Original Article
ARMS Archieves of Reconstructive Microsurgery
pISSN 2383-5257 eISSN 2288-6184
Arch Reconstr Microsurg 2015;24(1):7-12
http://dx.doi.org/10.15596/ARMS.2015.24.1.7

Long-Term Outcome of Free Rectus Abdominis Musculocutaneous Flap for General Soft-Tissue Reconstruction

Jungheum Park, Daegu Son*, Joongwon Song[1]

Department of Plastic and Reconstructive Surgery, Keimyung University School of Medicine,
[1]Kims & Song Aesthetic Plastic Surgery Center, Daegu, Korea

Purpose: The rectus abdominis musculocutaneous (RAM) flap has contributed to the efficient reconstruction of soft tissue defects. The flap has the advantage of easy dissection, minimal donor site morbidity, and the constant vascular anatomy with long pedicle. Authors used the free RAM flap to reconstruct multi-located soft tissue defects while still considering functionality and aesthetics. We present the long-term outcomes and versatility of free RAM flaps.

Materials and Methods: From 1994 to 2004, all patients who underwent soft tissue reconstruction with free RAM flap were reviewed retrospectively. The site of the reconstruction, vessels of anastomosis, type of RAM flap, and outcomes, including flap success rate, hospital stay after flap transfer, conduction of secondary procedure, flap complications, and donor-site complications were analyzed.

Results: Twenty-one patients underwent 24 free RAM flaps in site of breast, face, upper extremity and lower extremity. Mean follow-up period was 36.1 months (range, 3~156 months). The overall success rate was 92% with only a loss of 2 flaps. Minor complications related to transferred flaps were necrosis of 2 partial flaps, hematoma formation in 3 cases, and a wound infection in 1 case. Donor site morbidity was not observed. Debulking surgery was performed in 4 patients, and scar revision was performed in 3 patients.

Conclusion: Free RAM flap is a workhorse flap for general soft-tissue reconstruction with minimal donor site morbidity with aesthetically good results. Thus, the free RAM flaps are versatile, and sturdy for any sites of soft-tissue where reconstruction could be performed.

Key Words: Free tissue flaps, Rectus abdominis, Reconstructive surgical procedures, Treatment outcome

Received April 30, 2015
Revised May 13, 2015
Accepted May 15, 2015

*Correspondence to: Daegu Son
Department of Plastic and Reconstructive Surgery, Keimyung University School of Medicine, 56 Dalseong-ro, Jung-gu, Daegu 700-712, Korea
Tel: +82-53-250-7636
Fax: +82-53-255-0632
E-mail: handson@dsmc.or.kr

Financial support: None.
Conflict of interest: None.

INTRODUCTION

The rectus abdominis musculocutaneous (RAM) flap was first described by Holmström[1] in 1979 who based the flap on the deep inferior epigastric artery (DIEA). The RAM flap gained popularity with the work of Hartrampf,[2] with its utilization as a pedicled flap based on the superior epigastric artery, in breast reconstructions. The advent of microsurgical techniques has allowed this versatile flap to be transposed to repair soft-tissue defects of the head and neck, breast, and lower and upper extremities.[3]

The RAM flaps have contributed to the efficient reconstruction of soft tissue defects. The flap has advantages of simultaneous flap elevation with recipient site preparation, easy dissection, minimal donor site morbidity, and the constant vascular anatomy with long pedicle. Especially in transverse rectus abdominis muscle

(TRAM) fashion, its popularity is explained by the location of its skin island in the inferior abdomen, which results in a skin resection similar to that of conventional abdominoplasties.

The goals of reconstruction have progressed from filling a hole to providing improved function and appearance and minimizing donor-site morbidity.[4] Therefore, authors used the free RAM flap to reconstruct multi-located soft tissue defects while still considering functionality and aesthetics.

Despite there are huge papers about soft-tissue reconstruction using free RAM flaps. Almost every paper was concerned with breast reconstruction or specific site reconstruction. Papers about long-term outcome of the free RAM flap in multi-located soft-tissue defects are little. Therefore, we present our experience in this study, free RAM flaps were used for a variety of soft-tissue defects, and the long-term outcomes and versatility of free RAM flaps will be discussed.

MATERIALS AND METHODS

From 1994 to 2004, all patients who underwent soft tissue reconstruction with free RAM flaps at Dongsan Medical Center were identified. Charts were reviewed for patient demographics, site of soft tissue defect, recipient vessels, donor vessels, type of RAM flap and long-term outcomes. Authors endeavored to perform the microsurgical reconstruction with functional and aesthetic consideration, according to the

Table 1. Patient demographics; arterial selection, follow-up, indications and anatomical locations of reconstruction

Case No.	Age (yr)	Sex	Location of soft-tissue defect	Cause of soft-tissue reconstruction	Type of RAM	Pedicle artery	Recipient artery	Follow-up (mo)
1	38	M	Face	Postradiation facial deformity, right cheek	Chimeric	DIEA	FA	40
2	52	M	Face	Buccal cancer	TRAM	DIEA	FA	28
3	51	F	Breast	Foreign body granuloma, left breast	TRAM	DIEA	TDA	29
4	51	F	Breast	Foreign body granuloma, right breast	TRAM	DIEA	Serratus branch of TDA	29
5	43	F	Breast	Foreign body ganuloma, left breast	TRAM	DIEA	TDA	8
6	50	F	Breast	Amastia, left	TRAM	DIEA	TDA	20
7	39	F	Breast	Amastia, right	TRAM	DIEA	TDA	28
8	44	F	Breast	Breast cancer, right	TRAM	DIEA	TDA	3
9	33	F	Breast	Breast cancer, right	TRAM	DIEA	TDA	31
10	46	F	Breast	Amastia, left	TRAM	DIEA	IMA	13
11	42	F	Breast	Breast cancer, right	TRAM	DIEA	TDA	19
12	58	F	Breast	Foreign body granuloma, left	TRAM	DIEA	Serratus branch of TDA	156
13	58	F	Breast	Foreign body granuloma, right	TRAM	DIEA	TDA	156
14	35	F	Breast	Amastia, right	TRAM	DIEA	TDA	80
15	49	F	Breast	Breast cancer, left	TRAM	DIEA	TDA	55
16	31	F	Breast	Amastia, right	TRAM	DIEA	IMA	30
17	44	F	Breast	Amastia, right	TRAM	DIEP	IMA	3
18	47	F	Breast	Amastia, right	TRAM	DIEA	IMA	38
19	36	F	Upper extremity	Posttraumatic scar contracture, right arm	TRAM	DIEA	RA	13
20	53	F	Lower extremity	Foreign body granuloma, left calft	TRAM	DIEA	PTA	20
21	53	F	Lower extremity	Foreign body granuloma, right calf	TRAM	DIEA	PTA	20
22	67	M	Lower extremity	Degloving injury, left lower leg	VRAM	DIEA	ATA	3
23	47	F	Lower extremity	Diabetic foot ulcer, right foot dorsum	VRAM	DIEA	DPA	15
24	23	M	Lower extremity	Degloving injury, left lower leg	TRAM	DIEA	PTA	30

RAM: rectus abdominis musculocutaneous, M: male, F: female, TRAM: transverse rectus abdominis musculocutaneous, VRAM: vertical rectus abdominis musculocutaneous, DIEA: deep inferior epigastric artery, DIEP: deep inferior epigastric artery perforator, FA: facial artery, TDA: thoracodorsal artery, IMA: internal mammary artery, RA: radial artery, PTA: posterior tibial artery, ATA: anterior tibial artery, DPA: dorsalis pedis artery.

characteristics of the soft-tissue defect site during the primary reconstruction. Length of hospital stay after flap transfer, conduction of secondary procedure, flap complications (e.g., flap loss or partial necrosis), and donor-site complications (e.g., hematoma, wound infection) were assessed. Wound infection was defined as a positive wound culture.

RESULTS

Twenty-one patients underwent 24 free RAM flaps, including 3 cases of bilateral soft-tissue reconstruction (Table 1). There were 4 male and 17 female patients. Average age at the time of surgery was 45.4 years (range, 23~67 years). There were 21 TRAM fashion cases, 2 vertical rectus abdominis muscle fashion cases, and 1 chimeric flap. The location of soft tissue defects were breasts (16 cases), lower legs (5 cases), face (2 cases), and upper extremity (1 case). The pathologic conditions causing the soft-tissue defects included: cancer extirpation (12 cases), foreign body granuloma (7 cases), trauma (2 cases), release of scar contractures (1 case), diabetic foot ulcer (1 case), and postradiational deformity (1 case). In all cases, DIEA was used as a pedicle artery, except one case, a DIEA perforator was used as a pedicle artery. Recipient arteries included: a thoracodorsal artery (TDA) (10 cases), serratus branch of TDA (2 cases), internal mammary artery (4 cases), posterior tibial artery (3 cases), facial artery (2 cases), and 1 case each of anterior tibial artery, dorsalis pedis artery, and radial artery.

The median length of stay after a flap closure was 8.5 days (6~24 days), mean follow-up period was 36.1 months (range, 3~156 months). The overall success rate was 92% with only a loss of 2 flaps. Minor complications related to transferred flaps were necrosis of 2 partial flaps, hematoma formation in 3 cases, and wound infection in 1 case (Table 2). One necrotic partial flap was solved by debridement and primary closure, and the other was solved by split thickness skin graft after debridement of necrotic tissue. All hematomas were removed in the operating room. Wound infections were treated with daily dressings and intravenous antibiotics (Table 1). Donor site morbidity, including hernia or weakness of abdominal wall tensing interfering with daily activities, was not observed. In all cases, primarily the donor site was repaired, and no mesh application was used. Debulking surgery on the face, breast, and calf was performed on 4 patients, and scar revision was performed in 3 breast reconstruction patients.

Table 2. Complications of free rectus abdominis musculocutaneous flap reconstruction

Complication type	No. of patient (%)*
Recipient site	
Total flap loss	2 (8.3)
Partial flap necrosis	2 (8.3)
Hematoma	3 (12.5)
Wound infection	1 (4.2)
Donor site	
Donor site complications	-

*Twenty patients and 24 flaps were included in the study.

Case 1

A 58-year-old female patient represented paraffinomas on both breasts. Twenty years ago, she was injected with paraffine in both breasts for augmentation by a non-medical clinic. Her breasts were an irregular shape with folded lower poles, and had 13×9-cm-sized movable palpable masses. A wide excision of the foreign body granulomas and reconstruction with bilateral free TRAM flaps was performed. On postoperative 11th day, a hematoma was noticed on the left breast. The hematoma was removed in the operating room. After 6 months a nipple-areolar complex was reconstructed. Thirteen years later, the reconstructed breast was still well contoured and had maintained a good shape (Fig. 1).

Case 2

A 38-year-old male patient represented post-radiation with a facial deformity on his right cheek. Twenty-six years ago, he had undergone excision of nasopharyngeal cancer and post-operative radiation therapy. The excision had resulted in severe facial asymmetry with prominence of zygomatic arch, depressed cheek, and scar contracture with irregular margins and an oronasal fistula formation. To achieve functional and cosmetic recovery, a chimeric flap was used for the three-dimensional facial soft-tissue defect. Following reduction malarplasty with partial ostectomty, release of scar contracture, and excision of oronasal fistula, the soft-tissue defect was reconstructed using a RAM chimeric flap, including a muscular component for augmenting the depressed cheek, and a skin paddle for oral lining. There were no postoperative complications. Two years

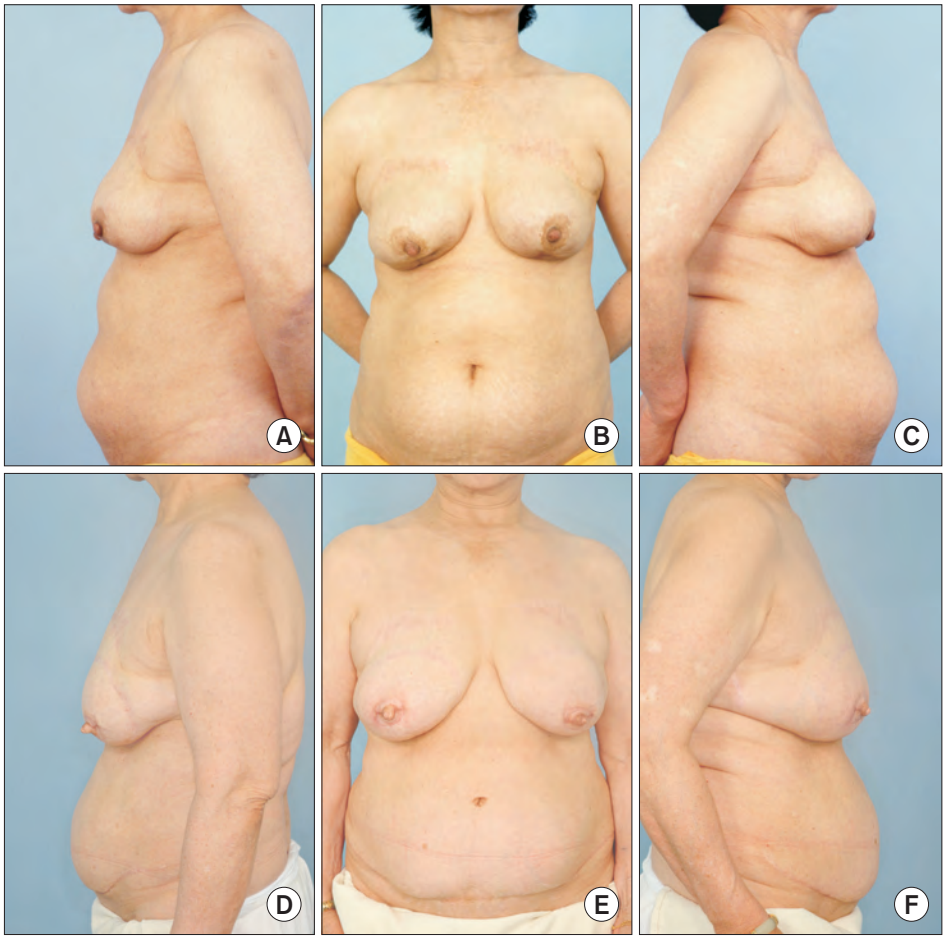

Fig. 1. (A~C) Preoperative picture of foreign body granuloma on both breasts. The patient sustained irregular shaped breasts with folded lower poles and had 13×9-cm-sized movable palpable masses on both breasts. (D~F) Thirteen years after reconstruction. Reconstructed breasts maintained a good shape and were well contoured.

after the operation, a debulking procedure was completed. 4 years after the initial reconstruction, the patient shows aesthetically good results (Fig. 2).

DISCUSSION

In general, the success rate of a free flap was 88% to 95%.[5-7] In this study of free RAM flaps for multi-located soft-tissue defects, the success rate was 92%. It was demonstrated that the flap is reliable in providing coverage of soft-tissue defects. Although there is a wide choice of donor sites available for free tissue transfers, most surgeons who perform a free flap are interested in a high success rate, including ease of dissection, a long and large-caliber pedicle, and a lack of donor site morbidity. In this situation, a free RAM flap was one of the most suitable flaps.

Free RAM flaps are suitable for relatively large defects, and could be used as a chimeric flap. This is especially true in a radical tumor extirpation in the head and neck region; the defect was usually extensive, and complicated due to it being three-dimensional. These defects are a challenge to the plastic surgeon and may require multiple tissue types to achieve functional and cosmetic recovery. At this time, a chimeric flap is an excellent choice for these defects.[8] The authors have successfully reconstructed a facial deformity using free RAM chimeric flaps. In this study, use of muscular components for augmenting the depressed cheek, and use of a skin paddle for oral lining resulted in a long-term satisfactory outcome.

The vascular anatomy of free RAM is uniform and reliable.[7] The RAM flap is very safe, as long as one respects its vascular anatomy. Small necroses of the flap are usually related to insufficient venous drainage and are located at the margins of the flap. Total flap losses are related to technical problems

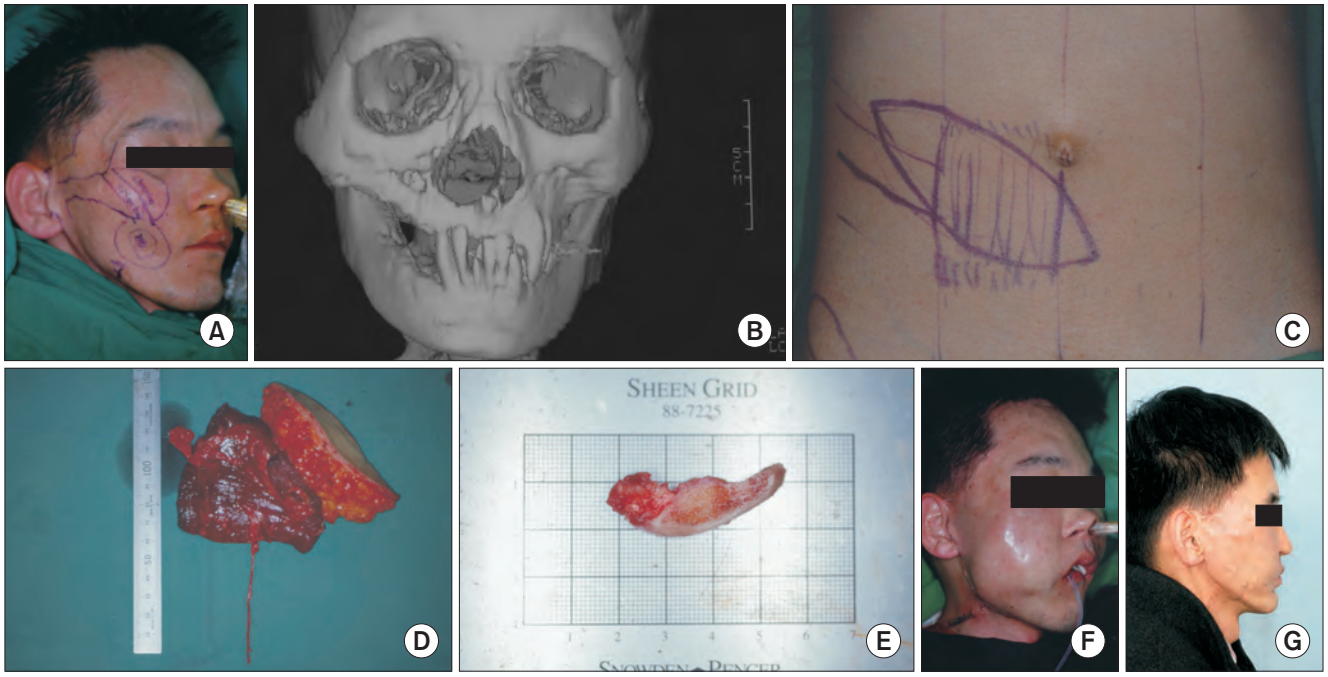

Fig. 2. (A) Preoperative picture of postradiation deformity on the right cheek. The patient sustained protruding zygomatic arch, and depressed cheek with severe facial asymmetry after excision of nasopharyngeal cancer and postoperative radiation therapy. Partial ostectomy of zygoma, and filling the depressed cheek using muscular components of a free rectus abdominis musculocutaneous (RAM) chimeric flap was planned. The facial artery was marked as a recipient artery. (B) Preoperative three-dimensional computed tomography. Protruding zygomatic arch was observed. Therefore, reduction malarplasty with partial ostectomy of zygoma was planned. (C) Design of donor site. Skin island was designed as an oblique fashion for coverage of introral defect, and vertical rectus abdominis muscle flap for filling the depressed cheek volume. (D) After elevation of free RAM chimeric flap. The chimeric flap consists of muscular component and skin paddle. (E) After partial ostectomy of zygoma. (F) Immediate postoperative picture. The contour of temple to chin was restored. (G) Four years after reconstruction with a free RAM flap with reduction malar plasty with partial ostectomty and release of scar contracture.

with the vascular anastomosis rather than problems with the dissection of the flap.[9] In addition, RAM flaps are technically relatively easy flaps. The DIEA, the main pedicle of a RAM flap has a mean of 7 cm (range 6~8 cm) of pedicle length, and a mean of 3.5 mm (range 3~5 mm) of pedicle caliber,[9] simplifying microvascular anastomoses. Comparing the success rate of free RAM flaps with other conventional free flaps (jejunum, latissimus dorsi, radial forearm, fibular, deep circumflex iliac artery, scapula, etc), the free RAM flap showed the highest success rate.[7]

Another great advantage of a free RAM flap is the position of the flap's skin island in the inferior abdomen. It is especially advantageous in women who have already been pregnant. Dissection of the flap can lead to a skin resection similar to a conventional abdominoplasty, resulting in not only a well-placed scar but also an improvement in body contour. However, 2 cases did require large sized vertically elliptical shaped skin islands. The authors used all free RAM flaps as a TRAM fashion for donor site scars, and in all cases, scars could be well hidden in bathing suit or shorts.

A disadvantage of a free RAM flap is widely known as its heavyness. In obese patients, the musculocutanoeus form of the rectus flap is very likely to be bulky for resurfacing objects. However, when the RAM flap is used in contour restoration, one must bear in mind that the muscle segment of the flap will atrophy by about 20% to 30% due to denervation. Authors reconstructed upper extremity defects using free RAM flaps, where a bulky flap may be unsightly. The final outcome resulted in good contouring and did not need any debulking procedures. Preoperative planning according to the patients characteristic (e.g., body mass index, skin color, etc) is absolutely essential. Rectus abdominis muscle at its origin is 6- to 7-cm-wide and at its insertion it is approximately 3-cm wide.[9] In cases including a muscular component, it is possible that a surgeon could use the selective muscular component. With the consideration of appropriate indications, the RAM flap can be used as a versatile

flap for reconstructing any part of the human body.

We reconstructed an irradiated wound in one case. In general, irradiation can cause successful closures of wounds more difficult, increasing acute and chronic wound complications. This is especially true of preoperative irradiation, which has been shown to significantly increase wound complications.[10] In addition, local options are limited because of surrounding irradiated tissue; thus, distant regional or free flaps are often needed. Radical excision of irradiated firm was completed, scar tissue on face, in considering with facial subunit and then reconstructed the defect with well vascularized healthy free RAM flap, and did not encounter any complications.

All donor site closures were performed as standard techniques. The closure is usually accomplished with interrupted figure-of-eight non-absorbable sutures reinforced with a running suture. As a result of this type of a careful closure of the aponeurotic layers, postoperative hernia was not encountered. As previously reported by some authors, materials to help (e.g., polypropylene mesh) support the abdominal wall were not used in any case because of the layers of tight closure[10,11] and because abdominal wall hernias were not encountered. The RAM and its aponeurotic margin not only causes tensing in the abdominal wall but also provides the first 30 degrees of flexion when passing from the supine to the sitting position. Fortunately, there were no complaints related to these functions.

There are huge papers about soft-tissue reconstruction using free RAM flaps. However, almost every paper was concerned with breast reconstruction or specific site reconstruction. Kulahci et al.[12] reported successful results in 25 RAM flap cases for reconstruction of multi-located soft-tissue defects. However, the mean follow-up was only 8 months, and they included 17 cases of pedicled RAM flaps.

Authors reported long-term soft tissue reconstruction defects with free RAM flaps (5 sites, 23 cases). The flap can successfully be reconstructed to various size defects needed for thin contouring and large volumes for most body parts, from the scalp to calf.

Free RAM flaps are a workhorse flap for general soft-tissue reconstruction with minimal donor site morbidity and typically have aesthetically good results. Thus, the free RAM flaps are versatile and sturdy for any sites where soft-tissue reconstruction that could be performed.

REFERENCES

1. Holmström H. The free abdominoplasty flap and its use in breast reconstruction. An experimental study and clinical case report. Scand J Plast Reconstr Surg 1979;13:423-7.
2. Hartrampf CR, Scheflan M, Black PW. Breast reconstruction with a transverse abdominal island flap. Plast Reconstr Surg 1982;69:216-25.
3. Xing-Quan Z, Shao-Dong W, Qing-Yu F, Bao-An M. Versatility of rectus abdominis free flap for reconstruction of soft-tissue defects in extremities. Microsurgery 2004;24:128-33.
4. Goh TL, Park SW, Cho JY, Choi JW, Hong JP. The search for the ideal thin skin flap: superficial circumflex iliac artery perforator flap: a review of 210 cases. Plast Reconstr Surg 2015;135:592-601.
5. Yeo HJ, Son DG, Kim JH, Han KH. Aesthetic microsurgical reconstruction of extremities. J Korean Soc Microsurg 2011;20:1-7.
6. Wei F, Jain V, Celik N, Chen H, Chuang D, Lin C. Have we found an ideal soft-tissue flap? An experience with 672 anterolateral thigh flaps. In: Hultman CS, editor. 50 studies every plastic surgeon should know. Boca Raton, FL: CRC Press, Taylor & Francis Group; 2014. p. 183.
7. Kroll SS, Schusterman MA, Reece GP, Miller MJ, Evans GR, Robb GL, et al. Choice of flap and incidence of free flap success. Plast Reconstr Surg 1996;98:459-63.
8. Huang WC, Chen HC, Wei FC, Cheng MH, Schnur DP. Chimeric flap in clinical use. Clin Plast Surg 2003;30:457-67.
9. Wei FC, Mardini S. Flaps and reconstructive surgery. Philadelphia: Elsevier Health Sciences; 2009.
10. Parrett BM, Winograd JM, Garfein ES, Lee WP, Hornicek FJ, Austen WG Jr. The vertical and extended rectus abdominis myocutaneous flap for irradiated thigh and groin defects. Plast Reconstr Surg 2008;122:171-7.
11. Nelson RA, Butler CE. Surgical outcomes of VRAM versus thigh flaps for immediate reconstruction of pelvic and perineal cancer resection defects. Plast Reconstr Surg 2009;123:175-83.
12. Kulahci Y, Sever C, Evinc R, Uygur F, Şahin C, Öksüz S, et al. Versatile use of rectus abdominis muscle and musculocutaneous flaps for soft-tissue reconstruction: our clinical experiences in 25 cases. Eur J Plast Surg 2011;34:437-44.