6 Fingertip Amputations: Coverage, Local and Regional Flaps

David T. Netscher and J. B. Stephenson

Introduction

Armed with the understanding of axial blood supply and perforator sites, the treatment of fingertip amputations has undergone substantial change in the last 40 years. Early innovators such as Kutler [1] and Atasoy [2] proposed local advancement flaps for small defects of the distal fingertip As our knowledge of the axial blood supply to the finger progressed, the principle behind these flaps allowed for the description of multiple local and regional flaps for coverage of finger defects. Today, these flaps serve to enhance the armamentarium of the surgeon when presented with a complex defect of the fingertip.

The arterial blood supply to the fingers (Fig. 6.1) comes primarily from the superficial palmar arch and the subsequent common digital arteries. These common digital arteries branch at the level of the metacarpophalangeal (MP) joint to become the proper digital arteries. Other sources of arterial inflow to the finger include distal branches of the deep palmar metacarpal arteries which arise from the deep palmar arch and distal branches of the dorsal metacarpal arteries. Between these sources of arterial inflow are ulnar to radial and palmar to dorsal communications. The ulnar to radial communications are the transverse palmar arches located at the neck of the phalanges deep to the flexor tendon sheath. The palmar to dorsal communications are located at the metacarpal neck and the base and necks of the phalanges. The more distal dorsal communications may actually exist as perforators that replace the contribution of the dorsal arteries. The inherent redundancy in these communications allows for the design and implementation of local flaps of the finger while preserving blood supply to the overall digit.

The Evidence: Literature Review

Many options exist for the treatment of fingertip amputations. These include primary repair, revision amputation, nonvascularized and vascularized composite grafting, skin grafting, and healing by secondary intention. Most of these well-established treatment options are surgically

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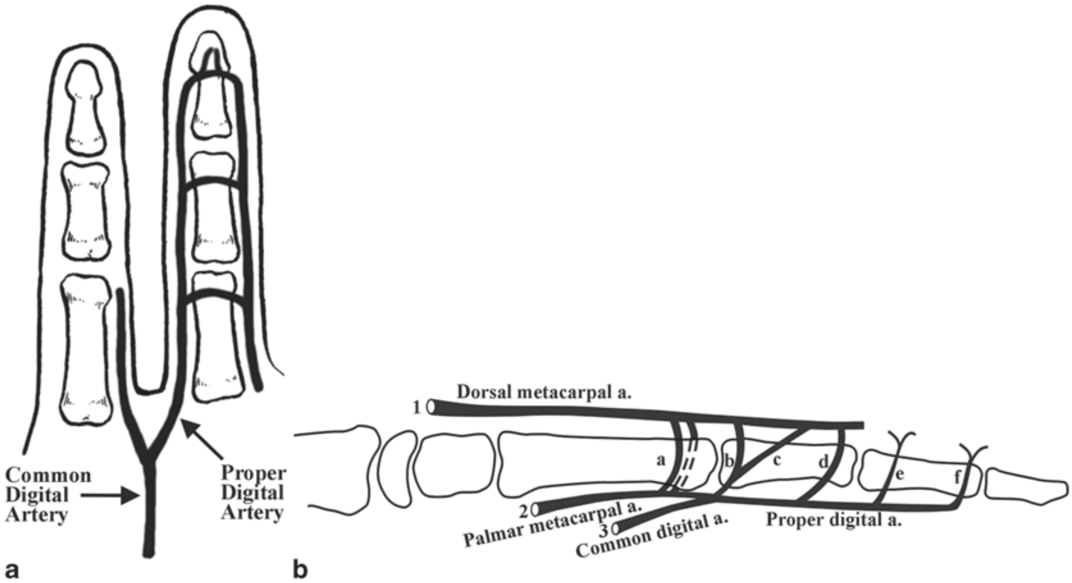

Fig. 6.1 **a** Transverse arterial connections exist between ulnar and radial digital arteries. **b** There are volar to dorsal arterial connections in the hand and finger (*1* Dorsal carpal arch, *2* Deep palmar arch, *3* Superficial palmar arch, **a**–**f** palmar to dorsal connections)

straightforward and are reliable choices for small defects of the fingertip.

Choosing the optimum treatment alternative depends on the goals of treatment. The primary goals of treating a fingertip defect are a functional, pain-free, sensate tip that meets the occupational and avocational needs of the patient. Secondary goals of treatment include restoration of volar pulp contour, avoidance of nail deformities, maintenance of functional length, and quick recovery.

The concept of the "reconstructive ladder" has traditionally been utilized to determine the balance between the reconstructive need of the defect and the reconstructive complexity of the surgery, with the simplest option being the preferred option (Fig. 6.2). However, this concept has been replaced with the "reconstructive elevator," where the best surgical option according to the needs of the patient and the skill of the surgeon may be the more complex option [3]. Bennett and Choudhary stated, "Why climb a ladder when you can take the elevator?" [4]. Hence, the optimum treatment alternative and its surgical complexity will vary according to the goals of treatment and the needs of the patient (Fig. 6.3). Healing by secondary intention may be the ideal choice for straightforward defects of the fingertip. In particular, wounds with minimal bone exposure (<3 mm), no tendon exposure, and less than 1 cm^2 total surface area can be expected to heal within 4 weeks with eventual recovery of normal sensation in the majority of patients [5]. While some have expanded secondary intention to include defects >1 cm^2, this is at the expense of increased time to healing and sometimes a tender and dry scar. A patient with planing injury 2.8 × 1.8 cm in site and no bone exposed (Fig. 6.4a) is shown. In secondary intention, within hours, phagocytosis of the necrotic tissue at the end of the finger occurs, local blood vessels dilate, and an exudate forms over the wound composed of fibrin clot and inflammatory cells. Phagocytes remove necrotic debris and fibroblasts lay down bridging scar tissue (Fig. 6.4b). Peripheral epithelial cells grow inward to cover the defect. The underlying scar contracts and the defect closes (Fig. 6.4c). New nerve endings subsequently grow into the subdermal layers and sense organs repopulate the newly covered area.

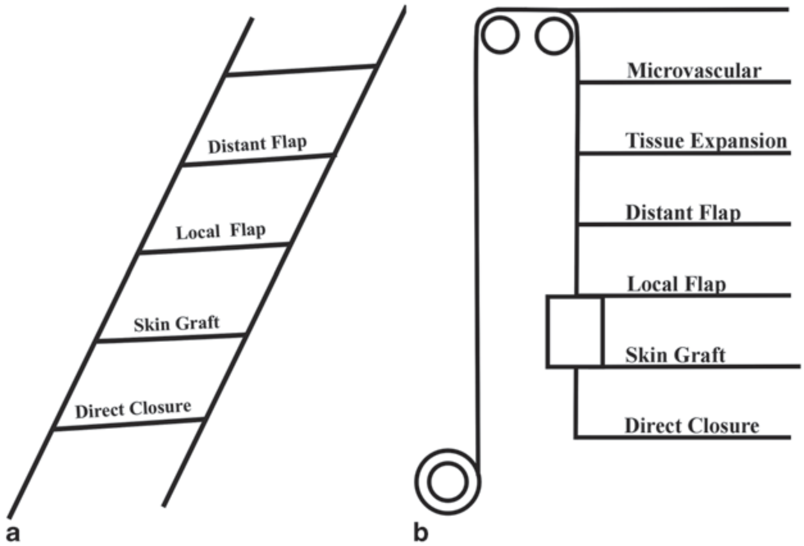

Fig. 6.2 **a** Reconstructive ladder. **b** Reconstructive elevator

Other advantages of secondary intention healing include low risk of acute infection, minimal long-term stiffness, and satisfactory aesthetics [5, 6]. Long-term complications associated with secondary intention healing include 36 % cold intolerance and 26 % scar tenderness at 6 months in one study [6]. Skin grafting is another option for coverage of similar fingertip defects. Full-thickness grafts from the hypothenar eminence or a flexion crease are preferred. However, skin grafts typically have poorer sensory recovery and aesthetics than healing by secondary intention.

Revision amputation remains a popular choice for complex defects of the fingertip. In the presence of significant bone loss, tendon loss, or devascularization, revision amputation is preferred over secondary intention or skin grafting. Advantages of revision amputation include less surgical demand and quicker return to work than more complex forms of reconstruction. Complications associated with revision amputation include residual irritating nail remnant, decreased tip sensation, painful neuroma, and cold intolerance.

Nonflap options for coverage of fingertip amputations including healing by secondary intention, skin grafting, and revision amputation remain widely popular and have their established roles and indications. However, secondary intention is limited to defects of appropriate size without exposure of critical parts. Revision amputation requires shortening of the digit and is limited by poor aesthetics and risk of neuroma formation. Therefore, when secondary intention will not suffice and length preservation is desired, local and regional flaps are preferred.

Indications and Classification

When considering more complex wounds in the appropriate patient, the surgeon should employ the reconstructive elevator and consider local or regional flap coverage. These flaps can be classified as traditional local advancement flaps, staged flaps, and island flaps.

Local Advancement Flaps

An advancement flap is a segment of tissue with an intact blood supply that is advanced forward to fill an adjacent defect. The primary examples of local advancement flaps used in fingertip injuries are the V–Y advancement flaps described by Atasoy [7] and Kutler [8]. Limited fingertip injuries that involve exposed bone are ideal candidates

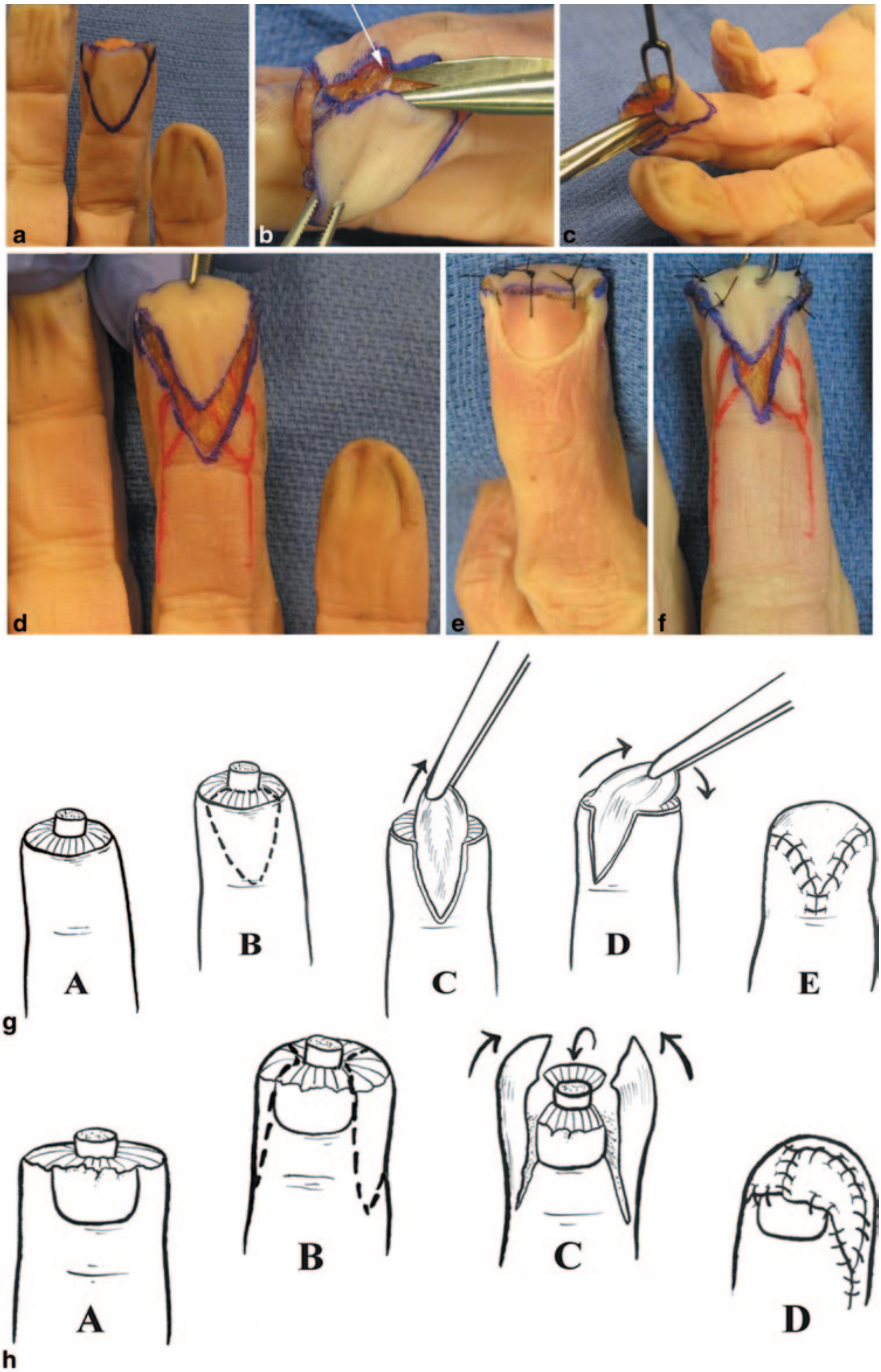

Fig. 6.3 **a** Preoperative markings of flap for transverse distal tip defect. **b** Fibrous septae (*white arrow*) are carefully identified and released. **c** Flap is elevated directly off the periosteum. **d** Flap is advanced to cover the defect. Note the red markings identifying the preserved oblique arterial vessels. **e**, **f** Sutures are placed distally through the nail plate to secure the advanced flap. If too much tension is required to close the proximal incisions, then these may be *left* open to heal secondarily. **g** Line drawing of volar V–Y advancement flap. (Atasoy). **h** Line diagram of Kutler flap

Fig. 6.4 **a** Acute planing injury of volar pad, no bone exposed **b** At 2 weeks, phagocytosis of the necrotic tissue, dilation of blood vessels, and exudate formation composed of fibrin clot and inflammatory cells. **c** Peripheral epithelial cells move towards the center to cover the defect, which begins to close by myofibroblast wound contraction.

for V–Y advancement flaps if too much bone debridement is required to allow healing by secondary intention. Patterns of amputation injury determine the most appropriate method of soft tissue advancement. In general, transverse or dorsally angulated amputations of the fingertip are suitable for a volar V–Y advancement flap as described by Atasoy and modified by others. Volarly angulated tip and apical fingertip amputations may potentially be covered by bilateral V–Y advancement flaps as described by Kutler; however, other flaps may be preferred. The advantages of V–Y advancement flaps are the low–moderate technical demand, digit and nail length preservation, and minimal donor-site morbidity.

Staged Flaps

Staged flaps involve two stages for completion of the fingertip reconstruction. The most popular staged flaps are the thenar flap and the cross-finger flap, both random pattern flaps that do not have a specific blood supply. The thenar flap and the cross-finger flap are used for volarly angulated fingertip defects, when local V–Y advancement flaps are not possible. The thenar flap was first described in 1926 by Gatewood [9]. Having undergone modification since its first description, the donor site is typically near the base of the MP joint of the thumb, which reduces the amount of finger flexion and utilizes donor skin redundancy, which reduces the degree of finger flexion and enables primary donor wound closure compared with the more proximal placement of the thenar donor site that was originally described. At the initial surgery, the flap is elevated and the injured finger is flexed to be inset into the elevated flap. After a period of time, to allow for vascular ingrowth of the recipient bed (typically 14 days), the flap is divided and inset in the volar pulp defect at a second stage. The risk inherent in the thenar flap procedure is that of recipient finger stiffness; hence, this flap is better suited for the pediatric and young adult population.

The cross-finger flap is also used in volar pulp defects with exposed bone or tendon not amenable to secondary intention healing. The dorsal soft tissue over the middle phalanx of the adjacent digit is used to cover the defect while the donor site is covered with a full-thickness skin graft. For skin graft adherence, the paratenon must be left behind on the donor digit. Like the thenar flap, the flap is divided and inset into the recipient bed after a period of time to allow for vascular ingrowth. An advantage of the cross-finger flap over the thenar flap is the ability to provide coverage to multiple traumatized fingertips in a stacked fashion. Additionally, the flap is useful in volar thumb defects where the thumb can rest comfortably against the donor index finger. Cohen and Cronin [10] described a technique for innervating the cross-finger flap to provide better sensibility by utilizing the dorsal branch of the digital nerve. Disadvantages of the cross-finger flap include finger stiffness, cold intolerance, and unacceptable cosmetic deformity of the donor site. The flap may not be suitable for elderly or female patients for these reasons.

Island Flaps

Island flaps are axial pattern flaps that maintain blood flow through a specific vascular pedicle. The idea of island flaps for fingertip coverage was not fully espoused until the principle of axial pattern blood supply to the hand and fingers was better understood. Armed with this understanding, the options for coverage of fingertip defects have flourished. Island flaps allow the surgeon to approach fingertip amputations with respect to the flap options and not the specific pattern of the defect. Island flaps may be classified as homodigital or heterodigital, antegrade or retrograde blood supply, and innervated or noninnervated. Multiple authors [11, 12] have discussed the advantages of island flaps which include:

1. More tissue is available to completely cover large defects.
2. Reconstruction can be completed in a single stage, which allows for early digital mobilization and reduced stiffness.
3. Single-stage coverage minimizes the potential contamination of hardware used for fixation and tendon spacers unlike two-stage procedures.
4. The flap is mobilized to reach the defect, not the fingertip flexed to reach the flap. This prevents immobilization in awkward positions for prolonged periods, which decreases the chance of postoperative stiffness.
5. Island flaps have more bulk and are more similar in texture to the recipient defect than are staged flaps.
6. Innervated island flaps allow the surgeon to provide sensate tissue to the defect with improved long-term sensibility.
7. A greater arc of rotation or advancement can be achieved when not tethered by skin or fascial connections.

When considering the reconstructive elevator, island flaps may be considered the ideal choice for soft tissue coverage and reconstruction of fingertip defects when preservation of length and maximal function are desired and critical structures are exposed or injured.

Techniques

Volar V–Y Advancement Flap

The volar V–Y advancement flap is indicated for transverse or dorsally angulated traumatic amputations of the fingertip involving exposed distal phalanx. The advantage of this flap over revision amputation is the preservation of nail length and the potential for minimizing hook nail deformity. The blood supply of the flap is the oblique terminal branches of the digital arteries arising from the trifurcation at the distal interphalangeal joint. This is, in essence, a subcutaneous pedicle flap.

A triangular flap is designed on the volar pulp of the remaining fingertip (Fig. 6.3 shows cadaver dissection). The width of the flap distally equals the width of the defect. The flap then tapers proximally to a V at the level of the distal interphalangeal flexion crease. Leaving the apex too distal will provide an insufficient flap to advance; leaving the apex too proximal will potentially cause scar contracture at the flexion crease. The volar skin incisions are made with care taken not to incise into the deep subcutaneous tissue. Under loupe magnification, the fibrous septae are released with longitudinal blunt spreading to allow for distal advancement of the flap, while preserving the adjacent oblique vessels. A single hook may be used to grasp the distal flap to create tension and allow for visualization of any tethering septae. The flap is then elevated off the periosteum sharply to release the deep attachments of the terminal pulp fibrous septae and allow distal mobilization. Advancement of up to 1 cm can be expected with adequate release. The distal edge of the flap is typically sutured in place. Proximal sutures may be placed, but if the flap appears ischemic after tourniquet release, then the proximal incision may be left open to heal secondarily. Some have suggested spearing of the distal flap with a longitudinal k-wire as a way to inset the flap without suture and minimize tension. We have not generally recommended this.

Staged Flaps: Cross-Finger Flap and Thenar Flap

Cross-finger flaps are indicated for volar pulp defects with exposed bone or tendon. Multiple “stacked” cross-finger flaps can be used when multiple digits are involved, as is seen in industrial injuries. The blood supply to this flap is considered random.

A dorsal rectangular flap of an adjacent finger is designed over the middle phalanx to match the size of the pulp defect (Fig. 6.5). The flap is elevated off the donor digit just above the paratenon of the extensor mechanism to allow for full-thickness skin grafting of the donor defect. The flap is hinged at the midaxial line on the side of the recipient defect and inset into the defect using interrupted suture. Sensory outcomes of cross finger flaps can be improved by coapting the donor dorsal branch of the digital nerve into the recipient digital nerve stump [13]. A full-thickness skin graft is then placed over the dorsal donor defect. The patient must be splinted postoperatively to prevent shearing of the flap. At 2 weeks postoperative, the flap is divided under local anesthesia. After the second stage, an aggressive range of motion protocol should be instituted to prevent flexion contracture of the digits.

A clinical case example is illustrated in Fig. 6.6. This case is also illustrative of another clinical point as an option when a patient brings in the amputated part of a fingertip amputation. Composite grafts of the amputated part often undergo necrosis. Replantation is difficult because of absence of suitable veins for anastomosis. The perionychial structures may be retained as a full-thickness graft and are supported by a “living” and bulky flap such as a cross-finger flap. The critical perionychial tissues have been preserved.

The thenar flap is indicated in similar volar pulp defects and is particularly well suited for the index and middle fingers of pediatric patients (Fig. 6.7). The affected finger is flexed down to the thenar region to locate the appropriate site of the subcutaneous flap. In children, the flap can often be located near the MP flexion crease, which will provide a well-hidden scar after flap division. The size of the flap is designed about one third larger than the size of the defect. The flap is elevated from the donor site and sutured to the recipient pulp defect. A dressing and splint are applied. Two weeks later, the flap is divided and the remaining raw edge is left to heal secondarily or it is loosely sutured. The donor site is closed primarily or with a small transposition flap. The available soft tissue redundancy at the MP region enables easy donor-site direct wound closure.

Antegrade Homodigital Island Flap

The precursor to antegrade homodigital island flaps was the oblique triangular flap, a local advancement flap popularized by Venkataswami and Subramanian for oblique pulp defects [14]. Island flap modifications were introduced to provide increased mobilization and allow for coverage of defects up to 10 × 20 mm at the pulp. The flap receives its blood supply from the digital vessel opposite the defect.

The skin pattern for the antegrade homodigital island flap is designed with its midaxis just dorsal to the digit midaxis (Fig. 6.8). The proximal portion of the flap is tapered as a V to the level of the proximal interphalangeal (PIP) joint. A longitudinal incision then extends along the digit’s midaxis to the MP joint to allow for proximal dissection of the pedicle. The medial/volar incision is made first, extending through the skin and down to the flexor tendon sheath. The dissection then proceeds laterally/dorsally along this plane until the neurovascular pedicle is visualized within the pedicle on its underside. The dorsal/lateral incision is then made, isolating the neurovascular pedicle within the skin island. After the entire skin island is elevated, retrograde dissection of the neurovascular pedicle with a fibrofatty cuff of tissue is performed with microvascular instrumentation under loupe magnification. The fibrofatty cuff must be generous and handled with care, as this contains the small venae comitantes which provide venous outflow of the flap. Continued proximal dissection will allow for greater flap advancement as the neurovascular pedicle is medialized along the digit. Sufficient mobilization is attained when

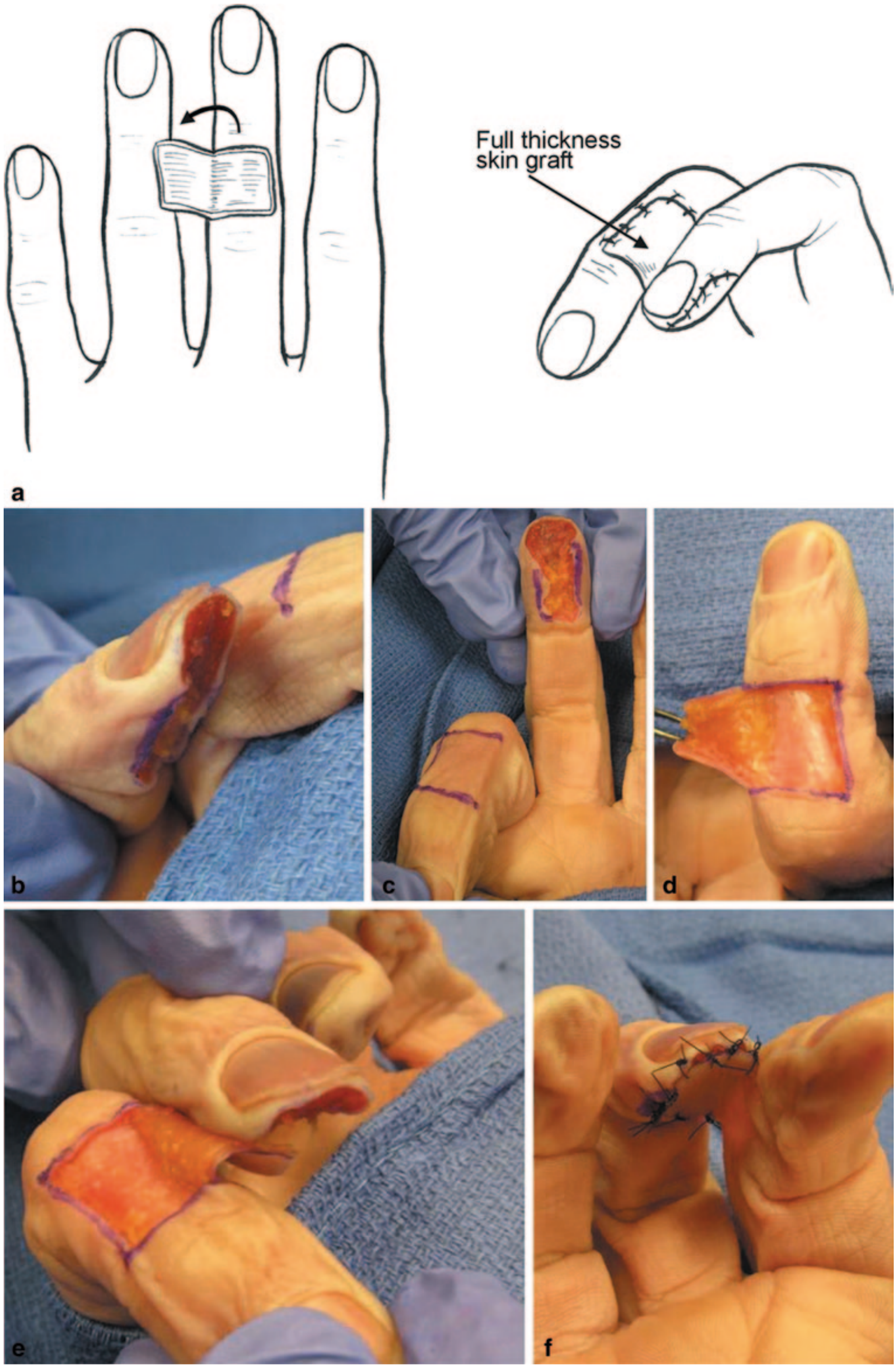

Fig. 6.5 **a** Line drawing of cross-finger flap. **b** Indications for cross-finger flaps include volar pulp defects. **c** Preoperative markings of dorsal rectangular flap on adjacent finger. Note that the flap is *not* incised on the midaxial line on the side of the recipient defect to allow turnover of the flap. **d** The subcutaneous flap is elevated just above the level of the paratenon to allow skin grafting of the donor site. **e** The flap is turned over to cover the adjacent pulp defect. **f** The cross-finger flap is sutured in place. The donor site is skin grafted (not shown)

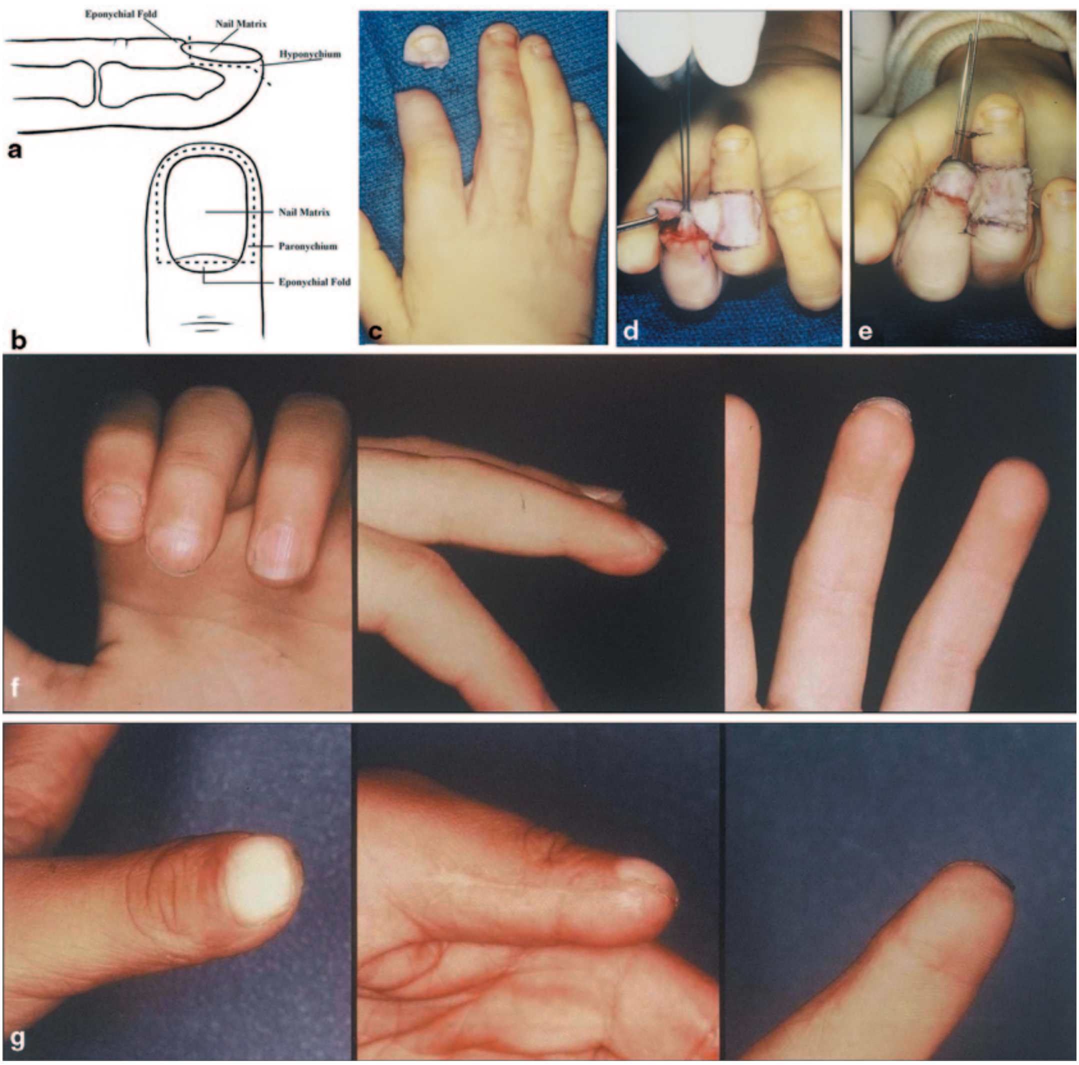

Fig. 6.6 **a** and **b** Perionychial structures are excised from the amputated part. **c** Amputated fingertip. Proximally, germinal matrix is present and will enable future nail plate growth. **d** Cross-finger flap provides volar pulp pad bulk and a vascularized bed for the perionychial graft. **e** Perionychial graft sutured in place. **f** and **g** Long-term result in the patient treated with cross-finger flap (*bottom*) and in a patient treated by perionychial graft and advancement Moberg flap for volar pulp support in a thumb

the flap can reach the defect. The defect should never be brought to an inadequately mobilized flap as this can lead to finger flexion contracture. The flap is inset loosely with interrupted sutures and the tourniquet is released to assess adequate vascularity of the skin island. Poor perfusion is remedied by release of suture and possible skin grafting of any donor defect unable to be closed without excessive tension. After initial healing (7–10 days), range of motion exercises are begun; nighttime extension splints can be used as well to prevent flexion contractures.

Using this flap, Foucher et al. [15] reported 84 % of patients achieving sensation with two-point discrimination of 3–7 mm. In patients whose index fingers were treated, 12.5 % substituted the middle finger for fine pinch activities. Eighty-three percent of patients achieved full

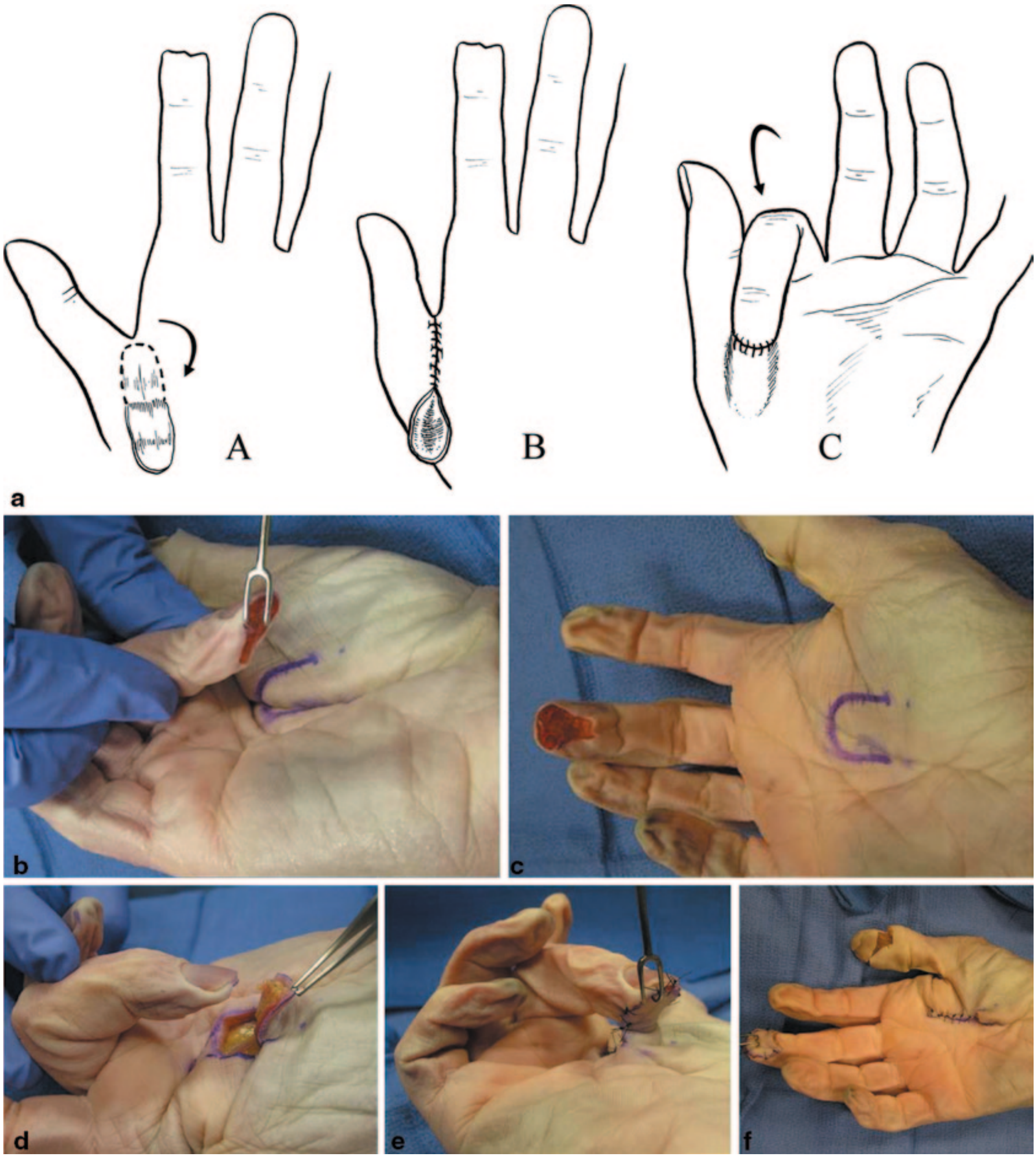

Fig. 6.7 **a** Line drawing of thenar flap with volar pulp defect. **b** and **c** The affected finger is flexed to the thenar region to locate the proper site for flap placement and design. **d** The flap is elevated in the subcutaneous plane at the level of the palmar fascia. **e** The flap is sutured in place with the finger flexed. **f** At the second stage, the flap is separated from the donor site. Dog ears of the donor site are tailored and the incision is closed

extension, with 17 % of patients developing PIP extension deficits (mean 23°, range 10°–70°). Total flap failures occurred in 3 % and the mean time off work was 61 days.

Contralateral pulp exchange island flaps have also been described [11] to provide sensate tissue to defects critical for fine pinch (e.g., radial-sided pulp defect of the index and middle fingers). Additional modifications of the antegrade homodigital island flap include a proximal extension of the skin island to the MP joint, a dorsolateral skin

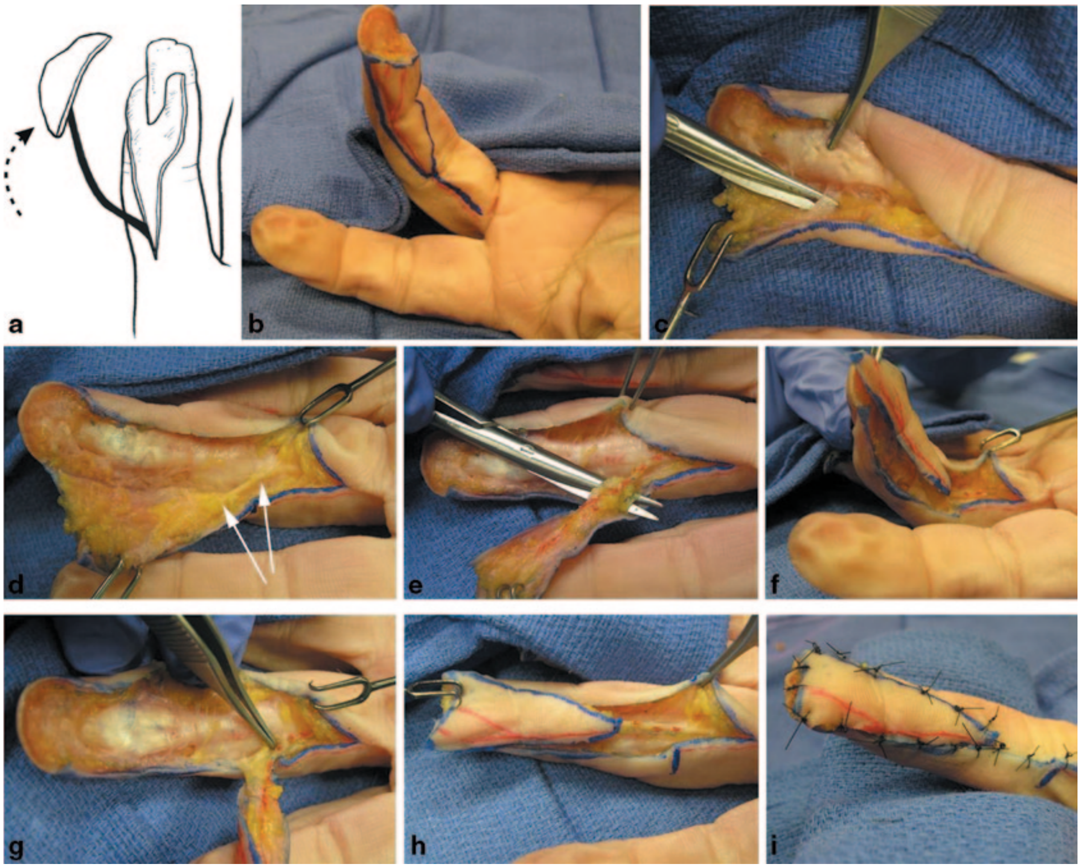

Fig. 6.8 **a** Line drawing of antegrade homodigital island flap for pulp defects. **b** Flap design extending from proximal interphalangeal joint distally to the defect. **c** The volar incision is made and both the flap and ipsilateral neurovascular bundle are elevated off of the flexor tendon sheath. **d** The neurovascular bundle is identified within the flap and dissected proximally (*white arrows*). **e** Once the location of the neurovascular bundle is confirmed within the elevated flap, the dorsal incision is made and the flap is elevated on the neurovascular bundle with a fibrofatty cuff. **f** An attempt is made to bring the flap to the defect, but in this demonstration, the flap is inadequately released and mobilized and so finger flexion is required to bring the defect to the flap. Closure at this point would inevitably lead to postoperative flexion contracture and finger stiffness. **g** Further mobilization of the flap along the neurovascular bundle proximally is warranted. Additional fascial bands are released. **h** Now, after adequate release, the flap can be advanced to the defect without finger flexion. **i** Final inset of the flap with the finger in full extension, minimizing the risk of postoperative contracture and stiffness

pattern to increase the size of the flap, and a step-ladder design to aid in donor-site closure.

Retrograde Homodigital Island Flap

First described to cover exposed PIP joints [16], the retrograde or reverse-flow homodigital island flap can be successfully used to cover both volar and dorsal fingertip defects. The advantages of the retrograde island flap over the antegrade island flap are its greater arc of rotation and potentially larger size. The disadvantages are the need for skin grafting the donor site, the intermediate quality skin compared to the distal glabrous skin captured in the antegrade flap, and the inferior long-term sensation, though the dorsal digital nerve can be retained in the flap and repaired to the digital nerve for improved sensation. The blood supply of the retrograde homodigital island flap is via the transverse communicating arterial arcade of the opposite digital artery. This arcade is located at the condylar neck of the middle phalanx at the base of the flexor tendon sheath.

The retrograde homodigital island flap is designed along the side of the digit overlying the proximal phalanx according to the size of the defect (Fig. 6.9). An additional line is extended longitudinally to allow for distal dissection of the vascular pedicle. Like the antegrade flap, the flap is incised along the volar/medial portion first and dissection proceeds directly down to the flexor tendon sheath. The flap is then elevated laterally/dorsally along this plane until the proximal neurovascular bundle is seen entering the flap. At this point, the flap may remain a noninnervated flap by dissecting the digital nerve from the flap while maintaining continuity of the digital artery with the flap. Some authors have described using either the digital nerve or the dorsal branch of the digital nerve to provide an innervated flap, with neurorrhaphy to the cut distal nerve end within the defect. The proximal digital artery is ligated and the dorsal/lateral incision is made, isolating the island flap on its distal vascular pedicle. The pedicle is then dissected with a generous fibro-fatty cuff of tissue to preserve the reverse venous outflow to the level of the distal portion of the middle phalanx, where the transverse communicating arterial branch crosses to the opposite digital artery. The flap is inset with interrupted suture and a full-thickness skin graft is placed in the donor site.

Lai et al. [17] reported an overall morbidity rate of 15 % using the retrograde island flap, with a total flap loss rate of 4 %. In a subset of 22 patients in their series, the average two-point discrimination was 3.9 and 6.8 mm in the innervated and noninnervated flaps, respectively. Han et al. reported an update of their experience with the retrograde island flap [18, 19]. They reported that they no longer perform innervated flaps because the long-term results of sensation were no different statistically or clinically compared to nonin-

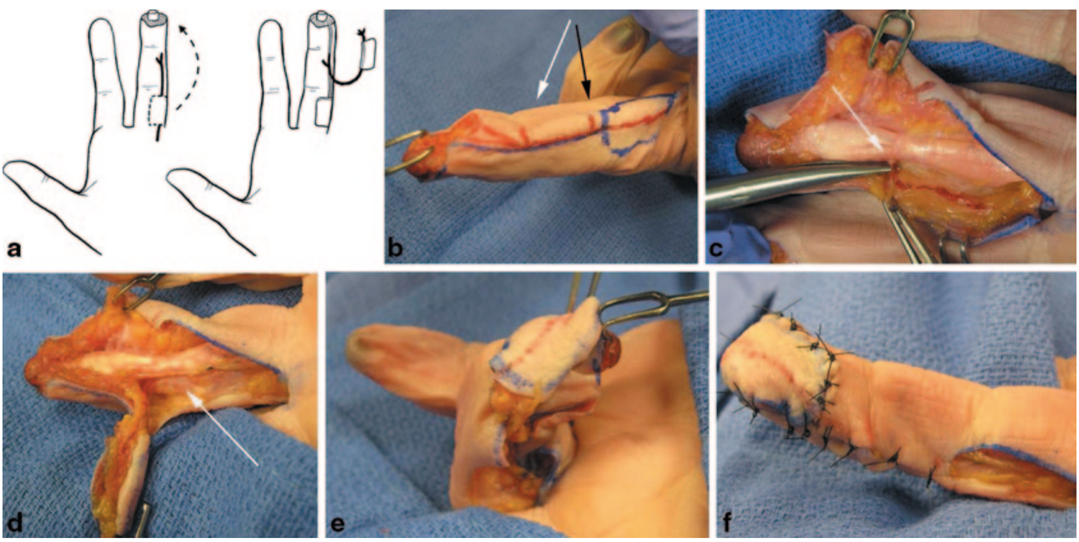

Fig. 6.9 **a** Line drawing of retrograde homodigital island flap. **b** Flap design along the side of the digit overlying the proximal phalanx. *Red* markings (*arrows*) indicate the transverse communicating arterial arcades at the necks of the proximal and middle phalanges. The flap will receive its retrograde blood supply from the distal arcade at the neck of the middle phalanx (*white arrow*). **c** The volar incision is made and the flap is elevated off of the flexor tendon sheath. The transverse communicating arterial branch at the neck of the middle phalanx is identified proximal to the distal interphalangeal joint (*arrow*). **d** The dorsal incision is made and the flap is elevated with its pedicle. For noninnervated flaps, the digital nerve is dissected away from the artery and preserved (*arrow*). **e** The arc of rotation for the retrograde flap allows coverage of dorsal finger defects. **f** The flap is inset in the volar wound shown. The donor defect on the side of the finger will require skin grafting

nervated flaps. They also prefer to design the flap in a stellate shape to avoid scar contracture.

Figure 6.10 is a clinical case of a patient who had a retrograde island homodigital flap for a large volar pulp fingertip injury.

Heterodigital Island Flap

The heterodigital neurovascular island flap was originally described by Littler to provide a sensate flap to the thumb tip [20]. Concerns regarding donor-site morbidity, decreased long-term sensation and difficulty with cortical sensory reintegration, and acceptable alternatives have substantially decreased its indications and use. The noninnervated heterodigital island flap, however, preserves the donor digital nerve and remains suitable for fingertip defects. In particular, large defects can be covered by the noncritical side of a longer, adjacent digit while preserving the donor digital nerve and donor pulp. The donor digit must be longer than the recipient digit so that donor pulp does not have to be violated in order to obtain sufficient flap size. An ideal scenario involves a large volar avulsion defect of the

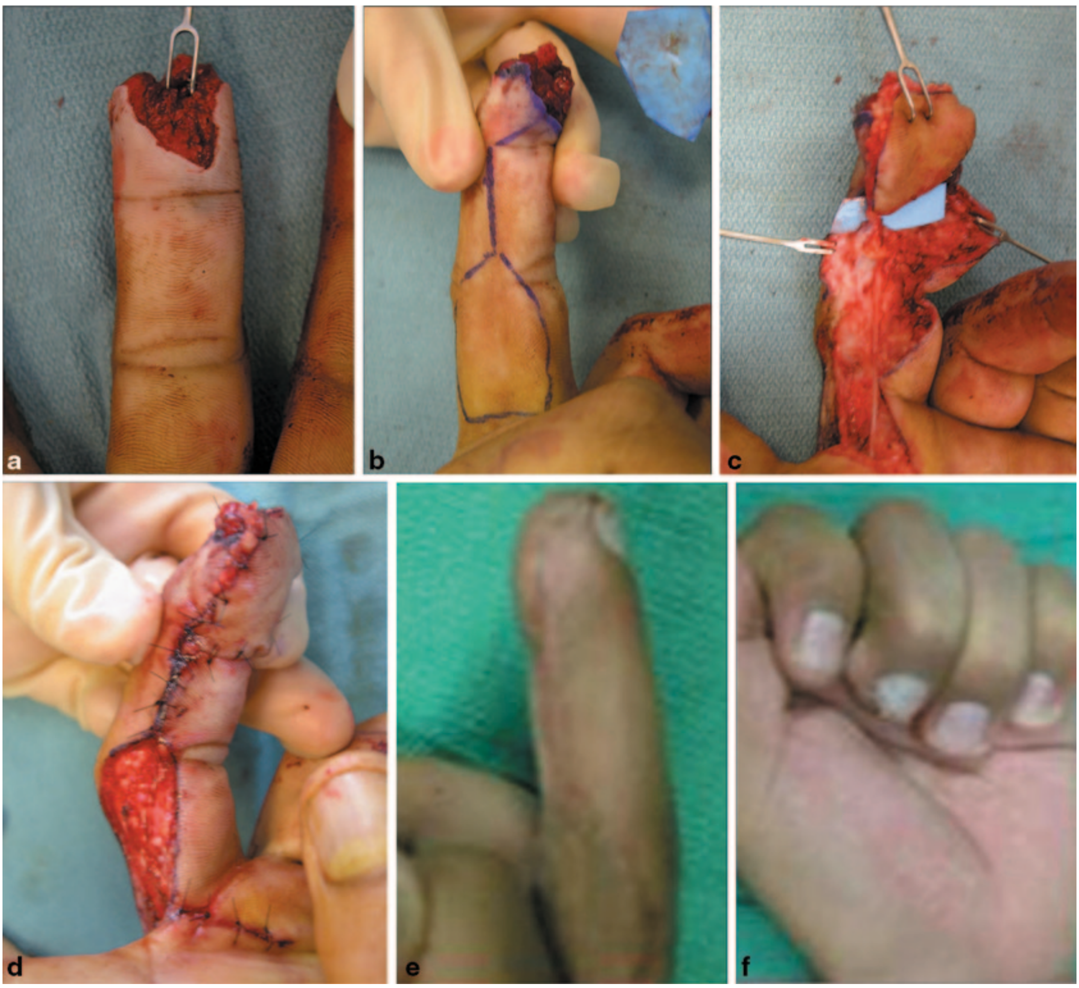

Fig. 6.10 **a** Volar fingertip injury. **b** and **c** Retrograde flow island flap design and transposition. **d** Insetting of flap. **e** and **f** Long-term outcome showing restoration of fingertip contour, finger is devoid of contractures, and skin-grafted donor site is on side of the finger

tip of the small finger wherein the ulnar side of the ring finger may be used as a donor.

The heterodigital island flap is designed along the noncritical border of the adjacent finger to match the defect (Fig. 6.11). The distal extent of the flap is to the distal interphalangeal joint, thereby avoiding the use of donor pulp tissue. The flap is incised and elevated in a similar fashion to the homodigital island flap. The digital nerve is dissected from the flap to preserve donor digit sensation. The pedicle and its fibrofatty cuff are dissected proximally to the common digital bifurcation and then the flap is transposed to the adjacent, smaller finger and inset into the pulp defect. Full-thickness skin graft is used to cover the donor-site defect.

Figure 6.12 shows a heterodigital island flap used to provide volar distal pulp reconstruction to the middle finger following vascular malformation excision.

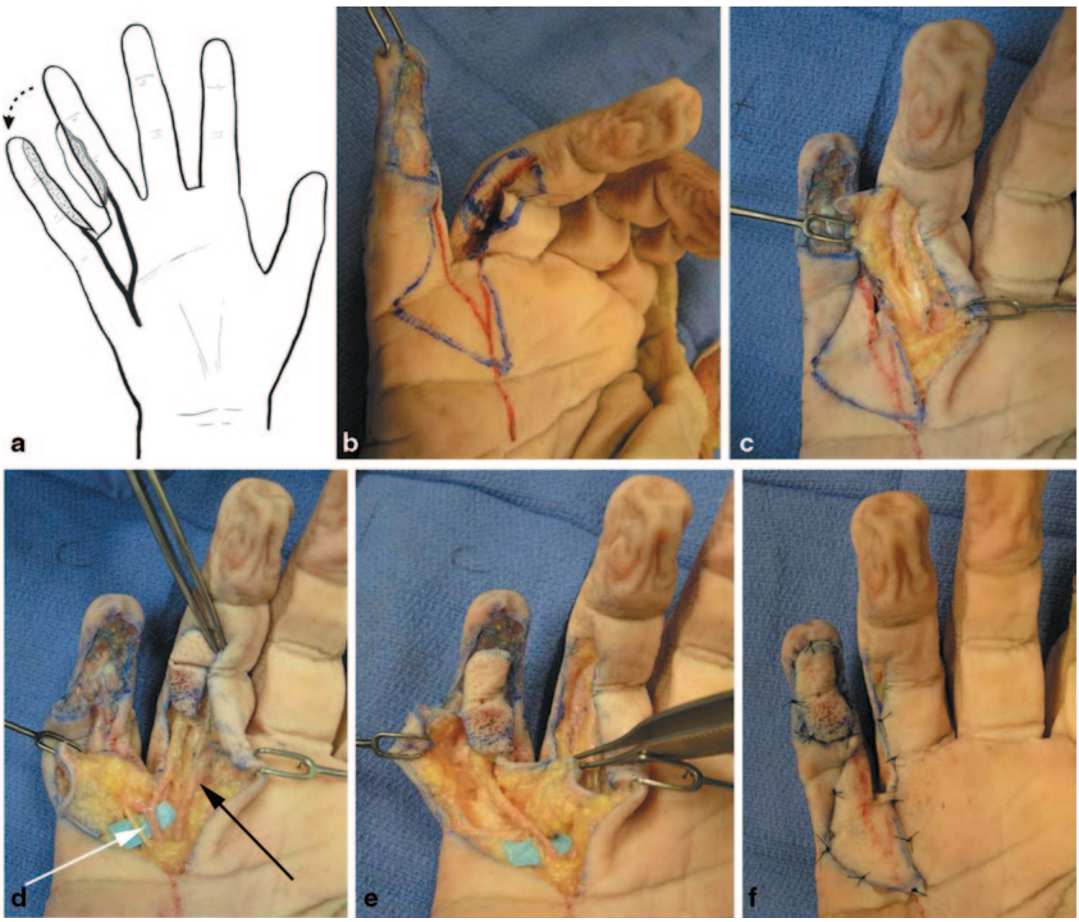

Fig. 6.11 **a** Line drawing of heterodigital island flap for small finger defects. **b** Flap design on the adjacent ulnar side of the ring finger. Note that the flap design does not involve the pulp of the ring finger. **c** The volar incision is made and the flap is elevated off of the flexor tendon sheath. **d** The digital artery is dissected proximally to the common digital artery bifurcation (*white arrow*). The digital nerve is dissected away from the flap and preserved (*black arrow*). **e** The flap is transposed into the small finger defect. **f** Final flap inset and closure. Note that often a skin graft will be required to close the donor defect

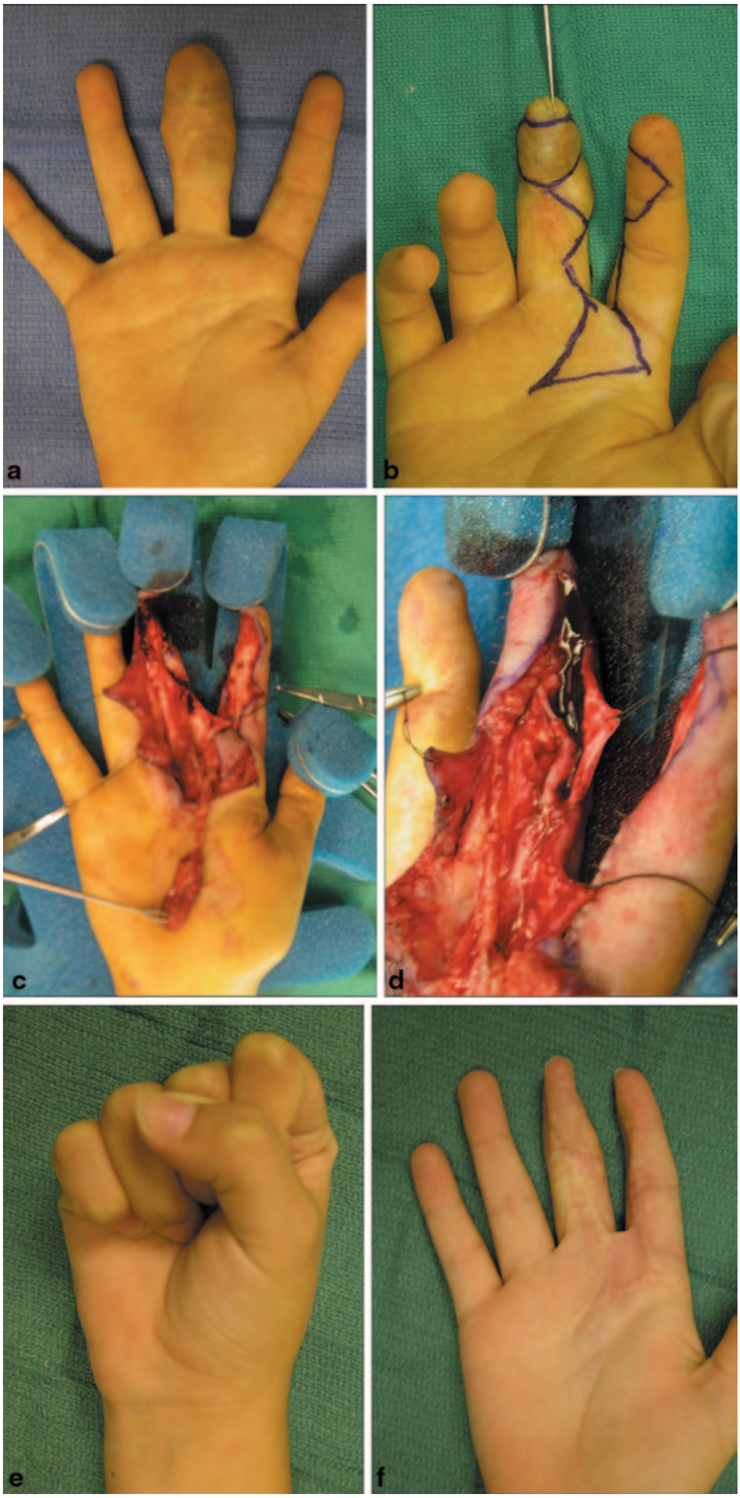

Fig. 6.12 **a** and **b** Vascular malformation is excised from middle fingertip. **c** and **d** Heterodigital flap is transposed from index and dorsal digital nerve coapted to digital nerve in recipient finger. **e** and **f** Long-term outcome with fully sensate volar fingertip

Author's Preferences

The older, previously axiomatic suggestions of a cross-finger flap for volar oblique wounds and Atasoy volar V–Y advancement flap for dorsal oblique wounds no longer necessarily pertain since we now have intrinsic finger flaps that carry a more generous bulk of tissue and can be advanced or transposed over greater distances. For this reason, our "workhorse" flap has become the antegrade homodigital island advancement flap.

This flap provides sensate tissue with sufficient bulk to cover most defects.

We have found that the Atasoy volar V–Y advancement flap is often insufficient except for smaller defects. When the Atasoy flap is employed, we typically leave the proximal donor portion of the advancement open to avoid a tight wound closure that may compromise the blood supply. Additionally, if a nail plate remnant is still intact, we routinely leave it in place as it provides for secure distal suturing of the Atasoy flap and minimizes later flap retraction.

The cross-finger flap has the disadvantages of more likely resulting in finger contracture and stiffness, being potentially injurious to an additional donor finger, as well as requiring two awkward stages and leaving a possible unsightly visible dorsal finger donor site. For these reasons, we do not routinely perform this operation on older adults or females. However, it is a straightforward dissection and it is still useful when crush injuries or fractures may preclude the use of homodigital flaps. Like the cross-finger flap, the thenar flap has similar disadvantages and is principally useful for index or middle finger volar pulp defects in younger patients.

The primary advantage of the retrograde homodigital island flap is the multiple degrees of freedom for its arc of rotation. It can equally easily cover the dorsum of the fingertip as well as the volar aspect. While the proper digital nerve is typically spared with this flap, a neurorrhaphy of the dorsal oblique sensory branch of the digital nerve can be performed when the flap is transposed to its recipient site. The donor site requires skin grafting and can be unsightly; however, if placed directly in the midaxis, the skin-grafted donor site is less visible.

The traditional heterodigital neurovascular island flap has been maligned for its donor-site morbidity and poor long-term sensory outcomes. However, the noninnervated heterodigital island flap described earlier in this chapter is useful for large finger defects. The ideal indication is for a large volar defect of the small finger with an intact adjacent ring finger. The flap is designed to preserve both the donor digital nerve and the donor pulp. With these modifications, one can use a heterodigital flap without the original disadvantages of the traditional flap design that may result in substantial donor finger morbidity.

Complications

Complications associated with local flaps for fingertip injuries include partial or total flap loss, flexion contracture, decreased sensation, and cold intolerance. Lai et al. [17] reported a partial and total flap loss of 12 and 5 %, respectively. Flap loss related to vascular insufficiency can be addressed by multiple maneuvers. First, the inclusion of a generous cuff of fibrofatty tissue around the digital artery ensures adequate venous outflow. Second, additional proximal dissection of the pedicle can ensure adequate length to allow the flap to reach the defect without undue tension. Third, the release of the tourniquet after flap inset to visualize appropriate capillary refill ensures that the flap is not sewn in too tightly; this can be addressed simply by suture removal.

Flexion contracture is a described complication of thenar and cross-finger staged flaps. As such, these random flaps should be avoided in most adults if a suitable alternative exists. Flexion contractures are reported after island flap reconstruction. However, they are typically better tolerated and can often be stretched out with therapy. It should be emphasized that the risk of flexion contracture is often directly related to the inadequacy of flap mobilization. A defect should never be moved to the flap—the flap should always be mobilized to reach the defect with the finger in full extension. This simple maneuver virtually eliminates the risk of functional flexion contracture.

Cold intolerance remains a problem with any form of reconstruction following fingertip injury. Van den Berg et al. reported 85 % cold intolerance in fingertip injuries regardless of whether healing by secondary intention, bone shortening, or reconstruction [21]. It is likely that cold intolerance is a result of the injury and not the reconstruction.

Lastly, decreased fingertip sensation is reported following local flap coverage of fingertip defects. The best outcomes for sensation following fingertip injury are with healing by secondary intention. However, when secondary intention is not an available treatment option, other forms of reconstruction must be used. In a large series of fingertip reconstruction with reverse digital island flaps, Han et al. reported a static two-point discrimination of 6–11 mm in noninnervated flaps and 4–8 mm in innervated flaps [18]. Takeishi et al. found similar results of innervated reverse island flaps with two-point discrimination of 3–5 mm [22]. Foucher et al. found comparable results for antegrade neurovascular island flaps with 84 % of patients having 3–7 mm static two-point discrimination [11]. Overall, island flaps are well tolerated and have an acceptable complication profile if judicious surgical technique is employed.

Summary

With a better understanding of the axial blood supply to the fingers, the discovery of island flaps has increased the surgical options of the physician treating fingertip amputations. The use of local flaps should be appropriately considered, depending on the nature of the injury and other patient factors. For the patient who desires length preservation and is an acceptable candidate, local flaps such as the antegrade homodigital island flap may be the ideal choice for fingertip coverage following amputation.

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