OPEN INJURIES OF THE HAND

Over 75 per cent of work injuries affect the hands; inadequate treatment costs the patient (and society) dear in terms of functional disability.

Clinical assessment

- Open injuries comprise tidy or ‘clean’ cuts, lacerations, crushing and injection injuries, burns and pulp defects.
- The precise mechanism of injury must be understood. Was the instrument sharp or blunt? Clean or dirty? The position of the fingers (flexed or extended) at the time of injury will influence the relative damage to the deep and superficial flexor tendons.
- A history of high pressure injection predicts major soft-tissue damage, however innocuous the wound may seem.
- What are the patient’s occupation, hobbies and aspirations? Is he or she right handed or lefthanded?
- Examination should be gentle and painstaking.
- Skin damage is important, but it should be remembered that even a tiny, clean cut may conceal nerve or tendon damage.
- The circulation to the hand and each digit must be assessed.
- The Allen test can be applied to the hand as a whole or to an individual finger: -(The radial and ulnar arteries at the wrist are simultaneously compressed by the examiner while the patient clenches his fist for several seconds before relaxing; the hand should now be pale. The radial artery is then released; if the hand flushes it means that the radial blood supply is intact. The test is repeated for the ulnar artery. An injured finger can be assessed in the same way. The digital arteries are occluded by pinching the base of the finger. When blood is squeezed out of the finger the pulp will become noticeably pale; one digital artery is then released and the pulp should pink up; the test is repeated for the other digital artery).
- Sensation is tested in the territory of each nerve.
- Two-point discrimination may be reduced in partial injuries. In children, who are more difficult to examine.
- Tendons must be examined with similar care. Start by testing for ‘passive tenodesis’ :-(When the wrist is extended passively, the fingers automatically flex in a gentle and regular cascade; when the wrist is flexed, the fingers fall into extension. These actions rely upon the balanced tension of the opposing flexor and extensor tendons to the fingers; if a tendon is cut, the cascade will be disturbed).
- Active movements are then tested for each individual tendon:(Flexor digitorum profundus is tested by holding the proximal finger joint straight and instructing the patient to bend the distal joint. Flexor digitorum superficialis is tested by the examiner holding all the fingers together out straight, then releasing one and asking the patient to bend the proximal joint).
- if there is any doubt about the integrity of the tendons, the wound should be explored.
- X-rays may show fractures, foreign bodies, air or paint.

Primary treatment

- PREOPERATIVE CARE
  - The patient may need treatment for pain and shock.
  - If the wound is contaminated, it should be rinsed with sterile crystalloid;
  - antibiotics should be given as soon as possible.
  - Prophylaxis against tetanus and gas gangrene may also be needed.
  - The hand is lightly splinted and the wound is covered with an iodine-soaked dressing.
WOUND EXPLORATION

- Under general or regional anaesthesia, the wound is cleaned and explored.
- A pneumatic tourniquet is essential unless there is a crush injury where muscle viability is in doubt.
- Skin is too precious to waste and only obviously dead skin should be excised.
- For adequate exposure the wound may need enlarging, but incisions must not cross a skin crease or an interdigital web. Through the enlarged wound, loose debris is picked out, dead muscle is excised and the tissues are thoroughly irrigated with isotonic crystalloid solution.
- A further assessment of the extent of the injury is then undertaken.

TISSUE REPAIR

- Fractures are reduced and held appropriately (splintage, K-wires, external fixator or plate and screws).
- Unless there is some specific contraindication. Joint capsule and ligaments are repaired.
- Artery and vein repair may be needed if the hand or finger is ischaemic. This done with the aid of an operating microscope. Any gap should be bridged with a vein graft.
- Severed nerves are sutured under an operating microscope (or at least loupe magnification) with the finest, non-reactive material. If the repair cannot be achieved without tension then a nerve graft (e.g. from the posterior interosseous nerve at the wrist) should be performed.
- Extensor tendon repair is not as easy and the results not as reliable as some have suggested. Repair and postoperative management should be meticulous.
- Flexor tendon repair is even more challenging, particularly in the region between the distal palmar crease and the flexor crease of the proximal interphalangeal joint where both the superficial and deep tendons run together in a tight sheath (Zone II or, more dramatically, ‘no man’s land’ because injuries in this zone are the most dangerous).
- Amputation of a finger as a primary procedure should be avoided unless the damage involves many tissues and is clearly irreparable.
- Ring avulsion is a special case. When a finger is caught by a ring, the soft tissues are sheared away from the underlying skeleton. Depending on the amount of damage, skin reattachment, microvascular reconstruction or even amputation may be required.

CLOSURE

- The tourniquet is deflated and bipolar diathermy is used to stop bleeding.
- Haematoma formation leads to poor healing and tendon adhesions.
- Unless the wound is contaminated, the skin is closed – either by direct suture without tension or, if there is skin loss, by skin grafting. Skin grafts are conveniently taken from the inner aspect of the upper arm.
- If tendon or bare bone is exposed, this must be covered by a rotation or pedicled flap.
- Sometimes a severely mutilated finger is sacrificed and its skin used as a rotation flap to cover an adjacent area of loss.
- Pulp and finger-tip injuries: In full thickness wounds without bone exposure, the wound should be thoroughly cleaned and then covered with a nonadherent dressing, and inspected only infrequently, then re-covered with the non-adherent dressing, until it heals. If the open area is greater than 1 cm in diameter, healing will be quicker with a split-skin or full thickness graft.
- Nail bed injuries: Nail bed injuries are often seen in association with fractures of the terminal phalanx. If appearance is important, meticulous repair of the nail bed under magnification.

**DRESSING AND SPLINTAGE**
- The wound is covered with a single layer of paraffin gauze and ample wool roll.
- A light plaster slab holds the wrist and hand in the position of safety (wrist extended, metacarpo-phalangeal joints flexed to 90 degrees, interphalangeal joints straight, thumb abducted). This is the position in which the metacarpo-phalangeal and interphalangeal ligaments are fully stretched and fibrosis therefore least likely to cause contractures. Failure to appreciate this point is the commonest cause of irrecoverable stiffness after injury.

**POSTOPERATIVE MANAGEMENT**

**IMMEDIATE AFTER CARE**
- Following an operation, the hand is kept elevated in a roller towel or high sling.
- If the latter is used, the sling must be removed several times a day to exercise the elbow and shoulder. Too much elbow flexion can stop venous return and make swelling worse.
- Antibiotics are continued as necessary.

**REHABILITATION**
- Movements of the hand must be commenced within a few days at most.
- Splintage should allow as many joints as possible to be exercised, consistent with protecting the repair.

**Replantation**
- With modern microsurgical techniques and appropriate skill, amputated digits or hands can be replanted.
- An amputated part should be wrapped in sterile saline gauze and placed in a plastic bag, which is itself placed in watery ice.
- The ‘cold ischaemic time’ for a finger, which contains so little muscle, is about 30 hours, but the ‘warm time’ less than six.
• For a hand or forearm, the cold ischaemic time is only about 12 hours and the warm time much less.
• After resuscitation and attention to other potentially life-threatening injuries, the patient and the amputated part should be transferred to a centre where the appropriate surgical skills and facilities are available.

INDICATIONS
• The decision to replant depends on the patient’s age, his or her social and professional requirements.
• The condition of the part (whether clean-cut, mangled, crushed or avulsed), and the warm and cold ischaemic time.
• Furthermore, whether the replanted part is likely to give better function than an amputation.
• The thumb should be replanted whenever possible.
• Multiple digits also should be replanted, and in a child even a single digit.
• Proximal amputations (through the palm, wrist or forearm) likewise merit an attempt at replantation.

RELATIVE CONTRAINDICATIONS
• Single digits do badly if replanted.
• There is a high complication rate, including stiffness, non-union, poor sensation, and cold intolerance.
• Severely crushed, mangled or avulsed parts may not be replantable.
• A long ischaemic time may not survive.
• General medical disorders or other injuries may engender unacceptable risks from the prolonged anaesthesia needed for replantation.

MANAGEMENT OF BURNS
• Generally, hand burns should be dealt with in a specialized unit.
• Superficial burns are covered with moist non-adherent dressings.
• The hand is elevated and finger movements are encouraged.
• Partial thickness burns can usually be allowed to heal spontaneously; the hand is dressed with an antimicrobial cream and splinted in the position of safety.
• Full thickness burns will not heal.
• Devitalized tissue should be excised; the wound is cleaned and dressed and 2–5 days later skin-grafted.
• Full thickness circumferential burns may need early escharotomy to preserve the distal circulation.
• Skin flaps are sometimes needed in sites such as the thumb web which are prone to contracture.
• The hand should be splinted in the position of safety; K-wires may be needed to maintain this position.
• **Electric burns**
  o may cause extensive damage and thrombosis which become apparent only after several days.
  o The patient may of course need resuscitation (treating cardiac anomalies and myoglobinuria).
  o The arm needs to be monitored and fasciotomy with debridement of dead tissue is often needed.
• **Chemical burns** should be irrigated copiously for 20 or 30 minutes, usually with water or saline but sometimes with a specific reagent (calcium gluconate for hydrogen fluoride burns, soda lime or magnesium solution for hydrochloric acid, mineral oil for sodium).

**MANAGEMENT OF INJECTION INJURIES**
• Oil, grease, solvents, hydraulic fluid or paint injected under pressure are damaging because of tension, toxicity or both.
• The thumb or index finger is usually involved.
• Substances can gain entry even through intact skin.
• Air or lead paint may show on x-ray.
• Immediate decompression and removal of the foreign substance offers the best hope.
• This means an extensive dissection.
• The outcome is often poor, with amputation sometimes being necessary.

**FROSTBITE**
• Frostbite requires special treatment.
• The limb is rewarmed in a water bath at 40–42 degrees for 30 minutes.
• Oedema is minimized by elevation, and blisters are drained.
• Digits sometimes need amputation.

**SECONDARY OPERATIONS**
• The primary treatment of hand injuries should always be carried out with an eye to any future reconstructive procedures that might be necessary.
• These are of three kinds:
  • secondary repair or replacement of damaged structures
  • amputation of fingers
  • reconstruction of a mutilated hand.

**Delayed repair**
• **SKIN**
  o If the skin cover is unsuitable for primary closure or has broken down it is replaced by a graft or flap.
  o As always, the skin creases must be respected.
  o Contractures are dealt with by Z-plasty, skin grafting, or local flaps, regional flaps or free flaps.
• TENDONS
  o Primary suture may have been contraindicated by wound contamination, undue delay between injury and repair, massive skin loss or inadequate operating facilities.
  o In these circumstances secondary repair or tendon grafting may be necessary.

• NERVES
  o Late-presenting nerve injuries must be carefully assessed.
  o The results of repair deteriorate with time, particularly for motor nerves where the end plate begins to fail and the muscle begins to fibrose.
  o If several months have passed, tendon transfer may be a more reliable alternative.

• JOINTS
  o The proximal interphalangeal joint is most prone to a flexion contracture.
  o Active and passive exercises can be supplemented by serial static splints or dynamic splints.
  o Surgery (capsulotomy, palmar plate and collateral ligament release) may be required but these operations themselves can invite further stiffness.
  o Unstable or painful joints are best fused.

• BONES
  o Malunion, especially if rotational, may require treatment.
  o Non-union is very uncommon, but if present grafting may be required.
  o Extensor tendons may stick to bone, most commonly after plate fixation of the proximal phalanx.
  o Plate removal and tenolysis is followed by aggressive active and passive movements: a fair result is usually achieved.

• AMPUTATION
  o A finger is amputated only if it remains painful or unhealed, or if it is a nuisance (i.e. the patient cannot bend it, straighten it or feel with it), and then only if repair is impossible or uneconomic.

• LATE RECONSTRUCTION
  o A severely mutilated hand should be dealt with by a hand expert.
  o If all the fingers have been lost but the thumb is present, a new finger can sometimes be constructed with cortical bone, covered by a tubular flap of skin.
  o An alternative is a neurovascular microsurgical transfer from the second toe.
  o If the thumb has been lost, the options include pollicization (rotating a finger to oppose the other fingers), second toe transfer and osteoplastic reconstruction (a cortical bone graft surrounded by a skin flap).