Postoperative Upper Extremity Function in Implant and Autologous Breast Reconstruction

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Abstract

Background After mastectomy and breast reconstruction, many patients experience upper extremity complications, such as pain, restriction in motion, and lymphedema. Despite an aesthetically satisfactory outcome, these occurrences can diminish a patient's postoperative quality of life. Several studies have investigated the causes and incidence of these complications. However, there is currently a paucity of data comparing postoperative upper extremity function according to reconstruction technique.

Methods A review was performed of patients enrolled in a physical therapy (PT) program after mastectomy and immediate breast reconstruction. PT initial encounter evaluations were used to gather data on patients' postoperative upper extremity function. Hospital records were used to gather surgical and demographic data. For each patient, data were collected for each upper extremity that was ipsilateral to a reconstructed breast. Data were then compared between patients who underwent implant-based versus autologous deep inferior epigastric perforator flap reconstruction.

Results A total of 72 patients were identified, including 39 autologous and 33 implant-based reconstruction cases. Proportions of patients who underwent sentinel lymph node biopsies and axillary lymph node dissections were similar between the two groups. The autologous-based reconstruction patients had significantly higher arm pain at rest ($p = 0.004$) and with activity ($p = 0.031$) compared with implant patients. Shoulder range of motion and manual muscle test results were similar between groups, with the exception of elbow flexion, which was weaker in implant patients ($p = 0.030$). Implant patients were also more likely to report "severe difficulty" or "inability" to perform activities of daily living ($p = 0.022$). Edema/swelling, axillary cording, and lymphedema girth measurements were similar between the two groups.

Conclusion Different techniques of breast reconstruction can result in different postoperative upper extremity complications. These data show specific areas where postoperative care and PT can be customized according to reconstruction type. Investigation is currently underway to determine the effect of PT on upper extremity function in these patients.

Keywords
- ► breast reconstruction
- ► upper extremity
- ► physical therapy

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More than 240,000 new cases of invasive breast cancer are diagnosed annually in the United States alone.[1] In addition to chemotherapy, breast cancer patients typically undergo a combination of extirpative and reconstructive surgery. Although modern treatment modalities have increased 5-year survival rates to over 90%, treatment can entail unwanted side effects.[2,3] Specifically, many patients experience a variety of upper extremity complications following mastectomy and reconstruction.[4] This can include restriction in motion, pain, lymphedema, and axillary cording, to name a few.[5–11] Despite an aesthetically satisfactory outcome, these occurrences can significantly diminish a patient's postoperative quality of life. As breast cancer becomes increasingly prevalent, it is imperative that surgeons critically evaluate their practices to optimize postoperative quality of life in these patients.[12]

Several studies have sought to characterize the postoperative upper extremity complications after breast reconstruction surgery.[4,13,14] For example, the prevalence of lymphedema and its impact on breast cancer patients has been well documented in the existing literature.[15–23] However, there is currently a paucity of data that compares the risk of upper extremity complications between different types of breast reconstruction. Traditionally, following mastectomy, patients can elect to undergo two-stage implant-based reconstruction or autologous flap reconstruction.[24] These two techniques involve very different anatomic approaches, and may have significant differences in their postoperative effect on upper extremity function.[24]

The aim of this study was to quantify and compare the postoperative upper extremity complications for implant-based and autologous flap reconstruction patients. The authors' hypothesized that the autologous flap group would experience more postoperative pain, whereas the implant-based group would have greater restrictions in upper extremity range of motion (ROM).

Methods

A review was performed of patients enrolled in a rehabilitation program after mastectomy and immediate breast reconstruction between the years 2013 and 2017. Inclusion criteria were all adult female patients who underwent mastectomy and immediate implant-based or autologous deep inferior epigastric perforator (DIEP) flap reconstruction. The patients of seven surgeons were included. Exclusion criteria were patients under the age of 18, those who underwent delayed reconstruction, and women who underwent reconstruction for purposes other than breast cancer, such as the correction of a congenital condition. This study was conducted under approval from the Institutional Review Board.

Hospital electronic medical records were used to gather demographic data, including age and body mass index (BMI), as well as past medical history and surgical data, including type of reconstruction and history of sentinel lymph node biopsies (SLNB), axillary lymph node dissections (ALND), chemotherapy, and radiotherapy. In the authors' health system, all breast reconstruction patients are referred to postoperative physical therapy (PT). Participation in the PT program is optional. PT initial encounter evaluations were used to gather data on patients' postoperative upper extremity function before beginning the PT program. For each patient, data was collected for each affected limb (i.e., each upper extremity that was ipsilateral to a reconstructed breast). Pain was measured on a self-reported scale of 1 to 10, both at rest and with activity. Patients were also asked to rate the degree to which they experienced difficulty performing six different lifestyle activities, using the following scale: none/minimal/mild/moderate/severe/unable. Various physical attributes, including edema/swelling, atrophy, discoloration, and cording, were counted as either present or absent based on physical examination findings. Physical exam was also used to determine the ROM of each affected limb for shoulder flexion, abduction, external rotation, and internal rotation. These ROM values were then converted to percent of normal ROM, based on established normal ROMs for the shoulder.[25] Lastly, manual muscle testing (MMT) data was gathered for the shoulder (flexion, abduction, external rotation, internal rotation) and elbow (flexion, extension). MMT for each motion was scored on a scale of 0 to 5 (►**Table 1**). For calculation purposes, any score with a "plus" (+) or "minus" (–) was rounded to 0.7 or 0.3 decimal places, respectively.

Statistical Analysis

Affected limbs were separated into two groups according to reconstruction type: implant-based or autologous DIEP flaps. The two groups were then compared to determine any statistically significant differences in any of the variables measured. Unpaired two-sided *t*-tests or Mann–Whitney U tests were used to compare continuous variables, such as pain

Table 1 Manual muscle testing (MMT) scoring system

Score	Definition
5	Holds position against maximum resistance
4+	Holds position against moderate to maximum resistance
4	Holds position against moderate resistance
4–	Holds position against slight to moderate resistance
3+	Holds position against slight resistance
3	Holds position against gravity
3–	Holds position weakly against gravity
2+	Able to move through full range of motion with gravity eliminated and hold position against pressure OR moves through partial range of motion against gravity
2	Able to move through full range of motion with gravity eliminated
2–	Able to move through partial range of motion with gravity eliminated
1	No visible movement, but palpable muscle contraction
0	No visible movement or palpable muscle contraction

scores and ROM. Chi-squared and Fisher's exact tests were used to compare nominal variables, such as presence or absence of pitting edema or cording. Any test with $p < 0.05$ was considered statistically significant.

Results

A total of 72 patients were identified. Of these, 39 patients underwent DIEP flap reconstruction and 33 underwent two-stage implant-based reconstruction. Within these groups, there was a mixture of unilateral and bilateral surgeries; in total, there were 67 affected limbs in the DIEP flap group and 60 affected limbs in the implant group. Among those who underwent implant-based reconstruction, all implants were placed subpectorally. There was no statistically significant difference in age, weight, or BMI between the two groups (►**Table 2**). Similarly, there was no statistically significant difference in incidence of SLNB or ALND or history of hormone therapy, chemotherapy, or radiotherapy between the two groups (►**Table 2**).

Self-reported pain scores were significantly higher in the flap group than in the implant group, both at rest (flap 3.3 ± 0.3 vs. implant 2.1 ± 0.3; $p = 0.004$) and with activity (5.7 ± 0.4 vs. 4.5 ± 0.5; $p = 0.03$) (►**Table 3**). There was no significant difference between the two groups in the prevalence of edema/swelling, atrophy, discoloration, or cording (►**Table 4**).

The implant reconstruction patients reported "severe difficulty" or "unable" to perform activities of daily living (ADLs) significantly more often than the flap patients (flap 3.0% vs. implant 23.3%, $p = 0.02$) (►**Table 5**). There was no significant difference in ability to perform other activities.

There was no significant difference in shoulder ROM between the two groups, as measured by percent of normal ROM (►**Table 6**). By MMT, elbow flexion was significantly

Table 2 Characteristics of subjects by DIEP flap and implant-based reconstruction

Characteristic	Flap reconstruction	Implant-based reconstruction	*p*-Value
Age (y)	51.5 ± 9.9	50.5 ± 10.3	0.65
Weight (kg)	77.2 ± 14.0	71.7 ± 17.7	0.15
BMI (kg/m^2)	28.8 ± 4.5	28.5 ± 6.6	0.80
Medical history			
SLNB[a]	97.0% (65)	90.0% (54)	0.15
ALND[a]	26.9% (18)	35.0% (60)	0.42
Hormone therapy	35.9% (14)	24.2% (8)	0.32
Chemotherapy	48.7% (19)	54.5% (18)	0.64
Radiotherapy	14.9% (10)	11.7% (7)	0.61

Abbreviations: ALND, axillary lymph node dissections; BMI, body mass index; DIEP, deep inferior epigastric perforator; SLNB, sentinel lymph node biopsies.
[a]SLNB and ALND were counted only if performed on an affected arm (i.e., ipsilateral to a surgical breast).

Table 3 Upper extremity pain scores for flap and implant groups. Pain scores self-reported on a 1–10 scale

Pain	Flap reconstruction	Implant-based reconstruction	*p*-Value
Pain at rest	3.3 ± 0.3	2.1 ± 0.3	0.004
Pain with activity	5.7 ± 0.4	4.5 ± 0.5	0.03

Table 4 Physical exam attributes

Characteristic	Flap reconstruction	Implant-based reconstruction	*p*-Value
Edema/swelling	34.4% (22)	65.6% (18)	0.60
Atrophy	46.9% (30)	45.0% (27)	0.83
Discoloration	21.9% (14)	11.7% (7)	0.13
Axillary cording	17.2% (11)	11.7% (7)	0.38
Elbow cording	3.1% (2)	0.0% (0)	0.17

Table 5 Upper extremity functional ability

Activity	Flap reconstruction	Implant-based reconstruction*	*p*-Value
Difficulty laying down	18.8% (6)	30.1% (8)	0.29
Difficulty lifting/ carrying	13.5% (5)	33.3% (10)	0.053
Difficulty reaching overhead	21.6% (8)	27.6% (8)	0.57
Difficulty dressing	2.8% (1)	17.2% (5)	0.08
Difficulty driving	33.3% (10)	26.1% (6)	0.60
Difficulty with ADLs	3.0% (1)	23.3% (7)	0.02

Abbreviation: ADLs, activities of daily living.

Table 6 Upper extremity range of motion.

Motion	Flap[a]	Implant[a]	*p*-Value
Shoulder flexion	72.2 ± 0.17	77.2 ± 0.21	0.14
Shoulder abduction	75.0 ± 0.22	76.3 ± 0.27	0.77
Shoulder external rotation	65.7 ± 0.27	70.1 ± 0.28	0.42
Shoulder internal rotation	72.8 ± 0.23	73.6 ± 0.27	0.87

Abbreviation: ROM, range of motion.
[a]Measured as percent of normal ROM.

Table 7 Manual muscle testing scores. Scores given on a scale of 1–5 (as described in ►**Table 1**) by physical therapist during initial physical therapy evaluation

Motion	Flap	Implant	*p*-Value
Shoulder flexion	3.67 ± 0.06	3.42 ± 0.09	0.65
Shoulder abduction	3.35 ± 0.06	3.41 ± 0.09	0.58
Shoulder external rotation	3.40 ± 0.06	3.49 ± 0.08	0.42
Shoulder internal rotation	3.44 ± 0.07	3.54 ± 0.08	0.36
Elbow flexion	3.94 ± 0.07	3.74 ± 0.06	0.03
Elbow extension	3.88 ± 0.07	3.69 ± 0.07	0.052

weaker in the implant group (flap 3.94 ± 0.07 vs. implant 3.74 ± 0.06; $p = 0.03$) (►**Table 7**). Elbow extension also trended toward being significantly weaker in the implant group (flap 3.88 ± 0.07 vs. 3.69 ± 0.07; $p = 0.052$). There was no significant difference in MMT scores for shoulder movements between the two groups.

Discussion

The data presented herein suggests different breast reconstruction techniques can result in different rates of postoperative upper extremity complications. As hypothesized, the DIEP flap reconstruction patients experienced more postoperative upper extremity pain than the implant-based reconstruction patients, both at rest and with activity. However, there was no statistically significant difference in shoulder ROM between the two groups. Interestingly, the flap group had significantly stronger elbow flexion than the implant group according to MMT. The implant patients were also more likely to choose "severe" or "unable" when asked to rate their difficulty with ADLs.

Autologous flap reconstruction is a more invasive surgical procedure than implant-based reconstruction.[24] Implant-based reconstruction is somewhat less intense, but may involve several more outpatient visits and implant-related surgeries, and is prone to unique complications such as capsular contracture and implant extrusion.[26–28] Although postoperative complications of the breast have been well documented for flap and implant-based reconstruction, few studies have focused on upper extremity complications. To the authors' knowledge, this is the first study to compare these two types of reconstruction with a focus on upper extremity function.

In this study, flap patients experienced more postoperative pain than implant patients. Although it is difficult to definitively discern exactly why this is the case, it may likely be due to the increased surgical sites of autologous flap procedures. In this cohort of DIEP flap patients, a rib-sacrificing technique was used to access the internal mammary vessels, which may have contributed to increased pain as well. Future studies that help further investigate the incidence and risk factors for postoperative pain in both flap and implant reconstruction could help elucidate these findings. Similarly, the data of this study cannot explain why the flap patients had stronger elbow flexion on MMT than the implant group. This result is likely related to the distortion breast implants can cause of the chest and upper extremity musculature, thereby resulting in upper extremity functional impairment.[29] Alternatively, these differences may simply be due to a type I statistical error. However, the implant patients did not have weaker strength in any other MMT measurements or more limited ROM in any shoulder movements.

The implant patients showed more difficulty with ADLs than the flap patients, according to the self-reported data. This is particularly interesting, given that elbow flexion was the only significantly weaker arm movement in the implant patients. Perhaps, then, the impairment in daily activities that the implant patients were experiencing was not due to limited upper extremity strength, ROM, or pain. It is possible that the limitations in ADLs were due to other complications specific to implant patients that were not measured, such as capsular contracture or animation deformity.[30–33] This study only included patients who underwent subpectoral implant-based reconstruction, a variable that can be an important risk factor in the development of complications such as animation deformity.[34,35] Future studies in this area could provide valuable insight into why implant patients might experience more difficulties with ADLs than flap patients.

There was no significant difference in the incidence of edema/swelling, atrophy, discoloration, axillary cording, or elbow cording between the flap and implant groups. This suggests that flap and implant breast reconstruction may have similar effects on the lymphatic drainage of the upper extremity. This can be useful information when counseling patients who are concerned about the appearance of the arms and underarms after reconstruction, since occurrences like axillary web syndrome can have a significant impact on postoperative quality of life.[36]

PT can be an important tool for diagnosing and treating postoperative complications in breast reconstruction patients.[4,37–39] The findings of this study can be used to help predict postoperative complications and guide PT strategies for flap and implant patients. For example, since flap reconstruction patients experienced more upper extremity pain, it might be valuable to include more pain management tactics in the postoperative care plan for these patients. Similarly, an occupational therapy-guided treatment plan might benefit implant patients, who reported more difficulties with ADLs. Strength training may also be beneficial in ameliorating the weakness in elbow flexion we observed in the implant patients. Future studies on the effect of PT in reducing the postoperative upper extremity complications of these two groups would be valuable. A prospective study that observed the incidence of the upper extremity complications before and after the implementation of a PT program could provide strong support for the use of PT in improving postoperative quality of life in breast cancer and reconstruction patients.

This study is not without limitations. First, the retrospective nature of this study limits the strength of the results. A prospective study would yield more convincing evidence. Second, the study was performed at a single institution.

A larger, multicenter study would give the study more power and provide more generalizable results. Third, there were limited inclusion criteria for our reconstruction patients. Only patients who underwent reconstruction immediately following mastectomy were included, and patients who underwent delayed reconstruction were excluded. These patients were excluded because delayed reconstruction adds an extra variable to the development of upper extremity complications that may have confounded our results. However, delayed reconstruction is not uncommon among breast cancer patients,[40] and evaluating the upper extremity complications in this patient group would be important. The flap reconstruction group was also limited to DIEP flap patients only. Further studies that include other forms of autologous flap reconstruction, such as gluteal artery perforator or profunda artery perforator flaps, could be valuable. Fourth, the PT evaluation forms that were used to collect data for this study were sometimes incomplete. Since many of the data points on the evaluation forms were dependent on patient self-reporting or the patients' willingness to have certain physical examination maneuvers performed, not all patients' forms were completely filled out for every data point. This may add some inconsistencies to our data that could be eliminated with more careful charting policies in the future. Furthermore, the pain scores used for data analysis were self-reported on a 1 to 10 scale. A validated pain scale, such as the Patient-Reported Outcomes Measurement Information System (PROMIS),[41] may have more accurately assessed patients' pain and been more valuable in this study.

Conclusion

Different techniques of breast reconstruction can result in different postoperative upper extremity complications. This result of this study shows that autologous flap reconstruction patients experience more postoperative pain, while implant-based reconstruction patients experience more elbow flexion weakness and more difficulty with ADLs.

Conflict of Interest
None declared.

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