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Reconstructive

Clinical Application of the Internal Mammary Artery Perforator Adipofascial Flap

Mari Nishimon, MD*†
Hirotoshi Ohara, MD†
Kanetoshi Ohara, MD‡§
Hisao Ogata, MD†¶
Kazuo Kishi, MD*

Background: Skin ulcers on the anterior chest wall are caused mainly by radiation therapy for breast cancer and anterior mediastinitis after thoracotomy, and they are often refractory. Some muscle flaps are commonly used for anterior chest wall reconstruction, but muscle flaps accompany high invasion. We used the internal mammary artery perforator (IMAP) adipofascial flap and IMAP skin flap for the anterior chest wall reconstruction.

Methods: We examined the IMAPs using a handheld Doppler device and contrast-enhanced computerized tomography preoperatively. Each flap was designed based on the location of the IMAP and the size of the flap was dependent on the coverage required by the size and location of the skin ulcer. The location of the IMAPs functioned as the pivot point of the flap and the flap was flipped or swung on the defect.

Results: We used IMAP adipofascial flap for 2 cases and IMAP skin flap for 1 case. In those 3 cases, we could elevate the flap with no complications even after the internal mammary artery had been harvested. There was no recurrence of the skin ulcer or wound infection after the operation.

Conclusions: In this study, we reported 3 cases of skin ulcer on the anterior chest wall reconstructed with the IMAP adipofascial and skin flap. To our knowledge, this is the first report of the use of the IMAP flap as an adipofascial flap. The IMAP adipofascial flap accompanies less invasion than muscle flaps and the surgical procedure is relatively easy. The IMAP adopofascial flap is considered as one of the effective means for anterior chest wall reconstruction. *(Plast Reconstr Surg Glob Open 2019;7:e2062; doi: 10.1097/GOX.0000000000002062; Published online 20 March 2019.)*

INTRODUCTION

Skin ulcers on the anterior chest wall are caused mainly by radiation therapy for breast cancer and by anterior mediastinitis after thoracotomy. They are often refractory. Generic treatments for skin ulcers are conservative treatment, include using ointment and negative pressure wound treatment, and reconstructive surgery. The pectoralis major muscle, rectus abdominis muscle, latissimus dorsi muscle, and omental flaps are commonly used for the anterior chest wall reconstruction. However, these flaps have either a high degree of invasion or may require a change of position during the operation. Past abdominal operations or peritoneal dialysis may also limit the use of certain flaps. Moreover, these flaps may cause incisional hernia or posture problems.

The internal mammary artery perforator (IMAP) flap was first described in 2006 as a modification of the deltopectoral (DP) flap.[1] IMAPs arise from the lateral border of the sternum from the first to the fifth intercostal spaces, pass through the intercostal muscle and pectoralis major muscle, and their branches spread laterally. The IMAPs choke the next IMAP, lateral thoracic artery, thoracoacromial artery, and intercostal arteries.[2–5] The limits of the IMAP flap are from the sternal midline to the anterior axillary line and from the clavicle to the level of the xiphisternum.[6] The IMAP flap is thin and flexible, allows primary closure of a donor site, and can be used as an island pedicle flap or as a free flap. Therefore, the IMAP flaps have been applied in various cases.[1,3,7–14]

*From the *Department of Plastic and Reconstructive Surgery, Keio University, Shinjuku-ku, Tokyo; †Department of Plastic and Reconstructive Surgery, National Hospital Organization Saitama Hospital, Wako-shi, Saitama; ‡Ohara Orthopedic and Plastic Surgery, Kawaguchi-shi, Saitama; §Department of Plastic and Reconstructive Surgery, Toranomon Hospital, Minato-ku, Tokyo; and ¶Nampeidai Ogata Clinic, Sibuya-ku, Tokyo.*

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In the present study, we applied the IMAP flap in 3 cases. The IMAP adipofascial flap was applied for a case of a skin ulcer on the anterior chest wall after radiation therapy for breast cancer and a case of anterior mediastinitis after thoracotomy. We also used the IMAP skin flap conducted with a reduction mammaplasty for a case of a skin ulcer on the anterior chest wall after radiation therapy for breast cancer. To our knowledge, this is the first report regarding to the use of the IMAP flap as an adipofascial flap.

METHODS

Preoperatively, we examined the IMAPs using a handheld Doppler device and contrast-enhanced computerized tomography and marked their location on the skin. Each flap was designed based on the location of the IMAP and the size of the flap was dependent on the coverage required by the size and location of the skin ulcer. The flaps were not over the clavicle, sternal midline, anterior axillary line, or the level of the xiphisternum. In all cases, the width to length ratio of the flaps was over 1:2.

In cases 1 and 2, after debridement of necrotic tissue, elevation of the IMAP adipofascial flap was begun from the edge of the skin defect. Dissection, large enough to cover the skin or bone defect and to allow primary closure, was performed under the subcutaneous layer to preserve the subdermal vascular plexus. The fascia of the pectoralis major muscle was incised at the distal end of the flap and dissection proceeded under the fascia from the distal end medially until the IMAPs were identified. The location of the IMAPs functioned as the pivot point of the flap and the flap was flipped over to cover the defect being careful not cause tension on the IMAPs.

In case 3, the IMAP flap was harvested as a skin flap during a reduction mammaplasty. The flap was designed along the IMAP vessels according to the skin markings, on the basis of the handheld Doppler device and contrast-enhanced computerized tomography, and the postoperative shape of the donor breast site. After the debridement of the necrotic tissue, the skin incision was made according to the design of the flap and dissection proceeded under the fascia as well as the IMAP adipofascial flap. The IMAP skin flap was swung over to cover the defect. The donor site was closed primarily and it was combined with reduction mammaplasty.

CASE REPORT

Case 1

A 71-year-old woman. At the age of 50, she underwent a modified radical mastectomy and radiation therapy for right breast cancer at the age of 50. At the age of 70, she developed a 1 cm ulcerating radionecrosis on the right anterior chest wall. A radical debridement and a reconstructive surgery were planned after 1-year period conservative treatment using several ointments. The skin defect was small, but it was necessary to remove the necrotic ribs and costal cartilage to prevent recurrent necrosis and infection. A less invasive surgical procedure other than a left pectoralis major muscle flap was deemed to be suitable for the patient, because the patient's hobby was playing tennis and right pectoralis major muscle had been removed already in the modified radical mastectomy. Therefore, a 12×11 cm sized IMAP adipofascial flap based on the first, second, and third left IMAPs was used to cover the defect after sufficient debridement. The skin defect was closed primarily. Her body mass index (BMI) was 20.8. After a year following the operation, there was no recurrence of the skin ulcer (Fig. 1).

Case 2

A 70-year-old man who had underwent coronary artery bypass surgery, using both internal mammary and gastroepiploic arteries as the vascular grafts, developed an anterior chest wall wound infection postoperatively. After 3 weeks of the initial wound opening, wound closure surgery was planned. His BMI was 22.9. The first, second, and third left IMAPs were identified by a handheld Doppler device, even though both the internal mammary arteries had been harvested previously. The pectoralis major muscle flap would provide too much volume and also require an additional skin incision; therefore, we chose the IMAP flap. After the debridement of the necrotic and infected tissue, the IMAP adipofascial flap measured 12×8 cm was raised without any complications. The flap was well perfused during surgery. We closed the wound primarily. There was no recurrence of the wound infection, and there was no visible deformity on his anterior chest wall 6 months after wound closure (Fig. 2).

Case 3

A 83-year-old woman. At the age of 59, she underwent modified radical mastectomy and radiation therapy for the right breast. At the age of 70, she suffered from ulcerating radionecrosis on the right anterior chest wall. She underwent conservative treatment with ointment for 10 years, but it was ineffective. Because of her age and repeated hospitalization for pneumonia, a less invasive surgery was deemed to be suitable for her. She also had severe mastoptosis of the left breast. Therefore, we planned wound closure using the IMAP skin flap on the left side and reduction mammaplasty of the left breast at the same time. Her BMI was 19.0. After the debridement of the necrotic tissue, the IMAP skin flap was elevated on the basis of the second and third left IMAPs. The skin defect after the debridement measured 10×9 cm and the flap measured 17×11 cm. After the flap was swung on the skin defect on the right chest wall, we determined the ideal position of the left nipple and areolar complex in a sitting position. Reduction mammaplasty of the left breast and lateral repositioning of the nipple and areolar complex were performed with satisfactory results. After a year following the operation, there was no recurrence of the skin ulcer (Fig. 3).

DISCUSSION

The skin ulcers on the anterior chest wall caused by radiation therapy and anterior mediastinitis are often refractory. The omental, pectoralis major muscle, rectus abdominis muscle, and latissimus dorsi muscle flaps are

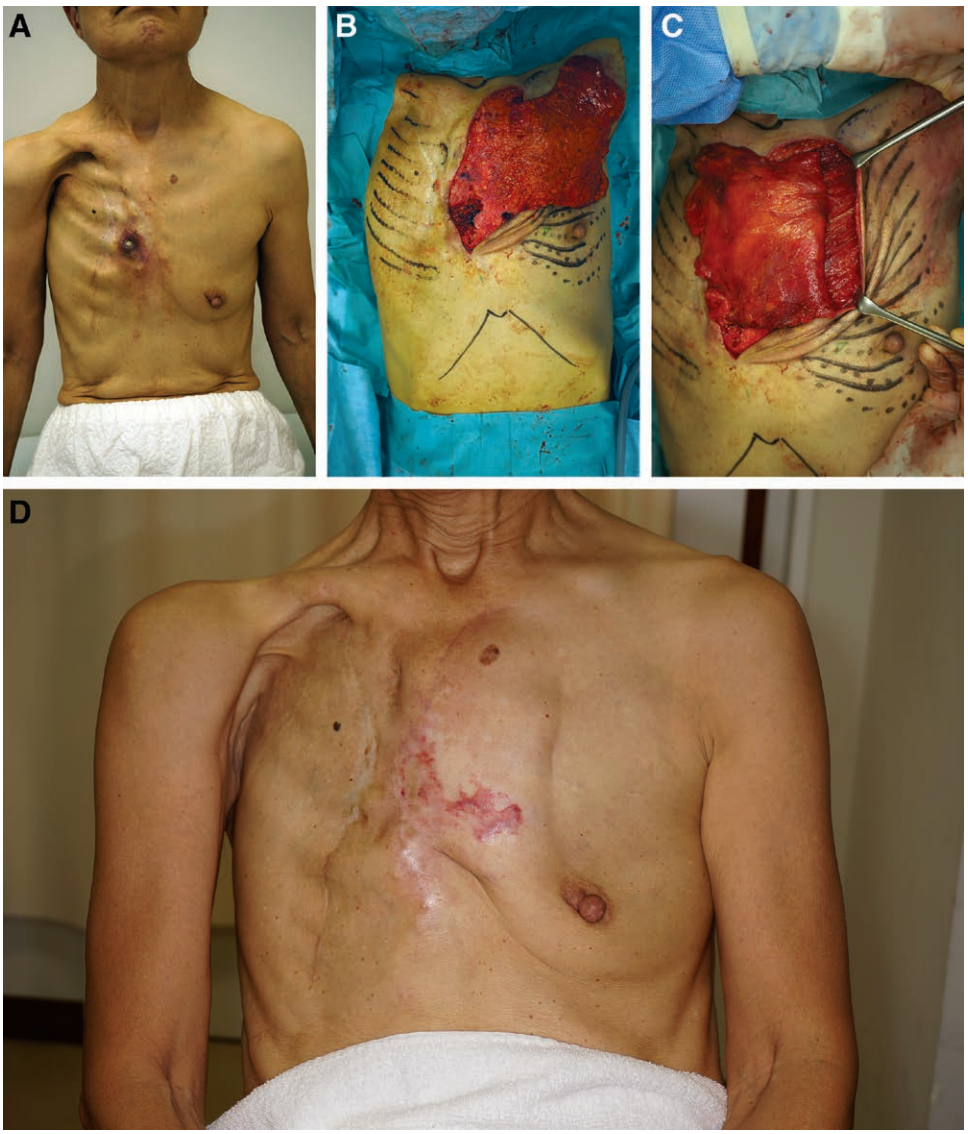

Fig. 1. A 71-year-old woman underwent modified radical mastectomy and radiation therapy for breast cancer and suffered from ulcerating radionecrosis measuring 1 cm on anterior chest wall (A). IMAP adipofascial flap based on the first, second, and the third left IMAP was elevated (B) and used to cover the defect after the sufficient debridement (C). A year after the operation, there is no recurrence of the skin ulcer (D).

commonly applied for anterior chest wall reconstructions. The omental flap, with its flexibility, can cover complicated defects, but it requires a laparotomy. The pectoralis major muscle flap that has 2 pedicles, the thoracoacromial artery and the internal mammary artery, can be applied to various reconstructions but it may provide too much volume. The rectus abdominis muscle flap is suitable for lower anterior chest wall reconstruction, but it cannot be used when the internal mammary artery has been harvested already. The latissimus dorsi muscle flap can cover large areas, but it is difficult to reach the anterior mediastinum and it involves a change of position during the operation.

The DP flap was first described by Bakaminjian in 1965 as an axial pattern flap perfused by the IMAPs and the thoracoacromial artery perforator.[6,8,15] The DP flap is thin and flexible and is commonly used for head and neck reconstructions. However, the DP flap has a high rate of necrosis and requires delay and skin grafting to the donor-site defect. It may also require revision of the dog ear and pedicle division surgery. DP flap is perfused by the first to fourth IMAP, but they could not be visualized at first.[6]

The IMAP flap was first described in 2006 as a modification of the DP flap.[1] The IMAP flap is designed based on the location of the IMAP. It enables a narrow design of the flap and allows certain perfusion provided by the IMAP. Therefore, the IMAP flap can overcome previously mentioned disadvantages of the DP flap. The IMAP arises from the first to fifth intercostal spaces, and it exists in the second and third intercostal spaces for more than 95%.[1]

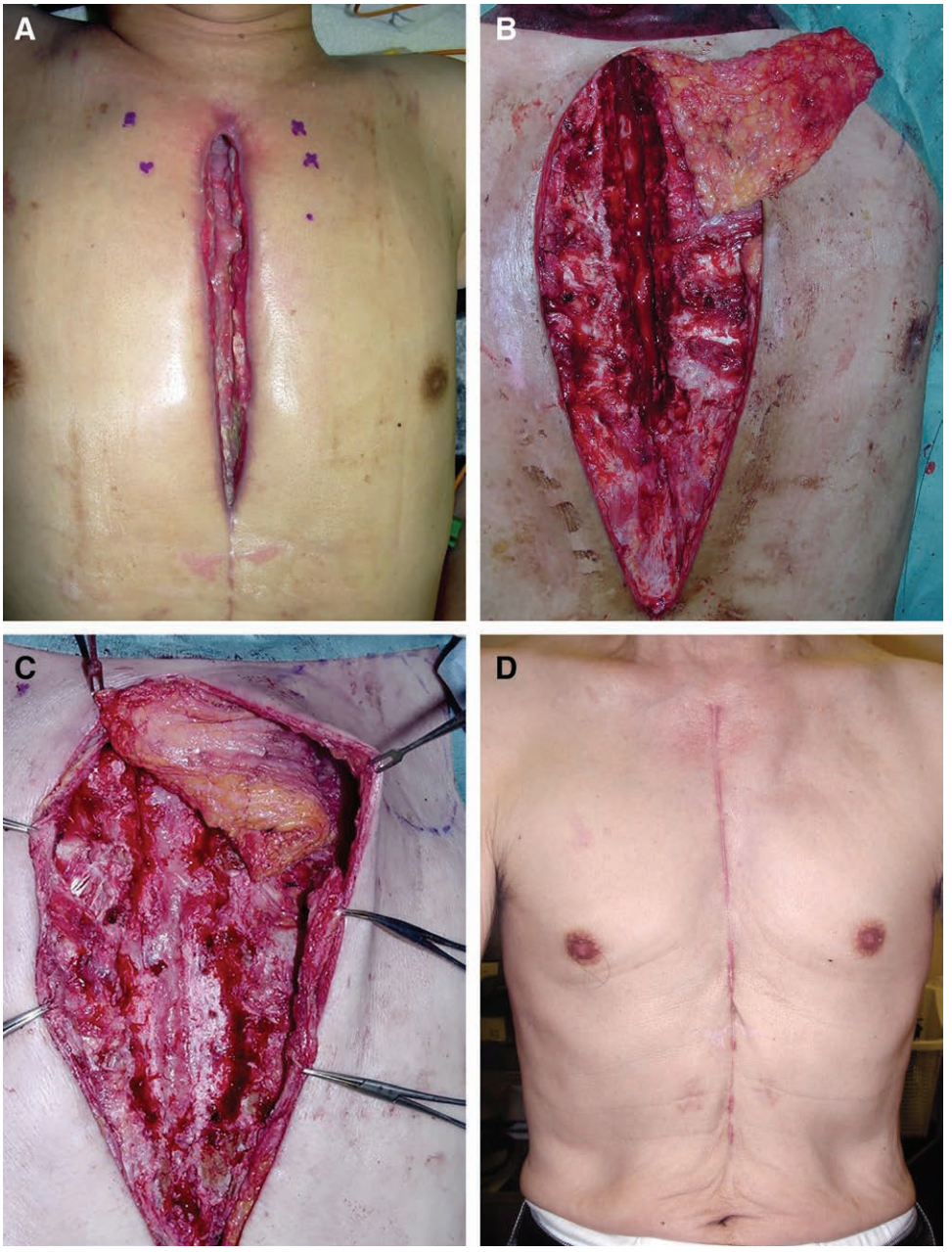

Fig. 2. A 70-year-old man underwent coronary artery bypass surgery using both internal mammary arteries as vascular graft. After the surgery, he suffered from anterior chest wall wound infection (A). IMAP adipofascial flap was raised (B) and flipped on the defect (C). Six months after the wound closure, there was no recurrence of the wound infection (D).

The IMAPs arise an average of 9.7 mm away from the lateral border of the sternum, pass through the intercostal and the pectoralis major muscles, and branch laterally.[2] The IMAPs choke the next IMAP, lateral thoracic artery, thoracoacromial artery, and intercostal arteries.[2–5] The diameter of the first, second, and third IMAPs is more than 1 mm. The second IMAP has the largest diameter that measures 1.6 ± 0.5 mm and it is the most reliable pedicle.[16] The mean size of the angiosome of the IMAP is 13 × 7 cm and that of the largest angiosome is 16 × 9 cm provided by the second IMAP.[16] The limits of the flap are from the clavicle to the level of the xiphisternum and from the sternal mid line to the anterior axillary line.[6]

The IMAP flap is thin and flexible, and it allows primary closure of the donor site. And it is less invasive, because it does not require the sacrifice of the muscle. Moreover, its surgical technique is relatively easy and it can be used as a pedicle flap or a free flap.[1] The IMAP flap has reportedly been used as a pedicle or free flap for head and neck reconstructions.[1,6,7] It has been used as a pedicle flap for a pharyngotracheal fistula closures,[3,10] a reconstruction after the division of a chest keloid,[12] and

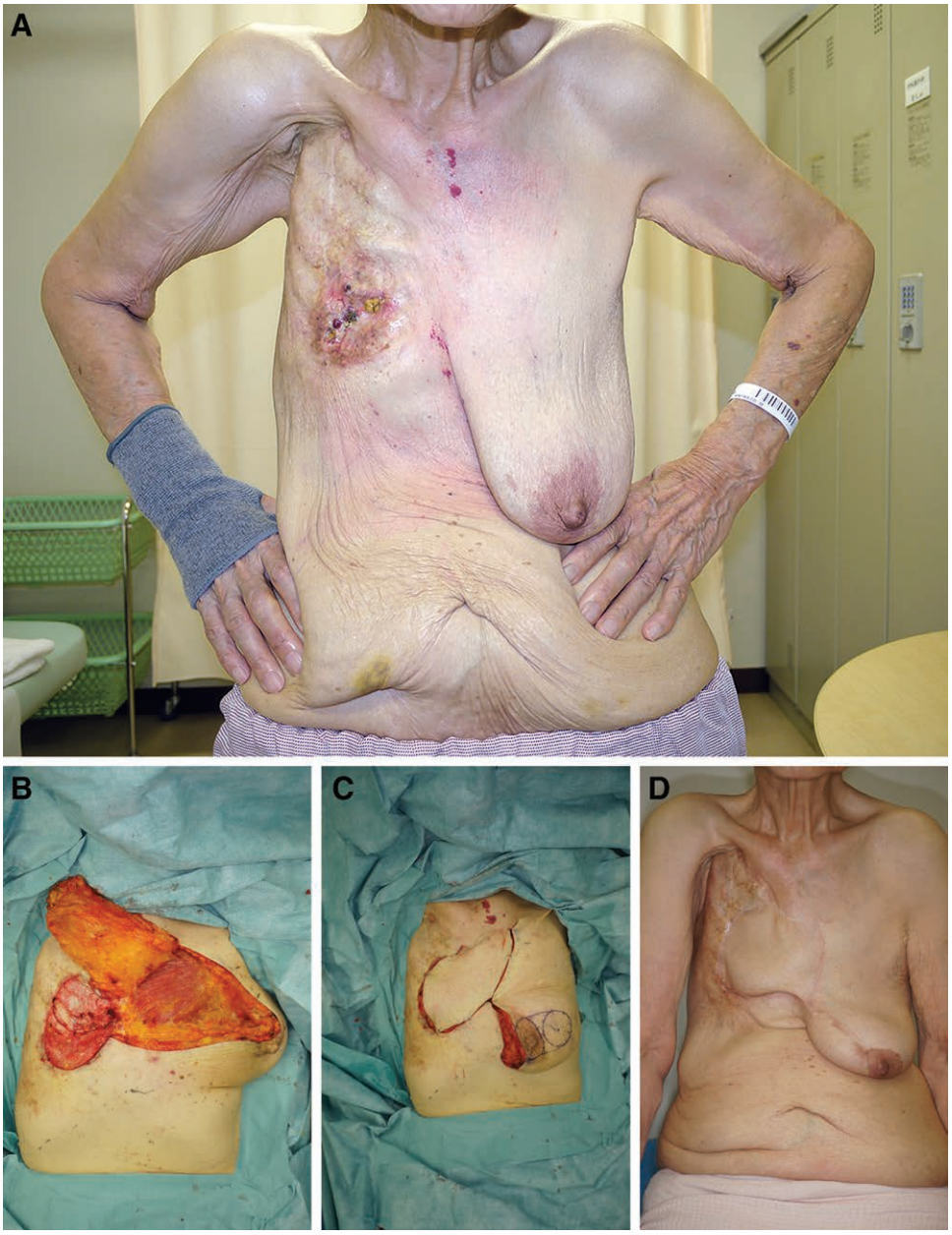

Fig. 3. An 83-year-old woman underwent modified radical mastectomy and radiation therapy for right breast and suffered from ulcerating radionecrosis on right anterior chest wall (A). IMAP skin flap was raised based on the second and third left IMAP (B). Reduction mammaplasty of the left breast and transportation of the nipple areolar complex were done at the same time were performed with satisfactory results (C). One year after the operation, there was no recurrence of the skin ulcer (D).

a reconstruction of a radiation ulcer and a sternotomy in the anterior chest wall.[7,14]

To our knowledge, this is the first report regarding to the use of the IMAP flap as an adipofascial flap. In case 1, the IMAP adipofascial flap was used for the treatment of an ulcerating radionecrosis on the anterior chest wall. The patient was a thin person and subcutaneous fat on the chest wall seemed thin, but the flap was elevated with no complications and there were no side effects such as skin necrosis on the donor site. In case 2, the IMAP adipofascial flap was used for the treatment of anterior mediastinitis following thoracotomy. In this case, both internal mammary arteries had been harvested in the coronary artery bypass surgery, but the first, second, and third IMAPs were identified in each intercostal space by using a handheld Doppler devise. The IMAPs choke each other and have a connection to the intercostal arteries, lateral thoracic artery, and thoracoacromial artery.[17] There are several branches that come off the internal mammary artery. One is the anterior internal branch that connects to intercostal artery and the another is the perforating branch. They may together have the common trunk leading to

the internal mammary artery.[17,18] In this patient, it is assumed that they had common trunk and that IMAP received the blood flow from the intercostal artery even after the internal mammary artery had been harvested, because we certified adequate blood flow by using handheld Doppler device before the operation. In this case, we elevated an IMAP adipofascial flap without any complications. A minimal additional skin incision enabled flap elevation and good posture was maintained after reconstruction. In case 3, as a breast sharing technique was reported previously,[13,19] a contralateral IMAP flap was used for the breast reconstruction after the mastectomy. Rüegg et al.[7] reported a case in which a dual-perforator propeller IMAP flap was used to cover the radionecrosis on the contralateral clavicular area. The concept of applying the IMAP flap during reduction mammaplasty in a patient with mastoptosis is similar to our case 3. Rüegg et al.[7] suggested that the IMAP flap as a true perforator flap, but we raised an IMAP flap with a skin pedicle and preserved the soft tissue around the pedicle to prevent venous congestion. It is more reliable in terms of the flap survival.

In another case, we used the IMAP adipofascial flap for coverage of the brachiocephalic artery after the removal of the larynx, and this approach was also successful.

However, the IMAP adipofascial flap is unsuitable in emaciated patients with diminished subcutaneous fat or large skin defects. It needs further examination to figure out minimum thickness of subcutaneous fat needed to elevate an IMAP adipofascial flap.

CONCLUSIONS

To our knowledge, this is the first report regarding to the use of the IMAP flap as an adipofascial flap. We used the IMAP adipofascial flap for anterior chest wall reconstruction and the IMAP skin flap during reduction mammaplasty. The IMAP flap is less invasive than the muscle flaps and there are minimal side effects, such as concavity and dysesthesia, on the donor site. The surgical technique pertaining to the use of the IMAP adipofascial flap is relatively easy. The IMAP adipofascial flap can be elevated even after both of the internal mammary arteries have been harvested. Thus, the IMAP adipofascial flap has possibility to be applied in various cases.

Mari Nishimon, MD
Keio University
35 Shinanomachi Shinjuku-ku
Tokyo 160–8582 Japan
E-mail: mari1022@nms.ac.jp

REFERENCES

1. Yu BT, Hsieh CH, Feng GM, et al. Clinical application of the internal mammary artery perforator flap in head and neck reconstruction. *Plast Reconstr Surg.* 2013;131:520e–526e.
2. Gillis JA, Prasad V, Morris SF. Three-dimensional analysis of the internal mammary artery perforator flap. *Plast Reconstr Surg.* 2011;128:419e–426e.
3. Neligan PC, Gullane PJ, Vesely M, et al. The internal mammary artery perforator flap: new variation on an old theme. *Plast Reconstr Surg.* 2007;119:891–893.
4. Wong C, Saint-Cyr M, Rasko Y, et al. Three- and four-dimensional arterial and venous perforasomes of the internal mammary artery perforator flap. *Plast Reconstr Surg.* 2009;124:1759–1769.
5. Palmer JH, Taylor GI. The vascular territories of the anterior chest wall. *Br J Plast Surg.* 1986;39:287–299.
6. Vesely MJ, Murray DJ, Novak CB, et al. The internal mammary artery perforator flap: an anatomical study and a case report. *Ann Plast Surg.* 2007;58:156–161.
7. Rüegg EM, Lantieri L, Marchac A. Dual perforator propeller internal mammary artery perforator (IMAP) flap for soft-tissue defect of the contralateral clavicular area. *J Plast Reconstr Aesthet Surg.* 2012;65:1414–1417.
8. Yu P, Roblin P, Chevray P. Internal mammary artery perforator (IMAP) flap for tracheostoma reconstruction. *Head Neck.* 2006;28:723–729.
9. Iyer NG, Clark JR, Ashford BG. Internal mammary artery perforator flap for head and neck reconstruction. *ANZ J Surg.* 2009;79:799–803.
10. Mirghani H, Leymarie N, Amen F, et al. Pharyngotracheal fistula closure using the internal mammary artery perforator island flap. *Laryngoscope.* 2014;124:1106–1111.
11. Ibrahim A, Atiyeh B, Karami R, et al. The deltopectoral flap revisited: the internal mammary artery perforator flap. *J Craniofac Surg.* 2016;27:e189–e192.
12. Xue D, Qian H. Surgical management for large chest keloids with internal mammary artery perforator flap. *An Bras Dermatol.* 2016;91:103–105.
13. Marshall DR. The contralateral breast flap in reconstruction of the breast and chest wall. *Ann Plast Surg.* 1993;31:508–513.
14. Kannan RY. The internal mammary artery perforator flap and its subtypes in the reconstruction of median sternotomy wounds. *J Thorac Cardiovasc Surg.* 2016;152:264–268.
15. Bakamijian VY. A two-stage method for pharyngoesophageal reconstruction with a primary pectoral skin flap. *Plast Reconstr Surg.* 1965;36:173–84
16. Schmidt M, Aszmann OC, Beck H, et al. The anatomic basis of the internal mammary artery perforator flap: a cadaver study. *J Plast Reconstr Aesthet Surg.* 2010;63:191–196.
17. Berdajs D, Zünd G, Turina MI, et al. Blood supply of the sternum and its importance in internal thoracic artery harvesting. *Ann Thorac Surg.* 2006;81:2155–2159.
18. Pietrasik K, Bakon L, Zdunek P, et al. Clinical anatomy of internal thoracic artery branches. *Clin Anat.* 1999;12:307–314.
19. Novo-Torres A, Fakih I, Aparicio-Alcazar JJ, et al. Breast sharing: new perspectives on an old method. *J Plast Reconstr Aesthet Surg.* 2015;68:1727–1732.