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Classic Versus Scarpa-sparing abdominoplasty: An infrared thermographic comparative analysis

Rita Valença-Filipe [a,b,*], **Ricardo Vardasca** [c,d], **Carolina Magalhães** [c,e], **Joaquim Mendes** [c,e], **José Amarante** [a,c,f,g], **António Costa-Ferreira** [a,f]

[a] *Department of Surgery and Physiology, Faculty of Medicine, Porto University, Porto, Portugal*
[b] *FMR Clinic - Aesthetic Surgery, Porto, Portugal*
[c] *LABIOMEP, INEGI-LAETA, Porto University, Porto, Portugal*
[d] *ISLA-Santarém, Santarém, Portugal*
[e] *Faculty of Engineering, University of Porto, Portugal*
[f] *Department of Plastic, Aesthetic and Reconstructive Surgery, São João University Hospital, Porto, Portugal*
[g] *Porto University, Porto, Portugal*

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Summary *Background:* Scarpa fascia preservation during abdominoplasty has been shown to have several clinical advantages. The mechanisms behind its efficiency have been the subject of several studies. Three theories have been proposed, relating to mechanical factors, lymphatic preservation, and improved vascularization. This study aimed to further investigate the possible vascular impact of Scarpa fascia preservation by using a thermographic analysis.
Methods: A single-center prospective study was conducted, involving 12 female patients randomly and equally assigned to one of two surgical procedures: classic (Group A) and Scarpa-sparing abdominoplasty (Group B). Dynamic thermography was applied before and after surgery (one and six months), and two regions of interest (ROIs) were considered. The latter had the same location on every sample, and corresponded to areas where different surgical planes had been used. Static thermography was applied intraoperatively, and four ROIs were considered, located over Scarpa and over the deep fascia. The respective thermal data were analyzed.
Results: The general characteristics of both groups were identical. Preoperative thermography demonstrated no differences between groups. Intraoperative higher thermal gradients between lateral and medial ROIs were observed in Group B ($P = 0.037$, right side). Dynamic

* Correspondence to: Rua Alfredo Ferreira de Faria 107, 4150-797 Porto, Portugal.
E-mail address: ritavfplastica@gmail.com (R. Valença-Filipe).

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thermography at one month demonstrated a trend for better thermal recovery and better thermal symmetry (P = 0.035, 1-min mark) in Group B. No other differences were found.
Conclusion: Dynamic thermography presented a better response when Scarpa fascia was preserved: stronger, faster, and more symmetric. Based on these results, improved vascularization may have a role in explaining the clinical efficiency of a Scarpa-sparing abdominoplasty.

Abdominoplasty techniques have considerably evolved over the past decades, and several strategies have been suggested to optimize results and reduce complications.[1-4] One of these strategies, Scarpa fascia preservation, has been shown to have clinical advantages such as lowering drain output, reducing time to drain removal and seroma rate, and eliminating long drainers without compromising the esthetic result.[1,5-9]

Over the years, some theories have been proposed to explain the clinical efficiency of abdominoplasty with Scarpa fascia preservation. However, this is still a matter surrounded by controversy, thus justifying further research.[10] Mechanical factors may play a role,[11,12] and the few studies focused on lymphatics showed different and contradictory results.[13,14] Vascular factors may also be a possibility,[15-18] as preserving the superficial and the deep inferior epigastric vessels could improve the vascular network when performing a Scarpa fascia abdominoplasty.[17-19] According to this model, it could be inferred that Scarpa fascia preservation in the infraumbilical area better respects the structure and physiology of the abdominal wall tissues compared to the classic technique.[10] An improved capacity to deal with surgical trauma and eliminate fluid could be expected by Scarpa fascia preservation.

Medical infrared thermography (IRT) is an imaging modality that allows the mapping and recording of body surface temperature, reflecting the physiology of blood microcirculation and autonomic nervous response[20,21] and providing indirect information on tissue perfusion.

The principle of infrared thermography is based on the physical phenomenon that any body with a temperature above absolute zero (−273.15 °C) emits electromagnetic radiation. There is a clear correlation between a body's surface and its emitted radiation's intensity and spectral composition. By determining its radiation intensity, an object's temperature can be determined by a non-contact way using a thermographic camera that creates an image using radiation, similar to a standard camera that forms an image using infrared light. Instead of the 400–700 nanometer (nm) range of the visible light camera, infrared cameras are sensitive to wavelengths from about 1000 nm (1 micrometer or μm) to about 14000 nm (14 μm). The consequent image—thermogram—is then computationally analyzed with specific software.[20]

Infrared thermography is a fast, precise, contactless, portable, non-invasive, and non-ionizing technique and, therefore, safe for the patient and operator, with reduced costs. It is an imaging method used in esthetic and reconstructive surgery[22-25] with similar accuracy to other invasive imaging techniques. It is also a good technique for evaluating abdominal skin perfusion after an abdominoplasty.[26,27]

To guarantee the quality of the method, guidelines[28-30] and international standards[31,32] were defined, specifying the preparation of the patient, equipment, and examination room since the collection has to be carried out in a controlled environment.

Dynamic infrared thermography (DIRT) is a more powerful tool than static thermography. It implies relative temperatures measured from the baseline after an external stimulus, providing more reliable tissue perfusion information.[21]

Despite some studies on the subject,[26,27] Scarpa fascia and its deep tissues have not yet been evaluated with thermography. IRT may provide additional knowledge about this structure and surrounding tissues and explain its clinical advantages when preserved during an abdominoplasty.

This study aimed to further investigate the possible vascular impact of Scarpa fascia preservation by using a thermographic analysis.

Patients and methods

A prospective clinical study was performed, including patients submitted to a full abdominoplasty with umbilical transposition at the Department of Plastic, Reconstructive and Esthetic Surgery, São João University Hospital, Faculty of Medicine, University of Porto. The patients were women who presented with abdominal deformities marked by excess abdominal skin and adipose tissue with muscle laxity. Exclusion criteria were significantly elevated operative health risks, major abdominal surgery with extensive scars (ex: vertical laparotomy, traditional appendectomy, cholecystectomy, and hepatectomy scars), diabetic patients, bariatric patients without weight stabilization for at least six months, and patients who anticipate future pregnancy. Patients were equally randomized to one of the two groups defined as Group A, patients submitted to classic abdominoplasty, and Group B, patients submitted to abdominoplasty with Scarpa fascia preservation in the infraumbilical area, as described by Costa-Ferreira et al.[6,8,10]

The thermographic protocol was designed and applied in collaboration with the Faculty of Engineering, University of Porto, and followed internationally accepted guidelines.[29,30]

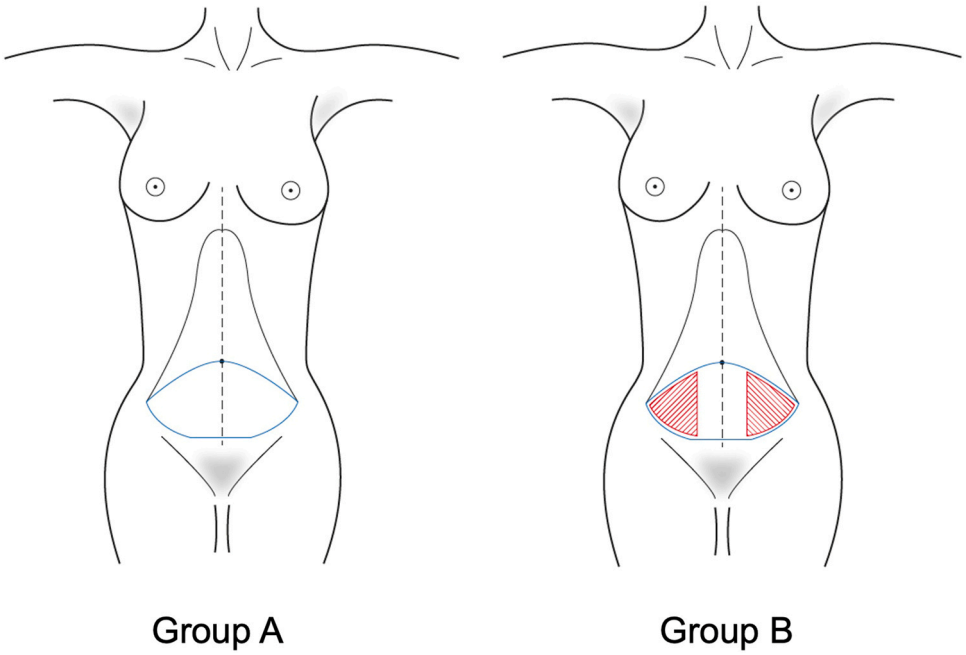

Figure 1 Study groups. Group A—patients submitted to classic abdominoplasty; Group B, patients submitted to Scarpa-sparing abdominoplasty. The only difference between groups was the dissection plane—Group A—on top of the deep fascia, Group B—two different dissection planes: one on top of the deep fascia in the supraumbilical area and midline, the other on top of Scarpa fascia in the infraumbilical area represented by the red dashed areas. The blue line limits the area of skin to be resected; the undermined area is represented within the black line in both groups.

Surgical methods

All patients underwent a complete abdominoplasty with umbilical transposition and rectus abdominis muscle plication, performed by one senior plastic surgeon.

The preoperative markings and abdominoplasty surgical technique are well-described elsewhere and well-known. Abdominoplasty was performed under general anesthesia. The surgical difference between groups was related to the dissection plane: in Group A it was done on top of the deep fascia, and in Group B it was done on top of the Scarpa fascia on the infraumbilical triangular areas marked by the red lines in Figure 1, and on top of the deep fascia on the other areas of undermining. As abdominoplasty performed in Group B uses two different dissection planes, it can be called dual-plane abdominoplasty. No tumescent infiltration with epinephrine, liposuction of the upper abdominal flap, or quilting sutures were used. Liposuction was limited to the flanks. No additional procedures were done.

Two closed-suction drains were used on all patients, each on the lower abdomen, one on each side. The intraoperative and postoperative care were the same in both groups.

Demographic outcomes

The demographic variables considered were age, body mass index (BMI), medical comorbidities, smoking, previous minor abdominal surgeries (C-section and laparoscopic surgery, which are supposed not to interfere with thermal recovery),[33,34] and previous bariatric procedures.

Infrared thermography assessment

Equipment

The equipment used for the collection of thermal data consisted of a thermographic camera FLIR E60 SC (FLIR Systems, Wilsonville, Oregon, USA), with the following specifications: focal plane array of 320×240, Noise Equivalent Temperature Difference (NETD) of < 50 mK at 30ºC, the accuracy of $\pm$ 2% of the overall temperature reading, long-wavelength (7–13.5 μm) and a 25º lens. It offers a temperature range of $-$ 20–650 °C (−4 to 1202°F) with an accuracy of $\pm$ 2% and a thermal sensitivity of < 0.05 °C.

To assure the quality of the captured images, the camera was previously calibrated with a blackbody ISOTECH HYPERION R 982. The hygrometer TESTO 175H1 was used to monitor ambient temperature (21 $\pm$ 1ºC) and relative humidity ($\leq$50%), guaranteeing optimal conditions for the thermal recordings as suggested by the internationally accepted guidelines.[29,30]

Acquisition protocol

The delineated protocol included the caption of thermographic images of the abdominal wall, in the infraumbilical area, at four different instants: preoperative (PRE-OP—control, dynamic), intraoperative (INTRA-OP-static), 1-month postoperative (PO M1—dynamic), 6-month postoperative (PO M6—dynamic) with the examiner in a stand position, 100 cm distance from the patient, who was in the supine position. The same examiner performed all the thermography protocol.

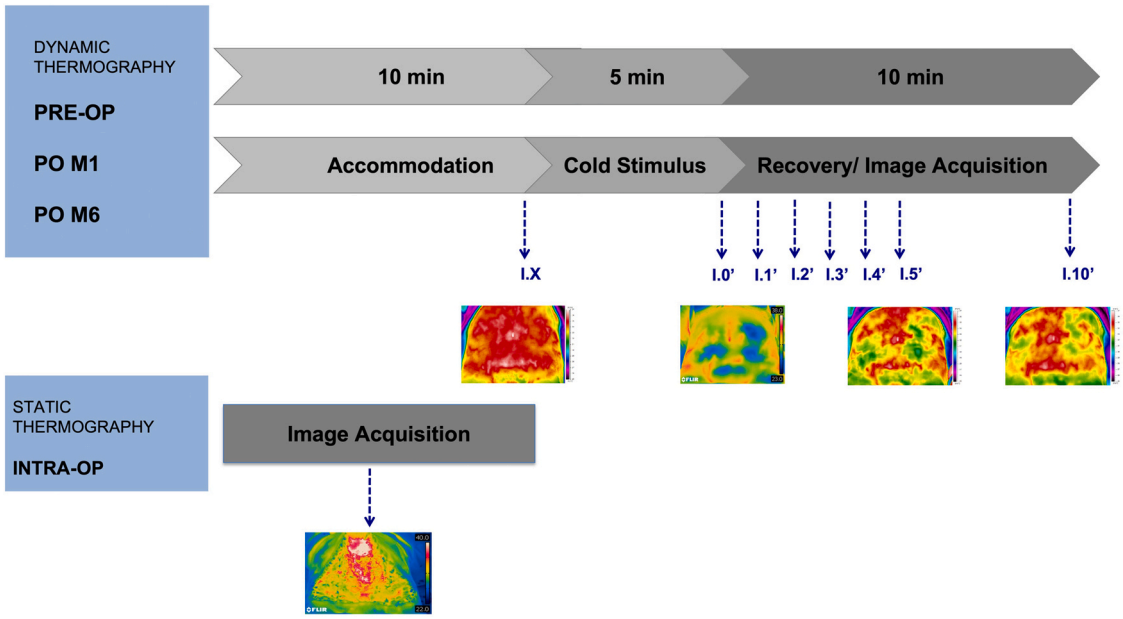

Figure 2 Acquisition protocol for static and dynamic thermography. Dynamic thermography was conducted in the PRE-OP, PO M1, and PO M6 periods in both groups—the thermograms were obtained at the baseline (I.X) after the cold stimulus (ice pack) (I.0) and sequentially (I.0′,1′,2,'3′,4′,5′) until the 10-minute mark to record the vascular response. Static thermography was performed in the INTRA-OP period. Some thermograms were included in the scheme of dynamic thermography (images I.X, I.0′, I.5′, I.10′) and static thermography to better illustrate the protocol applied.

DIRT

Before measurement execution, the patients were subjected to a period of acclimatization with the abdominal area exposed for 10 min (Accommodation). After that, images of the affected skin area (Image X—baseline) were captured. A provocation maneuver with a cold stimulus was applied to the infraumbilical area by applying for 5 min an ice pack (size of 37 ×18 cm, coated with a nylon bag) (Cold stimulus). A new thermal image was acquired immediately after the thermal stress (Image 0), and at each following minute, until the 5-minute mark, collecting five images representative of the thermal recovery (Images I.1′, 2′, 3′, 4′, 5′) and at 10-minute mark (I.10′) (Image acquisition) (Figure 2).

Static thermography

In the operating room, during surgery, just after the surgical specimen was removed and the upper flap undermining was completed, but before the muscle plication, the upper flap was pulled up to expose the lower surgical field. At this point, a thermogram of the infraumbilical area was obtained for each patient showing the umbilicus, midline, and the supra-deep fascia plane or supra-Scarpa plane in the lateral areas, depending on the group considered. The blood pressure (mmHg) was recorded when the thermograms were taken (Image acquisition) (Figure 2).

Image analysis

The software FLIR ThermaCAM Researcher Professional 2.10 was used to define the ROIs and calculate the basic thermal statistic parameters (maximum, minimum, standard deviation, mean, etc.).

DIRT image analysis (PRE-OP, PO M1, PO M6)

The dynamic thermography images analysis focused on the retrieval of the mean temperatures obtained in two regions of interest (ROIs), R1 and R2—which corresponded to circles with 45 pixels of diameter at the right and left sides, respectively. ROI's vertical location was defined at the mid-distance between the umbilicus and the pubis/abdominal horizontal scar (PRE-OP/PO, respectively). ROI's horizontal location was determined at the middle third of a horizontal line, between midline and waistline. The two ROIs correspond to areas where different surgical planes were used on each group (supra-deep fascia and supra Scarpa fascia).

The thermal images were obtained before and during the thermal recovery at the PRE-OP, PO M1, and PO M6 (Figure 3). The mean temperatures, gradients, and thermal symmetry ("degree of similarity" between ROIs mirrored across the human body's longitudinal axes, which are identical in shape, identical in size, and as near-identical in position as possible; values near zero translate better symmetry) between the ROIs mirrored across the human body's longitudinal axes were calculated.[35] The emissivity considered was 0.98 since the skin was the initial surface analyzed.

Steady-state/static image analysis (INTRA-OP)

The analysis of thermograms consisted of the definition of 4 regions of interest (ROIs) below the umbilicus. Two lateral circles at the right and left side (R1—red and R2—yellow, respectively) with 40 pixels of diameter were defined at mid-distance between the umbilicus and the abdominal inferior incision limit and located at the junction of the two medial thirds and the lateral third of a horizontal line from the midline to the lateral limit of the undermined area. In addition, two rectangles were

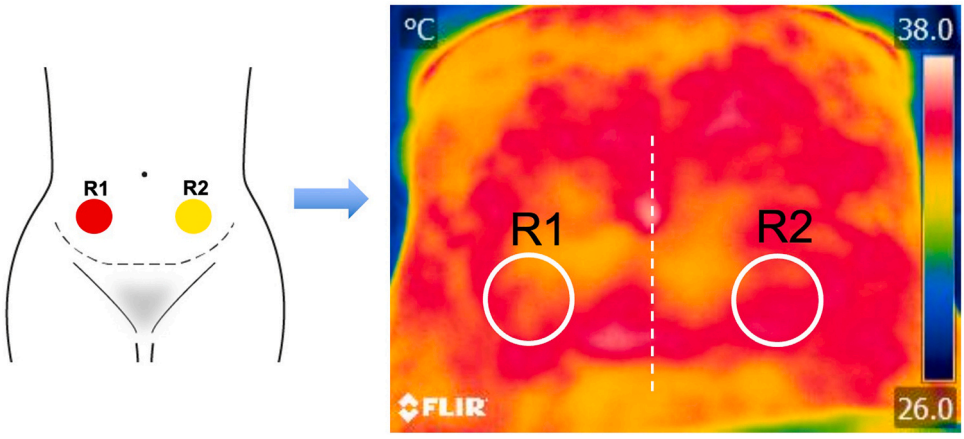

Figure 3 ROIs designed for dynamic thermography at the preoperative PRE-OP (control), postoperative of 1 month (PO M1), and postoperative of 6 months (PO M6). The ROIs' design is the same for both groups (Group A—Classic abdominoplasty; Group B—Scarpa-sparing abdominoplasty) and is represented on the first schema and in the thermogram on the right image. Red circle—R1, right side; yellow circle—R2, left side of the body. ROI's vertical location was defined at the mid-distance between the umbilicus and the pubis/abdominal horizontal scar (PRE-OP/PO, respectively). ROI's horizontal location was determined at the middle third of a horizontal line, between midline and waistline. The two ROIs correspond to areas where different surgical planes were used in each group (supra-deep fascia in Group A and supra Scarpa fascia in Group B).

also defined, with 50 × 15 pixels, with a vertical orientation, near the midline, on the right and left sides, without any areolar tissue—supra-deep fascia plane (R3—blue and R4—green, respectively), (Figure 4). A lateral circle was chosen to have absolute confidence that when Scarpa fascia was preserved, it would be included in the ROIs' area. Similarly, a vertical rectangle was chosen to have complete confidence that the deep fascia was assessed near the midline, without any Scarpa.

The mean temperatures, gradients (temperature difference between the lateral and central regions at each side: R1-R3, R2-R4), and thermal symmetry were calculated. The emissivity was adjusted to 0.95 as other soft tissues than skin were analyzed.

The thermograms were analyzed by two independent observers, a surgeon and an engineer, who were aware of the technique/group considered.

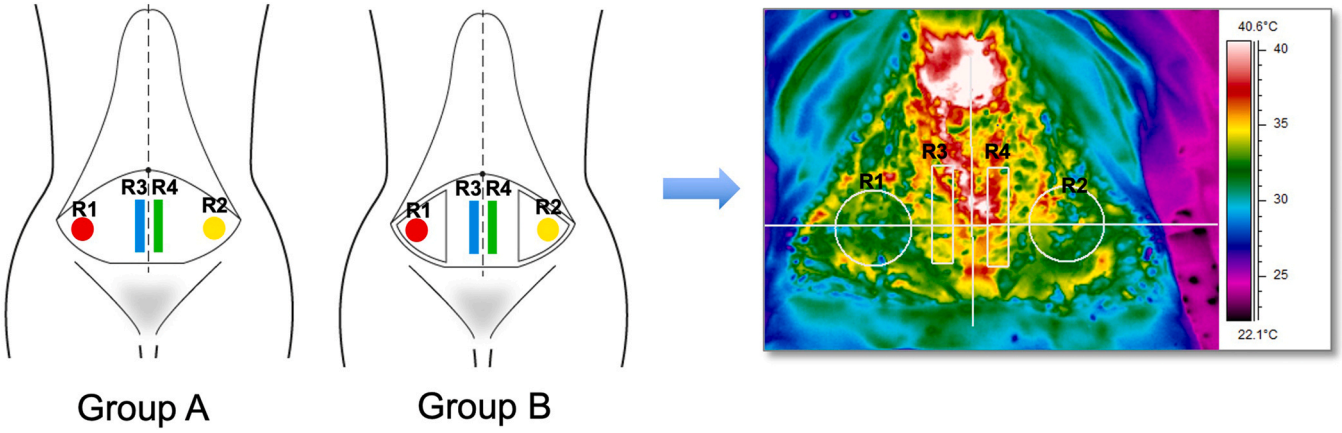

Figure 4 ROIs designed for static thermography at the intraoperative (INTRA-OP). The ROIs for the two groups, A and B, are represented on the left schemas and in the thermogram on the right. Group A—Classic abdominoplasty; Group B—Scarpa-sparing abdominoplasty. Red circle—R1, yellow circle—R2, blue rectangle—R3, green rectangle—R4. In Group B, the triangular areas of Scarpa fascia preservation are represented in a dark line. Two lateral circles at the right and left side (R1—red and R2—yellow, respectively) with 40 pixels of diameter were defined at mid-distance between the umbilicus and the abdominal inferior incision limit and located at the junction of the two medial thirds and the lateral third of a horizontal line from the midline to the lateral boundary of the undermined area. In addition, two rectangles were also defined, with 50 × 15 pixels, with a vertical orientation, near the midline, on the right and left sides, without any areolar tissue—supra-deep fascia plane (R3—blue and R4—green, respectively). A lateral circle was chosen to have absolute confidence that when Scarpa fascia was preserved, it would be included in the ROIs' area. Similarly, a vertical rectangle was selected to have complete confidence that the deep fascia was assessed near the midline, without any Scarpa. R1 e R3—right side; R2 e R4—left side of the body.

Table 1 Demographics of both groups (n = 12).[a]

	Group A PFS= 0 (n = 6)	Group B PFS= 1 (n = 6)	*P* value
Age, years			
Mean ± SD	50.3 ± 6.2	44.3 ± 11.3	NS
Range	42-55	33-53	
BMI, kg/m^2			
Mean ± SD	28.6 ± 0.8	26.9 ± 2.7	NS
Range	26.3-29.6	22.5-29.9	
Medical comorbidities, total no. (%)	2 (33.0%)	0 (0%)	NS
Smoking, total no. (%) - stopped 4 weeks before surgery	0 (0%)	1 (16.7%)	NS
Previous minor abdominal surgery, total no. (%)	5 (83.3%)	6 (100.0%)	NS
Previous bariatric surgery, total no. (%)	2 (33.3%)	3 (50.0%)	NS

[a] Group A: Classic abdominoplasty (n = 6); Group B: Scarpa-sparing abdominoplasty (n = 6). Age, body mass index were compared between groups using Student´s T test and normalized when needed. The other variables were compared using the X2 test. SD: standard deviation. NS: not significant.

Statistical analysis

Normality and homogeneity of variances were tested by Shapiro-Wilk and Kolmogorov-Smirnov tests and Levene's test, respectively, and normalized when appropriate (log transformation). Statistical evaluation was done by Student's test for parametric and Mann-Whitney U test, and Kruskal-Wallis test for non-parametric continuous variables, and the x2 test for categorical variables.

Differences were considered statistically significant at $P < 0.05$. All statistical analyses were performed using IBM Statistical Package for Social Sciences software package (IBM SPSS version 26.0).

Results

A total of 12 female patients were included in the study: 6 in Group A (classic abdominoplasty) and 6 in Group B (Scarpa-sparing abdominoplasty). Table 1 shows the general characteristics of both groups, which presented no significant differences.

DIRT (Pre-Op)

DIRT performed in the preoperative period did not present significant differences between groups considering the mean temperatures of R1 and R2 during the thermal recovery and symmetry values.

Static thermography (INTRA-OP)

The mean temperatures of all ROIs evaluated by static thermography performed intraoperatively didn't show differences between groups (Table 2). Nevertheless, comparing thermal gradients between lateral and medial ROIs, there were higher magnitude gradients in Group B (Scarpa-sparing), which reached statistical significance on the right side (thermal gradient R1-R3; P = 0.037) when compared to Group A. A similar difference was observed on the left side but did not reach statistical significance (P = 0.071) (Figure 5).

Table 2 ROIs' temperature at the intra-operatory for both groups.[a]

	Group A PFS= 0 (n = 6)	Group B PFS= 1 (n = 6)	*P* value
ROI Temperature (°C)	Mean ± SD Range	Mean ± SD Range	
R1	**31.4 ± 1.1** 30.3-32.6	**31.2 ± 0.9** 30.2-32.1	NS
R2	**31.5 ± 0.9** 30.6-31.9	**31.9 ± 1.1** 30.1-32.3	NS
R3	**32.1 ± 1.9** 30.0-34.1	**33.3 ± 1.7** 31.5-35.1	NS
R4	**31.4 ± 1.8** 31.3-33.3	**33.1 ± 1.7** 31.0-34.9	NS

[a] Group A: Classic abdominoplasty (n = 6); Group B: Scarpa-sparing abdominoplasty (n = 6). ROIs' temperatures were compared between groups using the Student´s T test. NS: not significant (*P* > 0.05). SD: standard deviation.

The arterial blood pressure values were recorded when the thermograms were taken and showed no differences between groups (mean blood pressure in Group A: 118/77.3 mmHg, Group B: 110/70.3 mmHg; P = 0.33). Ambient temperature and relative humidity did not show differences between groups, which complies with the international guidelines for this type of thermographic evaluation.[20,30]

DIRT (PO M1 and PO M6)

Looking at one-month postop (PO M1), Group B presented a trend for higher mean temperature values (Figure 6) from the beginning of the recovery phase until its end (Figure 7). On the other hand, Group B presented better thermal

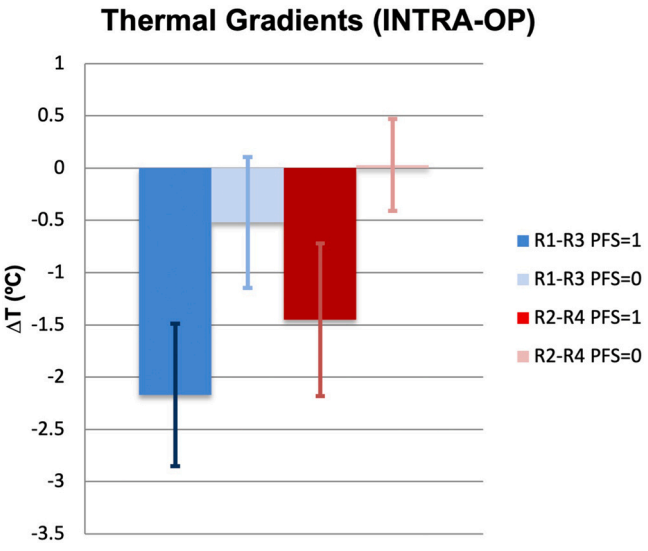

Figure 5 Static thermography at the INTRA-OP: Thermal gradients between lateral (R1, R2) and medial ROIs (R3, R4) -for Group A (PFS=0, classic abdominoplasty) and Group B (PFS=1, Scarpa-sparing abdominoplasty). Higher gradients were observed for Group B on the right side (gradient R1-R3; P = 0.037; Kruskal-Wallis test). R1-R3—right side; R2-R4—left side of the body.

symmetry (R1-R2 mean temperatures) when compared to Group A, and this difference was statistically significant at the one-minute mark after the cold stimulus (P = 0.035; Kruskal-Wallis test). Group B presented a trend for better symmetry at all minutes (Figure 8). No other differences were observed.

Concerning the six-month postop (PO M6), there were no differences in the thermal recovery of R1 or R2 between groups (Figure 9), looking at ROIs' mean temperatures and symmetry values.[26]

There were no differences between the mean temperatures of the same ROI (R1 or R2) over time (PO M1 *versus* PO M6).

DIRT results were not different between the bariatric (5) and non-bariatric (7) patients ($p > 0.05$, Kruskal-Wallis test), as they also were not different for the patients with or without comorbidities.

Discussion

This is the first infrared thermography (pre, intra, and postoperative) study performed in patients submitted to a full abdominoplasty using two surgical techniques: with and without Scarpa fascia preservation. The thermography results suggest an improved abdominal wall vascularization when Scarpa fascia is preserved and, thus, a fast recovery to the baseline temperature.

Dynamic thermography at 1-month postop demonstrated two important results:

- Group B shows a trend for faster recovery after the cold challenge when compared with Group A patients.

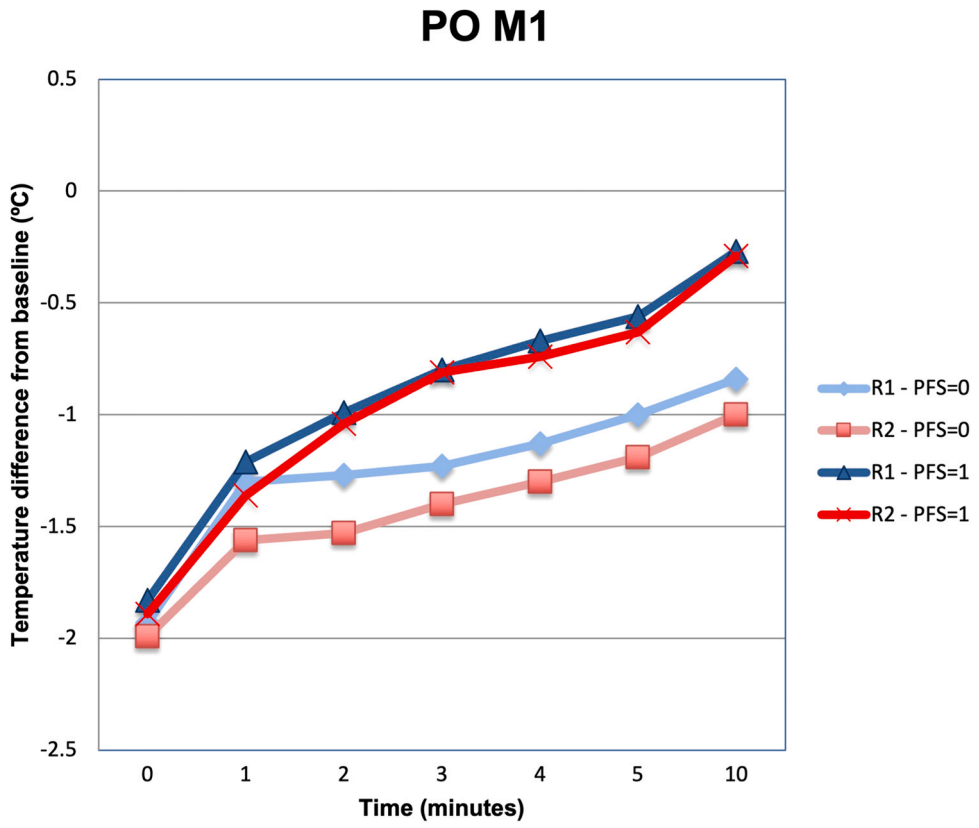

Figure 6 -DIRT at PO M1: Thermal recovery of R1 and R2 for both groups (Group A, PFS=0, classic abdominoplasty; Group B, PFS=1, Scarpa-sparing abdominoplasty) after cold stimulus, until 10 min mark.

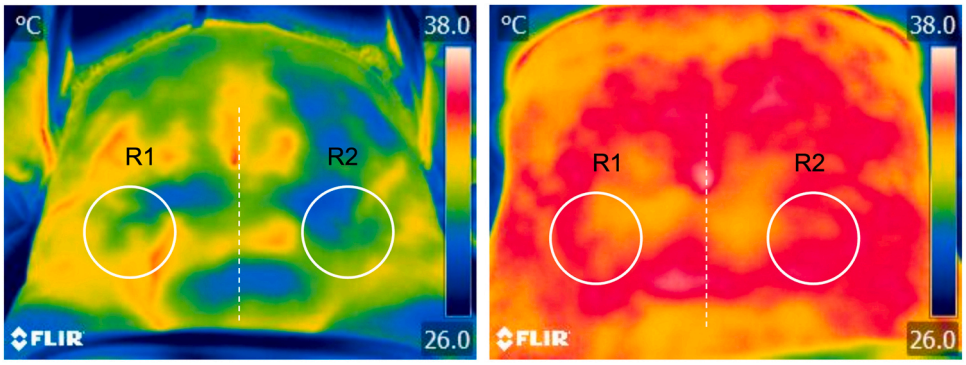

Figure 7 -DIRT at PO M1: Two thermograms of the two groups considered (Group A, PFS=0, classical abdominoplasty; Group B, PFS=1, Scarpa-sparing abdominoplasty) were captured at the end of the thermal recovery (10-minute mark), after the cold stimulus. Note that the thermograms are in the same thermal scale to be able to be compared and relate to the same minute of thermal recovery; the colors of the image are patient-specific. In thermography analysis, to compare thermograms/ thermal images, thermograms must be in the same scale/interval of temperatures and captured at the same moment of thermal recovery, as was done here. The color scheme is patient-specific and is of central relevance to looking at the sequence of thermal images of the thermal recovery and calculating the mean temperatures of the ROIs of each patient, which is patient-specific and infers about tissue perfusion.

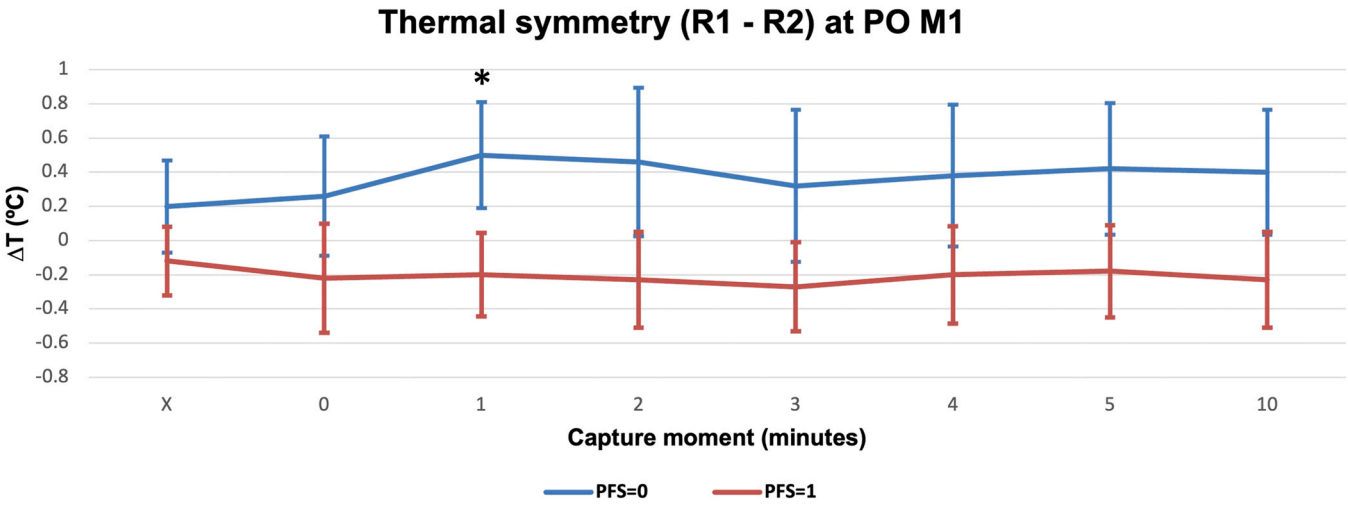

Figure 8 DIRT at PO M1: Thermal symmetry between R1 and R2 in the two groups (Group A, PFS=0; Group B, PFS=1). ΔT (°C)—temperature variation ± SD (standard deviation). (*Thermal symmetry at 1-minute R1-R2, P = 0.035; Kruskal-Wallis test); (X—baseline).

- Thermal symmetry between ROIs was better in Group B (P = 0.035, 1-min. mark). Thus, the skin temperature seems more uniform.

The asepsis requirements and the time to perform the DIRT analysis (25 min until the thermal recovery) that expose the patient to a hypothermic stimulus with the consequent risks limit the dynamic thermographic assessment intraoperatively. Consequently, intraoperative static thermography was used, demonstrating that thermal gradients between lateral and medial ROIs differed between groups, as higher values were found in Group B. This difference was highly significant on the right side (P = 0.037). These higher gradients may indicate that, in this case, the temperature is affected by highly vascularized deep structures in the intraperitoneal cavity, such as the epiploon and bowel. This possibility should be considered due to the low thickness of the deep fascia. On the other hand, in Group B, Scarpa fascia and the deep fat compartment were preserved, and their presence may have blunted the thermographic readings resulting in lower temperatures and higher negative gradients. In Group A, the dissection plane is essentially the same in the areas evaluated, which may explain the observed lower gradients. Other methods must be used to investigate this issue during surgery.

The presence of the aorta artery located mainly on the left side of the body can be the possible explanation for lower thermal gradients on the left side in both groups since, as a highly vascular structure, it improves thermography readings, resulting in higher temperature values of

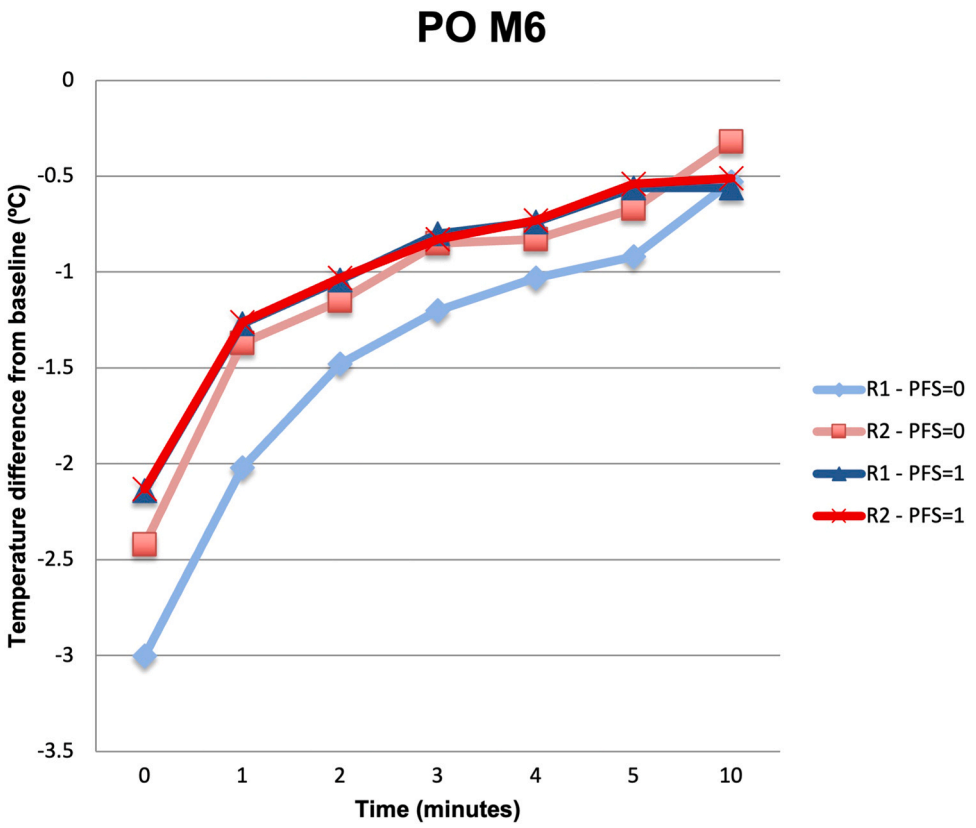

Figure 9 DIRT at PO M6: Thermal recovery of R1 and R2 for both groups (Group A, PFS=0, classic abdominoplasty; Group B, PFS=1, Scarpa-sparing abdominoplasty) after cold stimulus, until 10 min mark.

the left ROIs considered (R2, R4) compared to the right side. Verstockt et al.,[36] in their recent study, suggest that hot or cold spots on the skin surface are influenced by various subcutaneous factors such as metabolic processes or the presence of large blood vessels and bones.

We would not expect differences in thermography values after six months of surgery between groups—corresponding to the remodeling phase, with the healing process in an advanced stage and the neovascularization happening earlier in the proliferative phase. Thermography sensitivity is reported as 95.2–99.4% in the studies focusing on superficial venous insufficiency compared to a duplex ultrasound.[37] In a flap perfusion study, the diagnostic accuracy of a thermal imaging camera was calculated to be 96.43%, with a sensitivity of 98.7%, and specificity of 75%.[38]

The current research results add some knowledge to clarify the effects of Scarpa-sparing abdominoplasty. This technique, which preserves Scarpa fascia in the infraumbilical area along with the deep fat compartment, has been shown to have significant clinical advantages without compromising the esthetic result.[3,6–9] This point is widely accepted and subject to constant and new investigations.[1,19,39] A recently published systematic review and meta-analysis, conducted according to PRISMA guidelines, considered only level 1 and 2 studies, summarizes the best available evidence regarding the above-mentioned technique and confirms that Scarpa-sparing abdominoplasty has several clinical advantages.[40] The latter is also fully expressed in massive weight loss patients, a high-risk group for body contouring procedures.[9,41] Other systematic reviews also confirmed its clinical efficiency.[42–44]

Nevertheless, the mechanism underlying Scarpa fascia preservation is still controversial. Several theories have been proposed.[10] One refers to mechanical factors in an adhesive model.[12] Nakajima and Lancerotto, in two independent abdominal wall anatomical studies, verified that the superficial and the deep fat compartments differ in their physical properties.[11,12] The deep fat is more flexible than the superficial fat; consequently, the former achieves a higher lateral displacement. Ultimately, preserving Scarpa fascia and the deep fat may create a “stickier” interface between tissues, resulting in better resistance to shearing movements, tissue adhesion, and healing.

Another theory refers to lymphatics’ preservation. According to this model, when preserving Scarpa fascia and its deep tissues, the lymphatic drainage would be maintained as the lymphatic vessels would be kept along with their connection to inguinal lymph nodes, limiting fluid accumulation between surfaces, reducing dead space, and decreasing seroma rate. Claude Le Louarn first proposed this concept in 1992.[45] Nevertheless, there are very few studies on the subject, probably due to technical and procedural limitations for studying lymphatics, and the results are contradictory. Two recent anatomical studies demonstrate such opposition.[13,14] According to Tourani et al., most lymphatics are located in the subdermal plane.[13] At the same time, Friedman et al. found lymphatics near the fascial planes and in its deep tissues.[14] Further studies are needed to clarify this issue.

Another explanation, previously suggested by Luis Vásconez, refers to better vascularization when preserving Scarpa fascia and the underlying deep fat, respecting the normal physiology of the abdominal tissues. Several studies have been conducted to better understand the abdominal wall blood supply.[15–18] It has been shown that the superficial inferior epigastric artery travels just superficially to the Scarpa fascia and releases small branches to a fascial vascular network contained within the fascia.[15] In addition, the deep inferior epigastric vessels and their perforators may improve vascularization when performing a Scarpa-sparing abdominoplasty.[17,18] In a recent study, histological findings revealed more prominent blood vessels in the subscarpal-lipo-aponeurotic-system (SLAS) than in the fat layer overlaying Scarpa fascia.[19] Also, Pirri et al,[46] in a recent anatomical study, described a rich vascular dense network for Scarpa fascia, with an optimal and homogeneous distribution composed of arteries, veins, capillaries, and lymphatic segments. The present study results seem to provide additional arguments supporting this vascularization model.

Several authors have investigated Scarpa-sparing techniques, but differences exist among them regarding the exact surgical plane used (at the Scarpa level or in the middle of the deep fat) and the surgical manipulation of the deep fat compartment (with or without liposuction). The current research was done without manipulating the deep fat compartment, which may present advantages as its structure is better respected. This strategy to fully preserve the deep fat compartment is possible due to its low thickness[47] and has been shown not to interfere with the esthetic result.[7,8]

We can point out some potential limitations of the current research, such as the small sample size and the fact that we didn't use DIRT at the intraoperative. As for strengths, we can identify the following: only one surgeon was enrolled in the study, the complex and innovative protocol, and the extended follow-up (six months).

Further research is needed to fully clarify the mechanisms involved in Scarpa-sparing techniques for abdominoplasty and their preponderance.

Conclusion

For the first time, this study provided a thermographic evaluation of the lower abdominal wall before, during, and after a full abdominoplasty performed by either the classical or Scarpa-sparing techniques.

One month after surgery, dynamic thermography presented a better response when Scarpa fascia was preserved: stronger, faster, and more symmetric.

Based on the results of this study, improved abdominal wall vascularization may have a role in explaining the clinical efficiency of Scarpa-sparing abdominoplasty.

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Ethical statement

The study line was approved by the Ethical Committee of Centro Hospitalar São João/Faculty of Medicine, Porto (CES20100611). All patients who agreed to enroll in this study signed informed consent documents. The principles outlined in the Declaration of Helsinki have been followed. The authors adhered to STROBE guidelines.

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