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# Free tissue transfer to the traumatized upper extremity: Risk factors for postoperative complications in 282 cases

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Received 21 November 2013; accepted 11 May 2015

## KEYWORDS

Complications;  
Flap;  
Reconstruction;  
Trauma;  
Upper extremity

**Summary** *Background:* Complex traumatic upper extremity injuries frequently possess compromised local vasculature or extensive defects that are not amenable to local flap reconstruction. Free tissue transfer is required to provide adequate soft tissue coverage. The present study aimed to evaluate risk factors that contribute to postoperative complications and flap loss in complex upper extremity reconstruction.

*Methods:* Retrospective chart review was performed for all patients undergoing free tissue transfer for upper extremity reconstruction from 1976 to 2001. Data collected included patient demographic characteristics, timing of reconstruction, location of injury, fracture characteristics, operative interventions, and postoperative complications. Statistical analysis was performed using  $\chi^2$  and Fisher exact tests.

*Results:* In total, 238 patients underwent 285 free tissue transfers and met inclusion criteria, from which 3 were excluded because of inadequate information ( $n = 282$ ). Extremities were repaired within 24 h (75 cases; 27%), in days 2–7 (32 cases; 12%), or after day 7 (172 cases; 62%). Timing of reconstruction did not significantly affect postoperative outcomes. Proximal location of injury was significantly associated with superficial (relative risk [RR], 6.5;  $P < .01$ ) and deep infection (RR, 5.3;  $P < .01$ ), and osteomyelitis (RR, 4.0;  $P < .01$ ), although not with flap failure ( $P = .30$ ). Presence of an open fracture was significantly associated with developing superficial (RR, 3.1;  $P = .01$ ) and deep (RR, 1.9;  $P < .01$ ) infection, as well as

*Abbreviations:* ORIF, open reduction with internal fixation; RR, relative risk; RTW, return-to-work.

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<http://dx.doi.org/10.1016/j.bjps.2015.05.009>

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osteomyelitis (RR, 1.6;  $P < .01$ ). Having a closed fracture did not negatively influence postoperative outcomes.

**Conclusions:** This study supports the safety of early free tissue transfer for reconstruction of traumatized upper extremities. Injuries proximal to the elbow and open fracture were associated with a significantly higher infection rate. Gustilo grade IIIC fractures, need for interpositional vein grafts, and anastomotic revision at index operation resulted in significantly higher risk of flap loss, whereas the presence of fracture, fracture fixation, and injury location were not predictors of flap failure.

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## Introduction

Complex traumatic upper extremity injuries frequently possess compromised local vasculature or extensive defects that are not amenable to local flap reconstruction. In these instances, free tissue transfer is required to provide adequate soft tissue coverage. Its merits include preservation of exposed vital structures, earlier mobilization, and salvage of forthcoming amputation, fewer operations, decreased hospital stay and cost, and improved aesthetics.<sup>1–8</sup> Sensation may possibly be preserved in select cases of relatively proximal injury through the use of fasciocutaneous or musculocutaneous flaps.<sup>9</sup> When segmental vascular damage is present or to preserve arterial patency, flow-through flaps provide a novel opportunity for reconstruction without disrupting distal circulation.<sup>10–12</sup> Nevertheless, other factors besides flap utilization continue to be important in formulating an algorithm for treating the traumatized extremity.

Although there is general consensus that exposure of vital structures (eg, vessels, tendons, nerve) and orthopedic hardware requires emergent soft tissue coverage,<sup>9,13–17</sup> timing of reconstruction is still a contested issue. Some experts have advocated for early tissue coverage<sup>3,6,14,18–25</sup>, yet, others have shown success through approaching extremity injuries conventionally with serial débridements and secondary reconstruction in a delayed manner.<sup>26–31</sup>

In the largest study on this topic to date, Derderian et al.<sup>28</sup> found that reconstruction in the 6-to-21-day period after injury provides the most optimal results. More recently, investigators have suggested that changes in perioperative management—notably, use of the vacuum-assisted closure (VAC; KCI Licensing, Inc) therapy—allows for safe reconstruction, as well as serial débridements in the subacute period.<sup>29–31</sup> It has also been shown that timing may have no role in reconstructive outcomes.<sup>32</sup> However, because of differences in sample size, perioperative management, and operator experience with extremity reconstruction and proper débridement, the clinical significance of these findings is unclear.

Established practices in complex upper extremity management include the use of early definitive débridement to minimize infection risk. Early, definitive débridement of necrotic tissue has been shown to be of paramount importance in preparing the wound bed for free tissue transfer.<sup>9,18–20</sup> Similarly, where fracture is involved, early

aggressive and repeated débridement with fracture fixation and 1-stage soft tissue coverage is indicated.<sup>21</sup> Yaremchuk et al.<sup>26</sup> proposed that all large defects should be considered contaminated, if not infected, which suggests that Gustilo grade IIIB/IIIC open extremity fractures are likely contaminated at the time of closure. Furthermore, Gustilo grade IIIB injuries can be accompanied by vascular injury and, by definition, Gustilo grade IIIC injuries require vessel repair.<sup>33</sup> These issues offer a complex range of variables that merit exploration to determine their effect on reconstructive outcomes.

Despite the growing experience with extremity reconstruction, some questions still remain. Herein, we present our 25-year experience with upper extremity free flap reconstruction at a subspecialty tertiary care facility. An extensive literature review was performed to identify potential risk factors for untoward flap outcomes, including smoking, diabetes, timing of reconstruction, location of injury, fracture grade, operative interventions, and flap salvage procedures. The purpose of this study was to examine the role of these potential risk factors with regard to flap loss, infection, hospital stay, and return-to-work (RTW) time in the largest series to date, to our knowledge, on upper extremity free flap reconstruction following trauma.

## Methods

Retrospective chart review was performed for all patients undergoing free tissue transfer for upper extremity reconstruction from 1976 to 2001, following approval by the Mayo Clinic Institutional Review Board. Data collected included patient demographic characteristics, timing of reconstruction, location of injury, fracture characteristics, operative interventions, flap salvage procedures, postoperative complications, hospital stay, and RTW time. Derderian et al.<sup>28</sup> have described a decreased frequency of complications in 6–21 days postinjury. However, because of the insufficient number of patients in that study's subgroup, we used the timing classification described by Ninkovic et al.,<sup>34</sup> which classified cases as *primary* (<24 h of injury), *delayed primary* (days 2–7), or *secondary* (>7 days). Flap salvage procedures included reexploration and anastomotic revision. Postoperative complications included recipient site infection, osteomyelitis, and flap failure. Infections were classified as either *superficial* (requiring only antibiotics for treatment) or *deep* (requiring operative drainage). *Total flap failure* was defined as any flap loss >60%, whereas

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