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Primary Reconstruction for Thumb Amputation

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Abstract

Purpose: The goals of thumb reconstruction include restoration of its length, strength, position, stability, mobility, sensibility and aesthetics. Compared to other techniques of secondary reconstruction, it emphasizes the choice of primary reconstruction of the injured thumb for the functional and aesthetic benefits.

Materials and Methods: When replantation is not possible, thumb reconstruction is necessary. The technique of sub-dermal pocket is to afford a plenty venous drainage of microsurgical thumb replantation in those cases that do not have a suitable venous plexus for reliable microanastomosis.

The composite graft technique associated with the sub-dermal pocket procedure is a feasible resource when it is not possible to perform arterial revascularization of the amputated thumb tip.

The employment of the pedicled groin flap gives versatility and reproducibility to reconstruct degloving thumb. One-stage debulking procedure is performed after division of flap. The full thickness skin of the flap is first removed, fatty tissue is excised and the skin finally is regrafted.

Results: Based on the collected experience, the described procedures reach satisfactory results concerning length, mobility, sensitivity and skin coverage for a correct work performance and acceptable aesthetic outcomes.

Conclusion: The procedures for primary reconstruction of the thumb due to amputation or degloving injury is a reasonable and feasible proposal to achieve satisfactory aesthetic and functional results minimizing additional procedures or complications.

Introduction

The significant role of the thumb in hand function has been long understood: "on the length, strength, free lateral motion and perfect mobility of the thumb depends the power of the human hand" Sir Charles Bell [1]. It provides 40% of all hand function and as such traumatic amputation of the thumb is associated with significant functional deficits [2].

By far, the most common cause necessitating thumb reconstruction is trauma. Within the larger trauma classification, thumb injury can be the result of a variety of mechanisms, which include sharp cut, avulsion and crush. There are some mechanisms that have characteristics of more than one injury type. This phenomenon is best illustrated by saw and lawn mower injuries, which have both cutting and crushing components, resulting in a larger zone of injury. Other insults that can result in thumb loss requiring reconstruction include infections and neoplasms [3,4].

The advent of microsurgical techniques in the 1960s changed the way these injuries were treated, progressing quickly from the laboratory to clinical practice, when on July 27, 1965, Tamai and Komatsu performed the first successful thumb replantation [5-7]. When thumb loss occurs due to trauma, replantation is the best method of reconstruction for most patients. When replantation is not possible, thumb reconstruction is necessary [8-10].

The goals of thumb reconstruction include the restoration of thumb length, strength, position, stability, mobility, sensibility, and aesthetics. It is a rare case when all of these objectives can be achieved, and prioritization should be based on the goals and functional demands of the patient. Reconstructive techniques vary widely, not only in their potential to achieve the above goals, but also in their length of process, burden to the patient, and psychosocial implications. Patient education, shared decision-making, and mutual commitment to a reconstructive plan are absolutely critical.

In addition to patient input regarding reconstructive methods, the patient must also commit to the reconstructive process and must be a good candidate medically, socially, and psychologically. In many patients, thumb injuries occur in the workplace, and these patients are affected by the injury

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Figure 1A: Complete amputation of left thumb fingertip.

Figure 1B: Sub-dermal pocket procedure for venous outflow after revascularization with one digital artery.

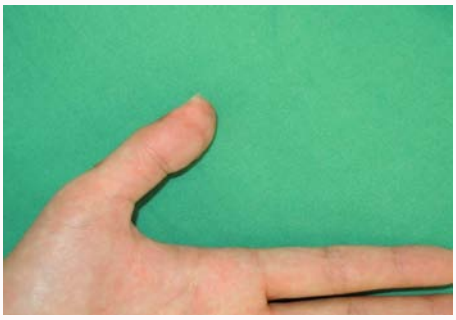

Figure 1C: Secondary healing of the pulp after division of left thumb from pocket.

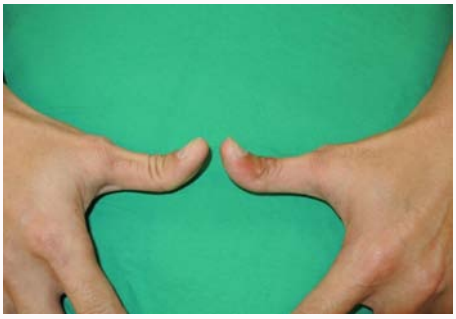

Figure 1D: Good functional and aesthetic outcome after 3 months follow up.

because their work requires significant hand use. In these patients, it is essential to work toward a thumb that has adequate length for both gripping and pinching, is stable during activities, has reasonable motion, and is sensate to give tactile input during these actions and to prevent recurrent ulceration or injury. However, adequate length, stability, motion, and sensibility are the end goals for any patient requiring thumb reconstruction, regardless of profession or vocation [11-14].

Thumb Tip Injury

The distal phalanx is the back bone of the thumb tip. However, the very distal tip includes only the soft tissues of the pulp and the nail edge. The arterial supply of the thumb or fingertip consists of multiple small branches of the digital arteries and the network of their terminal branches. The terminal parts of the digital arteries are located around the DIP joint level and the proximal half of the distal phalanges. The digital arteries run along the sides of the digit, they have a diameter of 1 mm to 1.5 mm, which is sufficient for microsurgical anastomosis. The arterial network beyond the middle of the distal phalanx is small and difficult to suture. The main draining veins of the tip run as a network on the dorsum of the digit. The digital arteries do not have venae comitantes but there is a venous plexus in the subcutaneous tissue surrounding each artery. Therefore, any flap based on a digital artery must include 2 mm to 4 mm of subcutaneous tissues around the artery and venous return is through the venous plexus around the artery. The flexor tendons terminate on the palmar aspect of the distal phalanx, and the digital nerves sent off terminal branches to form the transverse arch in the palmar subcutaneous tissue of the pulp. The branches of the digital nerves distal to the DIP joint are multiple and are difficult, or impossible, to repair surgically.

Two of the more commonly referenced are by Allen and Hirase [15,16]. Allen's classification can be utilized preoperatively as it employs gross landmarks to describe the level of amputation [15]. The Hirase classification system proposed that the level of injury in relation to the level of anastomosis of the digital artery determined the surgical method of reattachment [16]. An important distinction of Hirase's classification system is that the level of injury usually cannot be determined preoperatively.

Composite Graft

The composite grafting technique has need of set up either the distal edge of hurt thumb or detached tip for purposes of suturing immediately. Debridement and cleanliness of the ends is mandatory, taking off the fat of the tip and deepithelializing the injury end of the thumb to allow a better contact surface with the graft. The own pulp of the patient and its natural place achieves a satisfying result, either the efficacy of surgical time (because only local anesthesia is need), or the elevated rates of successes achieved in aesthetic outcomes and functional recovery. Furthermore the defeat of finger length is minimal comparing other methods [16-22]. For obtain better results it should improve contact surfaces between the ends so that the composite graft is adapted to skeletonized end of the thumb phalanx as a cap.

The cooling of the composite graft confers a helpful effect on its survival because it decreases tissue metabolism and avoids the bacterial development [23,24]. The supply of prostaglandin E1, which is a studied antiplatelet and peripheral vasodilator, has proved satisfactory benefits as an additional pharmacological assistance [24,25]. While it has not released detailed clinical information yet, the enforcement of hyperbaric oxygen therapy in experimental animal studies has revealed improvements during survival of grafts [26].

Tobacco smoking habit has been exposed as a statistically significant risk factor for failure of vitality of composite graft, according study by Heistein and Cook. Nevertheless, elderly patients, who have diabetes or those have suffered a high energy injury can

Figure 2A: Complete degloving of right thumb.

Figure 2B: Reconstruction with groin flap.

Figure 2C: Bulky appearance of right thumb.

Figure 2D: Good aesthetic result 3 months after one-stage secondary debulking procedure.

achieve suboptimal results.

Sub-Dermal Pocket Procedure

The technique of sub-dermal pocketing derivates from subcutaneous pocketing method and its premise is to afford a plenty venous drainage of microsurgical thumb replantation in those cases that do not have a suitable venous plexus for reliable microanastomosis. Thus, it is feasible to provide the generation of an early and plentiful angiogenesis [24,28-30]. It is well known that the precise connection between both sub-dermal pocket and thumb tip will allow generate a profuse network of vessels much more abundant of vascular interconnections than will fascia layer [31].

The physiological progression is the equivalent to the graft integration being the nourishment of the composite graft by serum imbibition at the beginning, followed by inosculation and then a concrete angiogenesis 48 hrs to 72 hrs later. Initially it is noted an early congestion in the digital end that gradually becomes pink appearance while one week has elapse [32].

It has been shown that neovascularization timing for separating finger tips from its abdominal pocket was at least 1 week when was made only arterial revascularization and no less than 2 weeks when it was required composite grafting for replantation, from studies published by Tsur et al. [32]. In the same way, report by Han et al. [33] has showed that the new venous network, created by neovascularization, was clarified at a mean of 7.6 days after the abdominal pocket was made for fingertip replantation.

The sub-dermal pocketing procedure might be employed when there is a complicated thumb tip injury due to possess various advantages. This approach may be chosen for thumb tip injury which has been revascularized with arterial anastomosis but does not have available veins to make available venous drainage. It is preferred the contralateral abdominal location as pocket place because this posture is more pleasant for comfort of the patient.

An accurate contact of dermal tissue between pocket and thumb tip allows a quick angiogenesis doing a period of time for their division briefer than traditional subcutaneous pocket. Indeed, it is much more profuse the vascular network that exists in dermis than that is in their underlying layers. It can be kept an eye on the thumb tip as a monitor and to observer the evolution of its integration or revascularization so that if the process tends to fail noticing necrosis, the approach could be interrupted in that moment [34].

The pocketing period of 2 weeks for thumb tips reconstructed with composite graft procedure and 1 week before partition for thumb tips revascularized with one digital arterial anastomosis (Figure 1A-1D). Partial thickness of the dermal tissue is conserved on the thumb tip for deepithelized thumb tip heals secondarily. The nail bed must be restored scrupulously with 6-0 Dexon stitches if that would be required [35].

Patients who have suffered cutting of thumb tip by guillotine mechanism reveal better outcomes than those patients with crush injury which has an unpredictable course when there is exposure of the phalanx bone or tearing of the thumb pad. Similar, it is statistically significant as success rates when it is achievable performing an arterial anastomosis.

It has already been commented harmful and pernicious role of smoking as a risk factor of importance for proper restoration of the tip of the thumb due to its actions over microcirculation [36-38].

Groin Flap Pocketing and One-Stage Secondary Debulking Procedure

It is considered that the best solution as a treatment of thumb with degloving injury is the immediate microsurgical revascularization. In this sense, is required that the neurovascular elements are suitable

for this purpose. However, in many cases, this mechanism of trauma makes both the neurovascular bundles as also its surrounding soft tissue have suffered a significant injury by crushing, shearing and torsion leading to the infeasibility of these tissues [39-47].

The collective proposal for immediate coverage of a thumb due to degloving injury is the employment of the pedicled groin flap described by McGregor and Jackson, given the versatility and reproducibility of this technique [48,49]. It is noted that this procedure involves separation of the pedicled flap at least two weeks after the initial intervention, and it is in this circumstance when we consider the opportunity to perform the debulking of the soft tissues to optimize the aesthetic outcomes. The pedicled groin flap keeps on one of the workhorses to cover many large defects in the hand and forearm. This flap was published by Mc Gregor and Jackson in 1972 and was the first axial pattern flap described, and then the first flap transferred microsurgically [50].

The one-stage secondary debulking procedure has revealed excellent outcomes when the defatting of the flap is required, according our experience in limb reconstruction. The overlying skin was shown analogous and resilient of a normal thumb after the subcutaneous defatting was performed because its full thickness skin could not have trouble to stick to the subjacent tissue, under proper contact between both surfaces. Without the interference of another procedure, it follows that nerve regeneration is developed properly in the dermis and thus a sensory improvement will be acceptable [51].

In summary, the approach with groin flap pocketing and one-stage secondary debulking procedure offers an undemanding technique for non-replantable amputation or degloving injury of thumb. The thin and strong skin coverage, that this technique can offer, leads to perform pleasing cosmetic and functional necessities (Figure 2A-2D).

Conclusion

We describe another proposal of primary thumb reconstruction with the use of sub-dermal pocket procedure when there is no available vein for venous drainage after rearterialization of the amputated thumb or using groin flap reconstruction and subsequent one-stage secondary debulking procedure when it is not possible to appeal thumb reimplantation. These methods can preserve the amputated thumb and prevent subsequent toe-to-thumb procedure.

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