Reconstruction of the Amputated Finger Tip with a Triangular Volar Flap

A New Surgical Procedure*

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Amputation of the finger tip is a common injury and good judgment in surgical reconstruction is needed to preserve maximum function and to minimize loss of time from work. The ideal procedure should maintain length and cover the defect with non-tender, well padded skin with normal sensation. Previously described methods usually provide good padding and coverage but without normal sensation. Even with Kutler's procedure, it is not uncommon to find diminished or absent sensation in the smaller lateral triangles.

The procedure we describe here, called the triangular volar flap, was developed for reconstruction when the distal phalanx is amputated and the bone is exposed. It can be applied to most finger-tip amputations, except those in which the soft-tissue loss is extensive and the plane of amputation is inclined volarward—an oblique palmar amputation (Fig. 1). Occasionally, the remaining part of the phalanx has to be shortened a few millimeters in order to facilitate the procedure. Amputations through the middle or proximal phalanx can be treated by this method in order to maintain maximum length. The procedure provides good contour and padding

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Fig. 1

Three commonest types of finger-tip amputations.

A Transverse
B Oblique Dorsal
C Oblique Palmar

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Skin incision and mobilization of triangular flap.

Advancement of triangular flap.

Suture base of triangular flap to nail bed and closure of defect, V-Y technique.

Transverse and dorsal oblique amputations are the most suitable ones for this procedure (Fig. 1). In cases of volar oblique (pad) amputations, the exposed bone should be covered by some other method unless the bone is shortened sufficiently to permit approximation of the base of the triangle to the nail matrix.

Technique

Metacarpal block anesthesia, using 1 per cent plain lidocaine hydrochloride, is performed before wound preparation. Blood is exsanguinated from the finger and a small Penrose drain is applied to the base of the finger as a tourniquet. The base of the triangle is the cut edge of skin where the amputation has occurred. This base should be at least the same width as the amputated edge of nail matrix. If the amputation is through the distal phalanx, the apex of the triangle should be placed...
at the distal flexion crease, since it is easier to advance a longer flap. This distally based triangular flap is developed by cutting only through the full thickness of skin. The nerves and blood vessels of the flap are preserved. Separation of the fibrofatty subcutaneous tissue from periosseum and flexor tendon sheath aids mobilization of the flap (Fig. 2).

After minimum débridement of the stump (smoothing of the sharp edges of the bone end), the flap is advanced over bone and the base of the triangle is sutured to the nail bed with 6-0 nylon sutures. The V incision on the palmar aspect of the distal phalanx is then closed by converting it to a Y (Figs. 3 and 4). The denuded nail bed can be covered with a Wolfe graft or occasionally a portion of the flap can be defatted to cover the defect.

Illustrative Cases

F.T.N., a thirty-seven-year-old male machine operator, sustained an amputation of the tip of the
CASE 1. J. M., a boy of eight, amputated the left index finger by a shear machine on August 20, 1968, and lost one-third of the distal phalanx. Under metacarpal block anesthesia, the tip was reconstructed with the triangular volar flap procedure. Sensation in the finger tip and the cosmetic result at follow-up were excellent (Figs. 5-A through 5-F).

CASE 2. D. K., a three-year-old girl, amputated the distal one-third of the right long and ring fingers in a door at home on August 5, 1969. Under axillary block anesthesia, the tips were reconstructed by using the triangular volar-flap procedure. The result was excellent (Figs. 6-A through 6-F).

Material

From September 1967 to October 1969, sixty-one patients with sixty-four finger amputations at different levels had their fingers reconstructed by this procedure at the University of Louisville Medical Center and affiliated hospitals. The youngest patient was fourteen months and the oldest eighty-five years old. There were forty-four male and seventeen female patients.

The procedure was performed on the distal phalanx fifty-four times, on the middle phalanx five times, and on the proximal phalanx five times.

Results

Fifty-six of the sixty-one patients were available for evaluation at follow-up. All had normal sensation except for two in whom finger sensation was initially lost but later gradually returned to nearly normal. All patients had normal motion and the appearance of the finger was excellent.

There were no serious complications. Two patients had a small area of superficial skin necrosis at the edge of the flap which later epithelialized. Three patients had some sympathetic dystrophy with hypersensitivity of the finger tip. This responded to conservative treatment and within a few weeks the hyperesthesia had subsided.

Not included in this study are cases in which the V-Y procedure was utilized as an elective method of reconstructing old unsatisfactory painful finger-tip amputations. In these cases, the end result was also excellent.

Advantages of the V-Y procedure

It is simple to perform. Scar is minimum and less painful since it is not located directly over the end of the finger. Cosmetically, the result is excellent with good finger-tip contour and padding. Most important, the procedure preserves normal sensation of the finger tip. Only a simple finger dressing and guard is required without immobilization as in other flaps and grafts, thereby lessening joint stiffness.

Metacarpal block anesthesia is adequate and a small Penrose drain suffices as a tourniquet.

Summary

A triangular volar flap has been used successfully for the reconstruction of amputated finger tips. It can be applied to most finger amputations except those with extensive soft-tissue loss on the volar side of the amputated finger tip. The distally based triangular flap, carefully prepared with intact nerve and blood supply, is advanced over exposed bone and approximated to the nail matrix. The V incision is closed by converting it to a Y.

References


DISCUSSION

Dr. William Metcalf, Bronx, New York: Dr. Atasoy and his associates have demonstrated another useful application to hand surgery of the well known and well tried V-Y principle in plastic surgery. It is an imaginative adaptation of Dr. Kutler's bilateral triangular-flap repair, having the same basic principle and application which he described in the Journal of the American Medical Association in 1947 and discussed at one of our meetings just a few years ago.

They have treated a sizeable series of cases, and they have presented the series briefly, succinctly, and with clear diagrams and photographs. The local complication rate has been at a minimum and the follow-up results are eminently satisfactory. The advantages claimed by the authors are well substantiated by their results, have been clearly stated, and do not need repetition. A major advantage not stated by the authors is that the method obviates the need for split-graft coverage of residual skin defects required by other methods of repair. One disadvantage, freely admitted by the authors, is the inapplicability of the method to volar oblique loss of tissue, and, I might add, to lateral or medial oblique losses.

I would like to indicate methods of using local tissue to repair such defects. For volar oblique loss incisions in each paronychial sulcus allow the two resulting flaps to be interdigitated covering the bone end and reconstituting the finger tip; the small proximal residual skin defect, about one centimeter in diameter, is covered with a split graft. For the dorsal oblique tissue loss, shortening of the bone by only three to five millimeters allows direct approximation to the nail base and this method may be as effective as the one presented by the authors. For the lateral oblique tissue loss including part of the nail, the V-Y procedure again is not applicable. Here an incision in the sulcus opposite the injury allows development of a flap to cover the bone (after trimming the little spike) and a small graft completes the repair.

In a crushing injury, resulting in the loss of the nail, the pulp, nail base, and the bone tuft, careful débridement resulted in two flaps which were interdigitated and supported the remaining nail base. A split graft covered the small residual defect. The result about ten weeks later was a regrown nail and nicely contoured finger tip.
cases may be seen. The classification of one lesion was observed in 12 generations. At a later date, the above mentioned lesions were appreciated and the results for connective tissue were estrating the granuloma.

A new omenclature was described for a phalangeal lesion. Granuloma were used as too broad a term for the lesion. We prefer the term "granuloma" to the broad group of potentially similar disorders with many observed normal use differences in the lesions. Granuloma are typical for granuloma disease with the presence of a granuloma on the surface.

The history and the age will be necessary. An "atypical giant cell" does not necessarily meet the criteria of giant cell reactions.

Fingertip injuries frequently result in avulsions of the nail bed. These injuries have been reported to produce irregular, thickened nails and a 1-2 mm cast of the nail. A complete nail must be replaced to adhere to the injured surface. A set of methods of treatment of this injury have been reported. When the avulsed segment was available, immediate replacement and suture, Schiller advocated normally developing nails. Full-thickness nail bed grafting from the second or third toe to the injured nail has been advocated by Flatt, Berson, and Stewart. Nonadherence of the growing nail to the skin graft is the common deformity. Kleinert et al. advocated the use of dermal grafts and noted adherence in all but the distal portion of the nail.

Experimental studies with squirrel monkeys indicated the feasibility of split-thickness grafting of segments of the nail bed. Thin grafts, when taken from the nail bed, achieved excellent take over of the avulsed areas. Thirty-one patients with avulsions of segments of the nail bed were treated with split-thickness nail bed grafts. The injured nail bed had sufficient residual nail bed to serve as a donor site in 24 patients. The remaining seven patients required split-thickness grafts from the lateral one third of the great toe. Of the 131 treated nail beds, there was a total of five deformities in which there was either nonadherence of the nail or irregularity of the nail surface. Twenty-six had nails with no deformity. No deformities occurred in the graft donor area. The nail bed graft offers the advantage of frequent availability of tissue on the same injured digit and the absence of donor site deformity, whether on the same injured digit or a donor great toe.


The squirrel monkey (Saimiri) was used. The nail structure resembles that of human nails grossly and microscopically. Complete nail regeneration in this species occurs within 3 weeks, while it takes human nails 4 to 5 months. The initial phase of the experiments involved creation of a model in which a deformed nail could be consistently reproduced by de-
Fig. 1. Squirrel monkey hand at 4 weeks. The normal index finger (upper) had nail bed grafting. The nail of the long finger is only partially attached to the nail bed after dermal grafting. The ring finger is the control and has an irregular, thickened nail. The small finger (lowest) has an irregular, thickened, partially adherent nail after skin grafting.

struction of the nail bed. A full-thickness excision of the nail bed was performed distal to the proximal nail fold and included the nail bed extension into the lateral nail fold. It was learned in early experimental work that failure to obliterate the epithelium of the lateral nail fold resulted in regeneration of the nail bed. In man, the lateral nail fold does not appear to have this capability.

Twelve adult male squirrel monkeys weighing 650 to 750 gm were used. Intramuscular ketamine hydrochloride was used with complete safety. Operations were performed on four fingers of one hand. One hand was left free of surgery to avoid debilitation. Selection of the fingers and hands was randomized. In all, the nail beds were removed. The control nail had no further treatment. The remaining three digits had either (1) split-thickness skin grafting, (2) dermal grafting or, (3) split-thickness nail bed grafting.

Split-thickness skin grafts were performed by free-hand removal of 0.01- to 0.012-inch thick split-thickness skin grafts from the palmar aspect of the forearm. These were sutured over the recipient area, with the aid of a microscope, with 7-0 chromic catgut.

The dermal grafts were performed by initially elevating a split-thickness skin graft from the forearm and then removing the dermal segment. The split-thickness graft was then replaced over the donor site and the dermal graft was sutured to the nail bed defect with 7-0 chromic catgut.

Split-thickness nail bed grafts were removed from the nail bed prior to the ablation of the nail bed and lateral nail folds. The microscope was used to allow the taking of thin grafts (0.007- to 0.009-inch thick. The thickness of nail beds, as shown by multiple microscopic sections, was from 0.012 to 0.017 inch. Due to the limitations of free-hand technique in so small a subject, the thickness of these grafts was not uniform. After taking the split-thickness nail bed graft, the remainder of the nail bed was ablated as in the control. The graft was then sutured over the defect. Pressure dressings were applied on all digits.

Results

After 1 week, all the bandages were removed and the wounds left open for inspection. Of the control nail two developed normally while 10 deformities were observed (Fig. 1). Deformities consisted of thickened, irregular nails with partial adherence to the underlying tissue. Of 12 nails in which split-thickness skin grafts were applied, there was complete nonadherence of the nail with irregular thickened nails in nine. Three had normal nails. Of 12 digits treated by dermal grafts, four nails were completely normal after 4 weeks. Eight had varying degrees of nonadherence beginning 2 to 4 mm distal to the proximal nail fold. Of the nails treated by split-thickness nail bed grafting, 10 were normal nails. In two there were linear irregularities, but with complete adherence of the nail to its nail bed. Microscopic sections of the split-thickness nail graft digits showed thinned, but otherwise normal, nail bed.

Clinical observations

Ongoing clinical studies were performed on nail bed injuries beginning in July 1972. Over an 8-year interval a total of 346 nail bed injuries were treated. There were 1445 hand injuries during this interval that required operations, making the occurrence of nail bed injury 23.9% of all hand injuries. Of the nail bed injuries 48 had associated avulsed segments of the nail bed representing 13.8% of all nail injuries.

Treatment. Of 48 nail bed injuries with avulsed segments, four were treated by rotation flaps. Rotation pedicle flaps were taken from the medial to the lateral aspect of the finger and used to cover the avulsed nail bed. The donor site was sutured in one case and skin grafted in three cases.

Split-thickness skin grafts were used in three instances. The donor site was the palmar aspect of the forearm. Grafts of 0.012 inch were taken and sutured in place over the avulsed segment of the nail. Seven chromic catgut was used in suturing the graft to the defect.

Dermal grafts were used in four instances. A 0.01
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The split-thickness grafts for nail bed avulsions were successfully used. The split-thickness grafts were 0.017 inch thick. The multiple grafts were used due to the small size of the defect. Due to the size of the defect, the uniformity was not maintained. The grafts were removed and the control nails were treated. The underlying dermis was excised. A split-thickness skin graft was elevated from the palmar aspect of the forearm. The underlying dermal segment was excised. A split-thickness skin graft was then sutured over the donor site with 6-0 nylon sutures and a pressure dressing was applied. The dermal grafts were then defatted and sutured in place over the nail bed with 7-0 chromic catgut. The removed nail was sutured over the graft and a pressure dressing was applied.

In six patients a full-thickness nail bed graft from the toe was taken. The donor defect was treated by excision of the lateral nail fold and primary closure of the defect. The full-thickness grafts from the toe were then sutured in place over the avulsive segments of the nail bed with 7-0 chromic catgut. The removed nail was sutured over the defect and a pressure dressing was applied.

In 10 patients avulsed segments of the nail bed were covered by split-thickness grafts of the nail bed. Subsequent to July, 1975, all avulsed segments of the nail were treated by this method (Fig. 2). In 24 cases the nail bed adjacent to the injured segment was large enough to provide sufficient graft to cover the defect. In

Fig. 2. A, Diagrammatical representation of full-thickness nail bed avulsion. B, Technique of removing a split-thickness nail bed graft. Magnification is used. C, Split-thickness nail bed graft sutured over defect with 7-0 chromic catgut. D, The nail, when available, is replaced over the defect and a pressure dressing is applied. E, When the nail is not available, a single thickness of Betadine gauze (Purdue Frederick Co., Norwalk, Conn.) is placed over the defect with the proximal portion slipped under the proximal nail fold.

Fig. 3. Technique of removing split-thickness toe nail bed grafts. One third of the nail is removed. A split-thickness of the underlying nail bed is removed. The defect is covered with a single thickness of Betadine gauze (Purdue Frederick), which is left in place until the advancing nail elevates it.
Fig. 4. A, “Mix-Master” injury of index finger showing exposed bone and near total avulsion of nail bed. Matrix was intact. This was treated by full-thickness toenail bed graft. B, Full-thickness toe nail bed graft sutured to avulsed fingernail bed. C, Normal nail after 6 months. D, Deformity of donor toe nail after 6 months.

Fig. 5. A, Lawn mower avulsion of great toenail bed. B, Taking of split-thickness nail bed graft lateral to avulsed defect. C, Split-thickness nail bed graft sutured with 7-0 chromic catgut. D, Result after 1 year.
Split-thickness grafts for nail bed avulsions

Of 31 nail beds treated by split-thickness nail bed grafts, there were a total of five deformities in which there was either nonadherence of the nail or irregularity of the nail surface. Twenty-six (84%) had normal appearing nails with no obvious deformity (Figs. 5-7).
the six toenails that served as split-thickness nail bed donors, none had subsequent deformities. In the digits that had nail deformities after this technique, the deformities appeared to be in the area of avulsion rather than the area of the nail bed donor site.

Discussion

Anatomical and physiological features of the nail mechanism have been given a diversity of designations and descriptions. The terminology of Zais\(^1\)\(^-\)\(^12\) is used in this paper (Fig. 8). The present study confirms the reports in the literature that success of nail bed replacement is inconsistent when tissues other than those of the nail bed are used. The nail bed represents a highly specialized tissue performing the very particular function of shaping and adhering to the advancing nail plate.\(^13\)\(^-\)\(^14\) "Like tissue" appears to be the only satisfactory replacement for this complex tissue. Full-thickness toenail grafts serve quite nicely as replacement. The only disadvantage of this procedure is the defect of the donor area. Split-thickness nail bed grafts taken from the toenail have proven successful in areas where insufficient nail bed has been available on the injured digit. Since no deformities of the donor toe have been observed, this procedure has merit. The advantage of using, where available, nail bed grafts from the injured digit is that there is no additional temporary disability to another part of the body and a second local anesthetic is not required.

The role of the microscope in this study must be emphasized. If microscopic evaluation of the injured digit indicates that the avulsion is of partial thickness, as in tangential lacerations by sharp objects, grafting is not necessary because the regeneration of a functional nail bed will occur without the aid of grafts. In the experimental animal there is a limitation as to the thickness to which grafts can be taken; in man there can be a considerable variation in thickness of grafts harvested from a nail bed. The question "how thick can split nail bed grafts be taken and still permit the regeneration of the donor nail bed?" has not been answered by these studies. Certainly when thin grafts are taken, sufficient tissue to restore function to the lost segment is provided without functional losses by the donor nail bed.

REFERENCES