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Reconstruction of traumatic losses of substance at the elbow

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ABSTRACT

Traumatic lesions at the elbow involving great loss of substance are uncommon, but represent a significant problem when such cases are referred to a trauma department. Most of these injuries may cause severe final functional impairment, thereby jeopardising future activities, particularly in cases where treatment was delayed or inappropriate. The timing and method of treatment are critical. The trauma may involve soft tissues only, or bone and joint, or several structures at the same time, which results in combined complex tissue defects. Each type of tissue loss should be managed by choosing the most suitable technique from the armamentarium of reconstructive surgery, taking into account different priorities and the optimum timing (immediate or delayed, one- or two-stages). The authors describe a spectrum of indications and techniques that can be useful tools in managing these injuries.

Introduction

There is little information in the literature about traumatic lesions at the elbow involving great loss of substance because of the low incidence and heterogeneity of these lesions.

The most common causes of lesions at the elbow involving great loss of substance include traumatic gunshot wounds, agricultural and industrial injuries, and road accidents (particularly trauma because of the elbow protruding out of the window).

The high functional requirements of the elbow depend not only on the complexity of the joint, but also on the maintained function of vessels and nerves and the soft tissue coverage. The high density of noble structures that may be involved in lesions at this level may cause severe functional impairment of the upper limb.

The skin of the volar region of the elbow differs from that of the dorsal region in terms of thickness, it has greater flexibility and is important for the coverage of noble structures. The dorsal skin is characterised by high mobility with respect to the underlying tissues to enable the complete flexion and extension of the elbow. Accurate reconstruction of the articular surfaces and early mobilization of the elbow joint are critical for restoring proper joint function.

General principles

Traumatic losses of substance at the elbow can be divided into three types:

1) prevalent loss of bone-joint substance with minor soft tissue involvement;
2) prevalent loss of skin, more or less associated with simple bone-joint lesions;
3) complex combined loss of substance (skin and bone).

Each of these types may be associated with injury or loss of neurovascular structures or muscle tissue.

As patients with traumatic losses of substance at the elbow have generally suffered from high-energy traumas, the first priority upon arrival in the emergency department is to stabilise the patient according to Advanced Trauma Life Support (ATLS). It is then possible to manage the complex peripheral injuries. The initial assessment must first determine any vascularisation problem distal to the lesion, then the extent and contamination of the wound is evaluated. The results of imaging studies (X-rays, CT scans, etc.) and the intraoperative evaluation of the complexity of the lesion will then determine which tissues are involved and the extent of the loss of substance. Only after this initial assessment a decision can be made about final treatment.

The principles that should guide the reconstructive surgeon in the process are the following: (1) extensive debridement of damaged tissues (it may be difficult to identify immediately which tissues are devitalised, particularly following high-energy traumas); (2) restore a good blood supply; (3) stabilise bone components with rigid fixation; (4) ensure stable and well-vascularised skin coverage; (5) early mobilization of the joint.

The authors developed a flow-chart for the management of bone loss, skin loss, combined loss of tissue and associated nerve lesions and these will each be examined below.

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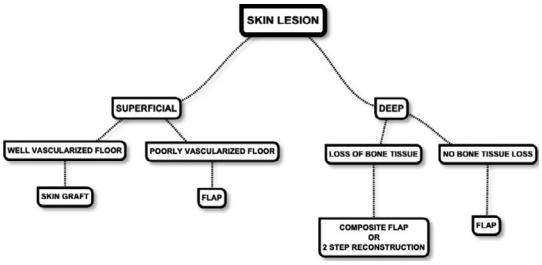

Management of bone loss

Bone loss is generally the result of high-energy traumas and is often associated with loss of the overlying soft tissue and sometimes involve lesions of the vascular-nervous structures. Bone reconstruction can be acute or delayed depending on the quality of skin coverage and the presence of possible infectious sources. Immediate reconstruction requires the patient to be in a stable general condition with wounds that are not excessively contaminated (early total care). Reconstruction with skin coverage within 3 days of trauma has been reported to be associated with a much lower risk of infection compared with delayed reconstruction [1]. The heterogeneous nature of these lesions, however, precludes the development and use of a standardised treatment.

The role of external fixation is crucial in unstable patients (damage control orthopaedics), patients with contaminated lesions, and in those with severe bone loss that is difficult to manage in an emergency context. In these cases, which are the majority of severe traumas in our experience, definitive reconstruction by internal osteosynthesis is delayed by at least 4–5 days [2–5]. Loss of bone substance of up to 5–6 cm without severe articular damage can be filled with free autologous grafts, provided they are implanted on a well-vascularised and clean site [6]. Vascularised grafts may be used in cases of greater bone deficiency in sites such as the fibula [7], the iliac crest and vascularised ribs. The vascularised grafts can then be set up as composite flaps with skin or muscle [8,9].

Reconstruction of the elbow in patients who have combined bone and cartilage loss is more demanding. Cavadas et al. [10] reported five cases of bone loss in post-traumatic elbows reconstructed with vascularised free flaps shaped and covered with periosteum or muscle (interposition arthroplasty). Prosthetic implants are a treatment option for extensive articular damage, particularly in elderly patients with low functional requirements [11–20]; however, particular attention needs to be paid to the implantation site to ensure it is as clean as possible, and coverage of the soft tissues should be optimised. Loss of joint surfaces remains the greatest challenge in young patients: in these cases, interposition arthroplasty may be used [21–25], although prosthetic implants are becoming increasingly reliable [11,18,19,26,27]. In our series, there was one late infection on four cases of elbow implants in traumatic bone and joint losses: these were preceded by a "wait and see" approach to observe and ensure good soft tissue conditions and complete absence of local infection (checked by clinical and laboratory data controls).

A further possibility is joint fusion, which may be difficult to perform when there is significant loss of substance [28]. In rare cases, it is possible to use distraction osteogenesis, usually managed by external fixation, to achieve a sufficient amount of diaphyseal bone. [29] Once the shaft is rebuilt, reconstruction of the joint surface can occur using the methods mentioned previously. Distraction osteogenesis is associated with several potential complications, including infection of the screw holes, axial deviation of the regenerated bone, fatigue post-distraction fractures, and non-union of the docking point. Management problems that may be experienced include frequent outpatient controls, long periods of treatment, and pain and nerve damage in the site of distraction. This technique can be replaced by the use of a vascularised fibular graft.

Management of skin loss

The options for skin coverage are numerous and include, from the simplest to the most complex: primary closure, grafts, local flaps, pedicled fasciocutaneous and muscular flaps, or myocutaneous flaps and free-flaps [30,31].

Most of the losses of substance at the elbow that require skin coverage are generally located posteriorly and require thin and elastic skin. In most patients, the coverage of traumatic injuries can be conducted within the first 24 h of trauma, after an adequate debridement, provided their overall clinical condition allows such procedures. Repeated surgical ablutions may be required in high-energy traumas: such wounds can be treated with advanced dressings or vacuum-assisted closure (V.A.C. Therapy) to remove all necrotic tissues [32].

The main factors that influence the reconstructive choice are the location and size of the loss of substance and the involvement of underlying tissues. Exposed subcutaneous tissue and muscle tissue may be covered with simple skin grafts. Structures such as tendons without paratenon, nerves, vessels and bone must be covered with flaps.

Composite flaps are useful in the reconstruction of complex loss of substance, such as bone and skin or even muscle [33]. Possible systemic problems, however, can modify the reconstructive options for the patient.

Local fasciocutaneous flaps

Axial flaps to the elbow can have antegrade and retrograde flow, all arranged on four arteries: radial, ulnar, anterior and posterior interosseous, from which perforating arteries originate to vascularise the skin. The most commonly used flap according to the literature is the Chinese flap. The risks of tendon exposure and delayed healing of the donor site can be reduced by setting up a single fascial flap. The main problem with this kind of flap is the sacrifice of the radial artery, so this method is no longer used. Other good options are the lateral arm flap, the ulnar forearm flap and the posterior interosseous flap. The recent introduction of the concept of flaps prepared on small terminal vessels, known as local perforator flaps, may save major vascular axes. Increasing numbers of small-to-medium-sized defects are covered by this type of flap (Fig. 1).

Local muscle flaps

Local muscle flaps are used when there is infection or when the loss of substance presents a dead space that needs to be filled. Muscle flaps can be used as coverage and as functional flaps for restoration of elbow flexion–extension: the most common example is the latissimus dorsi flap, which is generally used as a pedicled flap (Fig. 2). The main complication associated with this procedure is haematoma of the donor site and partial distal necrosis of the flap. To avoid this complication, Stevanovic et al. [34,35] recommended that the flap should not be used for lesions over 8 cm distally to the olecranon. In our experience of six latissimus dorsi pedicled flaps for elbow coverage, however, we had no problems of partial necrosis. Other authors describe the use of the brachioradialis muscle flap, the flexor carpi ulnaris and the anconeus muscle flap [36].