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Abdominal closure with different oblique planes in island TRAM flaps: a method for achieving a better scar and contour of the donor site

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Background An autologous abdominal flap can provide an aesthetically pleasing breast with a natural feel. However, contracted scars and hourglass contour deformities at the abdominal donor site can sometimes occur. These complications can reduce patient satisfaction and quality of life. Therefore, we performed different oblique plane closure of the abdominal donor site and evaluated the aesthetic scores in comparison with the conventional vertical single plane closure.

Methods The procedures begin with a beveled incision down to the fascia level during transverse rectus abdominis muscle flap elevation. At the time of donor site closure, Scarpa's fascia and the subcutaneous layers are sutured while being pulled downward. Sixty patients were divided into two groups: group A (single vertical plane closure) and group B (different oblique plane closure). Abdominal scars were scored by five reviewers using the scar scale.

Results There were no significant differences in scores for vascularization, dog-ear presence, and umbilical shape of the scar between the two groups. However, group B showed marked improvements in flatness, contracture, and thickness of the scar surface. Notably, the different oblique plane closure in group B achieved much higher scores for the abdominal contour than group A.

Conclusions The vertical single plane suture of the abdominal donor site may result in depressive contracture with poor cosmetic outcomes. The different oblique plane closure technique markedly improved the appearance of scars on the abdomen. This technique is likely to enhance patient satisfaction with both the breast and abdominal outcomes of breast reconstruction using an abdominal flap.

Keywords Surgical flaps / Scar / Abdominal closure technique / Esthetics

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INTRODUCTION

Breast reconstruction following mastectomy due to breast cancer can be broadly categorized into two approaches: those utilizing tissue expanders and permanent prosthetics, and those employing autologous tissues. The latissimus dorsi flap, developed in the late 1970s, and the transverse rectus abdominis myocutaneous (TRAM) flap, which utilizes the transverse rectus abdominis muscle and was introduced by Dr. Carl Hartrampf in the 1980s, are the most commonly used autologous tissue methods [1-3]. The TRAM flap, in particular, can create a more natural breast shape using the patient's own tissues, provides long-lasting results with minimal additional operations, and offers the added benefit of reducing abdominal fat. One significant drawback of the TRAM flap has been its potential to alter the inframammary fold's contour, but this issue has been mitigated with the advent of the island TRAM flap procedure [3]. The deep inferior epigastric perforator (DIEP) flap, which requires a high

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level of surgical expertise and thus a significant amount of experience and skill from the surgeon, can involve longer operation times. However, it has gained recognition for its ability to preserve abdominal muscles, which may help reduce postoperative complications. Despite the numerous benefits of using autologous tissue in surgical techniques, the extensive nature of the surgery, the possibility of residual scarring, and the need for ongoing management are recognized as notable drawbacks [4-6]. The scars from latissimus dorsi and TRAM flap surgery have been typically hidden by underwear. However, as the importance of quality of life, diverse lifestyles, and leisure activities has increased, the visibility of these scars has become a more pressing issue to address [7-10]. In this study, we employed the different oblique planes closure technique as an alternative to the traditional vertical single plane method for donor site closure in island TRAM flap surgery patients. We assessed the aesthetic appearance of abdominal scars at least 6 months postoperatively, once the scars had matured, and compared the results to those of the conventional method. The purpose of this research was to determine the effectiveness of this simple modified technique.

METHODS

This study was conducted with institutional review board approval (IRB No. 2023-06-040-002) and included 60 patients who underwent breast cancer surgery and reconstruction using the island TRAM method from 2021 to 2022. The inclusion criteria required that patients could be followed up for at least 6 months post-surgery. Photographs of their abdominal scars and contours were taken from the front and both sides. We developed an Abdominal Scar Scale based on the previous literature, as depicted in Fig. 1. The scale includes a "general appearance" category, which evaluates the overall first impression of the abdomen, rather than focusing on specific details. The "vascularization" category, commonly found in scar scales, assesses the visibility of blood vessels on the scar surface. "Thickness" refers to whether the scar is hypertrophic, while "pliability/stiffness" evaluates the apparent flexibility of the scar. The degree of irregularity is measured in the "scar contracture" and "flatness" categories, and "pigmentation" examines the coloration of the wound. The "abnormal sense appearance" category allows

Abdominal scar scale (island TRAM flap)										
General appearance	Not good looking									Good looking
	1	2	3	4	5	6	7	8	9	10
Common scar scales										
	Worst scar imaginable									Normal skin
Vascularization	1	2	3	4	5	6	7	8	9	10
Thickness	1	2	3	4	5	6	7	8	9	10
Pliability / Stiffness	1	2	3	4	5	6	7	8	9	10
	Bulging / Depressed									Normal
Scar surface height	1	2	3	4	5	6	7	8	9	10
	lrregular									Regular
Scar surface flatness	1	2	3	4	5	6	7	8	9	10
	Hyperpigmentation									Normal
Pigmentation	1	2	3	4	5	6	7	8	9	10
	Painful or itching looking									Normal looking
Abnormal sense appearance	1	2	3	4	5	6	7	8	9	10
Abdomen structures										
	Not good looking									Good looking
Abdomen volume	1	2	3	4	5	6	7	8	9	10
	Well-defined									Unnoticeable
Abdomen contour	1	2	3	4	5	6	7	8	9	10
	Large excess of skin									No excess of skin
Doggy-ear existence	1	2	3	4	5	6	7	8	9	10
	Large amount of fat									Adequate fat distribution
Abdominal overhang	1	2	3	4	5	6	7	8	9	10
	Not good looking									Good looking
Umbilical shape	1	2	3	4	5	6	7	8	9	10

Fig. 1. Abdominal scar scale (island TRAM flap). General appearance: aesthetic level when looking at the picture intuitively; Vascularization: the extent to which blood vessels are spread in the scar; Thickness: the degree of hypertrophic scarring; Pliability/stiffness: the extent to which the scar area looks hard; Scar surface height: the degree of bulging or depressed scar surface; Scar surface flatness: the degree of irregularity of the surface of the scar; Pigmentation: the degree of pigmented of the scar; Abnormal sense appearance: the degree to which the shape of the scar looks painful; Abdomen volume: whether the distribution of the overall volume of the abdomen is even; Abdomen contour: the degree of discontinuity above and below the incision line; Abdominal overhang: the extent to which the top and bottom of the incision line do not fit together.

the evaluator to score the scar based on the appearance of pain or itchiness. Additionally, we analyzed the abdominal structure in more detail. "Abdomen volume" assessed the even distribution of the abdomen's overall volume. "Abdomen contour" evaluated the smoothness of the transition across the surgical incision line. In the "abdominal overhang" category, we examined the continuity of the abdominal shape and the distribution of fat relative to the incision line. We also assessed "dog-ear presence" and "umbilical shape."

The evaluation team consisted of five individuals. To minimize bias, the senior author who performed the operations did not participate in the evaluations. The team included three plastic surgeons, one general physician, and one nurse. Evaluators were presented with randomly assorted photographs of patients' abdomens, taken from the front and both sides approximately 6 months following surgery. They conducted their assessments independently, without discussing their observations or opinions.

Surgical method

The overall surgical procedure adhered to the island TRAM flap method. To summarize the technique, the flap was designed to include approximately 2 cm above the navel in the preoperative plan. This ensured that the fascia could be clearly delineated at this level, and the flap primarily encompassed zones I and III of the breast volume. Additionally, a portion of zone II, extending beyond the navel, was incorporated into the flap.

In accordance with the island TRAM flap design, meticulous resection was performed to harvest the flap. During the initial abdominal incision, we opted for an oblique cut using a Bovie electrocoagulator, rather than the traditional vertical incision. We identified as many perforators in zone I as possible, ensuring that each perforator descended beneath the fascia. We then marked the Z-shaped incision line with a marking pen to facilitate later fascial repair, taking care to preserve the superior epigastric region intact with a vessel loop. Subsequently, we excised the rectus muscle near the arcuate line and de-epithelialized the area according to the breast reconstruction site's requirements. The muscle pedicle and the harvested flap were then secured with 2-0 silk, and the flap was transferred to the reconstruction site via tunneling. Following the transfer, we closed the fascia using 2-0 silk to prevent herniation. The remaining rectus muscle below the arcuate line was elevated to cover the arcuate line.

The focus of this paper is the closure of the abdominal surgical site. As mentioned earlier, some skin along the incision line was removed during surgery to eliminate non-viable tissue, and closure was performed in layers. Unlike the conventional single vertical plane closure, we closed the incision in a stepwise fashion across oblique planes (Fig. 2). To elaborate, the traditional method involves closing all layers–Scarpa's fascia, Camper's fascia (subcutaneous layers), and the skin–in a single, straight line. In contrast, our study closed each layer separately, in its own plane. We began

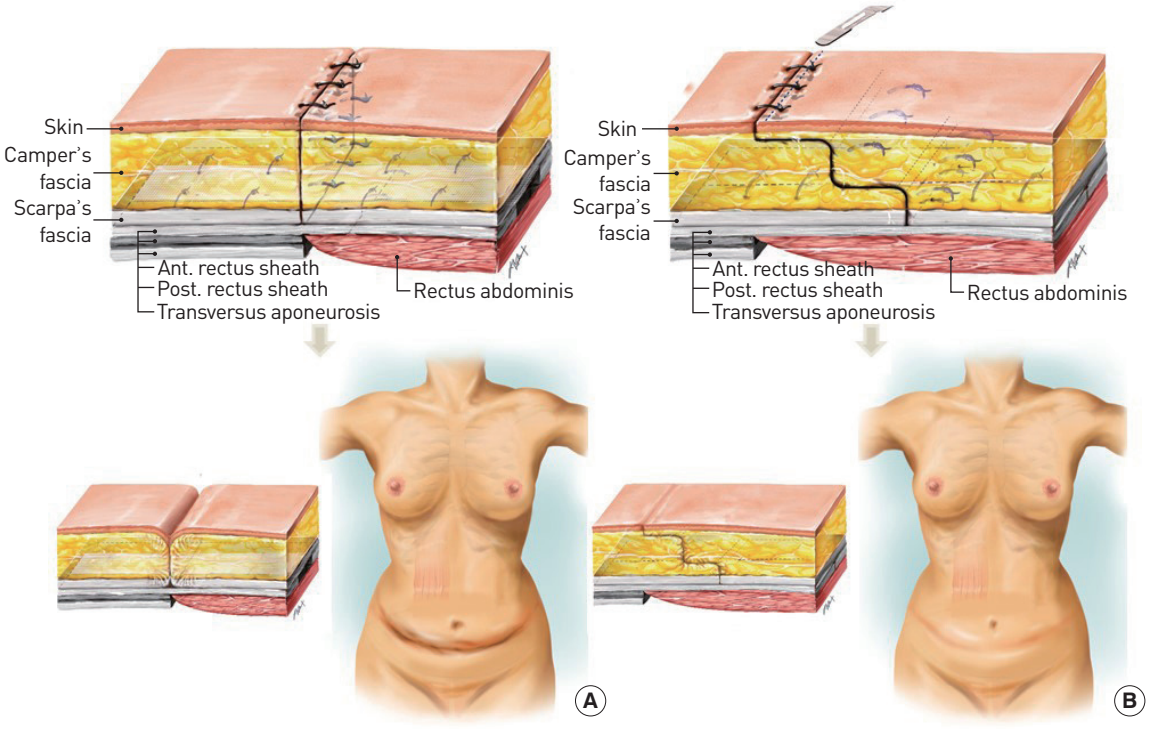

Fig. 2. Traditional "single vertical plane closure" technique (A) and the "oblique different planes closure" technique illustration (B). And a schematic of the shape of the final abdomen after surgery with each surgical technique.

by suturing Scarpa's fascia, the deepest layer. Then, we made diagonal incisions into Camper's fascia and the subcutaneous layer with a Bovie electrocoagulator, ensuring closure on separate planes. For the skin, the outermost layer, we excised any portion with reduced viability due to prolonged surgery and traction-related trauma. We then stretched the skin by 1–2 cm for a taut appearance before meticulous suturing. Skin trimming was performed at both the upper and lower abdominal margins, making incisions of approximately 1 cm to prevent skin overlap and to achieve closure on different planes (Fig. 3). This technique allowed us to close the incision

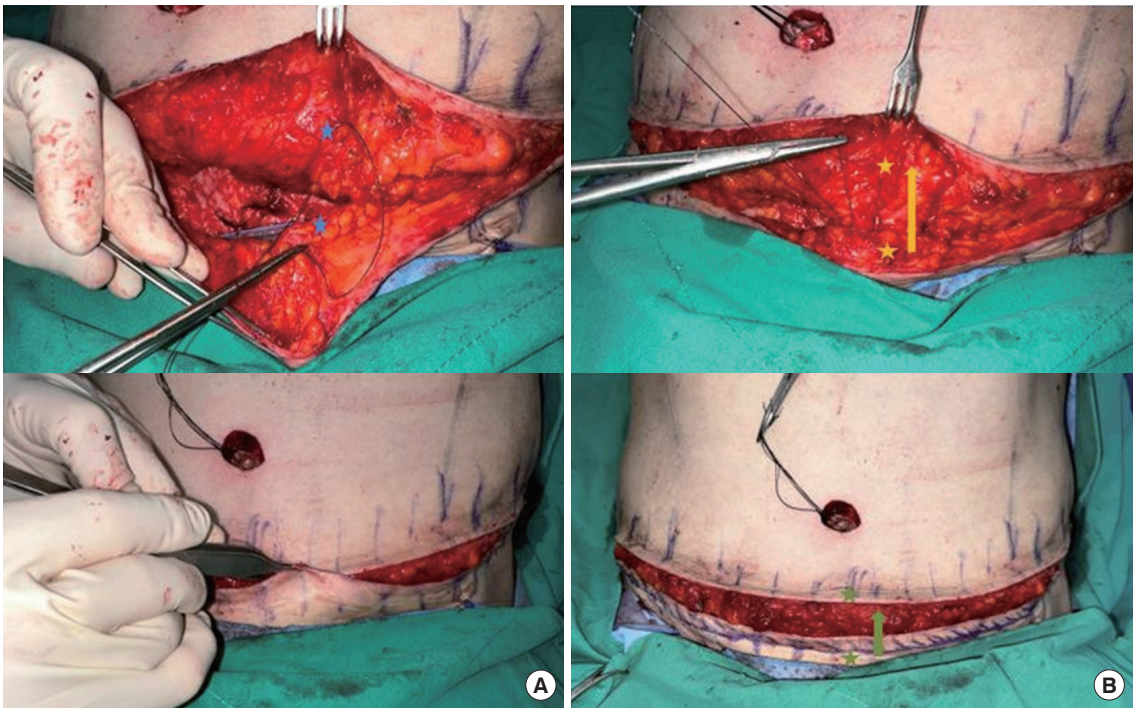

Fig. 3. Intraoperative photo of oblique different plane abdominal closure. (A) First, Scarpa's fascia (blue points) is sutured, followed by (B) pulling and suturing Camper's fascia (orange points). Next, the unviable skin (green points) from the surgery is trimmed appropriately up to the overlapping area, then pulled and sutured to achieve the different plane condition.

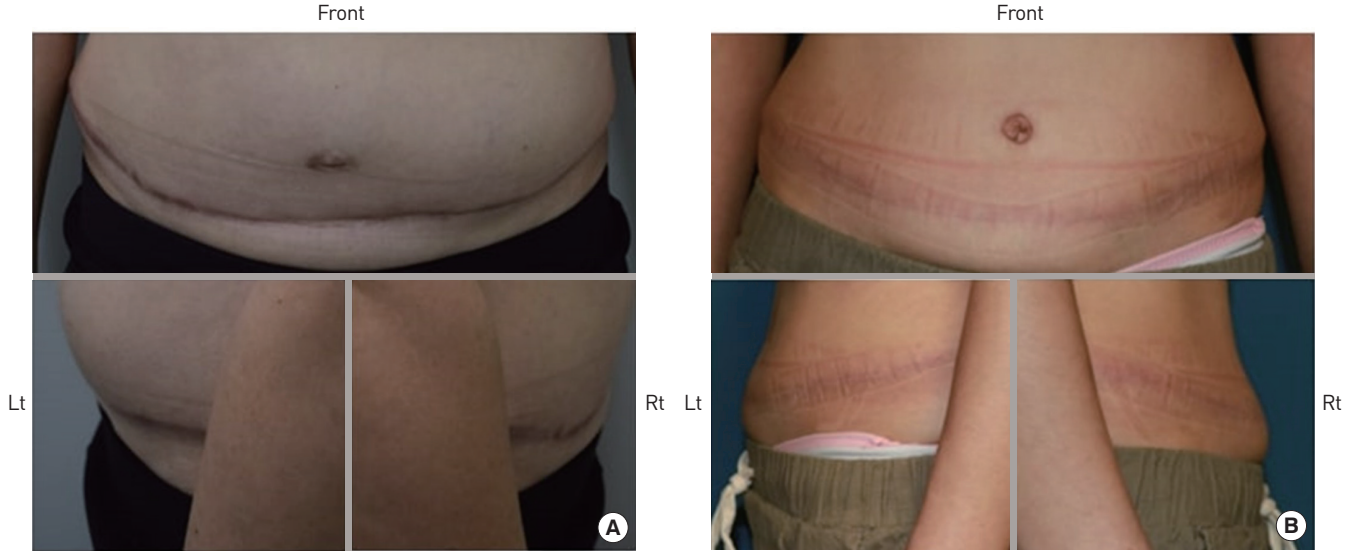

Fig. 4. Photos of patients who underwent the "single vertical plane closure" (A) and the "oblique different planes closure" (B). At least 6 months after surgery, five evaluators conducted assessments without receiving any information about the patient.

across various oblique planes. Both patient groups had their sutures removed on the fifth postoperative day to minimize scarring, and photographs of the abdominal scars were taken from the front and both sides at least 6 months later (Fig. 4).

Statistical analysis

In this study, to increase the ability of the study to detect statistical significance, 30 individuals were allocated to the vertical single plane closure group and 30 were allocated to the different oblique planes closure group. The sample size was determined using the G-power program. For the correlation analysis (two-tailed, with a correlation hypothesis H1: 0.8, α-error: 0.05, and power: 0.80), it was calculated that a minimum of 52 participants were needed. Similarly, for the Wilcoxon-Mann-Whitney test (with an effect size of 0.8, α-error: 0.05, and power: 0.80), 42 participants were required. Therefore, we concluded that a minimum of 52 participants was necessary. To account for potential non-responses and dropouts, we expanded the sample size by 10% to 15%. Furthermore, at least three evaluators were required to use the Cohen kappa coefficient to evaluate the reliability of the significance of the evaluation results. Therefore, we selected a total of five evaluators: three plastic surgeons and two general medical practitioners. The analysis was conducted using SPSS version 22 (IBM Corp.) to determine the significance of differences between the two groups at a 95% confidence level.

RESULTS

A total of 60 patients were included in the study and were divided into two groups of 30 patients each. Group A consisted of patients who underwent surgery using a conventional single vertical plane, while group B comprised those who underwent closures on different oblique planes. The average age of patients was 52.48 years in group A and 51.56 years in group B. The mean body mass index was 23.28 kg/m^2 for group A and 24.28 kg/m^2 for group B. In group A, there was one smoker, three patients with hypertension, and two with diabetes. In contrast, group B included four patients with hypertension and one with diabetes. No statistically significant differences were observed between the two groups regarding these basic patient characteristics.

Regarding the characteristics of breast surgery, there were 12, 11, and 7 patients in group A who underwent modified radical mastectomy, skin-sparing mastectomy, and nipple-sparing mastectomy, respectively. In contrast, group B comprised 8, 12, and 7 patients who underwent these procedures, respectively. The average weight of the mastectomy specimens was approximately 445.0 g in group A and about 453.8 g in group B. In terms of breast reconstruction, 19 patients in group A underwent immediate reconstruction, while 11 opted for delayed reconstruction; in group B, these numbers were 21 and 9, respectively. We also analyzed neoadjuvant and adjuvant treatments and found no significant differences relevant to the study outcomes between the two groups in any of these factors. The average follow-up period for both patient groups was approximately 7 months (Table 1).

Upon reviewing the evaluations from the five evaluators for the two groups undergoing different surgical methods, we observed that group B consistently received higher scores across nearly all categories. Specifically, in terms of "general appearance"—often considered the initial impression—group B scored approximately 6.97 ± 1.81 points, in contrast to group A's 4.30 ± 2.35 points. Furthermore, in assessing the criteria related to the common scar scale, group B demonstrated significant improvements, garnering higher scores than group A in scar surface flatness, contracture, thickness, pliability/stiffness, abnormal sensory appearance, and pigmentation. However, there was no significant difference in vascularization between the two groups, suggesting that the surgical

Table 1. Patient demographics and perioperative surgical details

Characteristic	Group A (n = 30)	Group B (n = 30)	P-value
Mean age (yr)	52.48	51.56	0.67
Mean BMI (kg/m^2)	23.28	24.28	0.22
Smoker	1	0	0.31
Hypertension	3	4	0.68
Diabetes	2	1	0.55
Types of mastectomy			0.43
MRM	12	8	
SSM	11	12	
NSM	7	7	
Mastectomy specimen weight (g), mean ± SD	445.0 ± 122.5	453.8 ± 143.6	0.81
Lymph node dissection			
SLNB/ALND	21/9	19/11	0.76
Type of breast reconstruction			0.52
Immediate	19	21	
Delayed	11	9	
Neoadjuvant treatment			
Chemotherapy	2	6	0.12
Radiotherapy	0	2	0.14
Adjuvant treatment			
Chemotherapy	10	11	0.77
Hormonal therapy	14	17	0.38
Radiotherapy	8	7	0.75
Follow-up (day), mean ± SD	223.8 ± 23.6	236.4 ± 22.8	0.69

Group A underwent the vertical single plane suture technique, and group B underwent the different oblique planes closure suture technique. No characteristics showed significant differences between the two groups.
BMI, body mass index; MRM, modified radical mastectomy; SSM, skin-sparing mastectomy; NSM, nipple-sparing mastectomy; SLNB, sentinel lymph node biopsy; ALND, axillary lymph node dissection; SD, standard deviation.

method in question did not influence this particular outcome. With respect to abdominal structure, group B showed more favorable evaluations in contour, overhang, and volume, yet no significant differences were noted in the presence of dog-ears or the shape of the umbilicus (Table 2, Fig. 5).

Table 2. Abdominal scar scale results

Scale components	Group A (n=30)	Group B (n=30)	P-value
General appearance	4.30±2.35	6.97±1.81	<0.001
Common scar scales			
Scar surface flatness	3.79±2.21	7.13±1.82	<0.001
Scar contracture (height)	4.62±2.24	6.86±1.97	<0.001
Thickness	5.24±1.90	7.17±1.90	<0.001
Pliability/Stiffness	5.12±2.02	7.00±1.97	<0.001
Vascularization	4.93±2.65	6.88±1.97	0.054
Abnormal sensory appearance	4.31±2.42	6.78±2.11	<0.001
Pigmentation	4.21±2.39	6.37±2.13	<0.001
Abdomen structures			
Abdomen contour	4.67±2.16	6.95±1.90	<0.001
Abdominal overhang	5.09±1.89	7.10±1.52	<0.001
Abdomen volume	5.21±2.07	7.20±1.68	<0.001
Dog-ear presence	5.56±1.95	6.86±1.94	0.081
Umbilical shape	5.78±1.61	7.05±1.47	0.096

Values are presented as mean±standard deviation.

DISCUSSION

Breast reconstruction following a mastectomy is a critical step in a woman's path to physical and psychological healing from breast cancer. In recent years, there has been a growing interest in and demand for autologous breast reconstruction, largely due to its superior aesthetic results and higher levels of patient satisfaction compared to implant-based reconstruction. Saldanha and colleagues have reported that studies show high patient satisfaction with breast reconstruction, especially with the DIEP and TRAM flap procedures [5]. Similarly, research conducted by Shiraishi et al. [9] has demonstrated high levels of satisfaction among patients who underwent breast reconstruction post-mastectomy, with the DIEP flap method receiving particularly favorable scores. These findings suggest an increasing preference for the use of autologous tissue in breast reconstruction.

The management of the donor site following flap transfer is a critical yet understudied aspect of the procedure. The scars that result at the donor site, particularly after TRAM flap and DIEP flap procedures, are a significant concern for many women. These scars can have substantial physical and psychological effects, leading to issues with body image, decreased self-esteem, and dissatisfaction with the overall outcome of the reconstruction. Niddam et al. [11] reported that 48% of individuals were dissatisfied with their abdomen post-surgery, with 34% preferring their pre-surgery abdominal shape. Specifically, 18% of these patients were unhappy with re-

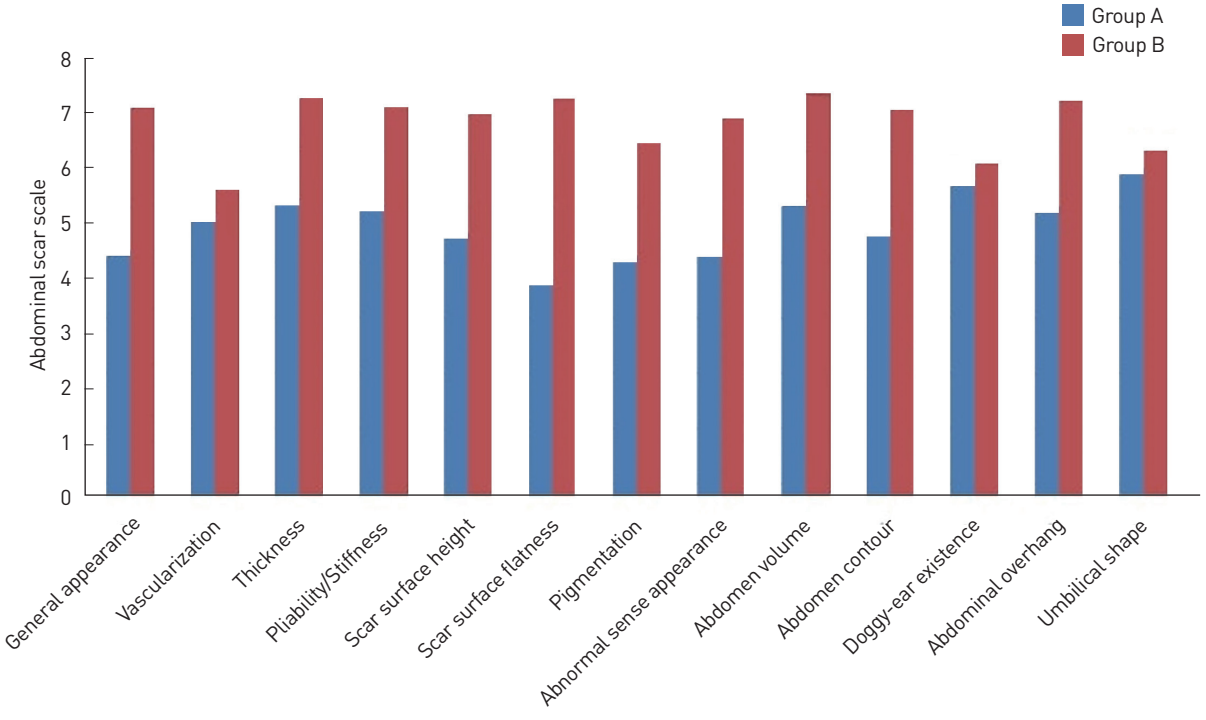

Fig. 5. Comparison of results between groups A and B based on the abdominal scar scale using a bar graph. Group A underwent the vertical single plane suture technique, and group B underwent the different oblique planes closure suture technique.

sidual abdominal overhang, and 12% were dissatisfied with the scarring. Lindenblatt et al. [8] also highlighted donor site complications such as wound dehiscence, seroma, and hematoma, underscoring the necessity for research into aesthetic enhancements for the donor site. Several studies have attempted to tackle these issues [8]. Koo et al. [12] investigated the impact of stromal vascular fraction on wound healing but found it to be ineffective, while Eom et al. [13] studied the placement of flap design in relation to the DIEP flap. They recognized that scarring was a disadvantage and pointed out the economic implications of using computed tomography angiography.

Therefore, we aimed to explore a method to improve the appearance of donor site scars by making a slight modification to the closure technique. This study addressed this important yet insufficiently studied element of autologous breast reconstruction. It investigated a novel closure technique that could diminish scarring and improve the aesthetic results at the donor site. Johnson et al. [14] have noted that omitting fascia closure is not less effective than performing it. Nonetheless, we contend that fascia closure is beneficial in restoring the body's original state as closely as possible, which in turn supports more rapid internal tissue healing. This approach is likely to lead to more visually appealing results and expedite patient recovery. Our research is intended to provide surgeons with a fresh perspective on abdominal closure. By examining an alternative method, we strive to equip surgeons with additional options to increase patient satisfaction, minimize morbidity, and improve the overall quality of life for women undergoing this complex procedure.

A method for evaluating these techniques and an abdominal scale were needed. Therefore, we examined prior research and incorporated the essential elements into our scale. We identified the components necessary for an abdominal aesthetic scar scale. Beausang et al. [15] discussed both the macroscopic and microscopic appearances of scars, introducing a clinical scale for scar assessment that quantifies the severity of various types of scars. Sood et al. [16] investigated specific aspects to consider as sub-questions regarding the aesthetic appearance of the abdomen. Our aesthetic abdominal scar scale was formulated drawing on the insights from these studies.

The single vertical plane closure method has traditionally been favored for its simplicity. However, the results of our study indicate that alternative methods may provide superior outcomes. In our surgical technique, we began by suturing the fascia, then advanced the apron layer, which includes both Camper's fascia and Scarpa's fascia, to fit the reduced area left after flap removal. The degree of advancement was variable due to the oblique nature of the incision. We also tailored and approximated the skin layer by approximately 1 cm, excising any non-viable tissue encountered during the procedure, thus allowing the donor site to close along an obliquely altered plane. Consequently, the different oblique planes closure method facilitates a more thorough and gradual closure, which may lessen the tension on the wound, potentially narrowing the scar and making it less noticeable.

To explain this phenomenon in more detail, the improvement in the abdominal scar can be attributed to the different oblique planes closure. This method effectively disperses the tension across separate planes for each layer, reducing the likelihood of contracture and indentation. It allows the surrounding, unaffected tissues to act as a cushion, diminishing the strain on any individual layer. During this process, we meticulously controlled for variables such as suture techniques to ensure a reliable comparison between the two groups. A possible limitation of this study is that, although we modified the suture planes during surgery and observed improvements through statistical analysis and patient follow-up photos, it is difficult to visualize the suture cross-section with imaging studies like ultrasound. This aspect warrants further exploration in future research.

The pursuit of donor sites with minimal scarring is not solely a quest for aesthetic improvement; it represents a comprehensive approach to enhancing the overall quality of life for breast cancer survivors. This work aims to expand the limits of our existing knowledge and practices, potentially transforming our perspective and methodology regarding the closure of donor sites in autologous breast reconstruction.

In conclusion, breast reconstruction is an important step in a woman's recovery from breast cancer, with autologous tissue-based procedures demonstrating superior aesthetic outcomes and patient satisfaction. However, the management of the donor site following tissue transfer, particularly the resulting scars, has been an underresearched aspect of this process. Our research addressed this gap by exploring innovative closure methods aimed at reducing scarring and improving aesthetic results at the donor site. Historically, single vertical plane closure has been favored for its simplicity. However, our findings suggest that alternative methods, such as different oblique plane closure, may provide better outcomes by reducing wound tension and, consequently, the visibility of scars. Importantly, these advancements are not solely for aesthetic improvement but also play a significant role in improving the overall quality of life for breast cancer survivors.

NOTES

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Ethical approval

The study was approved by the Institutional Review Board of CHA Bundang Medical Center (IRB No. 2023-06-040-002) and performed in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained.

Patient consent

The patients provided written informed consent for the publication and use of their images.

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