19 Controversies in the Treatment of Fingertip Amputations in Adults: Conservative Versus Surgical Reconstruction

Elena Bravo and E. Carlos Rodríguez-Merchán

19.1 Introduction

It is the most common amputation injury treated by hand surgeons. It is estimated that approximately 45,000 fingers amputations are performed in the USA per year with an incidence rate of 7.5/100,000 people [1]. This results in some 4.8 million visits to emergency departments each year. The highest rates of fingertip injuries are usually seen in children under 5 years of age and in working-class adults, due to occupational activities.

Multiple treatments are available, but none is the gold standard. However, the goals of treatment of these injuries are clear: minimize pain, optimize healing time, preserve sensation and digit length, prevent painful neuromas, avoid or limit nail deformity, minimize lost time at work, and achieve an acceptable cosmetic appearance. The face and hand are the most looked at part of our body [2].

Fingertip is defined as the part of the digit distal to the insertion of the extensor and flexor tendons at the distal phalanx. Injuries to this area can present in various forms including lacerations, avulsions, and crush injuries and result in post-traumatic fingertip amputation. The severity of soft tissue, bone, artery, and nerve damage will depend on the mechanism and will guide therapeutic decision-making [1].

The fingertip is vital for sensation, as it has a high concentration of sensory receptors, and therefore, the restoration of sensation is the most important goal of treatment. The three main goals of treatment are restoration of sensation, durability of the tip, and ensuring adequate bone support to allow nail growth. Many complications can arise after fingertip amputation, such as delayed wound healing, nail deformities with poor aesthetic results, hypersensitivity, residual pain, cold intolerance, scar retraction, flexion contractures, chronic ulceration, infection, and flap loss.

The treatment algorithm can often be complex, as a wide variety of physicians, including orthopedic surgeons, general surgeons, plastic surgeons, and emergency physicians, may care for these injuries, depending on the location and local culture. Sindhu et al. stated that in the United States, up to 90% of fingertip amputations were treated with techniques without replantation. However, most amputations are replanted in Asian countries due to moral values and the importance of bodily integrity [3]. Tip amputation injuries can be managed with local debridement, complex reconstruction, or simply with irrigation and application of a sterile dressing. The precise management of a fingertip injury in

E. Bravo
Department of Plastic and Reconstructive Surgery, "La Paz" University Hospital-IdiPaz, Madrid, Spain

E. C. Rodríguez-Merchán (✉)
Department of Orthopaedic Surgery, "La Paz" University Hospital-IdiPaz, Madrid, Spain

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adults will depend on the extent of the injury itself, and various surgical and nonsurgical techniques can be successfully employed. Psychosocial factors and clinician experience are determinant in selecting the most appropriate option. Psychosocial factors to be considered are occupation, hobbies, cultural norms, socioeconomic status, secondary motive, and clinician bias.

In this chapter we will present the various therapeutic options available for the management of injuries to the fingertips and the data available to support them.

The first step should be a physical examination to assess the sensitivity, mobility, and capillary refill of the injured finger. In addition, anteroposterior, lateral, and oblique radiograph views should be requested to detect dislocations, fractures, or foreign bodies.

19.2 Nonoperative Management

This treatment promotes secondary healing by granulation with occlusive dressing. Nonoperative management achieves a fast recovery and do not normally experience functioning issues with the fingers. Its results may be aesthetically superior to graft or flap reconstruction, without incurring donor site morbidity [4]. For fingertip amputations that have less than 1 square centimeter skin loss and no exposed bone and tendon, nonoperative treatment is recommended because healing by secondary intention is an effective and simple procedure. It remains a preferred treatment and multiple publications support this management.

19.2.1 Occlusive Dressing

In 1977, Fox et al. published a study on the nonsurgical treatment of 18 fingertip pulp amputations in adult patients. After wound cleansing and debridement, the wound was covered with an occlusive dressing. Healing of the amputated fingertip occurred within 4 weeks. The healed fingertips showed excellent sensory perception, a normal range of motion, and an acceptable cosmetic appearance. These satisfactory results were achieved with less than 10 days lost from work [5].

Even exposed bone and tendon promote granulation, which supports healing through secondary intention [6]. Farrell et al. in 1977 published a study of 17 patients (21 amputations), evaluating a nonoperative management for fingertip amputations which allowed spontaneous healing of the defects. Six patients had exposed bone in the lesion. These lesions healed with excellent results in terms of maintenance of maximum finger length, minimal aesthetic, and functional deformity. Rapid return to work was possible in most cases. In addition, morbidity associated with surgery was avoided [7].

In 2014, Krauss and Lalonde stated that conservative wound treatment with dressings and protective splints allowed patients to avoid immobilization and donor site morbidity; furthermore, good results were usually achieved with near-normal sensibility, minimal cold intolerance, and tip durability; early return to work was possible, which reduced overall healthcare costs and burden to society [8].

Champagne et al. support that fingertip amputation with exposed bone take the longest time to heal. Nonetheless, gradual formation of a granulation pad covers the exposed bone and healing is achieved. The wound begins to contract with time and the surrounding skin expands, resulting in a scar that covers the amputated finger. To perform this secondary healing treatment, a digital block is sometimes necessary to relieve acute pain and clean the wound. The bone should not be shortened to minimize the deformity of the nail even if it protrudes slightly above the amputation level. It is not necessary to cover the exposed end of the distal phalanx with soft tissue. Any nonadherent dressing material is adequate, and wound care is simple, with soap-and-water cleansing and dressing changes once or twice a week. Initial tenderness usually diminishes greatly by 7–10 days, and comfort, rather than healing, will indicate when patients will be ready to return to work. Complete healing usually occurs in 4–6 weeks. These authors stated that conservative healing was more likely to result in a sensate, nontender, and cosmetically acceptable fingertip than surgical treatment in many clinical scenarios. They also presented a classification that allowed prognosis and prediction of the need for secondary corrective surgery, Champagne classification [9].

There are multiple classifications to describe fingertip lesions and to guide us in choosing the appropriate therapeutic option. The most commonly used are the Allen [10] and Urbaniak [11] classifications. Other classifications are those of Merle and Dautel [12].

Boudard et al. in 2019 analyzed a series of patients who underwent a distal finger amputation and who were treated with occlusive dressing. They performed a retrospective study of 19 patients. At evaluation, an independent examiner assessed the time required for wound healing, the number of occlusive dressings used, fingertip trophic skin changes, epicritic sensibility using the Weber two-point discrimination (2PD) test, sensitivity based on the monofilament test, complications, the presence of dysesthesia or cold intolerance, and the QuickDASH score. The mean follow-up was 12.6 months. A mean of 3.2 occlusive dressings were used per patient, and the mean healing time was 4.3 weeks. The skin texture, fingertips, and nail bed were good to excellent in 18 cases. The 2PD test was good or normal in 16 cases. Eighteen patients were satisfied or very satisfied with the outcome. The mean QuickDASH score was 5.53. In the literature, the recovery of tactile sensation was good after the use of occlusive dressings (2PD from 2.5 to 4 mm). The mean sensitivity reported in various studies is better than that observed after the use of a skin flap. Although the sample size of this study was small, the functional outcome and appearance were good. Therefore, Boudard et al. preferred to use occlusive dressings in zone 1 and 2 fingertip amputations, and flaps in zones 3 and 4 according to the Merle and Dautel classification to ensure better fingertip viability and sensation [13].

In 2021, Masaki et al. presented the case of a 36-year-old woman suffering from Allen type III fingertip amputation injury with her right middle finger crushed in a thick iron door. The amputated fingertip was not recovered. The attending plastic surgeon initially recommended reconstructive surgery to the patient. However, the patient opted for conservative treatment. Conservative management with moist wound dressings (Plus moist™) was performed, and the wound healed after 12 weeks, with outstanding aesthetic and functional results. Therefore, conservative management with moist wound dressings can be a successful treatment modality for Allen type III fingertip amputation injury [14].

19.2.2 Semiocclusive Dressing and Splint Caps

In 2020, Ng et al. described a method for treating fingertip amputation injuries consisting of a semiocclusive dressing and splint cap and presented their short-term results. They performed a retrospective study of patients with isolated fingertip amputation injuries who were treated with the aforementioned method. The semiocclusive dressing used was UrgoTul. The splint cap was a three-dimensional thermoplastic splint to cover the semiocclusive dressing of the injured finger. Twenty-eight patients (31 fingers) were analyzed. The mean age was 39.9 years. Further, 89.3% were men, 75% were foreign workers, 96.4% were blue-collared workers, 40% had injuries in the dominant hand, and 25.8% had nail bed involvement. The mean duration of follow-up was 66 days and the mean duration of hospital leave was 6.5 weeks. The splint cap was applied for a mean of 18.1 days. Total tissue regrowth time was 27.5 days. Residual nail deformities were 14.8% and return of sensation took 31.5 days. Grip strength was 82.5% of the unaffected hand. The mean ROM at the distal interphalangeal, proximal interphalangeal, and metacarpophalangeal joints was 58.8°, 86.9°, and 81.4°, respectively, and 63.9° and 66.3° at the interphalangeal and metacarpophalangeal joint of the thumb, respectively. In short, fingertip amputation injuries had a potential for regeneration through healing by secondary intention under semiocclusive dressing conditions. The splint cap provided an easy to fashion, costefficient, and comfortable addition to semiocclusive dressings for fingertip injuries [15].

In spite of simplicity and good results of nonoperative management, it requires a few basic principles: not to remove bone length to avoid hook nail and to have adherence to dressings to avoid infection. Finally, there will be cases that will be managed surgically because of the type of lesion and patient choice (fear of having an open wound or thinking that surgery achieves better results).

19.3 Surgical Treatment

19.3.1 Primary Closure

This procedure usually entails shortening the protruding bone to close the wound. This management achieves fast return to work (Fig. 19.1). However, the process involves losing part of the skin, digital length, and fingernail deformities. This treatment occasionally causes function

Fig. 19.1 (**a–d**) Amputation of the second finger without bony exposure. (**a**) Palmar view after trauma. (**b**) Dorsomedial view after trauma. (**c**) and (**d**) Direct closure

issues related to cold intolerance. Cold intolerance may be caused by the damaged nerves at the time of the injury rather than the treatment procedure [1].

19.3.2 Grafts

19.3.2.1 Composite Grafting

The outcome of composite graft is generally predictable in young children [16] but outcomes were less predictable in adults [17]. In adults, the appearance of contour distortion and nail deformity is common, but if the patient accepts these limitations of the technique, it is a good surgical option without donor site morbidity.

In 2003, Adani et al. stated that the treatment of very distal finger amputations when the amputated portion is saved remains controversial. Both reattachment of the amputated portion as a composite graft and microvascular anastomosis may fail in this distal location. In fact, replantation is often associated with technical difficulties, risk of failure due to poor venous drainage, and high costs. Except for children, amputations at the level of the lunula tend to survive poorly direct replantation. To solve this problem Adani used the replantation model without vascular anastomosis described by Hirase or cooling composite graft. It consists of using ice water and aluminum foil to enhance survival of the composite graft. Cooling the entire recipient site retarded cellular degeneration in the graft until neovascularization occurred [18].

Adani et al. used the Hirase method in seven cases in which a finger amputation had occurred between the tip and the lunula. In four cases, the method was completely satisfactory; however, in two cases, an area of tip necrosis was observed. The Hirase method proved to be a simple and reliable surgical technique for fingertip reattachments [19].

In 2016, Idone et al. published their experience with the Hirase technique considering it a reliable alternative to microsurgery implantation. They analyzed eight patients and reported their clinical results after a 10-month follow-up. The amputated part survived almost completely in six patients; in these cases, the finger amputations were classified according to Allen's classification as level I in two cases, level II in three cases, and level III in one case [10]. Ultimately, Idone et al. considered that reattachment of an amputated finger with the Hirase technique was possible and could provide good distal soft tissue coverage and recovery of sensory and motor functions. Therefore, they stated that reattachment of the amputated portion as a composite graft represented an important alternative to microsurgery [20].

In 2011, Chen et al. stated that composite grafting was often used to treat nonreplantable fingertip amputations and that this technique had a high success rate and good results in the treatment of finger amputations in children, although in adults the success rate was lower. The authors analyzed 27 patients with 31 fingers with traumatic fingertip amputation. All 31 injured fingers had a nonreplantable distal amputated fingertip and underwent composite grafting. The surgical technique was refined by excising the bony segment, defatting, deepithelialization, tie-over suturing, and finger splinting to increase graft survival. The mean age of the patients was 40.5 years. The mean lesion size was 2.4 cm. Twenty-one fingers (67.7%) had been injured by crushing injury and the other 10 fingers (32.3%) by cutting injury. The overall graft survival rate was 93.5% (29 of 31). The average two-point discrimination was 6.3 mm at 6 months postoperatively. The aesthetic outcome assessed by a self-report questionnaire was 93.1% satisfaction, and 86.2% of patients were able to use their injured finger normally in daily work. In short, for Chen et al. a one-stage surgical procedure of easy performance was a reliable method for treating microsurgically nonreplantable fingertip amputations caused by hand trauma. The high success rate, satisfactory aesthetic outcome, and good functional preservation allowed patients to quickly return to their daily lives [17].

In 2016, Lai et al. published their experience using composite grafting with pulp adipofascial advancement flaps for treating nonreplantable fingertip amputations and thus improving fingertip contour. They analyzed 14 patients (16 digits).

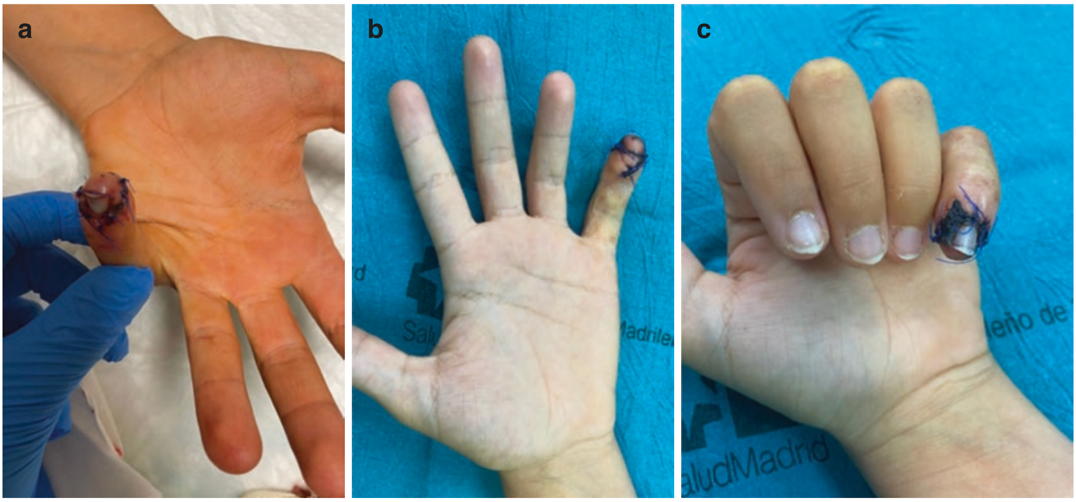

Fig. 19.2 (**a**–**c**) Composite pulpal graft: (**a**) Palmar view after surgery; doubtful viability of grafted tissue. (**b**) Palmar view 3 weeks after surgery. Viability of grafted tissue is visualized. (**c**) Dorsal view 3 weeks after surgery

The mean age of the patients was 43.9 years. All patients underwent the procedure under digital block anesthesia. First, a pulp adipofascial advancement flap for better soft tissue coverage of bone exposure stump was performed. The amputated parts were defatted, trimmed, and reattached as composite graft. The age and sex of the patients, injured finger, Hirase classification, mechanism of trauma, overall graft survival area, two-point discrimination (2PD) (mm) at 6 months, finger shortening length, average Disabilities of the Arm, Shoulder, and Hand (DASH) score, and subjective self-evaluation questionnaire score at 6 months were recorded. The mean graft survival was 89%. The mean shortening length was 2.2 mm. The 2PD at 6 months postoperatively was 6.3 mm on average (5–8 mm). The mean DASH (Disabilities of the Arm, Shoulder, and Hand) score at 6 months was 1.45. The self-assessed cosmetic results showed that 12 patients (85.7%) were very satisfied, and no patient was completely dissatisfied. Ultimately, in Hirase's [18] traumatic amputation of finger zone IIA, in which replantation is difficult, the modified technique of composite grafting with pulp adipofascial advancement flap provided an alternative option with a high success rate and acceptable functional and aesthetic results [21].

In 2021, Elzinga et al. stated that after a fingertip amputation, if vessels are present and in adequate condition, microsurgical replantation is the preferred therapeutic technique. Also, composite grafting has a limited role in the treatment of fingertip amputations due to its unreliable nature, but may be an option when the amputated fingertip is not replantable and the patient wishes to restore the length and aesthetics of the fingertip (Fig. 19.2). When composite grafting is selected as the treatment of choice for a particular patient, there are methods to optimize the chances of revascularization and graft survival, such as early grafting, graft cooling, and a moist wound healing environment [22].

19.3.2.2 Skin Grafts

Fingertip skin grafts are rarely used and must be full-thickness skin graft (FTSG). It is well known that a thin graft over bony prominence is the cause of tenderness and sensitivity [23, 24]. FTSG can be reliably and useful for pulp reconstruction [25], but sometimes loss of pulp contour and hypo- or hyperesthesia may appear [26]. The ulnar aspect of the hand has been used as a donor site, but we would avoid it because it is often a surface on which the hand rests during activity [27]. Skin grafts are associated with more tenderness, diminished sensitivity, and cold intolerance than what is seen after secondary healing [9].

19.3.3 Flap Reconstruction

There are a large number of flaps that can be used for fingertip reconstruction. Most fingertip amputations are adequately treated with V-Y advancement flaps and cross-finger flaps. The choice of flap is based on the type and location of injury, surgeon experience, and patient characteristics. Heterodigital flaps are usually avoided to limit the lesion to a single finger, and cross-finger flaps are avoided in older patients because of the risk of joint stiffness. Dissection and mobilization of the neurovascular bundle up to the common digital artery bifurcation with or without adjacent arterial division is routinely performed to facilitate flap advancement of 15–20 mm. Flexion of the IFP joint should be avoided and early mobility facilitated to minimize joint stiffness. Retrograde or reverse-flow flaps offer good coverage and thumb flexion and always check that the palmar arch is well preserved. Local flaps are tedious to perform and are associated with risk of flap failure and iatrogenic sensory loss is common even when experienced hand surgeons perform the surgery [9].

19.3.3.1 Volar V-Y Plasty

V-Y plasty can be used from the volar (Fig. 19.3), unilateral (Fig. 19.4), or bilateral side of the finger. Limited length is the major disadvantage of this technique [28, 29]. In 1985, Tupper et al. stated that V-Y plasty was a well-accepted method for the treatment of transverse fingertip amputations. Some authors had suggested that fingertip sensation was almost normal after the procedure. Tupper et al. analyzed 16 patients with 20 fingertip injuries, who reported a mean sensitivity estimate of 73% of normal. There was decreased sensitivity in two-point discrimination and/or von Frey monofilament testing in all fingertips compared with the digitocontralateral. Eight patients (12 digits) reported hypersensitivity, especially cryalgia. In almost all fingertips treated by V-Y plasty for transverse amputations, the sensitivity was not normal [30].

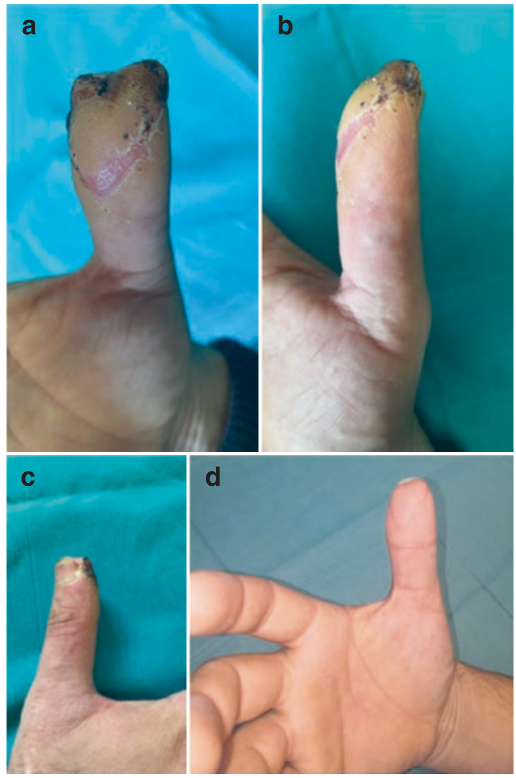

Fig. 19.3 (**a**–**d**) Palmar V-Y flap for first finger: (**a**) Palmar view 3 weeks after trauma. (**b**) Lateral view 3 weeks after trauma. (**c**) Dorso-medial view 3 weeks after trauma (**d**) Result 2 months after surgery

19.3.3.2 Advancement Flap

These are flaps such as V-Y plasty that use tissue close to the amputated area to cover the loss of substance. Their design and shape are variable. Dissection consists of releasing the structures that attach the cutaneous and subcutaneous tissue to the deep structures without injuring the neurovascular bundles of the digit (Fig. 19.5).

19.3.3.3 Cross-Finger Flap and Thenar Flap

These flaps require a two-stage surgery. Between two operations, patients must use a short-arm splint for approximately 3 weeks. The major dis-

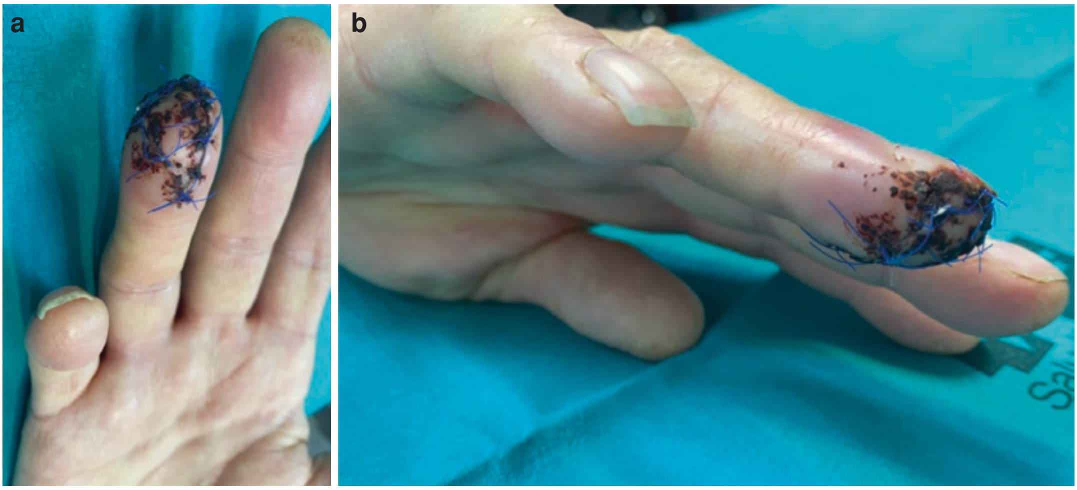

Fig.19.4 (**a**, **b**) Palmar V-Y flap: (**a**) Palmar view 1 week after trauma. (**b**) Medial view 1 week after trauma

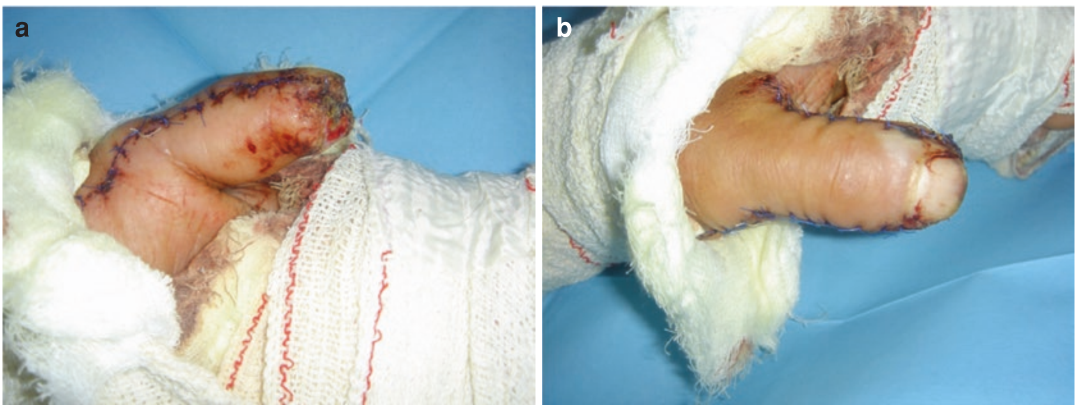

Fig. 19.5 (**a**, **b**) Moberg advancement flap for first finger: (**a**) Palmar view 1 week after trauma. (**b**) Medial view 1 week after trauma

advantage of the splint is joint stiffness [29, 31–33].

In 2016, Rabarin et al. performed a level IV evidence study in which they evaluated the long-term clinical outcomes of the use of cross-finger flap (CFF). It was a retrospective analysis of 28 patients operated on for fingertip amputation: 16 type III, 8 type II, and 4 type IV. The CFF was obtained from an adjacent finger on the dorsal side of the middle phalanx down to the epitenon. A dorsopalmar hinge was retained to ensure vascularization. The CFF was divided a mean of 18.7 days later. The following parameters were assessed: pulp volume (injured compared to contralateral finger), presence of neuroma, occurrence of complications (necrosis, infection, and donor site morbidity), cold discomfort, static and tactile discrimination, and patient satisfaction (from 0 to 10 on the VAS). The mean follow-up was 19.7 years; 22 patients (78.6%) were reexamined in person or contacted by telephone. The mean ratio of healthy to reconstructed pulp was 1.03. No postoperative complications, such as neuromas, were found. Cold sensitivity was present in seven patients. The flap was resensitized in all patients. There was no morbidity at the donor site. The mean patient satisfaction score was 9 (range 8–10). Ultimately, in the long term, the use of CFF resulted in near-normal fingertip metabolism, no complications, and good distal sensitization without pain or neuromas. CFF was found to be a simple, reliable, and durable reconstruction technique [34].

In 2017, Kwon et al. stated that although the thenar flap for single-finger amputation was a common and popular surgical technique, the double thenar flap technique for patients with two-finger amputations had rarely been published in the literature. In their case-control study, they presented the double thenar flap technique and compared the clinical outcomes between single thenar flap and double thenar flap surgical treatments. Over a 10-year period, 92 patients with single-finger amputations were treated with single thenar flap (group I) and 28 patients with two-finger amputations were treated with double thenar flap (group II). All 120 patients were followed up for a minimum of 12 months after surgery. At the last assessment, pain, cold intolerance in the reconstructed finger, functional outcomes according to Chen's criteria [35], and subjective patient satisfaction were evaluated in the two groups. At the last evaluation, all flaps in both groups had survived. No flap failure occurred. There were no significant differences in cold intolerance, donor site pain, fingertip pain, or paresthesia between the two groups. A total of 100 (83.3%) patients were completely or fairly satisfied. There was no significant difference in satisfaction between the two groups. According to Chen's criteria, 102 (85%) patients had excellent or good results. Ultimately, this study demonstrated that the double thenar flap technique used in patients with two-finger amputations produced complete survival with functional outcomes comparable to those of the single thenar flap technique [36].

19.3.3.4 Vascular and Neurovascular Island Flap

Vascular island flaps offer good skin coverage and are usually distant from the amputated area. They require experience in hand surgery for their dissection (Fig. 19.6). Direct-flow neurovascular island flap have better results in terms of sensitivity, providing direct blood flow without sacrificing a major artery. This technique is more favorable than reverse-flow flaps [37, 38] and it is elevated from the area close to the defect.

In 1986, Tsai and Juen analyzed 16 patients who had been treated with a neurovascular island flap for volar-oblique fingertip amputations with at least 2 years of follow-up. The mean active/passive ROM was 54/55 degrees at the DIP joint, 96/98 degrees at the PIP joint, and 83/83 degrees at the MP joint. Twelve of the 16 flaps (75%) had a two-point discrimination less than 10 mm. Moderate and severe problems included cold intolerance (6 patients), hypersensitivity (3 patients), stiffness (3 patients), and numbness (2 patients). Of the 16 patients treated with this technique, 14 were satisfied with the surgical outcome. This technique was safe and reliable for reconstructing volar-oblique fingertip amputations [39].

19.3.3.5 Reverse Homodigital Artery Flap Coverage

In reverse-flow flaps, the blood supply comes from the contralateral digital artery and has higher flow insufficiency rates. It requires dissection and transection of the major digital artery, has higher rate of insufficiency, and is elevated distantly from the defect area [37]. This flap is not indicated when direct-flow flap is possible [38].

In 2006, Alagoz et al. performed homodigital artery flaps to cover the bone and nail bed grafts taken from the amputation to restore fingertip function with acceptable results. They chose this flap because it provides vascularization of the grafts. Alagoz et al. mentioned how important it was to take into account venous insufficiency, as it could increase the likelihood of flap failure. They proposed to preserve a certain amount of soft tissue around the vascular pedicle to overcome venous insufficiency; they further opined that to preserve the length of the finger and the aesthetic appearance of the nail would mean sacrificing the digital artery [40].

In 2018, Sir et al. used reverse homodigital artery flap to cover the naked bone-nail complex and called it reposition flap [41], with good results as with homodigital artery flap.

Fig. 19.6 (**a**–**g**) Comet distal pedicled flap for first finger: (**a**) Injury and flap design. (**b**) Immediate postoperative period. Graft in donor site. (**c**) Immediate postoperative period. Flap in the thumb. (**d**) Result 1 week after surgery. (**e**) Result 1 month after surgery. (**f**) and (**g**) Result 4 months after surgery

Fig. 19.6 (continued)

19.3.4 Purse-String Suture as a Complementary Technique with Conventional Flaps in Repairing Fingertip Amputation

In 2011, Hassanpour et al. analyzed the use of purse-string suture as a complementary technique accompanying conventional flap repair in fingertip amputation. They studied 54 patients with fingertip amputations on the nail bed who had been referred to their hospital for fingertip reconstruction. Of these, 41 patients with at least one-third of the nail remaining (to preserve the nail) were chosen to undergo the aforementioned technique. Patient satisfaction with the functional results (pain and motion) was as follows: 32 excellent, 8 good, and 1 fair. Likewise, patient satisfaction with regard to the esthetic results obtained was excellent in 7 and good in 2 women ($n = 9$) and excellent in 19, good in 7, and fair in 6 men ($n = 32$). Ninety-three percent of patients (38 patients) had a two-point discrimination of less than 3 mm. No flap necrosis was observed in this study. The flap donor site was covered by primary closure (in 24 cases), secondary intention (in 11 cases), and skin graft (in 6 cases). The nail and finger contours were important to achieve a satisfactory esthetic and functional result. Hassanpour et al. considered that this complementary technique could be an easy way to achieve such a result. It was recommended that this technique was applied to all fingertip injuries to preserve the nail [42].

19.3.5 The Palmar Pocket Method

This technique consists of making a palmar subcutaneous pocket to cover the exposed areas of the fingertip amputation. This flap requires a two-stage surgery as cross-finger or thenar flap.

Brent in 1979 described a reimplantation technique, without vascular anastomosis, using a subcutaneous pocket. Brent chose the contralateral chest wall as a pocket site [43]. However, other clinical reports had used the abdominal wall. Complications, such as stiffness in the wrist, elbow, and shoulder joints and anxiety about pulling out the pocketed finger, were published in both locations.

Arata et al. in 2001 published their results using the Brent technique. To overcome these problems, they chose the ipsilateral palm and named this method the palmar pocket method. They used this technique in 16 cases in which amputation of a finger other than the thumb had occurred between the tip and lunula. In 13 cases, the method was completely successful, and in 3, there was a small area of tip necrosis. According to Arata et al., the palmar pocket method was a simple and reliable operation for fingertip reattachment and more comfortable for patients than pocketing in the chest wall or abdominal wall [44].

In 2012, Jung et al. used the pocket principle to treat 10 patients. All patients were adults and underwent complete fingertip amputation from the tip to the lunula in a digit. In all patients, the amputation was due to a crush or avulsion-type injury, and a microsurgical replantation was not feasible. In these patients we used the palmar pocketing method following a composite graft and prepared the pocket in the subcutaneous layer of the ipsilateral palm. Of the 10 cases, nine had complete replantation survival and one had 20% partial necrosis. In all cases, nail preservation was achieved, resulting in acceptable cosmetic results. In conclusion, a composite graft and palmar pocketing in adult cases of fingertip injury constituted a simple, reliable operation for digital amputation extending from the tip to the lunula. This method had satisfactory results [45].

19.3.6 Fingertip Replantation

Replantation is the primary option for amputation in terms of preserving function of the finger and getting good aesthetic result [46]. It uses the missing part by utilizing its original tissue and minimizes donor site morbidity (Fig. 19.7).

As published in 2021 by Van Handel et al., fingertip replantation is technically challenging, although in motivated patients, excellent aesthetic and functional results can be achieved [47].

This technique can provide excellent results and possibly reduce the risk of cold intolerance and painful neuroma when it is successful [9]. However, after fingertip replantation, cold intolerance was reported in 0%–35% [48, 49]. Hattori et al. compared 23 patients who had undergone fingertip replantation and 23 patients with fingertip revision amputation and found no statistically significant difference ($P > 0.05$) between the two groups in cold intolerance: 35% for replantation and 40% in revision amputation [48].

It is important to note that cold intolerance is assumed to be the result of vascular insufficiency and peripheral nerve injury rather than as a result of treatment [50, 51].

The publication's results can aid surgeons and patients to choose the best surgery option. After finger revision amputation, sensation can be similar or better than following fingertip replantation. Cold intolerance as well as DIP and PIP joint motion is similar to outcomes reported in the literature for replantation. The return to work time is shorter than what is reported after fingertip replantation. Future studies should evaluate health-related quality of life of both treatments [52].

In 2019, Yoon et al. concluded that with patient selection, replantation of all finger amputation patterns, whether single-finger or multifinger injuries, may be cost-effective compared with revision amputation. Multifinger replantations had a higher probability of being cost-effective than single-finger replantation. Cost-effectiveness may depend on injury pattern and patient factors [53].

Careful preoperative patient and lesion selection is essential to develop an appropriate treatment plan that takes into account the following factors [54]: (1) patient factors (medical comorbidity, age, physical and occupational demands, social factors, cultural and personal values, and psychiatric disease), (2) injury factors (level of injury, digits involved, mechanism, injury to adjacent fingers, and incomplete or complete amputation), and (3) Circumstantial factors (time to presentation and availability of post-replantation care).

Early indications for replantation are injuries threatening a catastrophic functional deficit (hands, thumbs, multiple digits, pediatric) [54–57]. Contraindications to fingertip replantation are consistent with those for amputation at any level and include severely crushed or mangled parts, multilevel injury to the same digit, comorbid or otherwise injured patients, severe atherosclerotic disease, and mental illness. A prolonged warm ischemia time is also a traditional contraindication to replantation, but the absence of ischemia-sensitive muscle at the fingertip level makes these amputations less time-sensitive. The traditional limit of warm ischemia for a digit replantation is 6–12 h [58], but even in excess of 12 h, success rates of more than 90% have been reported [59].

Fig. 19.7 (**a**, **f**) Reimplantation of the thumb: (**a**) Palmar view of the amputated fragment. (**b**) Dorsal view of the amputated fragment. (**c**) Radio-palmar view of the immediate postoperative result. (**d**) Dorsal view of the immediate postoperative result. (**e**) Palmar view 5 weeks after surgery. (**f**) Dorsal view 5 weeks after surgery

Fig. 19.7 (continued)

19.4 Do We Need to Repair the Nerves When Replanting Distal Finger Amputations?

In 2010, Wong et al. stated that distal replantation was an excellent model to study the results of nerve repair. In their study they attempted to demonstrate the differences in aesthetic, sensory, and functional outcomes in fingertip replantation, with and without nerve repair. They analyzed 28 fingers in 28 patients who underwent successful distal replantation over a 5-year period. Nerve repair was performed in half of the fingers. The mean follow-up was 39 months. Symptoms of pain, numbness, cold intolerance, scar hypersensitivity, pulp atrophy, and weakness were reported. Nail width, pulp length, two-point discrimination, Semmes-Weinstein test, and power were evaluated. No significant association was found between nerve repair and symptoms. No significant differences were found between groups, with and without nerve repair. All fingers showed a mean two-point discrimination of 5.6 mm, and Semmes-Weinstein test results were green in 3 fingers and blue in 17. There was no significant difference in the overall results when repairing or not repairing the nerve in distal finger replantation. Both groups had satisfactory results. Possibly spontaneous neurotization took place and nerve repair was not necessary [60].

19.5 Digit Tip Regeneration

This is a very promising field under study. The distal tip of the human is capable of endogenous regeneration after amputation and the identification of critical components of this response has led to treatments that expand the regenerative capabilities of nonregenerative amputation wounds. It is necessary to know the regeneration component cells and morphogenetic agents which are present at traumatic injury wound sites to stimulates a multi-tissue response that culminates in structural regeneration. Currently, regenerative failure is caused by a toxic wound environment that minimally lacks the signaling profile of a morphogenetic agent necessary to coordinate a multi-tissue regenerative response [61].

19.6 Conclusions

Injuries to the fingertips cause some 4.8 million visits to emergency departments in the USA each year. Multiple treatments are available (surgical and nonsurgical), but none is currently the gold standard. However, the goals of treating these injuries are clear: minimize pain, optimize healing time, preserve sensation and digit length, prevent painful neuromas, avoid or limit nail deformity, minimize lost time at work, and achieve an acceptable cosmetic appearance. Nonsurgical treatments include occlusive dressings and splint caps. Surgical techniques include the following: volar V-Y plasty, neurovascular island flap for volar oblique fingertip amputations, reconstruction of fingertip amputations with full-thickness perionychial grafts from the retained part and local flaps, cooling composite graft (Hirase technique), reverse homodigital artery flap coverage for bone and nail bed grafts, purse-string suture as a complementary technique with conventional flaps in repairing fingertip amputation, composite grafting, cross-finger flap, thenar flap, the palmar pocket method, reconstruction of incomplete distal thumb amputations, graft reposition on flap in Allen type IV amputation, and fingertip replantation.

Currently with the development of microsurgery, if the amputated part is in good condition, replantation is the favored intervention. If replantation is not performed, multiple chirurgical/nonsurgical options are available depending on the type of injury, patient characteristics, and surgeon preferences. The development of regenerative medicine would offer an ideal solution that is still in its very early stages.

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