Injuries of the Hand and Forearm

Treatment of Damaged Soft Tissues

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Soft tissue injuries of the hand and forearm generally result in considerable disability, either the temporary disability that causes loss of time from work or the deformity and loss of function that are permanently disabling. Special attention to primary care can often considerably reduce permanent disability.

The soft tissues of the hand and forearm provide cover of various types, include the tactile and nerve elements supplying sensation, and afford motion to the digits resulting in prehension. Dealing with injuries to the hands requires a detailed knowledge of specific regional anatomy and a crisp conception of orthopedic, neurosurgical and plastic specialty problems.

Successful primary reparative surgical treatment of an injured hand depends on reactionless healing.

It is important to appreciate the differences between lacerated wounds and crushed wounds of the hand, to evaluate the individual problem and to elect either immediate primary or delayed primary repair on the injured tendons and nerves in the soft tissues of the extremity (Table 1).

The incised wounds are clean-cut lacerations from sharp cutting surfaces. They are the so-called “tidy wounds.” Here, skin loss, if any, is clearly defined, cut nerves and tendons are common, fractures are uncommon and the wounds generally heal promptly.

Minor puncture wounds also cut soft tissues and are, all too frequently, the portal of introduction of infective organisms and of foreign bodies (pieces of glass, steel, wooden splinters, etc.).

Successful primary repair of soft tissue injuries of the hand and forearm holds the ultimate disability to a minimum. The kinds of trauma and the resultant soft tissue damage may be classified. Attention to details and technique in carrying out the primary reparative operation on the injured hand largely obviate a crippling deformity or the need for much reconstruction later.

The crushing wounds are the irregular, ragged, “untidy type” such as those from machinery like power saws, presses, belts and pulleys. In these there may be areas of skin loss, multiple fractures, incomplete amputations, exposed tendons and nerves and contused tissue with impairment of circulation. Healing is generally a problem, and recovery of function may take a long time.

Amputations may result from either lacerated or crush injuries but are generally associated with traumatic circulatory inadequacy.

In avulsed wounds there are areas of loss of skin cover, such as of fingertips, the entire surface of a digit, the dorsum or palm of the hand or a portion of the forearm. Providing a cover for the denuded areas often is a problem.

Wounds that do not of themselves do enough damage to tissue to require extensive repair but that become infected should be dealt with conservatively, with supportive care.

When dealing with a recent injury to the hand, one first must assess the individual problem and determine the extent of damage. This is accomplished by considering the nature of the injury, the time and the circumstances, what first aid care was rendered, the age, skill and major handedness of the patient—this along with a clinical examination of the injured hand to determine the region involved.

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**TABLE 1.—Classification of Soft Tissue Injuries of the Hand**

<table>
<thead>
<tr>
<th>Nature of Lesions</th>
<th>Interval for Primary Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacerations</td>
<td>12 to 18 hours</td>
</tr>
<tr>
<td>Puncture wounds</td>
<td>12 to 18 hours</td>
</tr>
<tr>
<td>Crush wounds</td>
<td>8 to 12 hours</td>
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<tr>
<td>Amputations</td>
<td>12 to 24 hours</td>
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<tr>
<td>Avulsions</td>
<td>8 to 12 hours</td>
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<tr>
<td>Infected wounds</td>
<td>Conservative treatment</td>
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</tbody>
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and what structures, in general, may have been damaged, and x-ray studies.

Of special interest is the time interval since injury, the degree of initial contamination, and the extent of meddlesome first aid interference such as exploring for foreign bodies or searching for cut ends of tendons.

One can elicit considerable information by simple tests of tendon function, such as posture, tendon tension on the digits or by observation of continuity of motion. Nerve continuity can be demonstrated by checking various motor functions of specific nerves, or by touching the exposed skin surfaces with a pin or wisp of cotton. X-ray studies should be made at this time. Thus, the evaluation of extent of damage and of probable need for repair may usually be accomplished by inspection of the hand without removal of protective dressings. Detailed examination of the wound itself should be withheld at this stage.

After the foregoing evaluative observations, one is in a position to outline a plan of management that will afford the patient maximum recovery. The choice of repair must be carefully evaluated with regard to degree of disability, time elapsed since injury and risk entailed in reparative procedure. The patient should be informed, to whatever degree possible, of the problem; but for the most part the surgeon must make the detailed decision.

It is permissible to generalize that primary repair is never attempted in hand wounds caused by being bitten by humans or animals or in wounds grossly contaminated with human or animal excreta. In cleanly incised wounds in which no bacteria are found upon microscopic examination of material swabbed from the surface of the wound, one is justified in carrying out tendon repair after elapse of as much as 18 hours after injury. In the crushing wounds, primary repair of the deeper structures is rarely justified after 12 hours.

Definitive treatment should be attempted only under the best surgical conditions: A hospital operating room, strict asepsis, trained assistants, proper instruments and adequate lighting are all important items.

Satisfactory anesthesia is necessary. General anesthesia is required in most cases of severe hand injuries. However, local block anesthesia in the nerve trunks often is adequate. Brachial plexus block is rarely used since it is time-consuming, requires an expert in the technique and is not without risk.

In cases of compound wounds, tetanus toxoid is given to persons with a record of adequate active immunization. If not, decision has to be made as to whether the circumstances warrant use of antitoxin prophylactically. Cultures should be made of material from the wound and sensitivity tests carried out if organisms are found, so that proper antibiotics may be administered.

The steps in the surgical care of hand wounds are important (Table 2). The wound should be protected with a thick sterile gauze pad from further contamination and trauma until treatment in surgery can be undertaken. Under anesthesia and asepsis, a thorough cleansing of the wound and the surrounding field can be accomplished. First the entire limb should be completely washed with soap and water, benzine if necessary, and shaved. Thorough rinsing is the next step. Then the wound itself may be mechanically lavaged, and gently but thoroughly washed. The extremity is then made bloodless by a pneumatic tourniquet and sterile drapes are placed about the field. Thorough debridement is mandatory, all layers of the wound edges and all ragged or severely traumatized tissue being excised, but with great care not to traumatize or to sacrifice usable or vital structures. Attention must be given also to removal of hematoma or any foreign material.

Although the advent of antibiotics has extended the time after injury that operation may be done, chemotherapy cannot offset inadequate debridement or rough handling of the tissues.

After debridement has brought about a clean surgical wound, a detailed examination of the damaged structures can be completed. Full inspection of the wound will determine the amount of skin loss, the viability of skin margins and the extent of injury to the deeper structures. The so-called "proper boulevards" in the skin must be observed in lengthening the wounds or making incisions to obtain exposure for treating the deeper structures. T-shaped scars and any incisions which might cause flexion contractures or jeopardize the circulation are to be avoided.

Of great importance toward restoration of function is the primary repair of divided nerve trunks in the forearm or hand, and even of the small volar sensory nerves within the digits. Repair of the nerves has first priority, as any delay results in irreversible atrophy of the important small muscles in the hand, or in trophic sensory changes of the digits.

Divided nerves must be brought together in an accurate hand-sewn junction made with fine interrupted No. 7-0 black silk sutures. Tension on the
suture line is to be avoided. Gaps from loss of nerve substance often can be overcome by flexion of the adjacent joints. The traumatized ends of the nerves in crush wounds are generally resected back a bit farther in order to have sound nerve ends at the point of suture. Splinting immediately after operation is generally required. Use of the snub-method of splinting is an adjunct in the later postoperative care.

In repairing severed tendons attention must be given not only to restoration of the continuity of the tendons but to preserving their gliding ability.

Extensor tendons are repaired with the minimum of suture material and generally require no additional exposure. Simple figure-of-eight sutures or roll-type monofilament stainless steel wire sutures generally suffice, followed by adequate postoperative splinting.

The flexor tendons generally retract to some degree, necessitating additional exposure. However, with judiciously placed accessory incisions, the tendon ends may be approximated with reactionless stainless steel wire sutures. The withdrawable pull-out stainless steel wire tendon suture technique of Bunnell is used in repairing flexor tendons within the thumb and fingers. These sutures are placed so they can be withdrawn from the digits as soon as healing permits. This method requires a minimum amount of suture material and affords a maximum of gliding ability. Buried braided Fagersta®, a Swedish stainless steel wire, is used in suturing tendons in the palm or forearm. Exercises can be carried out during healing.

Some surgeons are using primary tendon grafts within the finger when the flexor tendons are cut within the digital sheaths. This method avoids the obvious possibility of adhesions at the tendon suture line within the finger. However, it, has been my practice to carry out primary tendon suture even in "no man’s land" in the finger, and to reserve the free tendon graft (palmaris longus with its slippery paratenon sheath) for a possible reconstructive procedure if that becomes necessary later.

The repaired tendons, of course, need adequate soft tissue cover. Wound healing should be as reactionless as possible. Crushing wounds offer considerably more of a problem in restoring function than do lacerated wounds. Active exercises are instituted as soon as practical.

When the time interval permits and the physical facilities are available, primary repair of the injured soft tissues is, of course, desirable. But rather than compromise on time interval or technique, it is far better to get the hand or forearm closed with adequate cover, obviating infection; then several weeks later, after the induration of the tissues has subsided and the danger of latent infection has disappeared, the primary nerve and tendon repair can be done.

The bony framework must be restored—dislocations reduced and fractures set. Maintenance of position can best be accomplished by simple internal fixation by means of Kirschner wires. This permits proper temporary splinting of repaired tendons and nerves without disturbing the bony alignment. This method of maintaining immobilization also permits exercising of the repaired tendons during bone healing. A pistol-handled drill is an adjunct in placing the wire accurately and deftly. Kirschner wires used in compound fractures do not add to the hazard so long as they are cut off just beneath the skin, avoiding local irritation and permitting easy removal later.

The use of the dorsal exposure longitudinally through the extensor apparatus on the dorsum of the finger gives excellent access to the entire proximal phalanx. This procedure has been used previously to give exposure for doing surgical capsulotomy on metacarpophalangeal joints of the fingers. It can be utilized also in reducing and in wire-pinning severely displaced simple fractures and practically all compound fractures of the proximal phalanges of the fingers.

Neosporin antibiotic ointment gauze, scarlet red ointment gauze, or neocortef ointment, have been used as wound and skin graft dressings and have been found to be much less macerating to the tissues during healing since they are made up with a base of beeswax of a high melting point, rather than with Vasoline.

The importance of the immediate or primary closure of wounds of the hand cannot be overemphasized. The main object of primary treatment is the complete closure of the soft tissue wound no matter how extensive the tissue loss or how difficult for the surgeon.

There are several methods available in effecting wound closure (Table 3). If the wound is of the incised type, primary closure by suture, without tension, can be achieved. Because of its nonirritating quality, monofilament stainless steel wire is used for skin sutures. No buried absorbable or nonabsorbable sutures are used.

In the crushing wounds, there usually is varying degree of skin loss or skin damage from circulatory injury; or closing the wound, without tension, may
be impossible because of local edema or bleeding. In such circumstances, one closes as much of the wound as possible, without tension, and covers the remaining defect with a split skin graft. It is important that the vital or repaired structures have adequate tissue cover, even if this requires a local flap maneuver.

Local thick skin flaps from the sides of a finger may be advanced or rotated to provide full thickness cover. In selected cases of extensive loss of skin over the volar aspect of a segment of a finger, a cross finger flap may be expeditious for providing full thickness skin to cover exposed or damaged digital nerves and tendons. The adjacent donor site can be closed with split skin graft. The use of a palmar skin flap for covering fingertips by acutely flexing a digit is to be avoided, as is the use of an abdominal flap to a fingertip, which always results in a purple biscuit of unsatisfactory skin.

Not only must wounds be closed without tension but “dead space” must be avoided and the approximation of wound edges must not interfere with local blood supply. The tissues should be handled atraumatically and the formation of hematomas should be avoided even if a tiny rubber tube drain must be used for 12 to 24 hours.

A full thickness free Wolfe graft from the antecubital flexion crease at the elbow supplies a great deal of suitable skin where avulsion is a problem. This donor area is being used more frequently nowadays. The skin can be removed under the same tourniquet and the donor site defect closed by a single line of sutures by flexing the elbow to a right angle position. The elbow should be splinted postoperatively for several weeks. Only a linear scar in the skin creases results.

For wider areas of denudement, such as the back of the hand, the thumb cleft or the palm of the hand, a direct abdominal flap must be resorted to. An entirely closed method is used so that the defect is covered with full thickness skin and subcutaneous tissue and the donor site and undersurface of the flap are covered with split skin graft. Kirschner wires are used to control the position of the thumb, or the degree of rotation of the forearm, to avoid tension, rotation or circulatory embarrassment at the base of the flap.

One should always attempt to save maximum length of the thumb and afford serviceable cover to the fingers or stumps. Usually it is better to shorten a finger, especially if the tissues are crushed, to provide satisfactory cover rather than to close the stump with tension or with a button of pedicle skin graft.

If all four of the fingers are amputated, it seems best to close the hand with a direct abdominal flap to preserve length. One rarely can close the hand stump satisfactorily without tension.

If a finger is severely damaged and is to be sacrificed, its skin with the vessels and nerves should be utilized for full thickness cover by the fillet method. A filleted central finger generally requires the jogging over of the outside ray.

The principles of care after primary operative treatment are very important in the restoration of function of soft tissues of the forearm and hand. The repaired tendons and nerves must be properly supported by splints during healing. Elevation minimizes edema and digital stiffening. The early utilization of voluntary exercises and activity with a wooden block or flat rubber sponge, instead of passive manipulation and the dependent soaks so frequently used, helps restore useful function to the digits more rapidly.

In general, in carrying out various plastic procedures, one must be able to visualize the stages in the procedure and to appreciate the degree of restoration of function. Overenthusiasm for restorative procedures must be guarded against. Primary reparative operation, when carried out with, observation of special details and careful technique, largely obviates a crippling deformity or the need for much reconstructive operation later.

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REFERENCE