Skin and Soft Tissue Coverage of the Upper Extremity

The Cross-Finger Flap
An Established Reconstructive Procedure


Since its introduction in the literature 30 years ago, the cross-finger flap has become the single best reconstructive method for resurfacing fingers with significant loss of the soft tissue of the tip. Reports have steadily accumulated testifying to its superiority in terms of sensibility, reliability, durability, and efficacy in returning the injured patient to his or her previous occupation. In spite of the weight of the data, the cross-finger flap has still not achieved wide popularity among many hand surgeons, as evidenced by the discussion (or lack thereof) of finger tip reconstruction in the most current texts of hand surgery.

INDICATIONS

The indications for the use of the cross-finger flap have been clearly listed by several authors. The procedure is reliable and effective in providing sensibility, preserving the length of the finger, and covering exposed tendons and bones. It can be used primarily to replace an avulsed finger pad or secondarily to release a scar or to replace a hyperesthetic scar or an inadequate skin graft. Other indications include the need for tactile gnostic ability, preservation of length, and restoration of bulk and cosmetic appearance (Fig. 1). The cross-finger flap also provides a source for stable and resilient hand skin.

In fingertip loss, its chief competitors are V-Y flaps, either volar or lateral; shortening of the bone and primary closure; healing by secondary intention; split- or full-thickness skin grafts; palmar flaps; or distal pedicle flaps. In reviewing 235 patients, Sturman and Duran found the cross-finger flap to be equal or superior to these other methods in terms of lack of tenderness, less cold sensitivity, better touch sensation, and better size and texture discrimination. Patients with cross-finger flaps also had less subjective disability and tended to avoid their areas of repair less.

PATIENT SELECTION

In terms of patient selection, several factors have come under consideration. Use of this flap in the pediatric age group is controversial because of the relative immobilization required to protect the attachment of the flap. Certain authors have recommended that children aged...
7 to 8 years be the youngest patients, whereas others\(^1\) have shown no reluctance in applying cross-finger flaps in children beginning at age 1. The recommended upper limits of age also vary from 45 to 50 years,\(^2\) as persistent postoperative stiffness in the older age group appears to be a significant risk factor.

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Both sexes have been represented in the reviews.\(^9\) It may be considered chauvinistic, but in females cosmetic appearance becomes a significant consideration. Accordingly, if a cross-finger flap is elected, a full-thickness graft is highly recommended for reconstruction of the donor finger. Also, a groin donor site provides a less conspicuous donor area than the arm, with favorable characteristics for uncomplicated healing and a satisfactory scar. The donor site graft, unfortunately, may still be hyperpigmented and obvious. As an alternative, a thenar flap in the young female patient may indeed be preferred.\(^2\) The darker pigmented dorsal skin in the black patient will also be quite noticeable on the lighter volar surface of the recipient finger; palmar skin, if feasible, will provide a better color match for the volar finger and avoid a hyperpigmented skin graft on the dorsum of the donor finger.

**Socioeconomic Considerations**

Some controversy\(^8\) exists over the rapidity of return to work with the various reconstructive procedures. Obviously, this is usually not a consideration in the pediatric age group. Distant pedicle flaps from other areas of the body in most series\(^8\) represent the greatest delay in return to work. Cross-finger pedicles generally require longer temporary disability than methods with primary closure but may approximate the same disability period required by secondary healing. If, however, one considers that the cross-finger flap saves subsequent time off for definitive secondary reconstruction, then a significant percentage of unsatisfactory primary methods would be seen to actually contribute to increased lost work time. We have found also that many sedentary occupations or management positions\(^4\) may be conducive to return to work even prior to the definitive division and inset of the flap. Workers' Compensation benefits represent a cost to business and society but also make it possible to select the best long-term reconstructive procedure without the urgent need to return the patient to work as quickly as possible. In contrast, a self-employed farmer may decline a multistage procedure in favor of primary closure, even if it requires shortening of the injured digit.

Return to previous occupation in many industrial workers may be enhanced by reconstruction with a cross-finger flap when a combination of durability, sensibility, and lack of tenderness is required. This flap has also been quite satisfactory in allowing resumption of skilled manual duties in secretaries, musicians, and others requiring fine manipulative tasks in their vocation or avocation.\(^9\)

**Contraindications**

Contraindications to the procedure have been well documented.\(^8\) Multiple injuries to the hand, especially if they include the donor finger, may increase the risk of stiffness; however, having the shoulder and hand entirely free, preserving length in multiple amputations (Fig. 2), and covering repaired structures may offset that risk. Vasospastic conditions such as Raynaud's disease, diabetes mellitus, and Buerger's disease may represent absolute contraindications. Pre-existing disabling problems, such as Dupuytren's contracture, rheumatoid arthritis, and advanced age, present an increased hazard to the outcome of a cross-finger flap. Some authors\(^11\) also believe that this flap should not be used for the fourth and fifth fingers except in certain selected patients. We have, however, not hesitated to use it on any digit.

**Advantages**

The advantages of hand skin flaps are multiple. It provides a tough resiliency\(^18\) without...
Cross-Finger Flap

A well executed cross-finger flap does require a more formal operative setting than the emergency department. It also requires more hand surgical training and expertise than those procedures that could be provided by a physician trained in emergency medicine. Primary closure, split-thickness skin grafting, or just simple application of a dressing may indeed be handled by the emergency physician, but this "convenience" should not influence the choice of the most appropriate procedure for each individual patient.

Most often, these procedures can be performed in adults under a regional anesthetic as outpatient surgery. This represents a significant improvement in hospital bed utilization since Barclay's\(^1\) report in 1955 of an average hospital stay of 13 days. The pediatric patient will usually require a general anesthetic, and patients with other associated injuries may need a short stay in the hospital.

The technique has been often described in the literature\(^{10}\) since the initial report by Gurdin and Pangman.\(^7\) Our series, which includes more than 200 patients, led us to certain opinions that deserve to be shared. We have selected the donor finger on the basis of the ease of transposing the flap rather than whether it is radial or ulnar. Several authors\(^6\), \(^8\), \(^9\), \(^12\) have

Figure 3. A-E. A dorsal defect was treated with a de-epithelialized, "reversed" cross-finger flap. The donor defect and the surface of the flap were covered with a skin graft.
advocated plaster immobilization, whereas others have used K-wires for fixation during the period between stages. Except in the occasional uncooperative (young) pediatric patient, we have found a light dressing with cotton gauze, Kling bandage, and tape an adequate dressing and sufficient immobilization.

Attention to detail in positioning the fingers with gauze between them and rolled or fluffed gauze under them to support their gentle curve is important for comfort in the period between stages.

The excellent vascularity of the dorsal skin allows great flexibility in the design of the flap, although in our experience the classic lateral based flap is nearly always applicable. The flap may also be de-epithelialized to cover a dorsal defect in an adjacent finger (Fig. 3), and both the flap and the donor defect grafted. When an adjacent finger tip is resurfaced, nearly all of the dorsal skin over the middle phalanx is raised (Fig. 4), the surgeon being quite careful to preserve the vascular epitenon over the extensor tendon. This insures the take of the graft over this donor site. This larger donor site, which blends into the skin creases adjacent to the PIP and DIP joints and those extending from each midlateral line, results in a better cosmetic appearance than a small graft perched in the middle of the dorsal skin. Full-thickness skin grafts are significantly superior in appearance than are split grafts (Fig. 5). If the procedure is being done under a regional anesthetic, additional local anesthesia can be used to obtain a full-thickness graft from the groin. The groin would be our donor site of choice in females and children and the recommended site in the adult male as well. The tie-over bolster is advocated by many authors, but in the convex dorsum of the finger, this may actually create sulci at the margins and a potential space for hematoma to collect. Tacking sutures around the periphery of the graft, attention to hemostasis, and compression of the graft with the dressing material usually result in excellent take of the graft without the need for a bolster.

The uncommon complication of flap loss (in our series) is usually related to poor patient selection, for example, an uncooperative patient or a diabetic. (The remaining instances of flap loss in our series are seemingly inexplicable and may be related to technique.) One flap was lost in a patient, who, during readmission 4 months

![Figure 4. A–E, A standard cross-finger flap was raised with care taken to preserve the epitenon. The donor defect was covered with a full-thickness skin graft.](image)
results in a small graft. Full-thickness skin grafts (Fig. 5). If regional epitenon (Fig. 4) can be from the site of the amputation, the need for a tie-over graft, as described by the authors, is eliminated and a Tack or V-Y advancement of the flap, assists and allows for better result. Loss of motion or a total flap was lost 4 months later for finger tip revision, was found to have metastatic carcinoma.

Timing of division is most often 12 to 14 days, but early as 7 days has been reported in the literature. Delaying division until 3 weeks or longer is seldom indicated and may contribute to stiffness of the fingers.

Inset of the flap requires reconstituting the original defect by elevating the raw edge of the defect under the pedicle of the flap prior to suturing this last edge into the recipient finger. This results in a flatter, smoother flap. The flap is also divided at its origin near the midlateral line and the excess is discarded, again for optimal appearance of the donor site. Any subsequent tendency to form hypertrophic scar along the edge of the donor site is treated with a 1-inch Coban pressure wrap for several months. Occasionally, after inset of the flap in an asymmetric defect, the Coban wrap also proves to be helpful in "shaping the stump." Following final inset of the flap, an intensive program is begun to regain any lost motion and eliminate stiffness. This facilitates a rapid return to work and minimizes any residual disability.

METHODS

Our material consists of 205 patients seen over a period of 11 years. A questionnaire was mailed to all patients requesting historical data regarding the nature of the accident, the injury, and work status at the time of the injury and subsequent to it. Information was also requested about lost work time, requirements for therapy, and eventual disability awards, if any.

Twelve questions were also included to be answered with the description of excellent, good, fair, or poor as the patient's perception of his or her result. These questions specifically addressed motion, task performance, pain, durability, sensibility, and appearance. Those patients responding to the questionnaire were subsequently seen for objective measurements in our hand rehabilitation unit.

Individual and cumulative motion was recorded for the joints of all digits in the injured hand. Pinch and grip strengths were quantified. Sensibility was compared using pressure monofilaments, and two-point discrimination of the flap, the contralateral fingertip, and the donor site on the dorsum of the finger was assessed. A timed dexterity test was also performed. In addition, a Ninhydrin (triketohydrindene hydrate) test as described by Mob伊朗 was carried out on each patient.

RESULTS

In the initial phase of the study, 23 patients responded to the questionnaire and were available for objective testing. Thirty-eight charts were available for review of the clinical course and operative notes. It was at least 6 months postinjury for all patients. Males outnumbered females more than 4 to 1. The patients' ages ranged from 14 to 76 years. As would be expected, the majority of the patients belonged to the labor portion of the work force. Crushing predominated as a cause of injury.

Lost work time averaged 67 days. Management level patients, however, often returned to work during the period between stages. Nearly half of the patients received hand therapy, which we believe is, in large part, responsible for the minimal loss of range of motion.

Of 23 job-related injuries, there was only one financial disability settlement in a patient without associated injuries or amputations, and it was sixteen hundred dollars. All patients returned to their job, except one who had suffered multiple other injuries and partial amputations.
Of the 23 returning the questionnaire, all but 3 listed their motion as good or excellent. Two-thirds of the patients felt they performed fine motor tasks well. A similar number were relatively free from pain. Cold intolerance, however, was a complaint in nearly half of the group. Subjective evaluation of sensation was disappointing, as only 9 described their sensibility as good or excellent. However, only a third felt that durability of the flap was a problem or described strength as fair to poor. Over 80 per cent were able to perform work tasks well. The appearance of the flap and the donor site was described as good or excellent in two-thirds of the patients; there was a slight preponderance of full-thickness grafts in this group. When asked if they could use their injured hand normally, again, 80 per cent responded positively, and only 2 patients listed their overall satisfaction as fair or poor.

Right and left hands were equally injured. Index fingers were most commonly injured. Six thumbs and 5 little fingers received flap coverage. The long finger was the most common donor finger, as would be expected from its central location in the hand.

Division of the flap was performed as early as 11 days and as late as 24 days after the initial procedure. The average period between stages was 15.9 days.

Objective measurement of range of motion in patients under 50 years of age was uniformly good. A close scrutiny of the five patients older than 50 years revealed a minimal decrease in motion, except in two patients (Table 1). Patient M.R., the oldest patient at age 76, had a previous injury to a PIP joint, with pre-existing stiffness. Patient C.S. required an intramedullary K-wire across the DIP joint for a fracture in the injured digit. The results in this group are in contrast to results in patients older than 50 years in other series.

Pressure monofilament testing consistently showed a slight decrease in sensitivity in the flaps, but all of the fingers fell within the range of "normal results," which were established by testing the contralateral fingertips in the group.

Two-point discrimination averaged 8.25 mm in the cross-finger flaps, which is somewhat higher than the 6.0 mm reported by Gellis. Kleinert has stated that a two-point discrimination level of less than 8 mm is functional. Thirteen of the 24 patients had results of 7 mm or less and 5 had a discrimination level of greater than 10 mm. Interestingly, 17 patients demonstrated a two-point discrimination level in the flap that was actually better than the donor site on the contralateral hand. This was also observed by Sturman and Duran, who noted that the flap can take on the sensory characteristics of the recipient finger tip.

Dexterity testing, as described by Moberg, in 8 patients with injuries to thumb, index, or long fingers revealed that the tasks were performed, on the average, just 17 per cent more slowly. In performing these tests, four patients avoided using the injured finger, in each case an index finger.

Grip strength correlated more closely with hand dominance than with the hand of injury. Pinch strength, measured as lateral pinch, pulp to pulp, and "3-jaw chuck," showed mild diminution in the aforementioned 8 patients. Lateral pinch was 88 per cent of normal; pulp to pulp, 80 per cent; and 3-jaw chuck, 91 per cent.

Assessment of sudomotor function was attempted with the Ninhydrin test, but the results were generally unreliable and difficult to reproduce.

### SUMMARY

Cross-finger flaps have been performed by our group in more than 200 patients. Subjective questioning and objective testing in a random group of 23 of these patients confirms the value of this procedure for reconstruction of the injured finger. It is reliable and flexible in its application. The patients usually report their flaps to be functional, durable, and free of pain. Cold intolerance, as with other methods of reconstruction, remains a problem. Sensibility in the flaps proved to be functional in the majority of patients. The preservation of length and range of motion is reflected in the fact that disability settlement was a rare occurrence.

<p>| Table 1. Range of Motion in Injured and Donor Fingers of Patients Older than 50 Years |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th><strong>PATIENT</strong></th>
<th><strong>AGE</strong></th>
<th><strong>INJURED DIGIT</strong></th>
<th><strong>RANGE OF MOTION (DEGREES)</strong></th>
<th><strong>DONOR DIGIT</strong></th>
<th><strong>RANGE OF MOTION (DEGREES)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>M.R.</td>
<td>76</td>
<td>Thumb</td>
<td>10/35</td>
<td>Long</td>
<td>204</td>
</tr>
<tr>
<td>C.C.</td>
<td>69</td>
<td>Long</td>
<td>0/90</td>
<td>Ring</td>
<td>0/73</td>
</tr>
<tr>
<td>W.C.</td>
<td>58</td>
<td>Little</td>
<td>0/91</td>
<td>Long</td>
<td>0/100</td>
</tr>
<tr>
<td>C.S.</td>
<td>54</td>
<td>Long</td>
<td>0/95</td>
<td>Ring</td>
<td>0/91</td>
</tr>
<tr>
<td>H.B.</td>
<td>55</td>
<td>Thumb</td>
<td>24/90</td>
<td>Long</td>
<td>0/100</td>
</tr>
<tr>
<td>C.C.</td>
<td>69</td>
<td>Long</td>
<td>0/90</td>
<td>Ring</td>
<td>0/73</td>
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<td>0/90</td>
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</tr>
</tbody>
</table>

**MP** | **PIP** | **DIP** | **Total** | **MP** | **PIP** | **DIP** | **Total**
Cross-Finger Flap

This flap has been applied in patients of widely varying ages with minimal morbidity. Overall patient satisfaction has been quite rewarding. In the properly selected patient, the carefully performed procedure provides a superior means of reconstruction for the injured finger with loss of significant soft tissue.

REFERENCES


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