Radial Forearm Free Flap Donor Site Morbidity

Ulnar-Based Transposition Flap vs Split-Thickness Skin Graft

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Objectives: To evaluate morbidity associated with the radial forearm free flap donor site and to compare functional and aesthetic outcomes of ulnar-based transposition flap (UBTF) vs split-thickness skin graft (STSG) closure of the donor site.

Design: Case-control study.

Setting: Tertiary care institution.

Patients: The inclusion criteria were flap size not exceeding 30 cm², patient availability for a single follow-up visit, and performance of surgery at least 6 months previously. Forty-four patients were included in the study and were reviewed. Twenty-two patients had UBTF closure, and 22 had STSG closure.

Main Outcome Measures: Variables analyzed included wrist mobility, Michigan Hand Outcomes Questionnaire scores, pinch and grip strength (using a dynamometer), and hand sensitivity (using monofilament testing over the radial nerve distribution). In analyses of operated arms vs nonoperated arms, variables obtained only for the operated arms included Vancouver Scar Scale scores and visual analog scale scores for Aesthetics and Overall Arm Function.

Results: The mean (SD) wrist extension was significantly better in the UBTF group (56.0° [10.4°] for nonoperated arms and 62.0° [9.7°] for operated arms) than in the STSG group (59.0° [7.1°] for nonoperated arms and 58.4° [12.1°] for operated arms) (P = .02). The improvement in wrist range of motion for the UBTF group approached statistical significance (P = .07). All other variables (Michigan Hand Outcomes Questionnaire scores, pinch and grip strength, hand sensitivity, and visual analog scale scores) were significantly better for nonoperated arms vs operated arms, but no significant differences were observed between the UBTF and STSG groups.

Conclusions: The radial forearm free flap donor site carries significant morbidity. Donor site UBTF closure was associated with improved wrist extension and represents an alternative method of closure for small donor site defects.


Three decades after the first description by Yang et al., the radial forearm free flap (RFFF) has become a workhorse in head and neck reconstruction. Its thinness, pliability, pedicle length, and vessel size are particularly suited for oropharyngeal and oral cavity reconstruction.⁵

Although popular, the RFFF is associated with significant donor site morbidity. Common early complications include wound breakdown and skin graft loss, resulting in delayed wound healing and tendon exposure.⁵⁻⁶ Previous studies of long-term consequences have demonstrated reduced wrist mobility,⁴⁻⁷ wrist or hand weakness,⁴⁻⁸ sensory deficits,⁵⁻⁶ persistent pain,³⁰ decreased hand dexterity,¹⁰ and cosmetic deformity,³¹,32 in objective and subjective assessments.

A split-thickness skin graft (STSG) is most frequently used to close the donor site defect.³³ The STSG has been used with artificial dermis with some success.¹¹,¹² Alternative methods of closure include full-thickness skin graft from the forearm,¹³ inner arm,¹⁴ and abdomen,¹⁵ as well as the use of tissue expanders,¹⁷⁻²⁰ or free flaps.²¹ Few studies¹²,¹₄,²₂ have compared the different methods, and they failed to identify a technique of choice.

In 1988, Elliot et al.¹⁷ described their use of the ulnar-based transposition flap (UBTF) based on distal perforators from the ulnar artery as a reliable technique for the closure of small to medium donor site defects. This method allows for primary-intention wound healing and improved coverage of the tendons, nerves, and muscles, which should theoretically decrease donor site morbidity.
This study compares UBTF closure vs STSG closure of the RFFF donor site. Long-term function and aesthetics are evaluated.

PATIENT SELECTION

A case-control study design was used. Patients were identified from an institutional database of head and neck reconstructions since January 1, 2003, which included more than 400 patients. The study protocol was approved by the ethics committee of the University of Toronto, Toronto, Ontario, Canada, and informed consent was obtained from all participants. The inclusion criteria were RFFF reconstruction, flap size not exceeding 30 cm² (eg, 6 × 5 cm), and performance of surgery at least 6 months previously. A defect size of 30 cm² or less theoretically enables the use of either technique of forearm closure. The exclusion criteria were any preexisting condition affecting both upper extremities that interfered with the study analysis (eg, patients with wrist arthritis or diabetic neuropathy).

Because UBTF closure was performed far less frequently during past years, this cohort was identified first. Thirty-six patients with UBTF reconstruction who met the inclusion criteria were consecutively identified and invited to participate in the study. Twenty-two patients independently evaluated results using a 10-cm VAS for Aesthetics and for Overall Function marked with 3 descriptive terms (a score of 0 indicated very poor; 5, average; and 10, very good). The VSS, VAS for Aesthetics, and VAS for Overall Function were assessed. The level of significance was set at α = .05 for all tests. Commercially available statistical software (SAS 9.1.3; SAS Institute, Inc) was used.

SERIAL DIAGRAMS

Figure 1. Ulnar-based transposition flap closure. A, Design of the incision lines. The long axis of the radial forearm free flap is placed transversely across the wrist. B, Forearm closed by distal ulnar-based transposition flap advancement and a proximal V-to-Y plasty.

SURGICAL TECHNIQUE

All RFFFs were harvested in a standard fashion by 2 of us (D.J.E. and K.M.H.) using a suprafascial dissection technique in both groups. Radial nerve sensory branches were identified and preserved. The STSGs were harvested from the thigh using a Padgett dermatome at a thickness of 0.35 to 0.45 mm. The UBTFs were performed based on the initial description by Elliot et al.17 The harvested RFFF skin paddles were designed with their long axis transversely across the wrist and with their width (short axis) not exceeding 5 cm (Figure 1). Defects not exceeding 8 cm in length were elevated. A V-to-Y plasty was performed at the proximal aspect of the incision. The STSG group underwent postoperative splinting for 7 days.

METHODS

Objective measurements of donor site morbidity included pinch and grip strength, wrist mobility (extension, flexion, and range of motion), and hand sensitivity (using monofilament testing over the radial nerve distribution). These variables were obtained for the operated arms and for the nonoperated arms. Pinch and grip strength was evaluated using a hydraulic hand dynamometer and pinch gauge (Jamar; J A Preston Corporation). Cutaneous sensation over the radial nerve distribution was measured using the Semmes-Weinstein monofilament technique (Touch-Test; North Coast Medical, Inc). Measured sensitivity thresholds represent the smallest size of monofilament that elicited a response.

Subjective measurements included the Michigan Hand Outcomes Questionnaire (MHQ), Vancouver Scar Scale (VSS), and visual analog scale (VAS) scores for Aesthetics and for Overall Function. The MHQ is a validated questionnaire that evaluates both hands relative to activities of daily living, work performance, pain, aesthetics, and overall patient satisfaction.21 Patients independently evaluated results using a 10-cm VAS for Aesthetics and for Overall Function marked with 3 descriptive terms (a score of 0 indicated very poor; 5, average; and 10, very good). The VSS, VAS for Aesthetics, and VAS for Overall Function scores were obtained only for the operated arms. The aesthetic outcome was also assessed using the VSS.24 The VSS includes 4 measures of pliability, height, vascularity, and pigmentation. The VSS scores were rated by one of us (C.T.) who is familiar with this instrument.

Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>STSG Group (n = 22)</th>
<th>UBTF Group (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (range), y</td>
<td>65 (20-86)</td>
<td>66 (32-88)</td>
</tr>
<tr>
<td>Sex, No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Flap size, mean (SD), cm²</td>
<td>22.9 (4.9)</td>
<td>19.6 (3.6)</td>
</tr>
<tr>
<td>Donor site on dominant arm, No. (%)</td>
<td>1 (5)</td>
<td>0</td>
</tr>
<tr>
<td>Follow-up period, mean (range), mo</td>
<td>36 (6-83)</td>
<td>27 (7-82)</td>
</tr>
</tbody>
</table>

Abbreviations: STSG, split-thickness skin graft; UBTF, ulnar-based transposition flap.
RESULTS

PATIENT CHARACTERISTICS

Forty-four patients were included and reviewed at a single follow-up visit. Twenty-two patients with UBTF closure were matched to 22 patients with STSG closure. Demographic data are summarized in Table 1. The mean flap sizes were 19.8 cm² in the UBTF group and 22.9 cm² in the STSG group ($P = .01$). Two patients developed marginal skin necrosis of their UBTF, which required regular wound care and healed by secondary intention. Neither of these patients had exposed tendons, and no skin graft or reintervention was necessary. All skin grafts in the STSG group healed without local complication or partial skin graft loss.

OBJECTIVE MEASUREMENTS

Quantitative measures are listed in Table 2. The mean wrist extension was significantly better in the UBTF group (56.0° for nonoperated arms and 62.0° for operated arms) than in the STSG group (59.0° for nonoperated arms and 58.4° for operated arms). The mean wrist extension was better in the UBTF group for the operated arms, but this difference was not statistically significant. The improvement in wrist range of motion for the UBTF group approached statistical significance ($P = .07$). No between-group differences were found for other measured variables (pinch strength, grip strength, and hand sensitivity). A measurable difference between the operated arms and the nonoperated arms was noted for pinch strength, grip strength, and hand sensitivity. Pinch and grip strength measurements showed high variability (ie, high SDs) among patients. Overall, the mean values for wrist range of motion, pinch and grip strength, and hand sensitivity of the operated arms and the nonoperated arms in both groups remained within the range of published normative data for healthy subjects.$^{25-28}$

SUBJECTIVE MEASUREMENTS

The mean MHQ scores were significantly lower for the operated arms than for the nonoperated arms (80.4 vs 90.5) (Table 3). For comparison, patients with rheumatoid arthritis had scores of 45 to 50 on the MHQ,$^{29}$ and patients with carpal tunnel syndrome had scores of 50 (before surgery) to 63 (after surgery) on the MHQ.$^{30}$ The MHQ scores were similar between the both groups. The VAS for Aesthetics and the VAS for Overall Function demonstrated slightly better improvement in the UBTF group, although the difference was not statistically significant. Similarly, the VSS showed greater improvement for the UBTF group, but again this difference was not statistically significant. More hypertrophied scars (ie, ropes, contractures, or height > 2 mm) were observed in the UBTF group (3 patients) than in the STSG group (1 patient). In the UBTF group, 2 of 3 hypertrophied scars were observed in patients with darker skin types (Figure 2).

COMMENT

This case-control study compares STSG closure with UBTF closure in patients with forearm defects not exceeding 30 cm² after RFFF harvest. Although statistically significant, the difference in defect size between the 2 groups was small (3.1 cm²); therefore, our results warrant further study.

Low rates of early complications were found for skin graft loss and for UBTF partial necrosis. Skin graft-associated complication rates range from 0% to 30% in the literature.$^{8,12,22}$ Previous studies$^{17-19}$ on various ulnar artery–based local flaps reported low complication rates. Objective assessments showed similar results overall between STSG and UBTF. Only wrist extension and wrist range of motion were better in the UBTF group. All functional variables (wrist range of motion, pinch and grip strength, and hand sensitivity) were significantly reduced for the operated arms but remained within norm-
mal ranges of a standard population. Bardsley et al published a series on RFFF donor site morbidity and found no significant loss of hand power and wrist range of motion, except among those who sustained a radial fracture following composite flap harvest. However, other investigators have identified functional impairment of various degree among different variables that were measured. Timmons et al described high prevalences of reduced hand and wrist strength (40%), increased persisting wrist stiffness (27%), and decreased sensation over the radial nerve distribution. Richardson et al found significantly reduced wrist extension and pinch and grip strength compared with preoperative values in a subgroup of patients with fasciocutaneous flaps. In a case-control prospective series of 11 patients, Brown et al found measurable reduction in wrist flexion and pinch

Table 3. Subjective Outcome Measures

<table>
<thead>
<tr>
<th>Score</th>
<th>Group</th>
<th>Operated Arm</th>
<th>Nonoperated Arm</th>
<th>STSG Group vs UBTF Group</th>
<th>Nonoperated Arm vs Operated Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan Hand Outcomes Questionnaire&lt;sup&gt;a&lt;/sup&gt;</td>
<td>STSG</td>
<td>82.6 (16.8)</td>
<td>91.5 (11.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UBTF</td>
<td>78.1 (21.0)</td>
<td>89.6 (11.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual analog scale&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Overall function</td>
<td>STSG</td>
<td>6.9 (2.6)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>UBTF</td>
<td>7.3 (2.7)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aesthetics</td>
<td>STSG</td>
<td>6.4 (2.2)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>UBTF</td>
<td>6.8 (2.5)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Vancouver Scar Scale&lt;sup&gt;c&lt;/sup&gt;</td>
<td>STSG</td>
<td>4.0 (2.2)</td>
<td>NA</td>
<td>.60</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>UBTF</td>
<td>4.4 (2.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: NA, not applicable; STSG, split-thickness skin graft; UBTF, ulnar-based transposition flap.

<sup>a</sup>Score range, 0 to 100.
<sup>b</sup>Score range, 0 to 10.
<sup>c</sup>Score range, 0 to 14.

Figure 2. Long-term postoperative results of ulnar-based transposition flap closure (A-C) and split-thickness skin graft closure (D-F). A and B, Good results. C, Hypertrophic scar. D, Good results. E, Widening of the proximal scar and irregular skin graft surface. F, Divot deformity of the skin graft area and thick indurated proximal scar.
strength associated with RFFF harvest. Notably, Toschka et al7 found more pronounced postoperative limitation of wrist movements in patients who underwent RFFF harvest on their nondominant limb. More recently, Sardesai et al10 found no significant functional decrease in quantitative measurements (mobility and strength) following RFFF tissue transfer, whereas de Witt et al8 reported only diminished pinch strength. There is also conflicting evidence as to the level of sensory loss experienced over the radial nerve distribution.5-8 Using monofilament testing, we found significantly higher thresholds of hand sensitivity on the operated arms compared with the nonoperated arms, although values were still within normal ranges for all patients. Cutaneous branches of the radial nerve are prone to injury during RFFF harvest. Donor site UBTF closure showed no significant benefit over STSG closure, suggesting that adequate nerve coverage is obtained with the STSG.

In general, quantitative measures of donor site morbidity seem to minimally translate to real functional disabilities.5,6 Concomitant subjective and objective assessments demonstrate that patients perceive little change in donor site function.7-10

Aesthetic considerations may be underestimated in the population of patients with head and neck cancer. In their series of 100 donor sites closed with STSG, Bardsley et al3 demonstrated that women tend to be more affected by residual deformity than men. Authors have reported rates of poor aesthetic outcomes ranging from 7% to 28%.5,7,8 However, Sardesai et al10 found that cosmesis was the least important factor among all items of the MHQ among patients who underwent STSG closure. Our results are comparable to those of previous studies and show a discrete trend toward superiority of UBTF closure.

Some technical issues should be addressed. While the RFFF surface area helps determine the method of closure, suggesting that adequate nerve coverage is obtained with the STSG.

Available options when an ulnar-based transposition flap does not allow primary closure. A and B, Z-plasty modification to avoid a proximal skin graft.31 C, Purse-string suture reduction of the residual defect size and skin graft.31

Figure 3. Available options when an ulnar-based transposition flap does not allow primary closure. A and B, Z-plasty modification to avoid a proximal skin graft.31 C, Purse-string suture reduction of the residual defect size and skin graft.31

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ence, and (4) the forearm skin has good laxity on clinical examination. However, UBTF closure is not recommended in patients who have darker skin types or in those who are prone to hypertrophied scar formation.

In conclusion, the RFFF donor site carries significant functional and aesthetic morbidity. Donor site UBTF closure is an alternative method of closure for small do- nor site defects. Although the expected functional and aesthetic benefits of UBTF closure have not been established, there is a general trend toward better functional outcomes with its use, and further investigations are recommended.

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Author Contributions: Drs Jaquet, Enepekides, and Higgins had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Jaquet, Enepekides, and Higgins. Acquisition of data: Jaquet and Torgerson. Analysis and interpretation of data: Jaquet. Drafting of the manuscript: Jaquet. Critical revision of the manuscript for important intellectual content: Enepekides, Torgerson, and Higgins. Statistical analysis: Jaquet and Higgins. Administrative, technical, and material support: Enepekides and Higgins. Study supervision: Enepekides, Higgins.

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Additional Contributions: Marko Katic, BA, assisted with the statistical analysis.

REFERENCES


