



# Bilateral Hand Transplantation, a “Life-Saving” Operation?: A Case Report and Commentary

Scott M. Tintle, MD  
L. Scott Levin, MD, FACS

Department of Orthopaedic Surgery,  
University of Pennsylvania,  
Philadelphia, PA

## Introduction

The first hand transplant was performed in South America almost fifty years ago. Unfortunately, azathioprine and prednisone were unable to prevent acute rejection and the transplanted limb was amputated about 3 weeks later.<sup>1,2</sup> It was thirty-four years until the next hand transplant was performed in Lyon, France, and this was closely followed by the Louisville group who performed the first transplant in the United States in 1999.<sup>2,4</sup> The first bilateral hand transplantation occurred just two years later in Lyon, France.<sup>2</sup> These early successes began the modern era of hand transplantation. Since that time, hand transplantation has dramatically grown. Worldwide, more than 70 hand transplants have been performed, and there are at least seven centers in the United States that have performed a hand transplant. As time and experience have been gained, indications for transplantation have migrated proximally, and the first forearm transplant in the United States was performed in 2009. More recently teams have transplanted above the elbow, with early success as proximal as the deltoid region.<sup>5,6</sup> In this article, we present our experience with a 27-year-old female quadruplegic amputee who underwent bilateral proximal forearm-level hand transplantation at the University of Pennsylvania.

## Case Presentation

A 27-year old female quadruplegic amputee with bilateral proximal forearm amputations and bilateral transtibial amputations performed in the setting of sepsis presented to the hand surgery clinic one year following her illness. Prior to listing the patient for hand transplantation, the patient underwent an extensive preoperative screening process that included psychological, physical, financial, medical (to include infectious disease and cardiology), and surgical (plastic surgery, transplant surgery, hand surgery) evaluation. The patient presented with a chronic right knee wound that required a free scapular flap for below knee salvage and prosthesis fitting. After the patient's lower extremity function was improved and she was optimized medically and

psychologically, the patient was determined to be a hand transplant candidate and was listed for transplantation (Figures 1A and 1B).

Three weeks after listing the patient a suitable donor was identified. The donor was found to match the recipient in terms of ABO compatibility, age (within 10 years), gender, race, skin tone, viral status (CMV negative), and



A



B

**Figure 1A and B.** Preoperative radiographs demonstrating bilateral proximal-level transradial amputations.

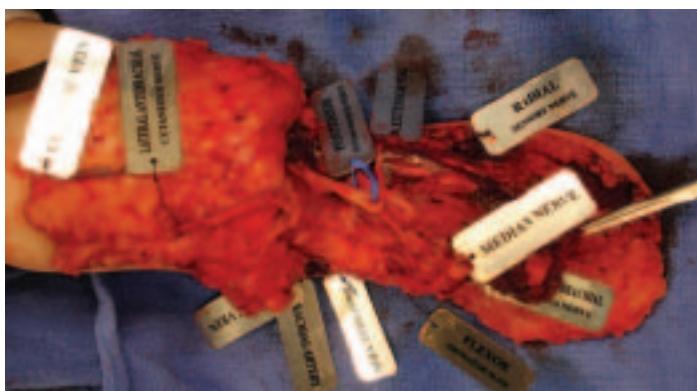
**Corresponding author:**  
L. Scott Levin, MD, FACS  
Paul B. Magnuson  
Professor of Bone and Joint Surgery  
Chairman,  
Department of Orthopaedic Surgery  
Professor of Plastic Surgery  
University of Pennsylvania  
3400 Spruce Street,  
2 Silverstein Pavilion  
Philadelphia, PA 19104  
scott.levin@uphs.upenn.edu



**Figure 2.** 90/90 flaps were developed for the insetting of the transplanted limbs.

limb size (within 15% of the recipient). A procurement team from the University of Pennsylvania was sent to the donor's location while the patient was simultaneously transported to the University of Pennsylvania. The donor upper extremities were procured at the proximal humerus level and the limbs were immediately perfused with University of Wisconsin preservation solution, wrapped in sterile moistened towels, placed in extremity drapes, and placed on ice for transportation.

The patient traveled to the University of Pennsylvania and the timing of surgery was planned to coincide with receipt of the donor limbs to the operating room. The donor and recipient limb dissections were performed simultaneously by four distinct surgical teams. Skin flaps from both the donor and recipient arms were raised in a 90/90 fashion so that inter-digititation of the flaps occurred at the time of closure (Figure 2). The neurovascular structures, including all named cutaneous nerves and veins were identified and labeled with pre-fashioned aluminum tags (Figure 3). The recipient proximal ulna and radius were identified and the distal osteopenic bone



**Figure 3.** Labeling of important structures in both the recipient and the donor limbs was performed.



**Figure 4.** Transplanted forearm immediately following surgery with Cook-Swartz implantable Doppler leads in place.

was removed. Approximately 9 cm of residual radius and ulna remained for fixation. Bone was removed from the donor arms to match the amount of residual bone left on the recipient's radius and ulna. The sequence of transplantation proceeded with open reduction and internal fixation of the ulna and radius using 3.5 dynamic compression plates, arterial repair, venous repair, neural repair, followed by muscle fixation of the flexor/pronator mass, and the extensors, to the distal humerus with the suture anchors. The patient's upper extremities were placed into posterior long-arm splints and the allograft was monitored with the use of internal Cook-Swartz Doppler probes (Cook Medical, Bloomington, IN; Figure 4).

## Results

Twenty-one months following transplantation, our patient has regained her independence. She currently lives alone and can perform activities of daily living with little modification. She has regained 4/5 strength of elbow flexion/extension, finger flexion and extension, thumb flexion/extension. She has also recently begun to regain intrinsic muscle function and is able to oppose her thumbs. There is evidence of early ulnar nerve function in the hand and protective sensation has returned. Two episodes of acute rejection have occurred which have been treated successfully with short-term steroid dose increases. She continues to have transplant biopsies performed on a regular basis and is maintained on triple drug therapy consisting of tacrolimus, mycophenolate mofetil, and methylprednisolone.

## Discussion

Our patient has had excellent motor and sensory recovery thus far. The long term follow up of patients in the International Registry on Hand and Composite Tissue Transplantation has demonstrated that these allografts will continue to improve in function for as long as five years from the time of transplantation.<sup>7</sup> We anticipate the possibility of improved intrinsic function as well as potentially discriminatory sensation as time goes on.

The admonition "primum non nocere" remains critical as the field of allograft transplantation continues to progress. In Dr. Cooney's position statement on hand transplantation for the American Society for Surgery of the Hand (ASSH) in 2002, he echoed this sentiment and indicated that the society recommended "great caution and a measured approach to the patient requesting limb transplant."<sup>8</sup> Additionally,



**Figure 5.** Bilateral hand transplants at 18 months from the time of transplantation.

the society advised that the procedure be limited until “immunosuppressive advances minimize the risk benefit ratio.” While significant success has been achieved in the field of allotransplantation and improvements in immunosuppression have been realized, a survey of the ASSH in 2010 still reflected this cautious outlook on hand transplantation.<sup>9</sup> The survey indicated that only 24% of responders were in favor of hand transplantation, while 45% were against, and 31% were undecided. The least controversial situation, however, was the bilateral upper extremity amputee, as 78% of the responders indicated that this was the ideal indication for transplantation.

The risk to benefit ratio guides us as surgeons and influences our decision to offer patients various procedures. This is no different in hand transplantation. It is critical that we define exactly the potential benefits of the procedure. The intermediate risks are relatively well-defined,<sup>7</sup> and long term risks may be extrapolated from the solid organ transplantation data. The benefits, however, may not be easily articulated, and are currently not fully understood. The depths of the psychological distress and depression that amputees face should not be underestimated. In one study evaluating the cause of death of amputee patients, the authors found significantly higher rates of suicide and accidental death rates in

this patient population.<sup>10</sup> This study did not specifically look at multiple limb amputees or quadriamputees, though one might expect even higher rates of these unfortunate outcomes in patients with increasing functional impairment. The risk to benefit ratio must be carefully considered by the surgeon and the patient on a case-by-case basis. While it has been stated that hand transplantation is a quality of life-giving transplant,<sup>11</sup> in our opinion, it is not unreasonable that hand transplantation also be considered life-saving when performed for the proper indication (Figure 5).

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