Pushing the Boundaries of Salvage in Mutilating Upper Limb Injuries

Techniques in Difficult Situations

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KEYWORDS

• Bilateral upper limb amputation • Free functioning muscle transfer • Flow through free flap
• Toe transfers • Mutilating hand injuries

KEY POINTS

- Even in most severe injuries of the upper limb, with the current available reconstructive armamentarium basic function can almost always be restored.
- In multilevel digital amputations, heterotopic replantation and rearrangement of parts can result in useful function.
- Even in most severe combined injuries with tissue loss of the proximal upper limb, if the hand is structurally intact it is worth salvaging. Free functioning muscle transfer can restore useful function.
- The more the mutilation, the more the conservation of parts. Salvage of skeletal segments and joints may prove useful in subsequent reconstruction particularly in bilateral injuries.
- Multistaged reconstruction is almost the rule. Timing and sequence of the procedures are key to success.

INTRODUCTION

When a surgeon is faced with a mutilated upper limb, the goal of management is to aim to obtain as good a functioning upper limb as his or her surgical experience and imagination can envisage. At times, a variety of factors, including the severity of the injury, will thwart this goal and the bar must be lowered to obtain, at the very least, enough basic function to enable the individual to perform the basic activities of living and lead an independent life. In the authors' opinion, this can always be achieved by surgeons with experience in this field.

In the acute situation and, sometimes later, particularly if circumstances force a lowering of the bar, the question arises: salvage or amputate? Unlike with the lower limb under these circumstances, there are no validated and acceptable scoring systems to guide the surgeon dealing with complex upper limb injuries. At present, the bias should always be toward salvage because the alternative means rehabilitation with a prosthesis and upper limb prostheses remain far from ideal.[1–5] For the lower limb, prostheses have a simpler task and work well. Not so with our current upper limb prostheses.[6–8] However, more

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sophisticated upper limb prostheses are being developed and may change this balance in the future.[9] The third option of hand transplantation is evolving surgically but retains the same long-term immune problems, awaiting useful advances in this field.[10,11]

Three factors have a bearing on the ultimate outcome following major upper limb injury: (1) patient-related factors, (2) injury-related factors, and (3) surgeon-related factors. The patient factors of age-associated comorbidities, coincidental injuries, work status, family support, social security status, and personal motivation are as always. The complexity of the injury to the upper limb per se and the time from injury to reaching an appropriate surgical facility are the two injury-related factors that have the most bearing on the outcome. As surgeons, we have little control over these factors, with the exception of speeding progress from the first telephone call to the anesthetic anteroom of our operating theater, particularly through our own hospital. Ultimately, the factors that most influence the outcome are surgeon related, namely, the skills and experience of the surgical team, their attitude toward salvage, and the infrastructure of the service. A skilled surgical team in a supportive infrastructure can make a very big difference to the outcome.[12] Available techniques, and knowledge of these, are most important and attention to detail is crucial. Almost always, the treatment plan has to be individualized. However, experienced senior surgeons will draw on their direct experience of previous cases and the more universal discussion of such cases internationally, both in meetings and in the literature of the last 40 years.[13,14]

This article uses a few cases to illustrate the thinking the authors use in such cases and illustrates the development of appropriate plans of management. These cases remain individual cases but aim to guide the reader in how to plan when faced with complex primary and secondary upper limb injuries. The article deals with instances of bilateral amputations and extensive unilateral injuries involving combined tissue losses. They came to the authors following road traffic accidents and industrial disasters, such as power press injuries, explosive blasts, and electrical burns.

BASIC PRINCIPLES

1. When there is extensive loss due to amputation in the upper limb, every effort is made to conserve the available parts, both those attached and those freed by the injury from patients. The greater the mutilation, the more the urgency to conserve all that is living and all that is undamaged.[15] This conservation should include attempts to preserve all attached parts at the start of surgery and all amputated parts for as long as necessary to allow surgical salvage by either cooling or by revascularization, in an appropriate position or ectopically. Nothing with potential to be used, either whole or as component spare parts, should be discarded during debridement.[16–20]
2. Primary healing of the wound should be a goal. When the wound heals primarily, the stage is set for success. Radical debridement and early soft tissue cover achieve this.[21,22]
3. Strong skeletal, tendon, and, if possible, nerve reconnections must be made. When the skeleton is badly disorganized, any fixation with which the surgeon is comfortable can be used but must be sufficiently strong to allow relatively early mobilization.[23] The same is true of the tendon sutures, particularly of the flexors. Early mobilization is necessary to counter the enormous fibrin edema of such injuries and avoid the gluing effect of the fibrin-to-scar conversion, which follows all such injuries and can lead to a living limb, which is functionally little more than a paperweight.
4. The available structures should be placed or replaced in the optimum position of function to be useful later. This point is particularly the case with the first ray: utmost care must be taken to keep the thumb in the ideal position.[24,25] It must be stabilized in abduction and in line with the outer border of the index finger in a slightly pronated position irrespective of whether there is adequate soft tissue cover or not. Most cases of crush and blast injuries destroy the thenar muscles, so provision of soft tissue cover without the convenience of the thenar muscles is not uncommon. Unless the position of the thumb is maintained as earlier, the fibrosis that follows these injuries to the first web space leads to web contracture, which is very difficult to correct later. The authors prevent this by either using axial K wiring or by bending a K wire in the form of a V and placing it to hold the first web space open for several months after the injury (**Fig. 1**).[26] With the thumb in a good position, soft tissue cover is provided.[27] With the thumb held out in this optimum position, flap requirement is much greater than with the first web closed.[28] Compromise here will result in contracture of the first web. Important also, if there is proximal skeletal injury, is that the forearm is stabilized and plastered with the forearm in the supinated position. It is easier to apply pedicled flaps to the supinated forearm.[29] Rehabilitation is also