Major amputation of the upper extremity

Functional results after replantation/revascularization in 47 cases

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Over a 7 year period, 47 patients underwent replantation of complete (19) and revascularization of incomplete nonviable (28) amputations of the upper extremity. Revascularization of incomplete nonviable amputations had a success rate of 100 percent, where as replantation of complete amputations had a success rate of 74 percent. 37 of the 42 patients with successful replantations had satisfactory functional use of the replanted extremity.

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Upper limb amputations were defined as injuries that occurred at any level proximal to the metacarpophalangeal joints of the hand (Russell et al. 1984). Amputations distal to this level were not included in the present study. Amputations of the upper limb may be either in the form of a complete separation of the distal part (complete amputation) or a disruption of the vital structures including major vessels, nerves and bone with a small nonviable portion of tissue intact. The later is considered an incomplete amputation which is not viable without restoration of arterial and venous circulation.

Patients and methods

47 patients with complete or incomplete nonviable amputations of the upper extremity underwent replantation or revascularization procedures from 1986 to 1993. 19 patients had a complete separation of the upper limb, while 28 patients had an incomplete nonviable amputation. 42 patients were men and 5 patients were women. Average age of the patients at the time of injury was 35 (5–55) years. Concerning the level of injury, 11 amputations were transmetacarpal, and 3 patients had amputations through the wrist joint. Of the remaining amputations, 24 were in the distal third of the forearm, 4 in the proximal third of the forearm, 3 in the distal and 2 in the proximal third of the upper arm.

Results

Of the 28 incomplete nonviable amputations, all survived, while 14 of the 19 complete amputations survived (success rate, 74 percent) (Figure 1). Overall, from 47 patients who underwent replantation/revascularization procedures, 42 were succesful with an average survival rate of 89 percent. Of the 5 unsuccessful replantation attempts, the effort was abandoned in 4 after 6–8 hours of surgery. This was due to the inability to achieve adequate venous return. In the 5th patient, the replanted lower forearm was amputated on the 21st postoperative day.

Chen's criteria for evaluation of function as adopted by the American Society for Surgery of the Hand were used to assess the functional outcome of replantation/revascularization (Table 1). According to this

Table 1. Chen's criteria for evaluation of functional result after upper extremity replantation

Grade	Function
I	Able to resume original work, range of motion exceeds 60 percent of normal, complete or nearly complete recovery of sensibility, muscle power of grade 4
II	Able to resume some suitable work, range of motion exceeds 40 percent of normal, nearly complete sensibility, muscle power of grade 3 and 4
III	Able to carry on daily life, range of motion exceeds 30 percent of normal, partial recovery of sensibility, muscle power of grade 3
IV	Almost no usable function of survived limb

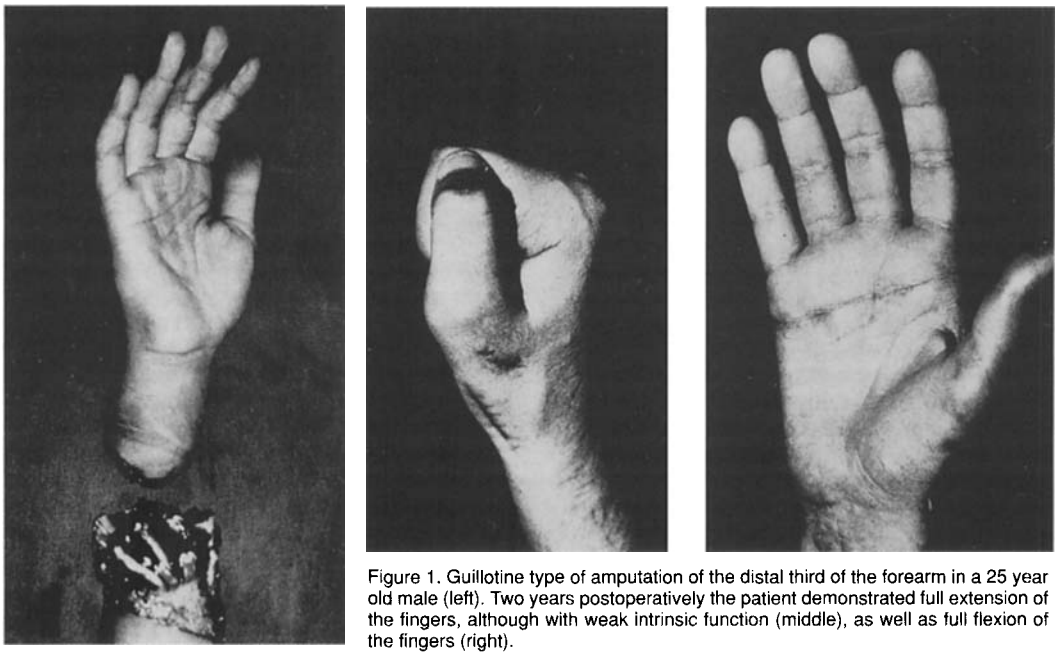

Figure 1. Guillotine type of amputation of the distal third of the forearm in a 25 year old male (left). Two years postoperatively the patient demonstrated full extension of the fingers, although with weak intrinsic function (middle), as well as full flexion of the fingers (right).

scale, 15 patients achieved grade I, 11 patients grade II, 16 patients grade III and 5 patients grade IV.

Discussion

Our results are compatible with previous reports on replantation/revascularization of the upper extremity. The type and level of injury, the severity of soft tissue damage, as well as the duration of ischemia are decisive factors in determining the functional results (Meyer et al. 1985, Wood and Cooney 1986). We are in agreement with other reports that superior functional results can be achieved by replantation of the upper limb compared to fitting with a prosthesis (Wang et al 1981). However, once the decision to replant has been made, the patient should be made aware that to provide useful function more than one reconstructive procedure may be necessary.

Bone shortening appears to be of paramount importance as, without jeopardizing function, a guillotine type of cut can be produced so that stable internal fixation can be achieved and, possibly, end-to-end anastomosis of vessels and suturing of nerves and tendons can be done (Axelrod et al. 1991, Nye 1982, Meyer 1985). We experienced a very low incidence of infection which may by attributed to thorough soft tissue debridement, restoration of only healthy muscle, stable fixation of bones after shortening and removal of avascular bone fragments from the site of injury.

Clean-cut amputations at the level of the distal forearm and metacarpal region which were not associated with extensive nerve damage, thus permitting end-to-end neurorrhaphy, were found to have the best functional recovery. In contrast, high-level injuries with extensive soft tissue damage had the poorest functional results. In our series, only 5 patients out of 42 did not have any use of their replanted limb, according to the criteria established by Chen. These included 1 patient with a mid-palm replantation who failed to follow a rehabilitation program and 4 patients with amputations at the elbow level which were associated with severe local crush and extensive nerve damage.

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