



## Volumetric change of the latissimus dorsi muscle after immediate breast reconstruction with an extended latissimus dorsi musculocutaneous flap

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Original Article

**Background** In immediate breast reconstruction using an extended latissimus dorsi musculocutaneous (eLDMC) flap, the volume of the flap decreases, which causes a secondary deformity of the breast shape. Since little research has investigated this decrease in muscle volume, the authors conducted an objective study to characterize the decrease in muscle volume after breast reconstruction using an eLDMC flap.

**Methods** Research was conducted from October 2011 to November 2016. The subjects included 23 patients who underwent mastectomy due to breast cancer, received immediate reconstruction using an eLDMC flap without any adjuvant chemotherapy or radiotherapy, and received a computed tomography (CT) scan from days 7 to 10 after surgery and 6 to 8 months postoperatively. In 10 patients, an additional CT scan was conducted 18 months postoperatively. Axial CT scans were utilized to measure the volumetric change of the latissimus dorsi muscle during the follow-up period.

**Results** In the 23 patients, an average decrease of 54.5% was observed in the latissimus dorsi muscle volume between the images obtained immediately postoperatively and the scans obtained 6 to 8 months after surgery. Ten patients showed an average additional decrease of 11.9% from 6–8 months to 18 months after surgery.

**Conclusions** We studied changes in the volume of the latissimus dorsi muscle after surgery using an eLDMC flap performed after a mastectomy without adjuvant chemotherapy or radiotherapy. In this study, we found that immediate breast reconstruction using a latissimus dorsi muscle flap led to a decrease in muscle volume of up to 50%.

**Keywords** Mammoplasty / Superficial back muscles / Myocutaneous flap

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### INTRODUCTION

Studies on the early detection and appropriate treatment of breast cancer have rapidly progressed in recent years, and active research in this field has led to the gradual recognition that

breast reconstruction after mastectomy should be considered mandatory, instead of merely an option available to breast surgeons. Delayed reconstruction was generally conducted in the past, but immediate reconstruction is known to be a better method when patient satisfaction and cosmetic outcomes are

considered [1-3].

Immediate breast reconstruction is most commonly performed using the latissimus dorsi musculocutaneous (LDMC) flap and transverse rectus abdominis musculocutaneous (TRAM) flap. The TRAM flap is beneficial because it provides excellent results in reconstruction procedures of large breasts, without requiring implants to be used. However, the TRAM flap has the drawbacks of causing greater donor site morbidity than the LDMC flap and requiring a longer operative time [2,3]. Satisfactory results using only the LDMC flap can be expected for reconstructions of small breasts. However, using implants with the LDMC flap for moderately-sized to large breasts has been reported to lead to better results than reconstruction with an extended LDMC flap for reasons relating to donor site morbidity [4-6].

When conducting immediate breast reconstruction using an LDMC flap, the motor nerve is ligated to avoid synkinetic muscle contracture. However, this procedure can cause latissimus dorsi muscle atrophy resulting from denervation, and it can also make it difficult to select the appropriate implant size for breast reconstructions in which implants are needed [7-9]. The primary objective of breast reconstruction is to achieve symmetry with the other breast. In order to accomplish this goal, the extent of pure muscle atrophy resulting from denervation must be accurately understood. The authors conducted an objective study among patients who did not receive adjuvant therapy, such as chemotherapy or radiation therapy, and analyzed post-operative volumetric changes of the latissimus dorsi muscle through computed tomography (CT) scans.

## METHODS

Research was conducted from October 2011 to November 2016 with Institutional Review Board approval (IRB No. 05-2018-051). Twenty-three patients were selected who received total mastectomy at the Pusan National University Yangsan Hospital and then underwent immediate breast reconstruction using an LDMC flap performed by a single plastic surgeon. All subjects received follow-up CT scans using the same protocol, and provided written informed consent for the CT scans and photography (120 kVp, 5.0 mm section thickness) (Discovery CT750 HD; GE Medical Systems, Milwaukee, WI, USA).

After mastectomy and axillary dissection were performed, the thoracodorsal pedicle pathway was confirmed through the axilla and the volume and range of the removed breast tissue were checked. A skin paddle was designed with a width of 3 to 5 cm and a length of 10 to 20 cm. For breast reconstructions in moderately-sized to large breasts, various types of implants were

used simultaneously (Table 1). The dissection was performed using a standard method. After complete division of the muscle near its origin, a thoracodorsal pedicle was completely released and isolated. The motor nerve that inserts through the latissimus dorsi muscle was confirmed to be present in the pedicle, and it was ligated at the proximal part and excised to be 1 cm in length in order to prevent synkinetic contracture of the muscle after the operation. After shifting the patient to the supine position, the upper body was elevated 60° to a near-sitting position. The latissimus dorsi muscle was folded and secured, considering the width and volume of the defect. When a portion of the skin of the breast or the nipple-areolar complex (NAC) was removed, the skin paddle was positioned outwardly. Even when the NAC was preserved, part of the de-epithelialized skin paddle was always positioned inferior to the NAC in order to maintain NAC projection after surgery.

CT scans were conducted with the consent of all patients 7 to 10 days after surgery, and again 6 to 8 months after surgery. Ten patients required additional CT scans 18 months after surgery. The muscle volume was measured using the axial view in a picture archiving and communications system (PACS). Each image showed the transpositioned latissimus dorsi muscle, and the cross-section of the muscle was manually measured using the built-in measurement tool in the PACS. These values were multiplied by 5 mm of thickness and added together to obtain the volume (Fig. 1). Two plastic surgeons (SBN and JWL) and one radiologist (KSC) conducted the measurements of the area and volume of the cross-sections, and the average values were calculated and used as representative values.

## RESULTS

In the 23 patients, the initial latissimus dorsi muscle volume that was measured 7 to 10 days after surgery ranged from 64.24 cm<sup>3</sup> to 177.31 cm<sup>3</sup>, with an average of 118.82 cm<sup>3</sup>. The volume measured 6 to 8 months after surgery ranged from 25.5 cm<sup>3</sup> to 107.19 cm<sup>3</sup>, with an average of 54.09 cm<sup>3</sup>. The extent to which the volume decreased varied considerably across cases, from 32.4% to 68.7%. The average volume decrease by 6 to 8 months after surgery was 54.5%. In the 10 patients who underwent additional CT scans 18 months after surgery, we found an additional volume decrease of 1.3% to 27.7% (average, 11.9%) compared to their measurements from 10 to 12 months before (Table 1). Ultimately, the final decrease in volume was 58% compared to the initial latissimus dorsi muscle volume.

In terms of the postoperative clinical results at the final follow-up, one patient complained of depression in the upper part of the breast, and one patient was not satisfied with the results be-

Table 1. Summary of cases

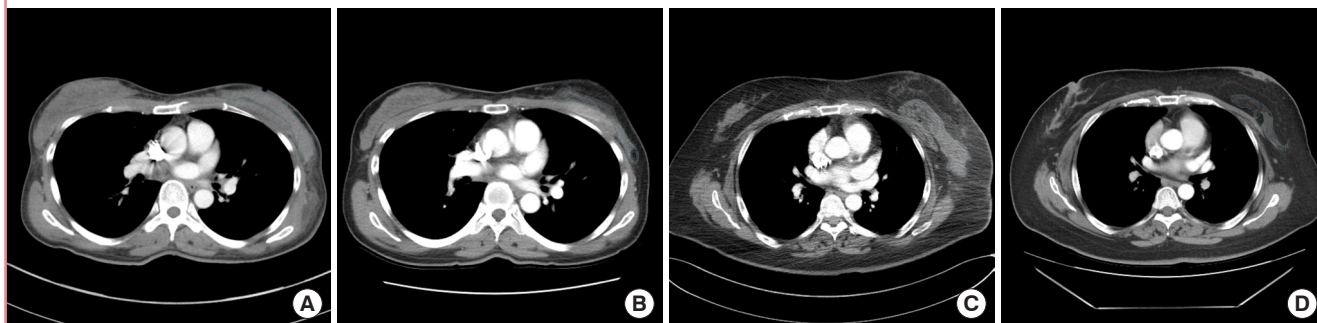
Case no.	Age (yr)	BMI (kg/m <sup>2</sup> )	Implant type and size (mL)	Immediate postoperative volume (cm <sup>3</sup> )	After 6–8 months (cm <sup>3</sup> )	After 18 months (cm <sup>3</sup> )	Volume decrease (%) <sup>a)</sup>	Volume decrease (%) <sup>b)</sup>	Total follow-up period (mon)	Clinical result <sup>c)</sup>
1	40	21.60	-	126.51	56.91	43.64	55.02	23.32	48	Fair
2	55	20.76	-	110.88	40.40	29.91	63.56	25.97	60	Good
3	43	18.73	-	64.24	25.50	-	60.31	-	42	Good
4	51	25.48	Saline bag, 120	98.39	38.76	-	60.61	-	37	Good
5	40	30.86	-	158.68	107.19	95.49	32.45	10.92	24	Good
6	50	21.64	Round, 90	102.56	44.48	32.14	56.63	27.74	25	Good
7	34	20.08	Round, 90	116.03	36.32	-	68.70	-	29	Good
8	35	21.88	Round, 90	102.58	44.07	37.28	57.04	15.41	29	Good
9	45	26.56	Round, 90	143.55	72.83	71.85	49.27	1.35	18	Good
10	40	21.83	Round, 90	110.32	46.68	45.34	57.69	2.87	30	Fair
11	36	16.82	Round, 90	86.11	34.64	-	59.77	-	24	Good
12	40	19.14	Anatomical, 155	79.69	39.18	38.37	50.83	2.07	25	Good
13	43	23.15	Round, 90	167.79	64.88	-	61.33	-	24	Good
14	43	20.96	Round, 90	119.72	47.56	42.40	60.27	10.85	24	Good
15	53	27.85	Anatomical, 215	156.71	71.12	-	54.62	-	19	Good
16	51	26.84	Anatomical, 155	112.98	65.67	-	41.87	-	23	Good
17	42	26.50	Anatomical, 135	136.05	69.00	64.00	49.28	7.25	18	Good
18	51	19.63	Anatomical, 190	99.20	42.60	-	57.06	-	18	Good
19	51	27.06	Anatomical, 120	177.31	93.52	-	47.26	-	21	Good
20	52	27.11	Anatomical, 190	134.10	68.85	-	48.66	-	20	Good
21	40	20.55	Round, 90	108.10	35.93	-	66.76	-	18	Good
22	49	25.56	Anatomical, 120	137.04	65.61	-	52.12	-	18	Good
23	47	18.66	Anatomical, 135	84.36	32.37	-	61.63	-	18	Good
Average	44.83	23.01		118.82	54.09	50.04	54.48	11.94	26.60	

BMI, body mass index.

<sup>a)</sup>The decrease in volume at 6 to 8 months after surgery; <sup>b)</sup>The additional volume decrease compared to the measurements from 10 to 12 months before; <sup>c)</sup>Clinical result, poor/fair/good.

Fig. 1. Muscle volume measurements on axial CT

Each image showed the transpositioned latissimus dorsi muscle, and the cross-section of the muscle was manually measured using the built-in measurement tool in the picture archiving and communications system. These values were multiplied by 5 mm of thickness and added together to obtain the volume. (A) Area of transpositioned latissimus dorsi muscle, immediate postoperative computed tomography (CT) view. (B) CT view of the area of the muscle 8 months after the operation. (C) Immediate postoperative view of another patient, (D) view 8 months later.



cause the contour of the implant was visible (Table 1). All the other patients were satisfied with the outcomes.

## DISCUSSION

Satisfactory results using only an LDMC flap can be achieved in breast reconstructions in Asian patients with small to moderate-

ly-sized breasts. However, for reconstructions of moderately-sized to large breasts, the additional use of implants improves the results of most procedures. The authors suggest that the results should be evaluated at least 6 to 12 months after surgery in patients who do not receive any adjuvant therapy, such as chemotherapy or radiation therapy, after breast reconstruction. When adjuvant therapy is conducted, the evaluation should be

performed 2 years after treatment is completed. This is due to the cytotoxic effects of chemotherapy [1] and the capsular contracture, lymphedema, cellular damage, and fat necrosis resulting from radiation that can continue for a certain period of time, even after adjuvant therapy is completed. Moreover, capsular contracture and a decrease in the volume of the latissimus dorsi muscle may continue due to the use of implants, even in patients who do not receive adjuvant therapy.

The latissimus dorsi muscle is categorized as type V in the Mathes-Nahai classification, and the circulation provided by a single dominant pedicle is very likely to enable the flap to survive; however, due to the decrease in blood supply resulting from the ligation of multiple secondary segmental pedicles during breast reconstruction using an LDMC flap, a decrease in the muscle volume is inevitable. In order to avoid synkinetic muscle contractures in the latissimus dorsi muscle after surgery, motor nerve ligation is necessary. However, motor nerve ligation can also cause muscle atrophy due to denervation [7,8]. In order to overcome these effects associated with decreased muscle volume, a flap with a larger volume than that of the defect must be harvested, but objective and quantitative studies on this pattern of volume decrease are still lacking. Since most breast cancer patients undergo both breast-conserving surgery and immediate breast reconstruction along with postoperative adjuvant therapy, long-term changes in the volume of the reconstructed breast during follow-up are extremely important.

For this study, subjects were selected who received both mastectomy and immediate breast reconstruction using an LDMC flap, but did not undergo chemotherapy or radiation therapy. The extent to which the volume of the latissimus dorsi muscle

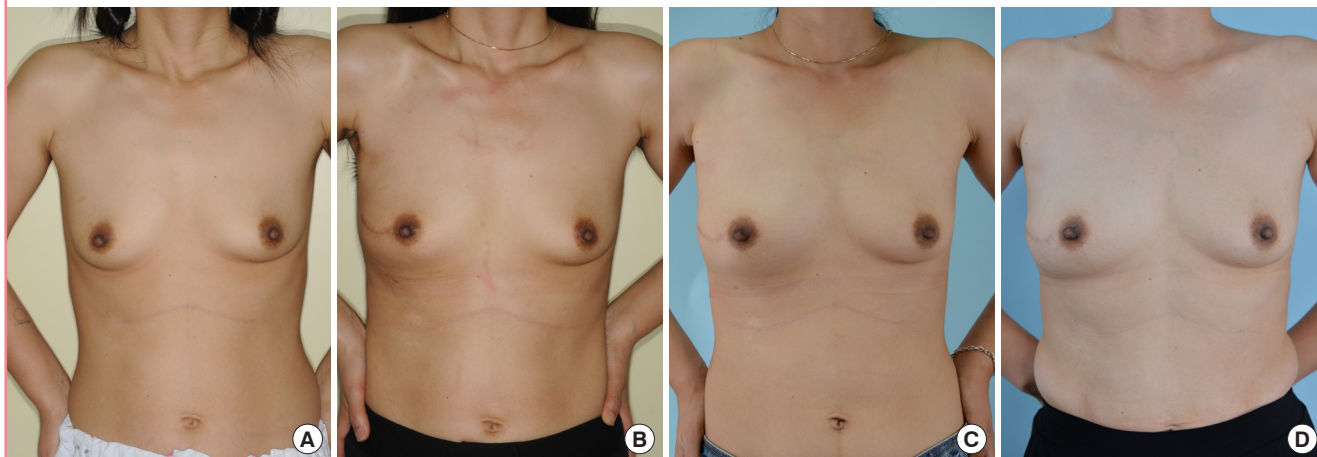
decreased in the study group was observed through follow-up conducted between 6–8 months and 18 months. Through these observations, this study can serve as a useful comparative study for future research on the decrease in latissimus dorsi muscle volume in patients who undergo chemotherapy and radiation therapy. Furthermore, this study can be helpful in preoperative planning for patients who will not receive adjuvant therapy. Although the number of patients in this study may be small, since only a portion of all patients who do not have axillary lymph node metastasis and undergo mastectomy can avoid postoperative adjuvant therapy, this study is important because it can serve as a reference for future supplemental research.

Furthermore, the authors clinically observed many patients who were excluded from this study due to the lack of a single consistent CT scanning protocol. Their progress was observed at 2-year follow-ups, and upon gross examination, the majority of these patients maintained the same breast volume without changes for 6 to 18 months after surgery. The reason for this is that many patients experience weight gain due to taking tamoxifen and similar medications, and dietary and exercise habits are different for each patient. In addition, the authors restricted patients from performing exercises involving the pectoralis muscle (e.g., swimming, tennis, and upper body exercises) other than upper body stretching for at least 18 months after surgery. A wire bra should be worn for 2 years after the operation, and this postoperative management method also affects the maintenance of breast volume.

In this study, we measured the degree to which muscle volume decreased through CT scans obtained 6 to 8 months after surgery. Some patients who underwent CT scans to check for re-

**Fig. 2. Follow-up after breast reconstruction**

Long-term follow-up after immediate breast reconstruction with an extended latissimus dorsi musculocutaneous flap. (A) Before the breast cancer operation. (B) After 4 months. (C) After 1 year. (D) After 5 years. Upon gross examination, the majority of patients maintained the same breast volume without changes for 1 year after surgery.



currence 24 months after surgery maintained the same breast volume, as observed in the gross examinations (Fig. 2); however, it was difficult to accurately distinguish the border of the latissimus dorsi muscle in the CT scans in most of those patients, which made it difficult to measure the volume of the pure muscle. Therefore, they were excluded from the study.

Immediate reconstruction using only an LDMC flap is possible for small to moderately-sized breasts, but most of the patients in this study used implants as well and showed favorable long-term follow-up results. The LDMC flap includes subcutaneous tissue and fat tissue, meaning that the pure muscle volume is not equivalent to the entire flap volume. However, since the detection of volume changes in the latissimus dorsi muscle is facilitated by understanding the degree of atrophy after adjuvant therapy, and since immediate breast reconstruction using both breast-conserving surgery and an LDMC flap requires chemotherapy or radiation therapy, our findings can serve as a reference for accurately assessing the volume of the latissimus dorsi muscle. This, in turn, will help improve surgical outcomes. This study observed changes in the volume of the latissimus dorsi muscle in patients who did not receive adjuvant therapy, with the goal of obtaining comparative data useful for further research.

## 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 Pusan National University Yangsan Hospital (IRB No. 05-2018-051) and performed in accordance with the principles of the Declaration of Helsinki. Written informed consents were obtained.

### Patient consent

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

### Author contribution

Conceptualization: Nam SB. Data curation: Nam SB, Kim HY, Lee SH. Formal analysis: Oh HC. Methodology, Choi JY, Bae SH. Project administration: Bae SH. Visualization: Choo KS. Writing - original draft: Nam SB. Writing - review & editing: Lee JW.

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## REFERENCES

1. Azzawi K, Ismail A, Earl H, et al. Influence of neoadjuvant chemotherapy on outcomes of immediate breast reconstruction. *Plast Reconstr Surg* 2010;126:1-11.
2. Mosahebi A, Ramakrishnan V, Gittos M, et al. Aesthetic outcome of different techniques of reconstruction following nipple-areola-preserving envelope mastectomy with immediate reconstruction. *Plast Reconstr Surg* 2007;119:796-803.
3. Saulis AS, Mustoe TA, Fine NA. A retrospective analysis of patient satisfaction with immediate postmastectomy breast reconstruction: comparison of three common procedures. *Plast Reconstr Surg* 2007;119:1669-76.
4. Shin IS, Lee DW, Lew DH. Efficacy of quilting sutures and fibrin sealant together for prevention of seroma in extended latissimus dorsi flap donor sites. *Arch Plast Surg* 2012;39:509-13.
5. Kim H, Wiraatmadja ES, Lim SY, et al. Comparison of morbidity of donor site following pedicled muscle-sparing latissimus dorsi flap versus extended latissimus dorsi flap breast reconstruction. *J Plast Reconstr Aesthet Surg* 2013;66:640-6.
6. Yezhelyev M, Duggal CS, Carlson GW, et al. Complications of latissimus dorsi flap breast reconstruction in overweight and obese patients. *Ann Plast Surg* 2013;70:557-62.
7. Kaariainen M, Giordano S, Kauhanen S, et al. The significance of latissimus dorsi flap innervation in delayed breast reconstruction: a prospective randomized study-magnetic resonance imaging and histologic findings. *Plast Reconstr Surg* 2011;128:637e-645e.
8. Paolini G, Longo B, Laporta R, et al. Permanent latissimus dorsi muscle denervation in breast reconstruction. *Ann Plast Surg* 2013;71:639-42.
9. Szychta P, Butterworth M, Dixon M, et al. Breast reconstruction with the denervated latissimus dorsi musculocutaneous flap. *Breast* 2013;22:667-72.