypertension have a higher incidence of wound-healing problems (4).

A special consideration should be made about the active smokers included in this study. Active smokers were instructed to stop smoking or to reduce smoking to three cigarettes per day 6 weeks before surgery (these participants were considered to be active smokers). This criteria explains the high percentage of smokers in both groups. In the classical abdominoplasty group, 16 patients were considered to be active smokers, but 11 patients either stopped smoking or reduced to 3 cigarettes a day 6 weeks before surgery and 5 did not. In Scarpa fascia

preservation group, 20 patients were active smokers, but 14 patients either stopped smoking or reduced to 3 cigarettes a day 6 weeks before surgery and 6 did not.

The randomized controlled trial involved four different surgeons. Each surgeon performed both procedures. For the dependent variables seroma rate, total drain output and time to drain removal, the effect of the two independent variables (effect of the procedure and effect of the surgeon) was evaluated. For all of them the surgeon´s effect was not statistically significant. Our results were consistent with different surgeons. A final level of Evidence of I was assigned by the Plastic and Reconstructive Surgery Journal independent panel of Level of Evidence experts. This is the first Randomized Controlled Trial, giving comparative data on the subject of dual plane abdominoplasty.

As we have already pointed out, there are two possible explanations for the results of the first clinical study (objective 3) and this line of thought also applies to the present study (objective 4): (1) functional model - preservation of lymphatic drainage and blood supply of the abdominal wall; (2) adhesive model - better adhesion between surfaces. Quilting sutures are a proven method of diminishing complications in abdominoplasty and it is a well-known fact that its efficacy avoids the use of drains (30, 46). This suggests that the adherence factors are important during the recovery phase of abdominoplasty but it is not sufficient to say that this is the only factor acting and justifying such a different behavior between both groups of our Randomized Controlled Trial study. The possibility that the contents (vessels) of the deep fat compartment play a role should also be considered and cannot be eliminated at the present moment. So an explanation based purely in mechanical/physical causes (adhesive model) or alternatively based purely in physiological causes (functional model) cannot be validated by the experimental data we have. It is very probable to have both models contributing to the clinical behavior we observed.

If one assumes a possible role for the functional model then it is reasonable to try to preserve all the structure of the deep fat undisturbed. Here lies the reason for avoiding surgical manipulation of the deep fat compartment and Scarpa fascia in our clinical studies, either by liposuction or by direct fat resection, as opposed to what others have previously done and published (36, 38, 81, 84). Another pertinent question is that previous publications suggested that preserving a small amount of loose areolar tissue from the deep fat compartment is enough to reduce seroma and the time with drains (57, 121). At the present moment we do not know if this will have the same effect as preserving the full amount of deep fat compartment. Another relevant point is that considering that the deep fat compartment has a minimal contribution to

the total thickness of the abdominal wall, probably it is very reasonable to leave it undisturbed to maximize the possible functional contribution. Manipulating the deep fat compartment could reduce efficiency of its role on better recovery.

Recent publications provided additional objective data on the advantages of using a more superficial plane during abdominoplasty. Clinical and statistical significant advantages were presented and are summarized on Chapter III in Table 5.

Saldanha (122) published a retrospective study with 940 patients (446 submitted to lipoabdominoplasty with Scarpa fascia preservation, 494 submitted to classical abdominoplasty). The superficial and deep fat compartments in the infraumbilical area were modified by liposuction with a 6 mm cannula. This was done before removing the excess skin to facilitate the visualization and preservation of Scarpa fascia during the abdominoplasty (122). Scarpa fascia was preserved in a very similar total area to the technique used in our prospective studies. Saldanha´s study showed an overall reduction of complications when lipoabdominoplasty with Scarpa fascia preservation was used, namely seroma (from 60 percent to 0.4 percent) but also epitheliolysis (from 3.8 percent to 0.2 percent), suture dehiscence (from 5.1 percent to 0.4 percent) and necrosis (from 4 percent to 0.2 percent). The previous differences were all statistically significant. This study also demonstrated a nonsignificant reduction of hematoma (from 0.6 percent to 0.2 percent).

Fang (121) published a retrospective study with 202 patients (103 submitted to dual plane abdominoplasty, 99 submitted to classical abdominoplasty). The “classical abdominoplasties” were performed using infiltration of tumescent solution and sharp dissection with the scalpel. The dual plane abdominoplasties were done using a similar infiltration tumescent solution, sharp dissection with the scalpel and a dissection plane located deep to Scarpa fascia preserving a thin areolar tissue just superficial to the muscular fascia. The authors state that in thin patients the dissection plane of the abdominal wall skin flap is developed just deep to Scarpa fascia layer. In heavier patients a deeper plane was used removing most of the sub-Scarpa fascia fat. The dual plane abdominoplasty was performed in one of two ways depending on the weight of the patient. The authors did not search for differences in outcomes between thin and fat patients. This study showed that by using a more superficial plane of dissection during abdominoplasty, it was possible to remove drains 3 days earlier ($P<0.0001$) (121). The criteria for drain removal was 30 ml of aspirate collected in each drain over a 24-hour period. Abdominoplasty complications were also recorded and there was no statistically significant difference when comparing classical technique with a more superficial plane of dissection, but there was a trend

toward a lower incidence of seroma when a more superficial plane of dissection was used. The incidence of seroma in the classical abdominoplasty group was quite low (7%), the authors attribute this to the use of sharp dissection without electrocautery (121).

Koller (123), based on a prospective study with 50 patients (25 submitted to abdominoplasty with Scarpa fascia preservation, 25 submitted to classical abdominoplasty), found that preserving Scarpa fascia during an abdominoplasty reduced significantly the total drain output and the seroma incidence. Nevertheless, for time to drain removal the difference was not statistically significant (123). In this study all the dissection were performed using an ultrasonically activated scalpel, the deep fat compartment was not modified by liposuction or lipectomy.

These three recent publications add important information on the subject of dual plane abdominoplasty. Nevertheless some differences must be noted regarding the surgical plane used and the manipulation of the deep fat compartment. The studies by Saldanha and by Koller use a similar surgical plane to the one used in this investigation but the former author did liposuction of the deep fat compartment while the latter did not. In the study by Fang, a more superficial plane of dissection was used but it is different from the one used in this investigation due to the fact that it is located in the thickness of the deep fat compartment. Despite the technical differences, these studies provide objective data on the advantages of using a more superficial plane of dissection during an abdominoplasty that are in accordance to the results of both our prospective studies (Chapter III table 5). There is enough scientific data to recommend a more superficial plane of dissection during abdominoplasty than the one used in a classical procedure.

The present study is the first Randomized Controlled Trial on the subject and presents several clinical and research implications. Considering the clinical impact, a modification of the classical plane of dissection of abdominoplasty proved to have a major impact on patient recovery and also on the incidence of complications without interfering with the aesthetic result. The different plane of dissection used in dual plane abdominoplasty is more difficult to access and not so “clean” as the one used in a classical abdominoplasty. One can easily disrupt Scarpa fascia if care is not taken. Nevertheless, this technical modification can be very easily introduced on one´s practice without interfering with the surgical time or the general principles of the classical abdominoplasty. It fits clinically with other recent trends in abdominoplasty (i.e. limited undermining, liposuction) very easily and with a tremendous impact in outcome as we have proved with our results.

Besides quilting sutures, suction drains are also a proven method to prevent complications after a full abdominoplasty. The use of drains for this goal is supposed to be more prevalent and generally used than quilting sutures. The reason for this is probably related to the fact that quilting sutures are not easy to place, dimpling of the flap may appear and surgical time is extended. Using suction drains adds no time to the surgical procedure. Using a more superficial plane of dissection reduces complications and improves recovery when suction drains are used. We do not know if that improvement is sufficient to eliminate drains when a more superficial plane of dissection is used. Another issue that also needs clarification is which is the best plane of dissection: the one used in our study or another one in the thickness of the deep fat compartment as others have suggested. Further research is needed to clarify these issues.

The mechanism of the decreased fluid collection still is not clear and needs further investigation. Lymphatic drainage studies on abdominoplasty patients will probably answer the question. Other potential areas exist for further research. Scarpa fascia preservation will probably have additional interest for specific high risk patients for complications after a classical abdominoplasty, namely men (25), obese patients (124) or the ones with massive weight loss (29). As the structure of the subcutaneous tissue seems to be identical in other areas of the body (62-64), one wonders if using a more superficial plane for the dissection in other areas like the arms or thighs will have the same advantages. Clinical studies with high levels of evidence are needed to answer these questions.

FINAL CONCLUSIONS:

The results of the morphometric study demonstrate a trilaminar structure with superficial compartment dominance and Scarpa fascia presence irrespective of the adiposity degree in the lower abdominal wall. The deep fat compartment has a minor contribution to the lower abdominal wall thickness.

The results of the prospective clinical studies demonstrate that the preservation of Scarpa fascia and the deep fat compartment during abdominoplasty carries several advantages. Lower drain volumes, earlier drain removal, avoidance of “long drainers”, shorter hospital stay are clinically very significant benefits that had not been described before. The classical advantage previously suggested was fully confirmed: using the dual plane dissection lowers the seroma rate. A reduction in hematoma and infection rates were also found and the aesthetical result was the same as the one obtained with a classical full abdominoplasty.

Based on this evidence, the authors recommend that surgeons consider performing abdominoplasties using a more superficial plane of dissection in the infra-umbilical area with total preservation of Scarpa fascia and the deep fat compartment.

CHAPTER VII

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