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Soft Tissue Coverage in Complex Fractures of the Lower Limbs

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Abstract

Complex fractures of the limbs are a clinical challenge for the multidisciplinary team that needs to treat them. The current advances in soft-tissue flap reconstruction techniques have significantly improved the results of the limb salvage attempts. Understanding the reconstructive concepts of zone of injury, aggressive debridement, timing and the possibilities of flap coverage are essentials to complete limb salvage in a timely and appropriate fashion. Complex extremity injury requires immediate and specialized attention via an interdisciplinary approach. The steps in surgical management include radical tissue debridement, adequate stabilization and reconstruction of viable structures by the use of autologous blood vessels or nerve grafts, and the bone and soft tissue reconstructions with a "custom-fit" flap. Generally all of them must be done in a unique surgery. These are the most powerful tools for infection control and to get the best results.

Indications for Limb Salvage Procedure versus Amputation

The practical questions are: is the limb feasible savage, is the limb salvage advisable (will limb salvage hasten the patient´s demise? if choosing salvage, what is the order of the steps? when does salvage fail and secondary amputation required? Numerous algorithms have been established to estimate the viability of damaged tissue and to assist in determine whether amputation is necessary [1]. These included the mangled Extremity Severity Score (MESS), the Limb Salvage Index (LIS), the Predictive Salvage Index (PSI) and the Hannover fracture Scale (HFS). All of them must be used after the debridement. To be more complex the Lower Extremity Assessment Project (LEAP), demonstrated that the patients who sustained a high degree of extremity trauma had several disadvantages prior to their injury (social, economic, personality), and that quality of life and functional outcome data seemed more related to these than to the injury [2]. Indications for primary amputation may include very advance patient age, prolonged warm ischemia time, presence of life threatening concomitant injuries. In case of trauma amputation, warm ischemia can be tolerated up to 8 hours and cooling may extend the safe time to re-implant to 24 hours. Bose et al. [3] showed comparable sensation outcomes in plantar sensation between patients initially lacking and patients with permanently preserved plantar sensibility at two years.

Thus, a surgeon must perform realistic risk-benefit stratification to determine whether amputation is justificated. Individual patient assessment remains the key step in determining if limb salvage procedure is indicated. The limb salvage is indicated if this extremity will be, in future, functional and without pain or chronic infection. Surgeons should try to optimally meet outcome expectations while keeping morbidity at the lowest possible level.

Surgical Technique

Marco Godina [4] was the first surgeon who introduces the concept of emergency coverage in the 80´s. To reduce the incidence of non-union fracture and osteomyelitis is necessary: 1) Early and adequate debridement of trauma zone injured 2) followed by immediate restoration of affected longitudinal structures and 3) early defect coverage by transferring a well vascularized tissue. Complex and contaminated wounds should be converted into surgically clean wounds to allow an appropriated closure [5,6]. The traumatic zone of injury [7] includes areas of increasing soft tissue destruction as the point of impact is approach. The direct trauma contact area is a zone of necrosis, with adjacent tissue becoming a zone of stasis and the surrounding region developing into a zone of hyperaemia. These stasis and hyperaemia areas, are marginally viable at the time of initial injury eventually die or become replaced by a fibrotic scar. Both, the soft tissue and the bone tissue are traumatized and if not adequately treatment during the initial management will develop soft tissue defects, non-union and osteomyelitis. Also, in the microvascular reconstruction, the vessels in the zone of injury are fibrotic, without suitable veins and difficult to dissect. The average distance between the anastomotic area and the zone of injury was around 45.7mm. Initial appreciations of the zone of injury and the extent of recipient vessel damage is crucial to develop a strategy for fracture stabilization, debridement and

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soft tissue coverage, which determine together the success of the patients' limb salvage outcome.

Radical Debridement

Radical and early debridement is a key step in surgical management and one of the most powerful tools for infection control. We have to transform the open fracture in a healthy and without dead spacer defect. Only we have to be careful in tendons and neurovascular structures. In case of damage or complete transection, they must be repair with a tendon, vessel, nerve or bone graft. Fasciotomy should be performing if there were a warm ischemia or if there were haematoma was accumulated.

Fracture Estabilization

Now days, recent studies show no difference between internal fixation (nail or plates) versus external fixator. And also it is recommended internal fixator if soft-tissues procedures are done expeditiously. Also, an adequate fixation of the fractures, reduce the incidence of infection or non-union. Trauma surgeon should choose the best fixation to the fracture forgetting about the soft tissue [8]. We should use the so called "fix and flap" concept. Gopal et al. [9] demonstrated less morbility in terms of non union and osteomyelitis if the sequence of treatment is aggressive debridement, fracture stabilization and well vascularized coverage in only one stage.

Soft-Tissue Reconstruction

Modern microsurgery allows reconstruction of complex bone and soft tissue defects with excellent aesthetic and functional outcomes. Although local flaps and skin graft are still considered in reconstructive surgery, they are associated either an increased rate of wound complications and compromises concerning results. Further compromise of a severely injured extremity by sacrificing local tissue should be avoided. Therefore, free tissue transfer provides the most appropriate repair for severe injured extremities. In general there are 4 principal indications for free flap coverage of traumatized extremities, 1) soft tissue defects in the distal third of the leg, 2) soft tissue defects with a functional defects in upper and lower extremities, 3) extensive defects in lower or upper extremities at any level and 4) salvage free flaps in non re-implantable amputation. Local flaps must be considered in low energy trauma patients with a small soft tissue defect (less than 5cm) and only when surgeon is completely sure that the local tissue is not damaged. Modern techniques range from super microsurgery free tissue transfer, functional composite free flaps, and pre-expanding and chimeric flaps to innervated functional myocutaneous flaps.

Primary flap cover for crucial closure prevents further tissue damage caused by desiccation and facilitates vascular in growing from the new surrounding soft tissue. Well-vascularized flaps provide healthy tissue, thereby allowing a radical debridement of the trauma zone. Because the primary goal in the treatment of complex extremity injury is a quick and functionally optimal recovery, the treatment of choice is the primary free flap cover within the first 24 hours after injury, preferable or I the first 5 days. This minimizes morbidity, tissue infection rate, requirement for secondary surgical procedures, rehabilitation time and total duration of hospital stay.

Flap Selection

Because of the huge variety of flaps available for reconstruction, flap selection must aim to optimally meet the specific functional and aesthetic requirements of the recipient site such as tissue volume and surface, vascular pedicle length, and functional exigencies [10]. Flaps with different tissues (bone, muscle, tendon, nerve, adipose, fascia and skin) are referred as composite flaps. Each flap has its property characteristic of functionality, durability, vascular supply and blow flow. Nowadays there is an upcoming trend toward using the fasciocutaneous flaps in reconstructive surgery [10]. There was no statistical difference in terms of flap survival, rate of postoperative infections, chronically osteomyelitis, and stress fractures between coverage with muscle flaps or with a fasciocutaneous flap. And both are useful to cover a three dimensional defects [11]. Only in muscle function reconstruction are muscle flap required [12,13].

In a one-stage "functional" reconstructive approach, the reconstruction is not simply for defect coverage, bone or tendon repair, but may also include tendon transfer for nerve palsy and tendon defect and functional muscle or myocutaneous transfer for composite functioning [14]. So, there is not a standardization of the flap used in the extremities reconstruction. A key principle is the individual flap selection depending on the recipient site requirements. Remember that the core concept in plastic surgery has been the replacement of "like-with-like" tissue [15,16].

Vessel Selection

The through-flow free flaps allows [17] arterial reconstruction and soft tissue coverage in the same stage. Without a flow-through flap, damaged extremities usually require second-stage operations, with vein grafts in the first stage and skin flaps or tissue transfers in the second stage.

Therefore, the proper selection of recipient vessels appears to have the utmost importance in the success of a microvascular tissue transfer. One of the most important problems in the trauma surgery is the election of the healthy vessel out of the zone of injury. To avoid it, surgeon can used The use of interpositional 1) vein grafts [18] to reach healthy recipient vessels remote from the zone of injury is much safer option than the suboptimal selection of the recipient vessels to decrease operative time or to avoid a more complex procedure. 2) Arteriovenous loops as [19] an alternative in which a constant high blood flow is established by shunting the arterial and venous portion and thereby achieving high-flow perfusion of the newly created loop. The free flap transfer may then be performed either as a simultaneous procedure or at a second stage after perfusion has been ensured for an appropriate time interval. 3) Choosing the recipient site distal to the zone of injury is the other possibility [20]. Distal vessels are more superficial, making the anastomosis easier requires a shorter pedicle and may obviate the possibility of tunnelling the pedicle or interposition grafts.

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The critical step is to evaluate the patency of the recipient vein intraoperative by injecting heparinized saline after division and noting an un-resisted flush. 4) Super-microsurgery or perforator to perforator surgery represents a modern technique of free tissue transfer. Donor site tissue is haverest in a superficial approach reducing the donor site morbidity. But, this dissection results in pedicles in limited length and calibre. Subsequently, in most cases, one cannot respect the basic principle of performing anastomosis outside of the trauma zone. So this a limited indication technique.

Conclusion

Early and radical debridement and early flap coverage of open fractures achieves infection free union. During the past decades, reconstructive microsurgery has strongly influences the management of complex extremity trauma. Isolated complex extremity injury requires immediate specialized attention via an interdisciplinary approach. Whenever possible, all efforts must be focus on primary surgical reconstruction and soft tissue coverage at the earliest point of time. Any delay in treatment may lead to a higher rate of complications, prolonged hospital stay an increase in invalidity, and higher cost treatment. In conclusion, the man goal of reconstructive microsurgery must be an optimal functional and aesthetic reconstruction, meeting the individual trauma site requirements with minimal donor site morbidity.

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