Hand and forearm reconstruction after skin cancer ablation

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Plastic surgeons are often called on to take care of patients with skin cancer. When present on the hand and upper extremity, the basic principles of skin cancer ablation apply. There is, however, a certain fund of knowledge that one must have to effect an adequate reconstruction of the defect resulting from the resection on the hand and upper extremity. First, it is important to know that despite basal cell carcinoma being the most common skin cancer, squamous cell carcinoma is far more common on the hand and upper extremity [1]. Skin cancer of the upper extremity has an estimated incidence of five per million per year and usually occurs in male manual laborers [2]. The thin layer of subcutaneous tissue combined with the myriad of structures of the upper extremity often result in exposed critical structures such as tendon, bone, vessels, joints, and nerves. The relative lack of excess surrounding tissues further complicates the issue and often results in difficult reconstructive problems. In addition, the reconstruction must not only close the wound, but also address the functional and cosmetic aspects that are so important in the hand.

This article deals only with the reconstructive options for the hand and the forearm. Amputations—which are considered part of the ablative procedure—are not discussed other than to say that if the cancer involves the periosteum, the paratenon, the synovial sheath of the flexor tendons, the adventia of an artery, or the perineurium, amputation is necessary. Amputations are considered part of the ablative process and are therefore not within the scope of this discussion.

“Most commonly, the failure of a reconstructive plan is the failure of the surgeon to analyze the deficiency properly and to outline the appropriate and correct reconstructive plan” [3]. Thus, it is important to understand the unique aspects of skin coverage of the upper extremity. As noted above, there are several important issues that dominate reconstruction of the hand and forearm after skin cancer ablation. The skin and subcutaneous tissue is thin in many areas, and exposed “white structures” (ie, tendon, nerve, and bone) are common after excisions. These structures often require coverage with more than a simple skin graft. Joint function is impacted significantly by soft tissue coverage and often is exposed after skin cancer ablation. A good-quality, full-thickness, well-vascularized replacement is necessary for the coverage of joints, to minimize contractures and resultant joint stiffness. Adding to the difficulty is the relative lack of redundant, mobile tissue in the upper extremity for local coverage.

The cosmetic aspect of reconstruction in the upper extremity often is underappreciated. Many patients’ psyches suffer more significantly from the cosmetic deformity than from the functional deformity. This factor should be addressed carefully, in addition to the functional reconstruction.

Closure of the defect begins with an analysis of the wound, its surrounding environment, and development of the reconstructive plan. Finding enough tissue of a like kind that can be transferred into the area for closure is mandatory. An exhaustive listing of coverage options for the upper extremity is beyond the scope of this article. The focus here is on those techniques that are most useful for reconstruction of the typical skin cancer defect, with particular attention given to the sun-exposed dorsum of the hand and forearm, because these are the most common sites for skin cancer in the upper extremity. Coverage options are organized by specific sites on the hand and forearm—
as the location of the ablation changes, so do the options for coverage.

**Associated topics**

Radiation therapy is an adjunctive treatment option for skin cancers, especially in individuals who are not good candidates for surgical resection and reconstruction. It is used for a variety of other problems as well. The effects on the skin are of significant importance to the plastic surgeon embarking on a reconstructive mission. Although the pathologic processes of radiation injury begin immediately after radiation exposure, clinical and histologic features continue to manifest themselves weeks, months, or even years after exposure [4]. Late effects in the skin include alopecia, pigmentation changes, telangiectasia, atrophy, retraction, fibrosis, and ulceration. Fibrosis, edema, and atrophy of the subcutaneous tissues that develop later are the result of damage to the vascular and connective tissues [5]. Thus, radiation therapy limits the natural pliability, plasticity, and ability for tissues to survive a reconstructive insult and therefore severely limits its reconstructive potential.

The decision of whether to use antibiotic prophylaxis during reconstructive procedures of the upper extremity usually is straightforward. If skin cancer ablation and the reconstruction are performed at the same operative setting, the wound is considered “clean” and needs no prophylaxis. The issue becomes less clear when the ablation and the reconstruction are separated in time by hours or even days. This is often the situation when a dermatologist or surgeon performs Mohs surgery and then refers a patient for definitive closure. This situation also occurs when permanent pathology is desired before complete closure. In these cases, there exists a colonization of the granulating wound. No antibiotics are needed for an open, well-vascularized wound. However, these wounds are probably best considered “clean-contaminated” and may benefit from a single prophylactic antibiotic dose given just before or during the operative closure. Obviously, meticulous debridement of the wound is essential in lowering the infection rates [6].

**Reconstructive concepts**

Typically, the simplest possible option that accomplishes the reconstructive goals is the best choice. Local skin has qualities that are similar to those of the skin lost and therefore is the most desirable means of providing coverage. This should be considered if the defect is relatively small and there is adequate mobile tissue in the area that can be recruited to close the defect with minimal tension. Next in complexity is a simple skin graft. In the hand, however, defects often are not suitable for these simple options, because there often is not enough surrounding tissue laxity, there are exposed vital structures, or the resulting scar would be less than ideal cosmetically or functionally.

Transposition flaps, including the rhombic flaps of Limberg and Dufourmentel, are extremely useful throughout the hand and upper extremity and are the most common type of flap used in the hand [7]. Rotation flaps are another option for the dorsum of the hand and the forearm where sufficient local skin exists [8]. A rotation-advancement flap of particular usefulness is the “hurricane flap,” which is discussed later.

Distant pedicled flaps are another very useful option for coverage of the upper extremity. These flaps include random-pattern cutaneous flaps from the chest, axial-pattern cutaneous flaps from the groin, and musculocutaneous flaps such as the rectus abdominus. All of these flaps require two stage transfers and are cumbersome to work. They are, however, effective in covering small, medium, and large defects of the upper extremity and provide an excellent alternative to other forms of reconstruction.

The most radical option is a free tissue transfer. This option should be reserved for those situations in which no good local options exist. However, despite this warning, a healthy free-flap often can provide the best reconstructive result and should not be dismissed without due consideration, even if a local option exists. It may well be worth the time, effort, and risk for the benefit of bringing well-vascularized, healthy, supple skin and subcutaneous tissue into the defect. Tendon, nerve, bone, and joints also can be transferred successfully using this versatile technique.

The most common free tissue transfers for the upper extremity include the lateral arm flap, the parascapular flap, the rectus abdominus flap, and the latissimus flap. The later two are used more commonly for massive reconstructive efforts after trauma or infection than for reconstruction after skin cancer ablation. There are many other free-flap possibilities, including those usually used as local upper-extremity flaps. Converting them to a free tissue transfer can increase significantly their arc of rotation. An example is the posterior interosseous flap extended on vein grafts to cover any defect of the dorsum of the hand. Perforator free-flaps are yet another option for good soft tissue coverage.
A free tissue transfer gives the reconstructive surgeon many excellent options to reconstruct a defect with healthy tissue that has a good blood supply and provides potentially excellent functional and cosmetic outcomes.

Specific reconstructive options by location

The fingertip

There are several solutions to a fingertip defect; generally, the solution chosen depends on the size of the defect and whether bone is exposed. Direct closure is a simple solution, but due to the round nature of the fingertip rarely is possible. Allowing the wound to heal by secondary intent is very effective for skin defects that do not have bone exposure and are less than 1 cm² in size. This conservative treatment results in a very small scar and the associated contraction of the surrounding skin brings sensate skin together with excellent results (Fig. 1) [9]. Full-thickness skin grafting also is a relatively simple solution to an open fingertip wound. However, the results of skin grafting can be poor with regard to stability of the graft, poor return of sensation, and hypersensitivity [10,11]. Local advancement flaps such as the Atasoy flap [12]; the Kutler lateral V-Y advancement flap [13]; the oblique V-Y advancement flaps; or, for the thumb, a Moberg advancement flap [14] are well described and can be quite useful for closing a relatively small defect on the tip of the finger.

For larger open wounds there are several well-described regional random-pattern flaps. These include cross-finger and thenar flaps. Cross-finger flaps are the best choice for large volar fingertip reconstruction because they are very reliable. Sensation after these reconstructive efforts can be quite good [15].

Littler [16] described neurovascular island flaps as heterodigital sensory island flaps, usually taken from an adjacent finger. The flap can also be raised from proximal healthy tissue on the same finger as the injury, creating a homodigital neurovascular island flap. Sensation usually is good, but cortical re-education for digit discrimination may be difficult [17].

In any type of closure, if there is loss of more than half of the distal phalanx or there is undue tension pulling the nail bed over the bone tip, a hook-nail deformity may result [18]. Treatment options can be difficult [19] and avoidance of the defect is strongly advised.

The nail bed

In closing a nail bed defect, it is important to consider the potential for further nail growth and the patient’s desire to maintain a nail. If the patient wishes to maintain a nail and germinal matrix still is present, then split-thickness nail bed grafting can be performed [20]. If, in this scenario, the patient no longer desires a nail, then germinal matrix ablation and skin grafting is all that is required (Fig. 2A, B). If the patient desires a nail and there is little or no nail bed remaining, a composite toenail bed graft can be attempted. To improve the aesthetics and more assuredly restore a growing nail, a free vascularized toenail bed graft should be performed [21,22]. This offers good results, but is technically demanding. If the resection includes the periosteum, a flap with more substance than just a skin graft may be required—for example, an island or a reverse cross-finger flap can be used, as mentioned above (Fig. 3).

The dorsal finger, web spaces, and hand

There are also several closure options for defects on the dorsum of the finger. Because the skin is slightly more pliable, direct closure of small defects is possible. Skin grafting also is a useful means of closing the
dorsum of the finger. Most surgeons prefer full-thickness skin grafts on the fingers because they tend to contract less than do split thickness grafts. For small defects, local rotation flaps or transposition flaps also are a useful means of closure. Reverse cross-finger flaps also are useful for closing dorsal finger defects [23]. They are based on the dorsum of a finger adjacent to the defect and are elevated just above the epitenon of the extensor mechanism in the same manner as is a regular cross-finger flap, except that the skin is raised first in the opposite direction and in the subdermal plane, leaving only the fat and fascia to compose the flap. This fat and facial flap then is transferred into the defect on the dorsum of the adjacent finger and is skin grafted. The donor site is covered with the skin that was raised initially. The flap then is divided and fully inset approximately 2 weeks later.

Noninnervated homodigital or heterodigital island flaps based on a digital artery are useful for small defects within a few centimeters of the web spaces. These flaps are therefore useful for defects proximal to the proximal interphalangeal joint (PIP) on the fingers and anywhere on the thumb [24].

A flag flap usually is raised by creating a flag-shaped incision over the proximal phalanx of a finger, with the “pole” of the flap containing a dorsal arterial branch from the digital artery and several dorsal veins. This flap is useful for coverage of the dorsal area surrounding the donor webspace [25,26]. A flag flap’s donor site is less morbid than that of the above-noted digital island flap.

Skin on the dorsal hand is the most mobile skin on the hand, which makes transposition and rotation flaps very useful. Direct closure also is easier due to the mobility. Skin grafting can be quite useful; however, it is not as pliable as its neighboring normal skin and thus can result in some functional defects.

Fortunately, there are a number of excellent local flaps for reconstruction of the dorsum of the hand. The kite flap is a versatile and reliable flap based on the first dorsal metacarpal artery. It is useful for coverage of the entire dorsum of the hand, the entire dorsum of the thumb, and the proximal dorsal portions of the fingers. This flap also can be based on the second dorsal artery for a slightly more ulnar reach [27].

The distally based, pedicled, radial forearm flap is another extremely reliable and useful flap for reconstruction of the dorsum of the hand and the distal forearm (Fig. 4A, B). This flap is based distally on retrograde flow through the radial artery via the arterial arches in the hand and antegrade flow through the ulnar artery. The intermuscular septum that arises from the radial artery reliably has perforators that can supply a large skin paddle on the proximal forearm. Once rotated, a large area can be covered and the donor site can be skin grafted easily. Potential drawbacks include the chance of vascular insufficiency to the hand.

Fig. 2. (A) Nail bed excised for subungual melanoma. (B) Healed skin graft on nail bed.

Fig. 3. Intraoperative picture of reverse cross-finger flap.
However, the deep palmar arch is complete 98.5% of the time and the superficial palmar arch is complete in 78.5% of hands [28]. Additionally, all five digits of the hand receive flow from both the superficial and deep arches [28]. These findings help to explain Martin, et al’s findings of no acute insufficiency in more than 200 radial forearm flaps [29]. In addition, the flap is relatively easy to raise and can incorporate multiple types of tissue, including skin, subcutaneous tissue, nerve, and tendon [28]. The only drawback to this flap is the donor site, which is in a visible area and has multiple underlying structures that can wear through a skin graft. We have found that the use of a vacuum-assisted, wound-closure device placed on the skin graft at the time of donor site closure significantly decreases these complications.

The posterior interosseus flap is based on the posterior interosseous artery and can be proximally or distally based. It therefore has a great reach, from the elbow to the metacarpal phalangeal joints [30]. Some have questioned the reliability of this flap and it therefore is used less frequently than other options [29]. However, Costa et al [31] reported uneventful healing of better than 90%, and only 1 in 78 flaps that suffered complete flap loss. This flap is an alternative when sacrifice of either the radial or ulnar arteries is undesirable.

Free flaps that are useful in this area include lateral arm flaps; parascapular and scapular flaps; radial forearm flaps; and perforator flaps. All of these flaps give a nice tissue match and can cover the entire dorsum of the hand and more if needed.

The dorsum of the forearm

The dorsum of the forearm is a very common site for skin cancer and familiarity with the closure techniques is essential for hand and plastic surgeons. The skin is pliable in this area, but there is little excess. Direct closure often is possible, and local flaps are

Fig. 4. (A) MOHS excision of squamous cell cancer of base of thumb. (B) Radial forearm flap reconstruction of dorsal thumb.

Fig. 5. (A) Forearm defect after cancer excision. (B) “Hurricane” closure of forearm defect.
extremely useful. The most commonly used flap, as mentioned above, is the rhomboid transposition flap, with or without skin grafting of the donor site. Several of the flaps mentioned in the hand section also are useful for reconstruction of the dorsum of the forearm, particularly the radial forearm flap. Another flap that has been useful in our practice is the “hurricane” flap (Fig. 5A, B), which is a rotation-advancement flap closure of a roughly circular defect. This flap can be used on the dorsum of the fingers and the dorsum of the hand, but is especially valuable on the dorsum of the forearm. To describe the technique briefly, two curvilinear incisions are made from the border of the circular defect. These incisions extend outward for a distance that is at least equal to the diameter of the defect. When completed, the defect and the incisions resemble the meteorologic symbol for a hurricane. The resulting flaps then are elevated, advanced, and rotated toward each other to close the defect. Care must be taken to fashion the flaps over the area of the most excess surrounding skin. We have used this flap extensively for coverage of the dorsum of the forearm.

Pedicled and free flaps are good salvage alternatives when local options are not adequate. The pedicled flaps that are most useful are the random patterned flap from the chest, the groin flap, and the pedicled rectus abdominus myocutaneous flap (Fig. 6A, B).

Summary

Skin cancer is common on the dorsum of the hand and forearm. The reconstructive challenges in this area are significant, and the options are myriad. Thus, the surgeon who takes on this challenge must know the various options. These options include the entire reconstructive ladder from direct closure all the way through to composite-free tissue transfer. Nail bed reconstruction should be mastered. In addition, the surgeon should be comfortable with all the reliable flaps, including the kite flap, the cross-finger flap, the reverse cross-finger flap, the rotation-advancement flaps, transposition flaps, and the radial forearm flap.

References


