Management of the injured hand - basic principles of care

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Introduction

The aim of this second article is to introduce basic principles in the management of injured hand. It is difficult to provide a uniform guideline with "one injury–one solution" approach, as every case is different and unique. Detailed description of the management and surgical techniques of each structure is beyond the scope of this article.

Hand injuries present either as an isolated injury or as a component of multiple injuries. In poly-traumatized patients hand injuries are not uncommon; often these patients are referred late. Resuscitation, stabilization and dealing with potentially life threatening injuries take priority over the injured hand. Haemostasis and initial wound irrigation along with a scrub of the injured hand is an acceptable during the initial management of multi trauma patient. Surgical management of the hand can be deferred till the patient is stabilized. However, there can be a significant negative impact on long-term quality of life if the hand injuries are not treated or significantly delayed [1].

Initial care

Thorough assessment of the injured hand is performed and documented. This is aided with digital photography as a means communication, teaching and recording. The only potential life threatening problem in the injured hand is bleeding. Haemorrhage can be controlled initially with direct, firm compression and elevation unless there is a coagulopathy. Initial wound irrigation and dressing is performed at the emergency department. Elevation of the injured hand is vital to minimize the development of oedema. Emergency room splinting is a useful adjunct to reduce pain.

Adequate regular analgesia should be provided. If local anaesthetic blocks are to be administered, it is essential that a neurological examination is carried and documented, prior to blocks. Immunization status for tetanus is assessed and addressed accordingly. Prophylactic antibiotics are started depending on the degree of contamination and should be used judiciously. Prophylactic antibiotics are not indicated in uncomplicated hand injuries without contamination [2]. Use of antibiotics should never replace the role of meticulous debridement and wound irrigation, which is the key in preventing infection [3].

Plain radiographs of two views should be the routine investigation in any injured hand. It is important to have true lateral and true antero-posterior views of the fingers, as rotated or angulated views might hide apparently minor fractures, as avulsion fractures and dislocations. In a true lateral view the radial and ulnar condyles of the phalangeal bones should overlap. An oblique view often provides additional information but cannot replace a true lateral view. Radiographs without a splint are the ideal as the splints mask details of bony injury. Further radiologic evaluation is indicated in selected cases by the expert.

Management of open wound

Wound debridement or wound excision, is the most important initial step that determines the functional outcome of the injured hand. This vital step should not be done by the junior surgeon in the team as proper wound excision requires experience and judgment. An adequate form of anaesthesia, tourniquet and magnification are essential prerequisites in operating on an injured hand. The affected area is irrigated with saline irrigation under anaesthesia. This step will not only help the mechanical debridement but also clean the whole region as the patient may not get a chance to wash the hand for a considerable period of time after the operation. Macroscopic contamination is carefully removed and devitalized tissue is debrided with sharp instruments. Loose strands of crushed and frayed tendons are carefully debrided preserving the healthy

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length. In debriding the injured nerves and tendons it is important to be conservative than to be radical. At the end of the debridement and thorough irrigation, tourniquet is deflated to assess the viability of the tissue and haemostasis is completed with bipolar diathermy, clips or ligatures.

Achieving adequate surgical access is mandatory in identifying the injured structures. These access incisions should be placed carefully and generally follows Brunner incisions, and are the extensions from the existing wounds. Skin flaps are raised with sharp dissection, guided by the palmar fascial bands and maintaining an adequate thickness. Narrow acute angled skin flaps are likely to become ischaemic. Straight line incisions on the volar aspect of fingers are strongly condemned as they will heal with contractures. It is important to remember that neurovascular bundles are just deep to the transversely oriented fibres of the palmar fascia in the palm. In the fingers the neurovascular bundles are subcutaneous in relation to mid lateral lines.

Management of vascular injury

Revascularization of digits, hands or wrist-proximal injuries require microsurgical expertise and appropriate cases need to be transferred to equipped centres. Prompt recognition of vascular compromise in partial amputations and crush injuries is imperative to avoid delay. Duration of ischaemia is critical for the long term recovery of small muscle function and nerve recovery. Thorough debridement, adequate exposure, bone shortening and achieving skeletal stability are essential prerequisites prior to anastomosing injured vessels. The revascularised hand can be functionally useless, unless all the nerves and tendons are repaired. The surgeon should select the indicated cases as some amputations may not be technically possible as in severe crush injuries, and unstable patients with concomitant severe injuries [4].

Soft tissue cover

Soft tissue coverage is crucial in terms of achieving healing without infection and to protect the repairs underneath. Majority of open hand trauma are amenable for immediate closure. In the presence of significant contamination, a subsequent debridement may be indicated with an interval of 24 to 48 hours. Primary closure is the best form of achieving early wound closure which is the usual case in cut injuries and majority of lacerations. In the case of soft tissue loss as in significant crush injuries and degloving injuries, soft tissue coverage has to be achieved. If the wound is a graftable, vascularised bed a skin graft can be used. A popular myth is that "one should wait till the wound is granulated as a requirement for a skin graft". In fact, primarily skin grafted hands do better than with a delayed graft. Definitive cover in the form of a graft or flap should ideally be provided within few days rather than weeks. The delay in achieving cover will promote granulation tissue that is destined to form scar, which is considered the enemy of a well-functioning hand. There are absolute indications for a flap (vascularised tissue); exposed bone devoid of periosteum, bare tendon without paratenon, exposed cartilage and joints and exposed neurovascular structures. A wound with these structures exposed should be referred to a plastic surgical unit without delay. The ultimate aim of soft tissue coverage is to achieve healed wounds with stable and durable coverage. It is best the coverage over the tips and volar aspect to be sensate [5, 6].

Skeletal injury

Fractures and dislocations of small bones of the hand are difficult and often unforgiving injuries. Many different fracture patterns are described in hand bones. Comprehensive discussion of each fracture is beyond the scope of this article. Stabilisation of the bony skeleton of the hand is essential prior to neurovascular or tendon repairs. General principles of fracture management apply to hand fractures as for other bones in the body. But special attention should be paid in meticulous and gentle tissue handling around these small bones. The impact of scar formation and the development of stiffness is significantly high in hand fractures. Relatively thin soft tissue envelope makes access easy, but maintaining cover for the injured bone is difficult. Majority of closed, stable fractures heal with splinting for 3–4 weeks followed by active moving [7,8]. Significant displacement, angulation and rotation have to be treated by closed manipulation or open reduction. Indications for operative intervention exist for individual fractures. In finger fractures, correction of significant rotational deformity is mandatory to avoid overriding and scissoring of fingers [9]. The aim of surgical intervention is to correct the deformity and to achieve stable fixation to allow early movement. Here the benefit of surgical intervention is weighed against

the surgical trauma and its consequences. Wounds with open fractures should be thoroughly and promptly debrided and early soft tissue cover should be achieved. K-wires are widely used fixation devices which are cheap, quick and easily inserted. It is used after open or closed reduction and inserted percutaneously with radiologic guidance. K-wires involve less tissue dissection and operative trauma compared with plate and screw fixation. The K-wires are removed in the clinic after 3-4 weeks. The drawback with K wires is that the stability of fixation may not be adequate to allow early active movement. Rigid fixations are favoured as this will allow early active movements of the fingers. They include plate and screws, lag screws, intraosseous wiring and rarely intramedullary nails. These involve significant tissue dissection and subsequent scar formation and stiffness [10,11].

Tendon injury

Primary repair of tendon injuries are the standard practice. Tendon injuries should be repaired early as the wound is easy to manage, the tendon ends are fresh, undue delay lead to changes in tendon ends and proximally in the muscle belly. In delayed cases the repair is technically difficult and sometimes primary repair may be impossible, and interposition tendon graft or staged tendon reconstruction would be the option. In flexor tendon injuries all the tendons must be repaired, and in the finger preferably both Flexor Digitorum Profundus (FDP) and Flexor Digitorum Superficialis (FDS) tendons are repaired. Isolated FDP repair, excising the FDS, is considered in occasions with severely injured, unclean or ragged tendon ends or insufficient tendons. In zone one injuries tendon to bone repairs are performed, traditionally with a core suture in the proximal tendon passed through the base of the distal phalanx or around it using the needle drill technique. The suture is tied on the nail dorsally to be removed in six weeks. Development of suture anchors has replaced this technique but in the authors setup the traditional method is still in practice. Zone two injures are the most challenging as both FDS and FDP tendons are running in the crowded flexor sheath and inherent with a higher chances of poor outcome. Zone 3, 4, and 5 flexor tendon injuries are treated with the same principles as for zone two, but these are more spacious and technically easy [12,13].

Anatomic multi strand locking suture techniques are favoured as they allow early active range of movement exercise. Repair suture should consist of a core suture and an epitendinous suture. In selecting a core suture, material used, caliber, number of strands crossing the repair, knot placement and suture locking are the important aspects to consider [14]. Epitendinous suture of fine non absorbable material would add the fine finishing touch to the repair site and helps to increase the strength. Polyester, polypropylene, and nylon are the commonly used material [15,16]. Repair site bunching and gap formations should be avoided. Bulky repair site may trap under a pulley. Poor repair can lead to gap formation and is associated with increased risk of repair rupture. The authors preferred technique is for strand locking core suture and circumferential epitendionus suture with non-absorbable material as polyester or polypropylene. Atraumatic surgical technique in retrieving and handling the tendons is essential to minimize subsequent scar formation. In retrieving the tendon ends several windows are made in the fibrous flexor sheath without damaging the full length of the pulleys. Maximal preservation of the A2 and A 4 pulleys is important to prevent bowstringing. In the case of severely injured pulleys can be reconstructed. Fine hypodermic needles are used to transfix the tendons in stabilizing the ends for the repair. The troublesome adhesion formation is minimized with early active movement of the fingers. Hence strict adherence to rehabilitation protocols is recommended for a good outcome [17,18]. Flexor tendon injuries remain a difficult problem in hand trauma, in terms of achieving optimal functional recovery. Hence these should not be left to be repaired by the inexperienced junior operator. Undesirable outcomes as stiffness, repair rupture, flexion contractures and adhesions should be managed by experts with the involvement of the hand therapist. Tendon repair re-explorations, tenolysis and staged tendon reconstruction should be done carefully in indicated patients and are not the operations for the occasional hand surgeon [19,20].

Extensor tendons are easily accessed as their subcutaneous location. Extensor retinaculum, juncturae, sagittal bands and retinacula ligaments are the structures that keep the extensor tendons in place. As extensor tendons are thin in calibre and flat distally the repair techniques are modified accordingly and standard core suture is impossible. Running suture or cross-stich is used in these areas. Proximally they become thick and

a core suture is indicated especially in wrist and forearm. Different therapy protocols are used to suit the zone of the injury. Traditionally zone 1 and 2 injuries are immobilized with splints for 6 weeks [21,22]. Further details of the rehabilitation of tendon injuries will be discussed in the third article.

Nerve injury

Early repair of injured nerves is essential for re-innervation of specific muscles and restoration of sensibility in the hand which are imperative for reasonable function. Proximal injury of the upper extremity nerves are notorious for long lasting disabilities as, loss of fine sensory and motor function. Recovery of sensation requires a long time to reach the optimum and undue delay is likely to compromise the ultimate sensibility of the hand. Often protective sensibility recovers following nerve repair but tactile discriminative function seldom recovers. Microsurgical technique including magnification is essential in handling peripheral nerves. Tension free nerve repairs should be performed with micro sutures such as 8-0 or 9-0 non absorbable monofilament. In sharp cut injuries primary repair is easy, since there is no loss of nerve tissue. Positional changes as flexing a joint to gain length for a primary repair, in the case of segmental nerve loss are not recommended. Inadvertent dissection or mobilization of a nerve over a significant length is strongly discouraged as this can potentially devascularise the nerve and stimulate formation of scar tissue. Epineurial repair is the commonly practiced technique where fascicular arrangement should be matched under magnification. Cross sectional anatomy and the pattern of vasa nervorum is the guide for the proper match. Poor repair technique often lead to fascicular escape and neuroma formation, resulting in poor sensory and motor recovery as well as a symptomatic neuroma [23]. In the case of a segmental nerve loss, interposition nerve grafts should be used. In the case of extensive soft tissue loss or severe contamination, primary nerve repair may be delayed till the rest of the wound is stabilized. In unsuitable wound bed, as in established infection or the presence of tissue with questionable viability, primary nerve grafting should be deferred. In such occasions, delayed reconstructive procedures as, delayed nerve grafting, nerve transfers, tendon transfers or joint fusions are indicated. Post-operative therapy is invaluable in sensory and motor re-education and rehabilitation. Early active movements within a protective splint facilitate nerve gliding. Desensitisation is useful in managing hypersensitive areas. Lack of nerve regeneration, chronic paraesthesia, symptomatic neuroma and complex regional pain can complicate the recovery after a nerve injury [24].

Fingertip injury

Fingertip injuries are unique in that they are seemingly minor but inherently associated with specialised problems. The priority is to provide the best possible coverage with good quality skin which is sensate. They are commonly managed with local nerve blocks except in small children. Crushed fingertip is probably the commonest hand injury in the paediatric group. Simple pulp lacerations are often primarily repaired but when there is a significant pulp loss it should be reconstructed. In the presence of exposed distal phalanx bone a flap is indicated, while a hypothenar graft can be used in replacing the pulp skin. The amount of remaining tissue and its configuration determines the reconstructive option. Nail bed injuries require careful repair with fine absorbable suture. Nail plate or a substitute is placed as a splint after nail bed repair. Minor skin loss is often managed with dressings, although they take at least two to three weeks to heal. A distal phalanx tuft fracture is often present in tip crush injuries which are generally managed only with a soft tissue repair. Even though a large number of flaps are described for the reconstruction of tissue loss of the fingertip, they are generally managed with less traumatic surgical techniques. More proximal injuries with non-salvageable tips require proper amputation with primary repair. The potential secondary deformities of the fingertip injury can cause a great deal of inconvenience to the patient preventing the use of their hand [25].

Immediate post-operative care

Local anaesthetic nerve blocks are an essential part in alleviating post-operative pain. Regular and adequate analgesia is mandatory in hand injury as this is the key to allow early rehabilitation. The dressing and the splints used at the end of the operation should be tailored according to the injury and the repairs done. Elevation of the hand is essential in reducing the inevitable oedema. Rehabilitation of the injured hand is critical to

ensure the best outcome after any form of trauma. Any hand injury management is incomplete without appropriate rehabilitation in the post repair period.

Conclusion

Hand is a complex anatomical organ which is frequently exposed to injuries. Complex and severe hand injuries can potentially exclude young people from their professional life, often contributed to by improper management. Detailed assessment of the injured hand is the key for the successful repair of the damaged structures. The outcome depends primarily on the prompt and skilled treatment. The treating surgeon should have a sound understanding of the rehabilitation of the injured hand and be patient enough to complete the appropriate therapy programs.

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