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A new percutaneous method for inframammary fold reconstruction in implant-based breast reconstruction

Vertical pendulum suture

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Abstract

Several operative techniques for inframammary fold (IMF) reconstruction have been described and have resolved the shortcomings of conventional methods. However, there are still difficulties with IMF reconstruction, that is, performance through small mastectomy scars, creation of a smooth IMF curve, transfer of external IMF markings to the interior chest wall, or determining correct IMF without an implant in place. We have used a type of anchor suture with a completely percutaneous approach, the vertical pendulum suture (VP suture), to reconstruct the IMF easily in implant-based breast reconstruction.

The VP suture requires a pair of skin incisions a few millimeters in length (incisions A and B). The needle passes through the subcutaneous tissue from incision A, the chest wall, again through the subcutaneous tissue, and exits from incision B. Then, the needle passes through the edge of the dermis from incision B, the superficial layer of the subcutaneous tissue, again through the other edge of the dermis, and exits from incision A. The knot is tied and buried in the subcutaneous tissue. The whole technique can be performed percutaneously without visualizing the inside of the pocket. A retrospective case series study of photographs and chart review was conducted for all cases of unilateral implant-based breast reconstruction performed from December 2016 to December 2017 at Ina Central Hospital, Ina, Japan.

Nine consecutive patients underwent unilateral implant-based breast reconstruction. Five patients treated using the VP suture were included in this study. All 5 patients showed good esthetic results over the follow-up period (average, 11 months). Scalloped appearance was observed in all patients, but flattened spontaneously and disappeared within 3 months postoperatively. There were no complications, such as hematoma, infection, skin necrosis, pneumothorax, seroma, scar contracture, or implant injury.

The VP suture is completely percutaneous, parallel to the IMF, and is easy to perform at any time during surgery regardless of whether the implant is in place or not. IMF reconstruction is facilitated by freeing the surgeon from the need to visualize the inside of the pocket.

Abbreviations: BMI = body mass index, IMF = inframammary fold, VP suture = vertical pendulum suture.

Keywords: breast reconstruction, inframammary fold reconstruction, percutaneous approach, vertical pendulum suture

1. Introduction

The inframammary fold (IMF) is a critical landmark and esthetic structure in breast surgery.[1] A well-defined IMF is essential for esthetic satisfaction with breast reconstruction.[2–4] Cordeiro et al prefer reconstruction of the IMF as the first major step in the operation.[5] Many operative techniques for IMF reconstruction have been developed to resolve the shortcomings of conventional methods. Pennisi and Ryan used the lower thoracic advancement flap with dermal-periosteal anchorage in the external approach.[6,7] Versaci sutured the dermis and fat of the IMF to the rib periosteum in the internal approach.[8] Nava performed capsulotomy and superficial fasciotomy, and fixed the superficial fascia to the thoracic wall.[9] Handel harvested a flap containing subcutaneous tissue and Scarpa's fascia, and fixed the flap to the deep fascia.[10] However, there are still difficulties with IMF reconstruction. The conventional internal approach is difficult because of recent small mastectomy scars leading to a limited field of view and limited space in which to use instruments.[4,11,12] Conventional interrupted suture is technically difficult because each suture must be placed perfectly to create a smooth curve to prevent the IMF being rough or deformed.[10] It is difficult to transfer external IMF markings to the interior chest wall.[13–15] Preoperative marking of the IMF on the skin helps to reconstruct the IMF. However, it is difficult to reconstruct the external IMF along the external markings looking at the inside of the pocket. It is difficult to determine the correct position of the IMF without an inserted implant.[11] Preoperative marking of the IMF is an important indicator. However, conclusive positioning of the IMF is determined with an inserted implant. To resolve these

Editor: Mahmood S. Choudhery.

The authors have no funding and conflicts of interest to disclose.

Supplemental Digital Content is available for this article.

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Medicine (2018) 97:33(e11964)

Received: 24 April 2018 / Accepted: 27 July 2018

http://dx.doi.org/10.1097/MD.0000000000011964

Table 1

Inframammary fold score.

Esthetic outcomes	Score
Definition of IMF	Clear, partially unclear, unclear
Symmetry of IMF	Good, fair, poor
Scalloped appearance	Severe, moderate, mild, no

difficulties, we have used the vertical pendulum suture (VP suture) for IMF reconstruction. This article describes a new technique for IMF reconstruction with a percutaneous approach in tissue expander/implant-based breast reconstruction in a case series.

2. Methods

2.1. Design and patients

This study was reviewed and approved by the Committee for Medical Ethics of Ina Central Hospital Institutional Review Board. A retrospective photography and chart review was performed for all unilateral implant-based breast reconstruction procedures performed from December 2016 to December 2017 at Ina Central Hospital, Ina, Japan. Patients who underwent total skin-sparing mastectomy, primary expander reconstruction after mastectomy, and final implant placement with IMF reconstruction in a second surgery, that was immediate 2-stage tissue expander/implant-based breast reconstruction, were included in the study. One patient who underwent revision of capsular contracture with IMF reconstruction using VP suture in third surgery, with no IMF reconstruction in second surgery, was also included. We excluded patients with any type of secondary, delay, or one-stage breast reconstruction or radiation therapy.

Final photographs were used to evaluate IMF esthetic outcomes. Three criteria were assessed on a 3- or 4-point scale: definition of the IMF, bilateral symmetry of the IMF, and scalloped appearance (Table 1). Definition of IMF: clear, a smooth line could be drawn along the IMF; partly unclear, a partly uneven or vague line; unclear, almost the whole line was uneven or vague. Symmetry of IMF: good, bilateral symmetry was achieved; fair, there was asymmetry but esthetic result was obtained; poor, there was asymmetry requiring revision. Scalloped appearance: severe, the deformity could be pinched and pulled with the fingers; moderate, obvious deformity but could not be pinched and pulled; mild, deformity could be seen if looking closely; none, no deformity. Two plastic surgeons graded the esthetic results using photographs independently in a blinded manner. Patients were asked to rate their satisfaction with the reconstructed breast at the latest visit.

2.2. Surgical method

Cutaneous markings are drawn preoperatively in the standing position, marking the bilateral IMF based on the level on the contralateral side. Incisions through the mastectomy scar and expander removal are performed under general anesthesia. After inferior or circumferential capsulotomy to lower the IMF and reduce the risk of capsular contracture, we then perform the VP suture for IMF reconstruction (Fig. 1A–D, and see Video,

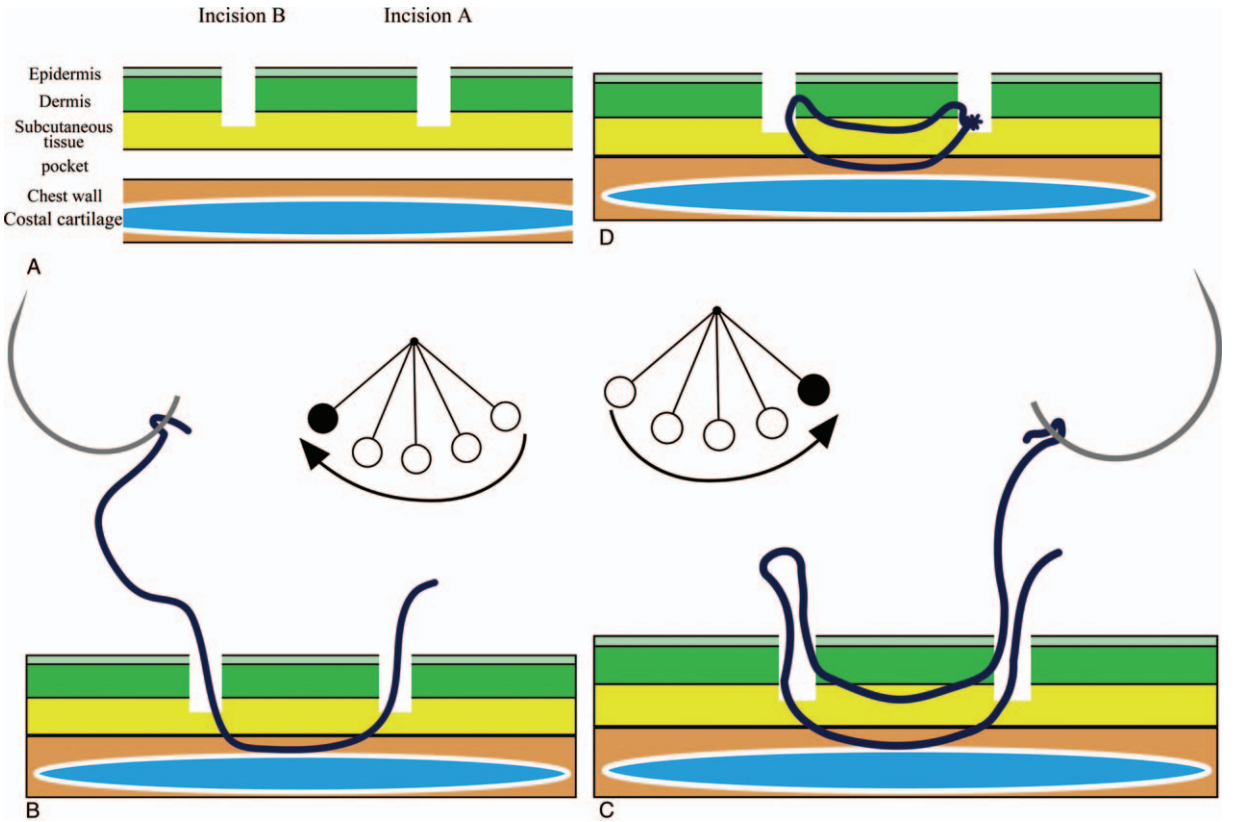

Figure 1. Schematic illustration of the vertical pendulum suture. (A) A pair of skin incisions a few millimeters in length. (B) The needle is inserted into the subcutaneous tissue through incision A. The needle passes through the chest wall and again through the subcutaneous tissue. Then, the needle exits from incision B. It can be performed without stopping and looking inside the pocket from the first insertion through incision A to exit from incision B. (C) The needle is then inverted to pierce the dermis through incision B. The needle passes through the dermis, superficial layer of the subcutaneous tissue, and again through the dermis. The needle exits from incision A. It can also be performed without stopping from insertion through incision B to exit from incision A. (D) The suture is tied and the knot is buried and hidden in the subcutaneous tissue.

Supplemental Digital Content 1, http://links.lww.com/MD/C413, which demonstrates the VP suture). It does not matter whether the patient is in the supine or sitting position, with or without the implant in place. A half-circle round-bodied needle over 15 mm in diameter with 3-0 polyglactin suture (VICRYL; Ethicon, Somerville, NJ) is prepared. A pair of skin incisions a few millimeters in length, incisions A and B, at an interval of 1 cm along the IMF marking are made using a no. 11 scalpel (Fig. 1A). The incisions must be sufficiently deep to allow the suture and knot to be buried later in the subcutaneous tissue. The needle is inserted into the subcutaneous tissue through incision A. The needle passes through the chest wall, if possible the costal periosteum or perichondrium, and again passes through the subcutaneous tissue. Then, the needle exits from incision B (Fig. 1B). This first procedure from insertion through incision A to exit from incision B can be performed without stopping and visualizing the inside of the pocket. It is important to confirm strong fixation to the chest wall. The needle is then inverted to pierce the edge of the dermis through incision B. The needle passes through the dermis, superficial layer of the subcutaneous tissue, and the other edge of the dermis, finally exiting from incision A (Fig. 1C). This second procedure from insertion through incision B to exit from incision A can also be performed without stopping. Finally, the suture is tied and the knot is buried and hidden in the subcutaneous tissue (Fig. 1D). Moderate scalloped deformity and unnatural subduction are not matters for concern at this stage. It is sometimes difficult to determine whether the first needle procedure, described in Figure 1B, is correct during surgery. In such cases, the first needle procedure from incision A to B is divided into 3 parts, and the second part, where the needle passes through the chest wall, is performed while visualizing the inside the pocket.

Several of the sutures are placed along the IMF marking to complete IMF reconstruction. Four to 5 VP sutures are required when the medial and central parts of the IMF are made. One or 2 more VP sutures are required when it is necessary to define the lateral part of the IMF clearly. At the final confirmation of the esthetic results after wound closure, we are able to add the suture. Postoperative hydrocolloid dressings are applied to the incisions along the IMF.

3. Results

Patient demographics and the results are summarized in Table 2. Nine consecutive patients underwent unilateral implant-based breast reconstruction between December 2016 and December 2017 at Ina Central Hospital, Ina, Japan. Four patients without IMF reconstruction were excluded from the study. Five patients underwent IMF reconstruction using VP sutures. All 5 of these patients underwent skin-sparing mastectomy with oblique spindle incision and immediate 2-stage tissue expander/implant-based breast reconstruction performed by the authors (SK, HN, KK) without postoperative radiotherapy. Four patients underwent IMF reconstruction at second surgery for tissue expander exchange for implant 6 months after final expansion, whereas the other underwent IMF reconstruction at third surgery 9 months after second surgery, tissue expander exchange for implant without IMF reconstruction, because of capsular contracture. Patients ranged in age from 38 to 48 years (mean, 44 years). Body mass index (BMI) ranged from 20 to 25 kg/m^2 (mean, 22 kg/m^2). Implant size ranged from 220 to 370 cm^3 (mean, 297 cm^3). The follow-up time ranged from 8 to 14 months (mean, 11 months). Photographic evaluations of esthetic results were the following. Definition of IMF: 3 were graded as clear, 2 as partly unclear, none as unclear. Symmetry of IMF: 1 was graded as good, 4 as fair, none as poor. Scalloped appearance: none was graded as severe, 1 as moderate, 4 as mild, none as no.

A scalloped appearance was observed postoperatively in all cases. However, this resolved completely in all cases by 3 months postoperatively. Wounds of incisions A and B healed with no complications. Four had no scars. Case no. 1 had unremarkable scars. All patients were satisfied with their reconstructed breast and required no revision surgery. No complications were identified, such as hematoma, infection, skin necrosis, pneumothorax, seroma, scar contracture, implant injury, and so on.

3.1. Case presentation

Case no. 1 (Fig. 2A–F): A 48-year-old woman underwent unilateral skin-sparing mastectomy with no axillary dissection and tissue expander placement in immediate 2-stage tissue expander/implant-based breast reconstruction. Second surgery, tissue expander exchange for implant, with 4 VP sutures for IMF reconstruction was performed 6 months after the final expansion. A moderately scalloped appearance was observed postoperatively. However, the appearance spontaneously became flat within 2 months. She received no radiation therapy. There were no other complications. Clear IMF definition and good IMF symmetry

Table 2

Patient demographics and results.

Case	Case 1	Case 2	Case 3	Case 4	Case 5	Average
Age, y	48	39	43	46	46	44
Body mass index, kg/m^2	20	24	20	21	25	22
Axillary dissection	No				Yes	
Implant size, cm^3	250	365	220	280	370	297
Timing of IMF reconstruction	Second surgery, exchange for implant				Third surgery, capsular contracture	
Follow-up time, mo	13	13	14	8	7	11
Photographs evaluation						
Definition of IMF	Clear	Clear	Partly unclear	Partly unclear	Clear	
Symmetry of IMF	Good	Fair	Fair	Fair	Fair	
Scalloped appearance (just after surgery)	Moderate	Mild	Mild	Mild	Mild	
Scalloped appearance (at the latest visit)	Completely disappeared					
Period before disappearance of scalloped appearance, mo	2	3	2	2	3	2.4
Patient satisfaction	Satisfied with their reconstructed breast and hope no revision surgery					

All patients underwent skin-sparing mastectomy, immediate 2-stage implant-based breast reconstruction without postoperative radiotherapy. Six months from final expansion to exchange for implant. There was no postoperative complications except for scalloped appearance.

Figure 2. Case no. 1: (A and B) Preoperative view with tissue expander after final injection. (C and D) Postoperative view just after surgery in a supine position. (E and F) Postoperative view after 13 months of follow-up.

were observed after 13 months of follow-up. She was satisfied with the reconstructed breast.

Case no. 2 (Fig. 3A–F): A 39-year-old woman underwent unilateral skin-sparing mastectomy with no axillary dissection and tissue expander placement in immediate 2-stage tissue expander/implant-based breast reconstruction. Postoperative wound dehiscence and partial flap necrosis occurred and healed with conservative treatment. A wide scar remained. Second surgery, tissue expander exchange for implant, with scar revision and 4 VP sutures for IMF reconstruction, was performed 6 months after the final expansion. A mild scalloped appearance was observed postoperatively. However, the appearance spontaneously became flat within 3 months. She received no radiation therapy. There were no other complications. Clear IMF definition and fair IMF symmetry were observed after 13 months of follow-up. The medial part of the IMF had slight asymmetry compared with contralateral side. She was satisfied with the reconstructed breast.

Case no. 3 (Fig. 4A–D): A 43-year-old woman underwent unilateral skin-sparing mastectomy with no axillary dissection and tissue expander placement in immediate 2-stage tissue expander/implant-based breast reconstruction. The amount of expander injection was up to 200 cm^3 because she had small breasts. Second surgery, tissue expander exchange for implant, with 4 VP sutures for IMF reconstruction, was performed 6 months after the final expansion. A mild scalloped appearance was observed postoperatively. However, the appearance spontaneously became flat within 2 months. She received no radiation therapy. There were no other complications. Partly unclear IMF definition and fair IMF symmetry were observed after 14 months of follow-up. The medial part of the IMF was vague and the caudal part of the IMF was caudal to the contralateral side. The upper pole had more volume than the contralateral side. She was satisfied with the reconstructed breast.

Case no. 4 (Fig. 5A–D): A 43-year-old woman underwent unilateral skin-sparing mastectomy with no axillary dissection and tissue expander placement in immediate 2-stage tissue expander/implant-based breast reconstruction. Second surgery, tissue expander exchange for implant, with 5 VP sutures for IMF reconstruction, was performed 6 months after the final expansion. The IMF was reconstructed cranially to the contralateral side because her contralateral breast was ptotic and she hoped for a reconstructed breast suited to correction

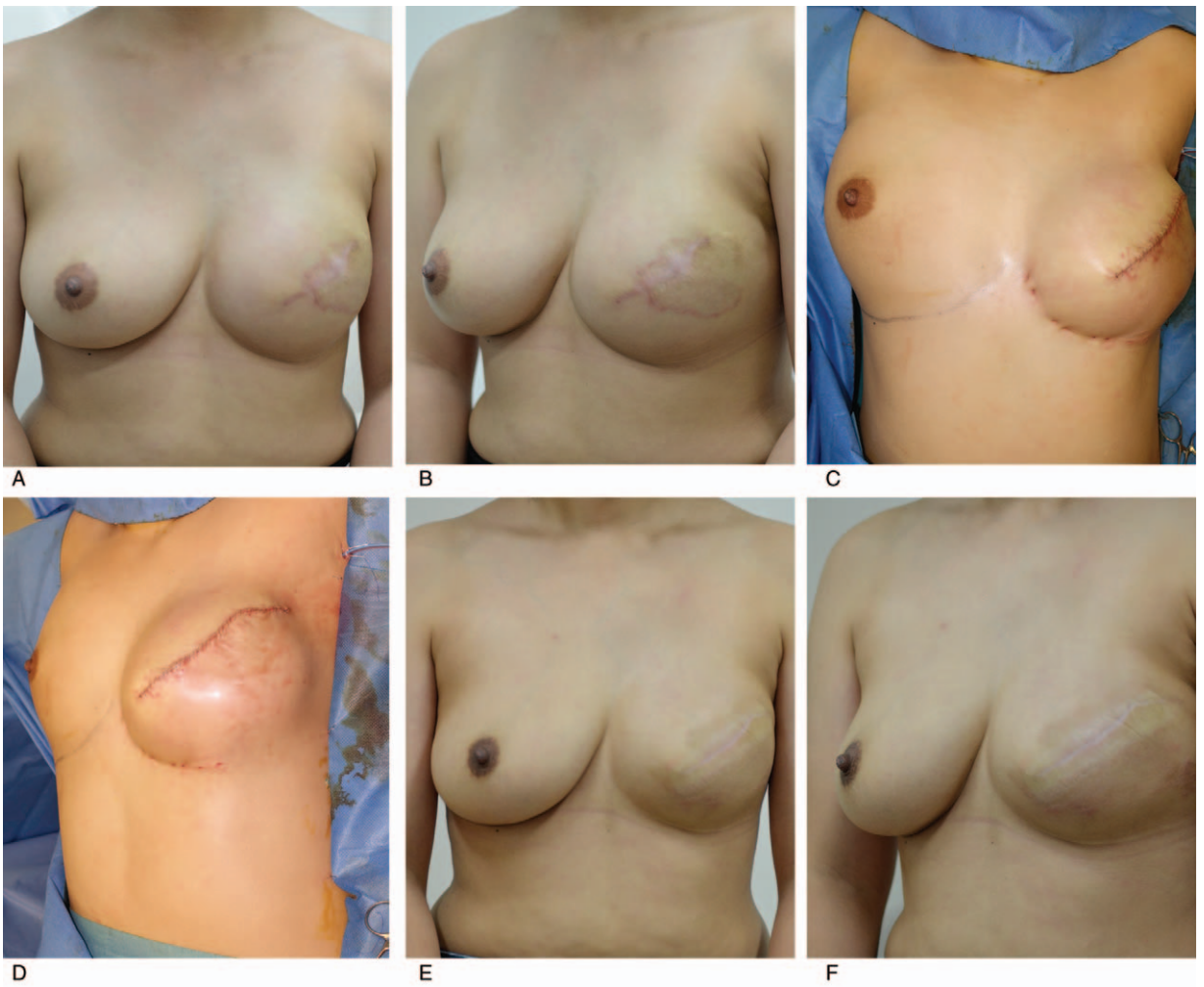

Figure 3. Case no. 2: (A and B) Preoperative view with tissue expander after final injection. (C and D) Postoperative view just after surgery in a supine position. (E and F) Postoperative view after 13 months of follow-up.

underwear. A mild scalloped appearance was observed postoperatively. However, the appearance spontaneously became flat within 2 months. She received no radiation therapy. There were no other complications. Partly unclear IMF definition and fair IMF symmetry were observed after 8 months of follow-up. The medial part of the IMF was vague. The caudal part of the IMF was cranial to the contralateral side. However, its cranial position was intentional and she was satisfied with the reconstructed breast suited to correction underwear.

Case no. 5 (Fig. 6A–D): A 46-year-old woman underwent unilateral skin-sparing mastectomy with axillary dissection. She simultaneously underwent immediate 2-stage tissue expander/implant-based breast reconstruction with no IMF reconstruction. Nine months after tissue expander exchange for implant, capsular contracture was observed. Therefore, revision was performed. Strong capsulotomy, IMF reconstruction with 4 VP sutures, fat graft to the upper pole and axilla, and nipple-areola complex reconstruction were performed. Postoperatively, a mild scalloped appearance was observed. However, the appearance spontaneously became flat within 3 months. She received no radiation therapy. There were no other complications. Clear IMF definition and fair IMF symmetry were observed after 7 months of follow-up. Capsular contracture partly recurred and pulled the IMF cranially. However, she was satisfied with the reconstructed breast.

4. Discussion

This case series indicated that use of the VP suture enables surgeons to easily develop the IMF as required looking at the surface of the skin, and confirmed the wide applicability of the VP suture. This is the first report of IMF reconstruction performed with visualization only of the surface of the skin from the beginning to the end of the procedure without the need to visualize the internal surface of the pocket. We developed the VP suture for use in "double eyelid surgery" in Asian subjects.[16] Similar to the double eyelid, the IMF consists of a skin fold. Therefore, we applied this double eyelid surgery method to IMF reconstruction, and named the surgical technique for IMF reconstruction the "vertical pendulum suture" because of the vertical aspect of its needlework, which is reminiscent of the cycle of a pendulum.

Several internal approaches for IMF reconstruction have been developed. However, problems still remain. The conventional internal approach is difficult because of recent small mastectomy scars.[4,11,12] Conventional interrupted suture is technically

Figure 4. Case no. 3: (A and B) Preoperative view with tissue expander after final injection. (C and D) Postoperative view after 14 months of follow-up.

difficult because each suture must be perfectly placed and positioned to create a smooth curve.[10] The VP suture can be performed percutaneously regardless of the size of the mastectomy scar. Therefore, it is easier for the surgeon to place the VP suture as required, compared with internal approaches, which require them to look inside the pocket and create the outside IMF. In addition, the VP suture can create a smooth curve because its suture line lies parallel to the IMF. The size of the needle and polyglactin (VICRYL; Ethicon) suture should be altered as required in accordance with the thickness of the subcutaneous tissue of the anterior lobe of the pocket. Especially, the size of the needle has the greatest effect on performing the VP suture because it is performed without stopping from the first insertion through incision A to exit from incision B, and its return trip is also the same.

It is difficult to transfer external IMF markings to the interior chest wall.[13–15] To make this procedure easy, transfixed needles are dipped in methylene blue,[10,12,17] transfixed needles guide transverse capsulotomy,[9] and a sterile metal pin template is placed into the breast cavity.[13,15] The VP suture requires no such transfer method because of its percutaneous approach.

It is difficult to determine the correct position of the IMF without an inserted implant.[11] The VP suture can be performed with an inserted implant in place, which is accompanied by a

Figure 5. Case no. 4: (A and B) Preoperative view with tissue expander after final injection. (C and D) Postoperative view after 8 months of follow-up.

theoretical risk of implant damage. However, there is little risk if the surgeon pays special attention to avoid damaging the implant, that is, after confirming the line where the VP suture is performed with an inserted implant, the implant should be gently pushed cranially to avoid damage.

The VP suture can be widely applied. For areas where we wish to add the VP suture at final confirmation of the esthetic result after wound closure, that is, to prevent implant malformation or to create the lateral most part of the IMF, the VP suture can be performed.

We used a modification of Nava's technique, with multiple simple sutures fixing the superficial fascia to the thoracic wall in the internal approach.[9] We developed the VP suture when we encountered the above problems. However, we may consider using the internal approach for patients requiring keloid constitution.

4.1. Complications

A mild-to-moderate scalloped appearance was observed as the surgeon tied the knot tightly. However, the scalloped appearance gradually disappeared in all cases. The most obvious scalloped appearance was observed in case 1, but disappeared completely within 2 months postoperatively. This phenomenon may be

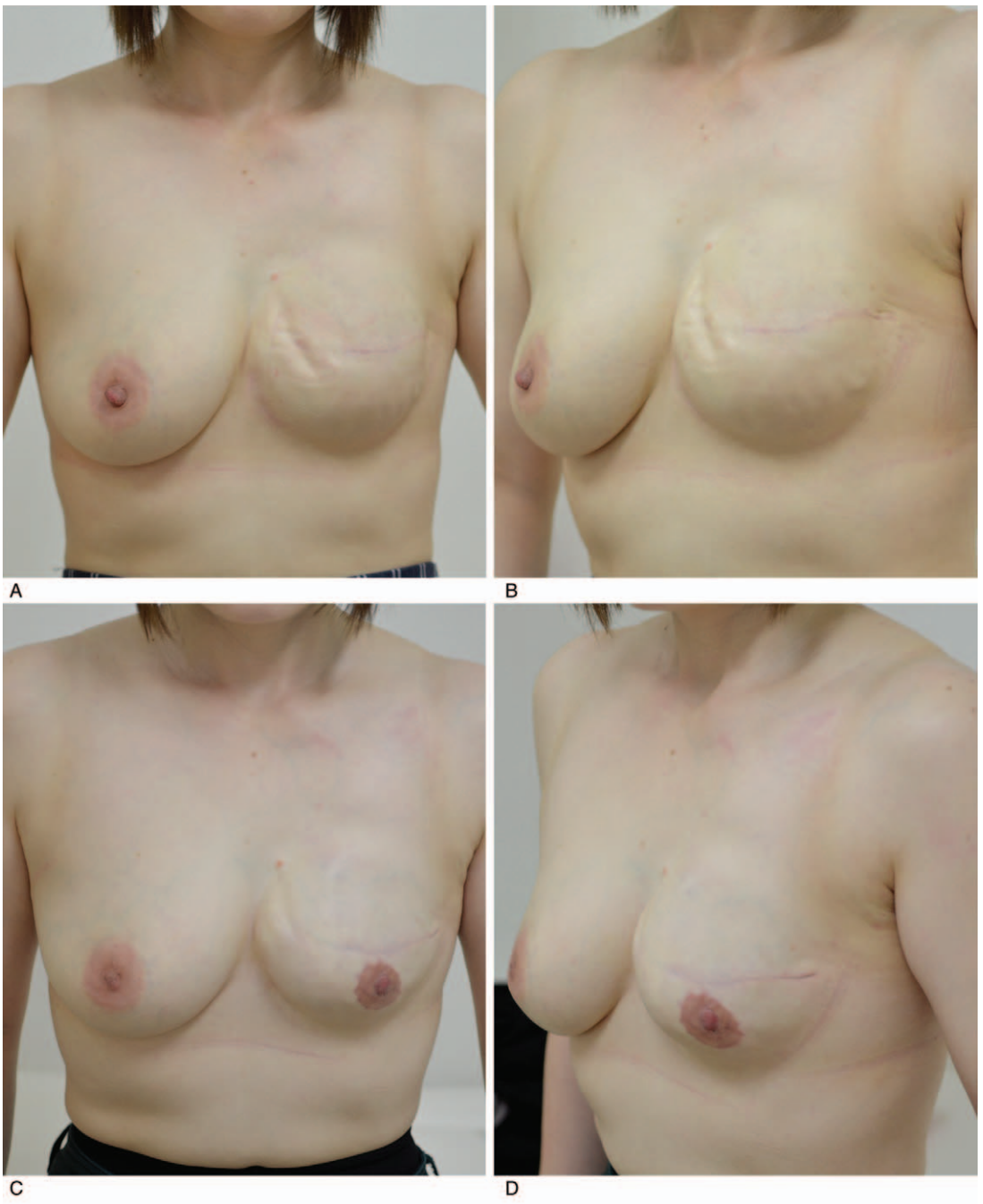

Figure 6. Case no. 5: (A and B) Preoperative view with scar contracture. (C and D) Postoperative view after 7 months of follow-up.

explained by the small amount of dermis through which the second needlework of the VP suture passed, as described in Figure 1C. This small amount of dermis may provide short-term rigid fixation of new IMF against the weight of the implant, and a scalloped appearance. At around 2 months postoperatively, the suture can lose its tension and the scalloped appearance disappears. However, scar formation around the whole surface of the implant can be achieved and provide long-term rigid fixation of the IMF.

The risks of infection and pneumothorax may be higher than with other internal approaches. To prevent infection, special attention is required to ensure that the suture and knot are buried in the subcutaneous tissue through incision A and B. To prevent pneumothorax, it is necessary for the surgeon to concentrate on what the needle touches.

4.2. Limitations

This study was limited by the small number of patients and short follow-up period. The number of breast reconstruction procedures was limited at Ina Central Hospital. The number of patients requiring IMF reconstruction was small because precise tissue expander placement frequently requires no IMF reconstruction in Japanese patients with relatively small breasts. We do not

evaluate application of the VP suture to patients whose body mass index (BMI) is higher because body mass index of all 5 patients was below 25 kg/m^2. Further studies are required to ensure the utility of the VP suture in the long term.

5. Conclusion

The VP suture is completely percutaneous, parallel to the IMF, and easy to perform at any time in surgical operation regardless of whether an implant is in place or not. The lack of requirement for visualization inside the pocket in IMF reconstruction makes it easy for the surgeon to reconstruct the IMF as required.

Author contributions

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Investigation: Yuta Nakajima.
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