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Cosmetic

Ultrasonography as a Tool to Improve Preoperative Marking in Body Contour Surgery

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Background: Body contouring surgery and surgical drawings are usually performed based on the surgeon's experience without considering the nature of the unique anatomical structures of each patient. Thus, we propose a more reliable surgical design approach that considers the anatomical structures of each patient. Ultrasonography is increasingly used in plastic surgery and helps plastic surgeons to highlight anatomical features representing results in their interventions by providing a better understanding of the patients' unique structures.

Methods: This study presents a series of cases involving 100 recruited patients (36 men and 64 women) between 18 and 60 years of age. Five surgeons examined the patients and created a presurgical design based on palpation, which was validated later by a physician skilled in evaluating the anterior wall of the abdomen using ultrasonography. The concordance between the findings of the palpation and ultrasonography was assessed for each patient.

Results: The concordance rate for each structure in both evaluations was midline (49%) ($P > 0.92$), diastasis recti (15%), semilunar line (23%), upper edge of rectus abdominis muscles (12%), lower edge of pectoral muscles (16%), border of oblique muscle (13%), number of tendinous intersections (12%), shape of tendinous intersections (11%), serratus anterior muscle (15%), subcostal triangle (15%), and oblique triangle (26%) ($P < 0.0001$).

Conclusion: All the structures evaluated by palpation in comparison with ultrasound show discordance, except the midline where agreement is evident, with a very good level of statistical significance. *(Plast Reconstr Surg Glob Open 2023; 11:e5431; doi: 10.1097/GOX.0000000000005431; Published online 27 November 2023.)*

INTRODUCTION

Body contouring procedures such as high-definition liposuction and muscle volume augmentation techniques provide athletic and aesthetic profiles. The aim is to achieve a natural-looking and well-defined muscular look according to modern aesthetic patient preferences. To this end, the use of technology is becoming increasingly popular in the evaluation and performance of cosmetic procedures.[1,2]

Analyses of the superficial, middle, and deep layers of the abdominal wall are essential to identify the direction of muscle fibers in each layer. During high-definition liposuction procedures associated with lipografting, specific anatomical landmarks such as the alba line, semilunar line, suboblique triangles, subcostal triangles, triangles of the semilunar line, and tendinous intersections play a crucial role.[3]

Ultrasonography (US) plays a central role in presurgical planning by delineating accurate assessment of the patient's natural anatomy, which likely could lead to improved postsurgical outcomes. This study focuses on the use of US in the preoperative stage, which allows for precise visualization of two anatomical layers of each patient, which may result in superior aesthetic and functional results.[4–6]

The objective of this study is to assess the precision of identifying anatomical structures during the presurgical

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design for liposuction body contour surgery, conducted through conventional palpation.

MATERIALS AND METHODS

In this study, we evaluated 100 potential candidates for high-definition liposuction surgery between August and October 2022. The study included 34 men and 64 women aged between 18 and 60 years who had a BMI less than 28 for the convenience of researchers. The exclusion criteria include previous abdominal surgery (aesthetic or otherwise), thoracoabdominal deformities that alter the anatomy in this region, previous aesthetic treatments (eg, carboxytherapy), and patients with flaccidity (Matarasso ≥ III). Plastic surgeons with less than 2 years of experience were not considered for evaluating the designs.

Before the study, all patients were informed about the objectives and signed a consent form agreeing to participate. Additionally, they agreed to the use of audiovisual material made from their images for the purpose of this study. This study adheres to the principles of the Declaration of Helsinki and was approved by the local ethics committee in Lima, Peru. Data were stored in a Microsoft Excel database (Microsoft Corp., Redmond, Wash.) and analyzed using the statistical program SPSS version 25 (IMB Corp., Armonk, N.Y.).

The study of this research was on a visualization basis whether the markings were exactly in the same place or not. There was no margin of discrepancy. Differences between scores were not measured. The 100 participants were evaluated by five plastic surgeons, who performed the presurgical markings using conventional palpation techniques. Subsequently, the same 100 patients were evaluated by a certified surgeon specialized in US, who used a US evaluation to validate the correct identification of anatomical structures. Each ultrasound evaluation was conducted separately from the evaluated surgeons, so the design and the evaluator were unknown to each other. [**See Video 1 (online)**, which shows the ultrasound design technique.] [**See Video 2 (online)**, which shows the palpatory design technique.] First, the plastic surgeon makes the markings by palpation with a pen of one color, and then the certified surgeon specialized in US makes a new marking following the anatomical lines found with the ultrasound with a pen of another color. [**See Video 3(online),** which compares the palpatory versus ultrasound design technique.] (**See figure, Supplemental Digital Content 1**, which shows the checklist used to correlate presurgical design, **http://links.lww.com/PRSGO/C888**.) A verification checklist was used to ensure the accuracy of the results, made by a trained nurse, for the following findings: midline, semilunar line, subcostal triangle, triangles of the semilunar line, suboblique triangles, tendinous intersections and, serratus anterior muscle. These results were found by the ultrasound to coincide with the palpatory marking or to not coincide.[14] All the information collected during the study was recorded in the Microsoft Excel database for further statistical analysis. A correlation study with Kappa coefficient, was conducted to determine the similarity between the markings made by the plastic surgeons and the US evaluation. We consider similarity to be a percentage level of agreement to 50%. The US evaluations were performed using an Ultrasonography Mindray Z60 scanner equipped with a linear transducer.

Takeaways

Question: Is the palpation method ideal for identifying anatomical structures and performing the presurgical design, respecting the individuality of each patient?

Findings: Except for the midline, ultrasonography showed significant disagreement with all the other variables.

Meaning: Palpation-based presurgical design has limitations in identifying the individual anatomical structures of each patient.

Ultrasonography Evaluation Method

The steps below are consistent with the sequence of the ultrasound evaluation procedure [**see Video 1 (online)**].

Description of the Marking Technique

In a standing position, the plastic surgeons located the predetermined anatomical structures (midline, semilunar line, subcostal triangle, triangles of the semilunar line, suboblique triangles, tendinous intersections, and serratus anterior muscle) by palpation, and marked them with a designated colored marker (Fig. 1).

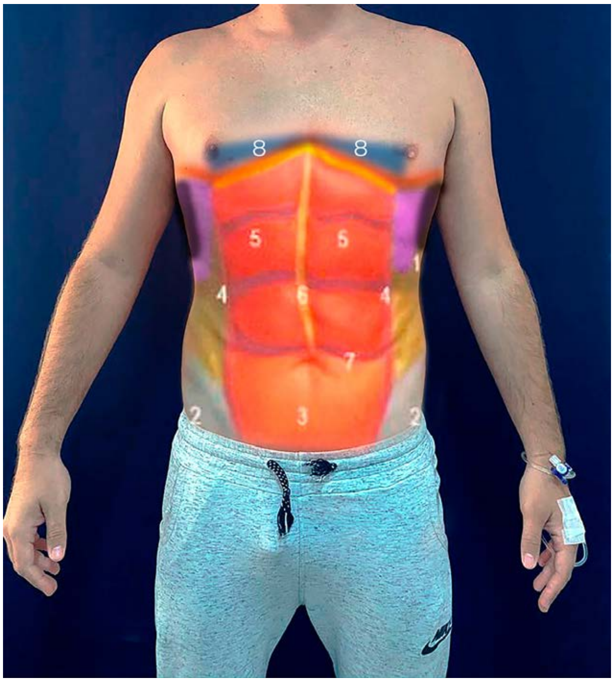

Fig. 1. Photograph of analyzed anatomical structures. 1: Superior border of oblique muscle. 2: Suboblique triangle. 3: Hypogastrium. 4: Semilunar lines. 5: Rectus abdominis muscles. 6: Midline. 7: Inferior tendinous intersections. 8: Pectoral and subcostal triangle. Purple lines: tendinous intersections. Orange lines: lower border of the pectorals. Yellow zone: upper edge of the rectus abdominis. Purple zone: anterior serratus muscles. Black zone: latissimus dorsi muscles.

Midline and Location of the Diastasis Recti

On an image projector, the midline of the patient may be identified by the shadow created by the fusion of the paired rectus abdominal muscles. The width of the midline equates to the degree of diastasis and can be quantified when the transducer is placed in a cross-section at the level of the umbilicus. In the same cross-section orientation, the upper limit of the midline may be established by linearly sliding to the upper fusion point of the rectus abdominis. Once the location and the width are established, a marking of approximately 0.5 is made at the outer limits of the midline on both sides (left and right). The rectangle formed between the points of superior fusion, inferior fusion, and width of the median line will be the design of the marking. Findings beyond the limit of the rectangle formed will be midline diastasis through the US evaluation. In some cases, there may be a marking of the infraumbilical midline due to muscular diastasis observed during the US examination.[3] To determine the marking of the midline, the width of the midline plus 0.5 cm is considered, which configures the degree of diastasis, plus the costal arch projection. The projection of the costal arch must be considered, as it configures in the region supraumbilical, a natural widening of the midline to posterior narrowing in the xiphoid region. Standard measurements for midline width at the three reference points are as follows: xiphoid 1.5 cm, 3 cm above umbilicus 2.2 cm, 2 cm below umbilicus 1.6 cm.[24]

Upper Insertion of the Rectus Abdominis into the Costal Arches (Subcostal Arch)

To start marking, we identify the point of union between the ninth rib and the lateral edge of the rectus abdominis muscle bilaterally. This is the start of the subcostal triangle. Thereafter, the symmetry is checked using a ruler to measure the rectus abdominis muscle, which is typically around 8 cm in length. Two reference points are first identified at the level of the lateral edge of the rectus abdominis muscle, one at the umbilical level and the other at the infraumbilical level, this one in between the umbilicus and pubis. This allows us to determine the anatomy of the muscle, whether it is straight or convergent. Then, with the transducer in a linear position, starting from the central point of the areola, a sliding down movement is performed in a craniocaudal direction to observe the beginning of the muscle fibers of the rectus abdominis. This is how the subcostal triangle is defined.[7–12]

Identification of Semilunar Line

To identify the semilunar lines, which correspond to the lateral margins of the rectus abdominis muscle and are formed by the aponeurosis divisions of the internal oblique muscle, the transducer is placed in a cross-sectional position. The sliding maneuver is then performed on both sides (right and left), moving laterally, until the lateral edge of the rectus abdominis muscle is located at three points from the midline: supraumbilical, umbilical, and infraumbilical. The supraumbilical point begins approximately at the median height between the xiphoid process and 3 cm above the umbilicus, continuing laterally until it finds the point below the ninth rib of the subcostal triangle. The semilunar line marking point will be slightly medial to the point of the ninth rib of the subcostal triangle. The umbilical point begins at the navel itself and goes laterally where the point on the semilunar line will be slightly medial to the previously marked point on the subcostal triangle. The infraumbilical starting point is in the median region between the pubis and the umbilicus, continuing laterally until the convergence between the fibers of the rectus muscle and the external oblique muscle. Thus, the three points of the semilunar line must converge. To identify the medial edge of the oblique muscle and limit of the ninth rib, we first mark the subcostal triangle. From there, we draw a 2-cm parallel line to the semilunar line, originating at the end of the subcostal triangle. This line narrows as it approaches the pubic region. Next, we draw a line from the beginning of the semilunar line to the iliac spine, creating a larger base triangle, known as the suboblique triangle. The negative areas of the marking are the median line, subcostal triangle, semilunar line, and suboblique triangle.[7–12]

Identification of Suboblique Triangle

First, the apexes of the anterior superior iliac crests are marked with a dot. Then, from the point where the semilunar line begins, previously defined, to the apex of the anterior superior iliac point, with the transducer positioned diagonally and perpendicular to the height of the inguinal ligament, we draw a line joining these points. From the point of the apex of the iliac spine, with the transducer, we proceed to infer medially following the edge of the external obliquus muscle until the end of the rectilinear segment. This will be the third point for defining the suboblique triangle.[7–12]

Identification of Tendinous Intersections of the Rectus Abdominis Muscle

To identify the tendon intersections, with the transducer in a linear position, starting from the superior fusion point of the rectus muscle, we slide the transducer in the cranial to caudal direction toward the median region between the semilunar line and the midline to identify the tendinous intersections. Once identified, in a second maneuver, we slide medially and laterally to find the ends of each "pack" and mark the points respectively to highlight the negative areas to be demarcated. The process is done bilaterally in reference to the midline. Thus, the number and shapes of these intersections vary between patients. Therefore, correctly identifying each one is essential in this study.[7–12]

Identification of the Serratus Anterior Muscle

To identify the grooves of the serratus anterior inferior muscle, the transducer is placed longitudinally at the upper edge of the rectus abdominis muscle, and a sliding maneuver is performed in the anterolateral direction until the edge of the oblique muscle is identified. From there, a diagonal movement is performed in the posterolateral direction toward the anterior and middle axillary lines. This maneuver is performed bilaterally, and its purpose is to demarcate the grooves of the serratus anterior inferior muscle located between the sixth and eighth rib.[7–12]

Table 1. Descriptive Table of Patients

Description	Men	Women	Total
No. patients	36	64	100
Age (y)	30.03 (19–40)*	29.30 (19–40)*	29.56*
Weight (kg)*	69.78 (60–78)*	66.72 (53–78)*	67.82*
Height (cm)*	171.1(160–183)*	169.5 (155–183)*	170.08*
BMI*	23.98 (20–27)*	23.27 (19–27)*	23.53*
Absence of flaccidity	8	24	32
Flaccidity without ptosis	15	18	33
Flaccidity with slight ptosis	13	22	35
Flaccidity with moderate ptosis	0	0	0
Flaccidity with severe ptosis	0	0	0

*Mean values.

RESULTS

Presurgical markings were performed on 100 patients (36 men and 64 women) who underwent body contour surgery. The mean age was 30.03 years old for men and 29.30 years old for women, with a mean BMI of 23.98 and 23.27, respectively. All patients were highly educated; some experienced mild flaccidity or sagging (Table 1).

All markings were performed by five plastic surgeons with at least 2 years of experience. The presurgical design was performed on 100 patients and classified as shown in Table 2. US evaluation was performed by a physician trained in soft-tissue US to correlate the presurgical markings, and the concordance rate for each structure was obtained as follows: midline (49%) ($P > 0.92$), diastasis recti (15%), semilunar line (23%), upper edge of rectus abdominis muscles (12%), lower edge of pectoral muscles (16%), border of oblique muscle (13%), number of tendinous intersections (12%), shape of tendinous intersections (11%), serratus anterior muscle (15%), subcostal triangle (15 %), and oblique triangle (26%) ($P < 0.0001$) (Table 3).

DISCUSSION

The advances in corporal contouring techniques are the principal motivation to be able to contribute a little more to the happiness of each patient. In this way, the plastic surgeon, whether for aesthetic or restorative purposes, is at the forefront of patient care. The goal is a safe surgery, without unexpected complications. Therefore, plastic surgeons and the scientific community are motivated to explore innovative techniques, to use multidisciplinary equipment, to improve the accuracy of preoperative markings.[13]

Table 2. Distribution of Patients for Each Physician Evaluated

Plastic Surgeon	Men	Women	Total
1	10	7	17
2	4	13	17
3	8	15	23
4	7	14	21
5	7	15	22
Total	36	64	100

Table 3. Agreement Analysis

Indicators	% Agreement	% Cal Theoric	*P*	Interpretation
Midline	49.0	50	0.92	Agreement
Diastasis recti	15.0		0.0001	No agreement
Semilunar line	23.0		0.0001	No agreement
Top edge of the rectus abdominis muscle	12.0		0.0001	No agreement
Lower edge of the pectoral muscle	16.0		0.0001	No agreement
Oblique muscle edge	13.0		0.0001	No agreement
No. TIRA	12.0		0.0001	No agreement
Shape of the TIRA	11.0		0.0001	No agreement
Serratus muscle	15.0		0.0001	No agreement
Subcostal triangle	15.0		0.0001	No agreement
Oblique triangle	26.0		0.0001	No agreement

Hypothesis: Ho: agreement between the measurements; H1: no agreement between measurements.
TIRA, tendinous intersections of the rectus abdominis.

During high-definition liposculpture, US has been useful for intramuscular fat graft placement and volume endpoints, by locating each patient's individual anatomical structures and their unique variations. The use of US deepens basic understanding of anatomy and helps to reveal individual differences and further tailor techniques.[14–15] US enables us to further personalize the areas to highlight while respecting each patients' individual characteristics.[16–18]

US is an easy way to improve the marking technique for liposuction of the rectus abdominis or other surgical interventions on the anterior wall of the abdomen in clinical practice. In this study, we have shown that preoperative use of US can improve the marking technique for liposuction and thereby, possibly intramuscular fat grafting. Taking advantage of these findings can lead to safe and possibly more satisfactory outcomes.[19–23]

Our study aimed to evaluate the agreement between presurgical markings made by five plastic surgeons using the conventional palpation technique. Later, it validated these markings with US, giving results that were consistent only in one evaluated structure (midline). That is, this structure is easily recognizable with clear anatomical relationships; thus, a good palpation examination is sufficient for its accurate location. However, there was no statistical agreement in the other structures. In fact, there was a high degree of disagreement between the findings, and the anatomical location was more conceptual than precise. (**See figure, Supplemental Digital Content 2**, which shows the first presurgical design evaluated, **http://links.lww.com/PRSGO/C889**.) (**See figure, Supplemental Digital Content 3**, which shows the second presurgical design evaluated, **http://links.lww.com/PRSGO/C890**.)

The results obtained in our study show the limitations of using palpation as a method for presurgical markings. This is evidenced by the disagreement between the palpation findings and those obtained through US analysis. Therefore, incorporating abdominal US in the preoperative marking process can provide greater reliability to the surgeon, paving the way for better aesthetic outcomes and improved patient safety.

CONCLUSION

Compared with US evaluations, the method of presurgical markings using palpation on the anatomical landmarks such as diastasis recti, semilunar line, upper border of the rectus abdominis muscles, lower border of the pectoral muscles, margin of the oblique muscle, number and shape of tendinous intersections, subcostal triangle, and suboblique triangle showed no agreement, except for the midline ($P < 0.0001$).

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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