

# Donor Site Morbidity in Phalloplasty Reconstructions: Outcomes of the Radial Forearm Free Flap

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**Background:** The radial artery forearm free flap (RFFF) is the workhorse technique for phallus reconstruction. The RFFF provides good cosmesis and potential sensory recovery. However, the donor site is large in comparison to other applications of the RFFF which may increase the potential for donor site morbidity, such as nerve injury, delayed wound healing, and decreased hand strength. This study systematically reviewed the current literature to assess the donor site morbidity associated with RFFF phalloplasty (RFFFP).

**Methods:** A systematic review utilizing Preferred Reporting Items for Systematic Review and Meta-Analyses guidelines was completed of the current literature pertaining to donor site morbidity after RFFFP. Two investigators independently reviewed the literature to determine eligibility for inclusion. Two hundred sixty-seven studies were reviewed and 10 were included in the final analysis after application of exclusion criteria.

**Results:** Nine hundred forty flap reconstructions were identified. Gender affirming surgery was the indication in 77.7% (n = 730) of patients. The overall donor site complication rate was 7.9% (n = 74). Skin graft failure occurred in 41 patients (4.5%) and was the most frequent complication. Donor site infection (n = 3, 15.8%), hematoma (n = 1, 0.8%), neuroma (n = 1, 10%), compartment syndrome (n = 1, 0.8%), decreased strength or sensation (n = 15, 4.9%), lymphedema or limb swelling (n = 10, 3.9%), and contracture (n = 2, 6.5%) were also found.

**Conclusions:** The most common donor site complication after RFFFP is skin graft failure. Decreased forearm sensation and strength affected a significant proportion of patients within each reported cohort. Prospective studies should continue to evaluate donor site morbidity with objective measures, such as grip strength evaluation, and long-term follow-up for vascular changes following radial artery harvest. (*Plast Reconstr Surg Glob Open* 2019;7:e2442; doi: [10.1097/GOX.0000000000002442](https://doi.org/10.1097/GOX.0000000000002442); Published online 26 September 2019.)

## INTRODUCTION

It is estimated that 0.6% of the US population identifies as transgender or gender-nonconforming, and as such patients pursuing gender affirming surgery (GAS) are increasing in number annually.<sup>1</sup> A NSQIP study performed by Tran et al<sup>2</sup> demonstrated a 46-fold increase in GAS from

2010 to 2015. GAS for transgender male patients includes “top surgery”, or chest wall reconstruction with mastectomies, and “bottom surgery”, or genital reconstruction.<sup>3</sup> Phalloplasty utilizing the radial artery forearm free flap (RFFF) is a workhorse technique for genital reconstruction in the transgender male patient or for reconstruction following trauma or oncologic resection of the penis.<sup>3</sup>

Outcomes following reconstruction related to physiologic and sexual function at the recipient site have been evaluated previously, and in comparison to the anterolateral thigh flap, the RFFF has the benefits of providing more robust sensation through the antibrachial cutaneous nerves, improved cosmesis, and the ability to void while standing. The RFFF may also offer the advantage of maintenance of sexual function with an implanted prosthesis.<sup>4-6</sup>

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However, unlike the anterolateral thigh flap, the RFFF donor site exposes tendons and nerves essential for grip strength and overall hand function, which places the patient at risk for more morbid complications.<sup>7</sup> As the RFFF donor site frequently requires a subtotal harvest of the skin from the forearm with inclusion of cutaneous nerves, the potential for donor site complications impacting hand function and strength is increased in comparison to smaller flaps typically used in extremity or head and neck reconstruction. Additionally, the donor site is in a highly visible area which can cause the patient stress from the social stigma associated with the procedure.<sup>2</sup>

Given these differences, it is unclear if the RFFF phalloplasty (RFFFP) reconstruction creates a unique profile of donor site complications, or variance in comparative rates of donor site morbidity. As such, this study aimed to review the current literature for donor site morbidity following RFFFP to accurately assess risk for postoperative complications and donor site functional impact and in comparison with other intended reconstructive applications of the RFFF.

## METHODS

### Study Design

A systematic review of the current literature pertaining to radial forearm free flap donor site morbidity after phalloplasty was performed according to the “Preferred Reporting Items for Systematic Review and Meta-Analyses” guidelines.<sup>8</sup> Search terms such as phalloplasty, radial, forearm, donor site, complication, and flap were used to perform the literature search. Authors A.K. and S.C. performed independent reviews of the literature within the PubMed and Ovid/Medline databases.

Articles pertaining to adult patients, written in English language, and assessing donor site outcomes after radial forearm free flap phalloplasty were included. Non-English language, use of alternative free flaps, single case reports,

cadaver studies, non-human studies, and expert opinion articles were excluded. Articles were independently reviewed for inclusion and if there was disagreement, group review for consensus was achieved. The bibliographies of included articles were also reviewed for additional relevant studies.

For all included studies, the following data were collected: author, publication year, title, number of patients, average age of patients, average follow-up time, indication for phalloplasty, frequency, and type of donor site complication.

### Statistical Analysis

Patients from each included study were pooled together to form a population group. Pooled analysis of the overall population was performed to evaluate rates of various donor site complications after radial forearm flap phalloplasty. Within each specific donor site complication, only studies that reported that specific outcome was pooled to assess an overall rate. Results are reported as percentages of the total group.

## RESULTS

The literature search identified 267 studies for possible inclusion from PubMed and Ovid/Medline. Two hundred twenty-one articles were excluded by title or abstract content review. Full text review was performed on 46 remaining studies, and ultimately 10 studies met inclusion criteria for final analysis (Fig. 1). All 10 studies were retrospective case series. The total cohort included 940 patients who underwent RFFFP.

The most common indication for surgery was gender affirmation in 77.7% (n = 730). Other indications included trauma/oncologic injury (n = 32), bladder or cloacal exstrophy (n = 26), and agenesis/aplasia (n = 8). Postoperative follow-up ranged from 1 to 216 months, with an average of  $38.7 \pm 27.2$  months. Average patient age was 32.9 years (range, 19–55). RFFF sizes ranged from  $4 \times 17 \text{ cm}^2$  to  $16 \times 16 \text{ cm}^2$  (average,  $167 \text{ cm}^2$ ). Table 1 displays patient demographics by article.

### Donor Site Complications

Donor site complications included infection, hematoma, dehiscence, neuroma formation, nerve compression/compartment syndrome, skin graft failure, decreased strength/sensation, lymphedema/swelling, and contracture. Skin graft failure and decreased strength/sensation were the most commonly reported complications with 8 of the 10 studies and 6 of 10 studies describing these results, respectively.<sup>9–13,16–18</sup> Complications of infection, hematoma, dehiscence, and neuroma development were less frequently reported.<sup>9,14,15,17</sup> The overall complication rate in the cohort of 940 patients was 7.9% (n = 74). Table 2 displays reported donor site complication by specific study.

### Skin Graft Failure and Contracture

Eight out of 10 studies reported skin graft failure rates, totaling 911 patients. Skin graft failures were described as partial or total loss of the skin graft applied to the donor site following radial forearm free flap phalloplasty. In the pooled cohort of 911 flaps, 321 (35.2%) donor sites

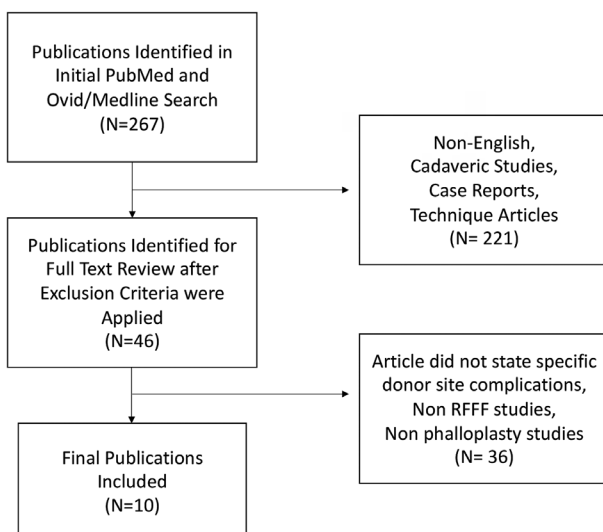


Fig. 1. Literature Search Results

**Table 1. Included Study Cohort Average Age, Follow-Up, Indication for Surgery**

Author	Year	Patients	Age	Follow-Up	Gender Confirmation	Trauma/ Oncologic/ Medical	Bladder/ Cloacal Exstrophy	Agensis/ Aplasia
Selvaggi et al <sup>9</sup>	2006	125	—	43 (6–108)	125	—	—	—
Monstrey et al <sup>10</sup>	2009	287	—	—	280	3	—	4
Garaffa et al <sup>11</sup>	2009	15	43.6 (39–54)	85.2 (24–216)	—	15	—	—
Garaffa et al <sup>12</sup>	2010	115	34.9 (20–55)	—	—	—	—	—
Garaffa et al <sup>12</sup>	2010	27	40.4 (30–55)	9.2 (1–32)	—	—	—	—
Doornaert et al <sup>13</sup>	2011	316	—	—	306	4	—	4
Song et al <sup>14</sup>	2011	19	—	(12–120)	19	—	—	—
Massanyi et al <sup>15</sup>	2013	10	19	14 (2–52)	—	—	10	—
Garaffa et al <sup>16</sup>	2014	16	23,619–29	20,52–38	—	—	16	—
Falcone et al <sup>17</sup>	2016	10	36 (27–52)	—	—	10	—	—

underwent full thickness skin grafting and 590 (64.8%) underwent split thickness skin grafting. Forty-one patients (4.5%) had delayed healing and 25 of those 41 patients (61.0%) required secondary skin grafting. The articles did not report on the distribution of partial versus complete skin graft loss. The remaining 16 patients either underwent conservative management and healed by secondary intention, or their management was not specifically discussed.<sup>9–13,16–18</sup> Two studies reported on contracture, which was seen in 2 of 31 patients (6.5%) and was caused by skin graft failure.<sup>11,16</sup>

#### Decreased Strength/Sensation

Decreased strength or sensation in the upper extremity from the RFFF donor arm was described in 6 of the 10 articles, for a total of 308 patients.<sup>3,12,13,17</sup> Of these, 15 (4.9%) patients experienced decreased strength or sensation postoperatively in the donor extremity. These were based on subjective assessments of the patient's perceived strength and sensation, without dynamometer testing or 2-point discrimination.

Loss of sensation over the dorsoradial forearm and wrist was the most common subjective complaint in 12 of the 15 patients (80.0%), presumably due to injury or harvest of the lateral antebrachial cutaneous nerve and/or dorsal radial sensory nerve branch. Garaffa et al reported 2 patients who experienced “permanent but minimal loss of mobility” in the donor extremity, but no objective measures such as grip strength were noted.<sup>12</sup> One patient developed temperature insensitivity that subsequently resulted in a burn of the donor site.<sup>9</sup>

#### Lymphedema/Upper Extremity Swelling

Postoperative lymphedema or swelling in the donor site extremity was reported in 3 of 10 articles, with a total of 255 patients.<sup>9,11,12</sup> Of these, 3.9% (n = 10) experienced lymphedema. In the study by Selvaggi et al,<sup>9</sup> 7 patients experienced lymphedema which resolved with physical therapy in 2–6 months. In the remaining 3 patients, the lymphedema was permanent but only impacted hand mobility in 1 patient.<sup>11,12</sup> Lymphedema or swelling was a subjective outcome measure and no studies reported objective measurements such as forearm circumference or water displacement. Additionally, an objective measure for “decreased hand mobility” was not discussed.

#### Compartment Syndrome and Neuroma Development

Neuropraxia, nerve injury, or compartment syndrome after RFFF harvest was documented in 2 of the included articles. Of the 125 pooled patients in this group, 0.8% (n = 1) patient experienced compartment<sup>17,12</sup> syndrome in the hand of the operated extremity. This resulted in a permanent contraction and limited functional range of motion or strength in the donor hand.<sup>12</sup> Of the 10 patients evaluated for neuroma development, 1 (10%) patient was required surgical excision of the neuroma.<sup>9</sup>

#### Infection and Hematoma

The remaining donor site complications included donor site wound infection and/or hematoma. Only 1 study reported outcomes for infection, hematoma, or forearm wound dehiscence. Infection, described as cellulitis, was reported in 3 of 19 patients (15.8%) and was treated with antibiotics.<sup>14</sup> The study did not specify oral versus intravenous antibiotic treatment. One (0.8%) patient experienced a postoperative hematoma at the donor site that required operative drainage.<sup>17,9</sup>

## DISCUSSION

This study systematically reviewed the literature for donor site complications associated with RFFF and included 10 articles for patient outcome and data analysis. The overall donor site complication rate was 7.9% in a cohort of 940 pooled patients undergoing RFFF. The most common complication was skin graft failure in 41 patients, unfortunately comparison between full thickness skin grafting and split thickness skin grafting cannot be made due to the lack of detail in the included studies. Decreased strength or sensation in the donor extremity occurred in a significant proportion of patients at 4.9% (n = 15). Rates for specific complications like infection and development of compartment syndrome ranged from 0 to 15.8%. Although complications like infection and neuroma development had high prevalence at 15.8% and 10%, respectively; the actual number of patients affected were small (n = 3, n = 1). Pooled patient groups ranged from 10 patients in the dehiscence and neuroma development groups to 911 in the skin graft failure groups.

In comparison to other reconstructive applications of the RFFF, the donor site profile does not appear to be significantly elevated when selecting for phalloplasty. In a

**Table 2. Donor Site Complications by Article**

Author	Year	Patients	Infection	Hematoma	Dehiscence	Neuroma	Nerve				Contracture	
							Compression/ Compartment Syndrome	Skin Graft Failure	Decreased Strength/ Sensation	Lymphedema/ Swelling		
Selvaggi et al <sup>9</sup>	2006	125	—	1 (0.8%)	—	—	—	—	—	—	—	—
Monstrey et al <sup>10</sup>	2009	287	—	—	—	—	—	—	—	—	—	—
Garaffa et al <sup>11</sup>	2009	15	—	—	—	—	—	—	—	—	—	—
Garaffa et al <sup>12</sup>	2010	115	—	—	—	—	—	—	—	—	—	—
Garaffa et al <sup>12</sup>	2010	27	—	—	—	—	—	—	—	—	—	—
Doomaert et al <sup>13</sup>	2011	316	—	—	—	—	—	—	—	—	—	—
Song et al <sup>14</sup>	2011	19	3 (15.8%)	—	—	—	—	—	—	—	—	—
Massanyi et al <sup>15</sup>	2013	10	—	—	—	—	—	—	—	—	—	—
Garaffa et al <sup>16</sup>	2014	16	—	—	—	—	—	—	—	—	—	—
Falcone et al <sup>17</sup>	2016	10	—	—	0 (0%)	—	—	—	—	—	—	—

study by Cigna et al<sup>19</sup> prospectively evaluating outcomes after retromolar trigone reconstruction utilizing the RFFF in 30 patients, the authors actually found a higher rate of donor site complication rates when compared with this study, with immediate and late complications in 46% of the RFFF group. Among the group, 13% of patients reported limited pronation and manual dexterity. Additionally, 13% of the forearm donor sites were judged to be “very good” in appearance by patient evaluation, 40% as good, 33% as satisfactory, and 13% as unsatisfactory. Huang et al<sup>20</sup> studied the donor site morbidity associated with RFFF reconstruction of tongue defects and found the most frequent complication was associated with the skin graft. Hypertrophic scarring, numbness, and paresthesia were among the most common complications. Yun et al<sup>21</sup> evaluated donor site morbidity in 164 patients undergoing RFFF for head and neck reconstruction and found a 26% complication rate, the majority of which were partial skin graft failures at a rate of 16%. The study had a similar rate of sensation loss at 3.5% (n = 6) compared with 3.9% (n = 12) in our phalloplasty donor site outcomes, but an increased rate of loss of hand strength [2.0% (n = 3) compared with 0.6% (n = 2)], despite having much smaller flaps (mean, 60.6 cm<sup>2</sup>).<sup>21</sup>

Long-term complications associated with radial artery harvest, such as decreased exercise tolerance and hand ischemia, has been previously demonstrated.<sup>22,23</sup> Gaudino et al<sup>24</sup> demonstrated higher peak systolic velocities and higher prevalence of atherosclerotic plaques in the ulnar artery of the operated versus control arm 10 years postoperatively from coronary artery bypass surgery when using the radial artery. Song et al<sup>14</sup> and Garaffa et al<sup>11</sup> were the only studies with follow-up lengths up to 10 years included in this analysis. Additionally, between these 2 articles, only Garaffa et al reported outcomes pertaining to strength and sensation. Patients undergoing phalloplasty for GAS are often younger in age than those typically seen in the head and neck reconstruction population, as the average age in this study was 32.9 years. Future studies evaluating donor site morbidity after RFFF should consider long-term follow-up and possible evaluation of the ulnar artery flow, as this procedure could increase the chance of developing ischemia of the extremity. However, there are no available reports of hand ischemia following RFFF in the phalloplasty population.

Direct comparison of complication rates by phalloplasty indications, like GAS versus trauma, were not feasible due to the heterogeneity of reported results in the included studies. GAS patients require systemic hormonal therapy and the literature is mixed on the perioperative implications of these medications. There is also much controversy in the literature whether to discontinue cross-sex hormonal therapy (CSHT) before GAS.<sup>25,26</sup> A systematic review of the literature by Boskey et al<sup>27</sup> demonstrated no increase in perioperative complications due to CSHT and concluded there is insufficient evidence to discontinue CSHT before GAS. Future, prospective studies should evaluate the difference in donor site outcomes in the various patient populations.

As with any systematic review, this study is limited by the nature of the literature search. By including English only articles, there is the possibility we are missing key

studies that could impact the results of our study. There was a high degree of heterogeneity of complications reported among the various articles. Although the overall pooled cohort was 940 patients, within each complication that was analyzed, the patient cohort was much smaller. Prospective studies with larger patient populations will be needed to validate these results. The available average follow-up duration ranged from 1 month to 18 years, with the average being 3.25 years. To fully understand the complications associated with RFFF, follow-up for 10 years or longer may be preferred. Lastly, there are no validated patient-reported outcome measurement tools in the literature to assess the subjective results of gender confirmation surgery in the transgender population, as demonstrated by Andreasson et al<sup>28</sup> Future studies evaluating the subjective differences between phalloplasty techniques and the impact on quality of life should be performed but would require a validated tool for comparison.

### CONCLUSIONS

Donor site morbidity after RFFFP occurs in 7.9% of patients based on the available literature. The most frequent donor site complication was skin graft failure; however, a significant proportion of patients experienced decreased sensation and strength in the donor extremity. In comparison with other reconstructive applications of the RFFF, phalloplasty does not seem to increase the comparative rate of complications, despite utilizing much larger flaps.

Surgeons and patients should thoroughly discuss the flap options for genital reconstruction and compare the phallus outcomes with the donor site morbidity to determine the appropriate surgical plan for the patient.

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