REVIEW ARTICLE

The Correction of Postburn Contractures of the Second Through Fourth Web Spaces

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The release of postburn contractures in the hand is one of the most commonly performed procedures in burn injuries. Contractures of the web space may involve palmar, dorsal, or both sides of the web skin and require various surgical techniques. In this report we provide general guidelines for the release of these contractures, with special emphasis on reconstruction of the second through fourth web spaces. (J Hand Surg 2007;32A:556–564. Copyright © 2007 by the American Society for Surgery of the Hand.)

Key words: Burn injury, contracture, reconstruction, skin graft, web space.

Despite advances in the overall management of burn injuries, postburn deformities still occur and are the most common cause of skin contracture in the hand.[1] These deformities affect hand function and the vocational and socioeconomic status of the patient.

In general, postburn contractures of the hand are classified into 4 categories: flexion contractures involving digits, palmar contractures, contractures of the dorsum of the hand, and interdigital syndactyly.[2] To release these contractures, a number of surgical techniques have been described according to the contracture classification; however, burn contractures often include more than one deformity and may require using multiple surgical techniques. Digital flexion contracture, for example, often is associated with various degrees of interdigital syndactyly, palmar skin contracture, and sometimes joint contractures. A surgical technique directed toward the release of the proximal interphalangeal (PIP) joint may improve only the range of motion, but may fail to establish an optimal aesthetic outcome. In this article, we outline principles of contracture release of the second through the fourth web spaces, focusing on the surgical techniques directed toward skin coverage. Surgical techniques aimed at tendon and neurovascular structures are beyond the scope of this article.

Anatomy

In the normal hand, the skin between the digits is rectangular in shape and slopes 45° in a distal to palmar direction from the metacarpal head to the midproximal phalanx. In burn contractures, the web anatomy changes markedly, requiring thorough evaluation using objective criteria. We used the following 4 basic anatomic features to evaluate patients before surgery and to assess the outcome of surgery. Deviations from normal anatomy were used to describe the deformity[3] (Fig. 1): (1) web space slope, (2) rectangular skin fold, (3) web commissure distance from metacarpophalangeal (MCP) and PIP joints, and (4) palm-to-finger length ratio.

Classification and Surgical Technique

Contractures involving the second through fourth web spaces are classified into 3 groups: (1) dorsal web contractures, (2) palmar web contractures, and (3) interdigital (syndactyly type) contractures. The basic differences are summarized in Table 1. The mechanism of injury (flame, contact, hot liquid, electric) and the position of the hand at the time of the injury (palm facing toward the flame, hands protecting face) are both important factors in determining the location of these contractures (palmar, dorsal, both) and the surgical technique. The common denominator of these techniques is the application of

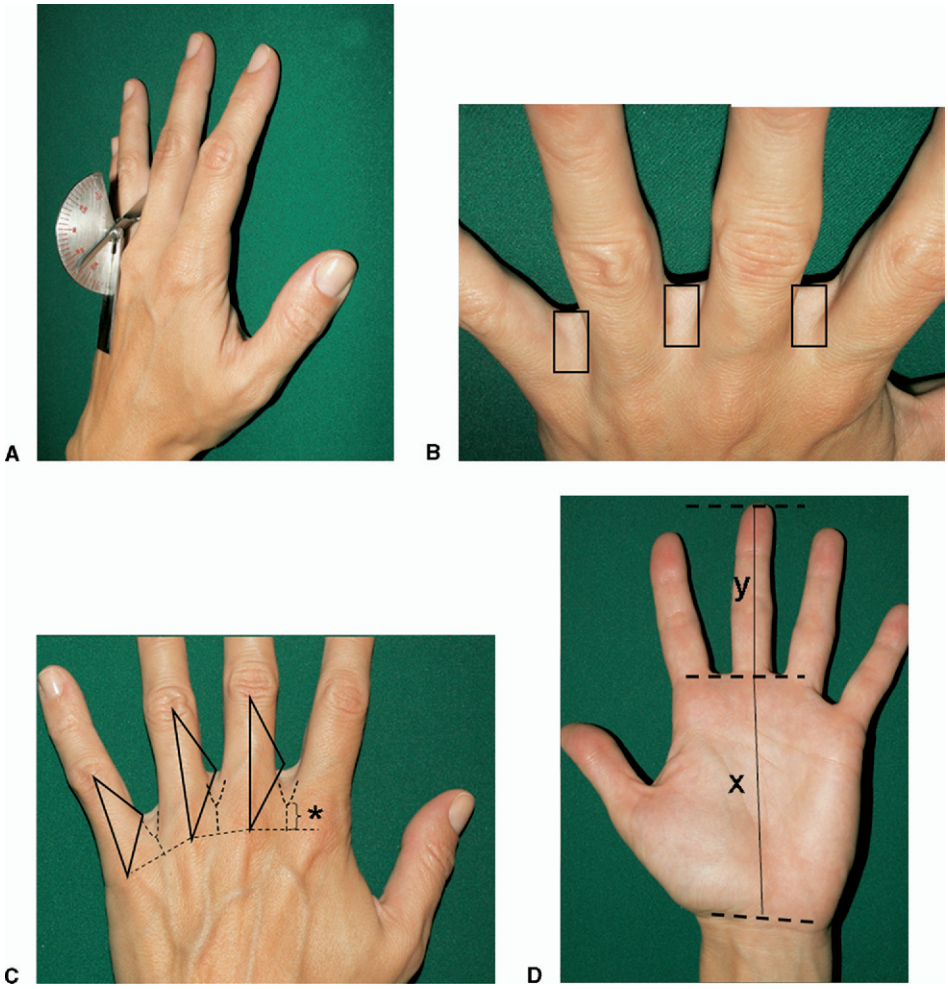

Figure 1. (A) Palmar border of the web space is more distal than the dorsal border, resulting in 45° of slope directed in a palmar to dorsal direction. (B) Skin fold between the second through fifth digits are rectangular in shape. (C) Solid lines are drawn between the head of the metacarpal, distal end of the proximal phalanx, and midpoint of the web commissure, which is in equal distance from the MCP and PIP joints. In contractures involving the dorsum of the web space, this measure almost always is changed. Dashed lines show that the dorsal border of the web commissure is approximately 1 cm distal to the line drawn between the 2 metacarpal heads as shown by an asterisk. (D) Ratio of distance x to y shows the palm-to-middle-finger-length ratio which is 1.2 to 1.3 in the normal hand. This ratio changes in favor of the palm in palmar contractures, making the fingers shorter than they actually are. X is the distance between the distal wrist crease and the proximal digital crease. Y is the distance between the proximal digital crease and the tip of the middle finger. We use the palm-to-middle-finger ratio in contractures involving the second and third web spaces. For fourth web space contractures, the palm-to-small-finger length-ratio is 1.4 to 1.5.

Table 1. Group Differences in Contractures Involving Web Spaces from 2nd to 4th

Definition	Web Slope (N = 45°)	Palm-to-Finger-Length Ratio (N = 5/4)	Additional Deformities
Dorsal web contraction: dorsal margin of the web skin fused	Increased	Normal	May cause MCP joint hyperextension
Palmar web contraction: palmar margin of the web skin fused	Decreased	Increased	Associated with various degrees of MCP, PIP, and DIP joint contractures
Interdigital (syndactyly type) contraction: radial and ulnar sides of finger fused	Increased	Increased	Extensive contracture may result in almost complete fusion of the 2 digits

Figure 2. Characteristic features of dorsal web contractures are seen in this patient. (A) A 26-year-old woman sustained a flame burn of the entire upper extremity. (B) Contracture only on the dorsal side of the web spaces (arrow). The radial and ulnar sides of the web spaces are preserved. Web space slope is reversed, but the palm-to-finger-length ratio remains the same because this side is not affected. (C) Dorsal borders of web spaces are fused almost to the level of the PIP joint. Dotted lines depict a dorsal web space triangle, which is no longer isosceles.

the skin grafts after the release. We prefer to use full-thickness skin grafts over split-thickness grafts because of the lower rate of late contracture and better match to the normal skin.[4] The inguinal area, antecubital fossa, and wrist creases are used commonly for harvesting. At the end of each surgery, compressive dressings are placed over the grafts for 5 days.

Dorsal Web Contractures

A dorsal web contracture occurs when the dorsal border of the web skin forms a thick scar tissue (Fig. 2). To restore the web, a rectangular flap, based on the radial or ulnar side of the digit, is designed to match the original shape of the web skin (Fig. 3). The decision to use the radial or the ulnar side depends on the skin quality. An area of unburned skin is preferred. The width and the length of the rectangular flap are important in determining the shape of the web space to be reconstructed (Fig. 4). The width of the flap (Figure 3, label a), once rotated, determines the width of the web, and consequently the lateral motion of the digits and the ability to perform palmar cupping. The length of the flap (Figure 3, label b) determines the slope of the web and the shape of the dorsal triangle (Figs. 5, 6).

Palmar Web Contractures

A horizontal incision technique is used to release the contracted skin between the proximal, middle, and distal digital creases (Fig. 7). If the contracted skin is cord-like and has irregular surfaces on the palmar aspect of the digit, zigzag incisions are added to break the line of contracture and to provide a smoother surface (Fig. 8).

Before incisions are made, the length ratio of the palm to the middle finger is measured (Fig. 7A). Under tourniquet control, multiple horizontal skin incisions are made on the palmar side of the hand over the proximal, middle, and distal digital creases in each contracted digit. These incisions extend on the side of each digit, covering more than the palmar aspect of the digit (Fig. 7B). At the proximal digital crease, the incision covers the palmar, radial, and ulnar aspects of the digit, leaving only the dorsal skin intact, turning 270° around the digit on the coronal

Figure 3. First, longitudinal skin incisions are made to separate the digits. These incisions are extended 1 cm distal to the line connecting the 2 metacarpal heads. Second, a rectangular skin flap is designed on the narrow area of unburned skin between the digits. The width of the flap (a) determines the width of the web space. This usually is designed as wide as the palmar to dorsal width of the finger. The length of the flap (b) determines the depth and the slope of the web. This should be long enough to reach the proximal end of the incision, which is 10 mm distal to the line connecting the metacarpal heads. This usually allows 45° of inclination.

plane (Fig. 7C). The extended incision not only ensures the release of the flexion contracture, but also allows lateral motion for the digits. In contrast, at the middle and distal digital creases, lateral motion is not needed at the PIP and distal interphalangeal (DIP) joints. Thus, the incisions are extended only to the midline on the ulnar and radial sides of each digit, covering 180°.

Once these incisions are made, skin and subcutaneous tissues are dissected carefully to the level of the digital neurovascular bundles. In contractures in which only soft tissues are involved, these horizontal incisions are satisfactory to restore the digit length. If there is any articular contracture, further contracture releases should be directed toward the joint at this stage. Full-thickness skin grafts are placed over each defect on the palmar flexion creases. Horizontal mattress sutures are preferred using 5.0 nylon sutures (Fig. 7D).

If there is cord-like contracted skin that is causing flexion deformity, removal of all the contracted skin may not be feasible (Fig. 8A, B). In this case, 3-angled zigzag incisions are made after the horizontal

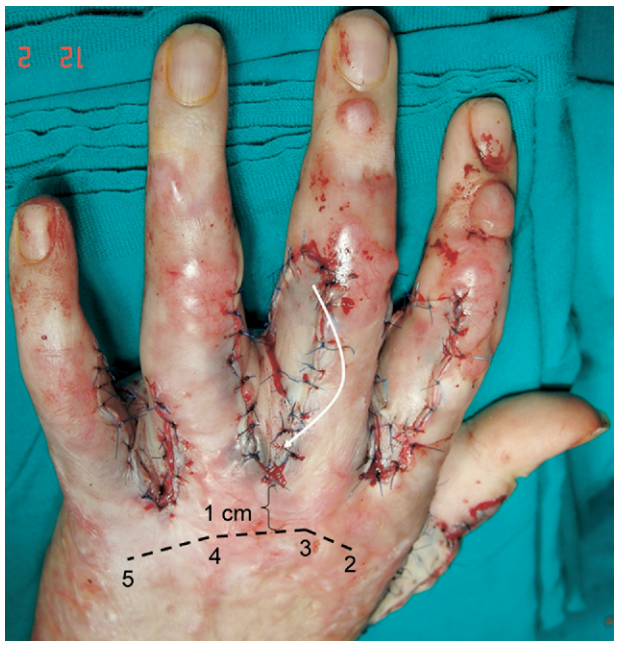

Figure 4. Arrow shows the arc of rotation of the rectangular flap. Dotted lines show the metacarpal heads, which are 1 cm away from the web commissure at the end of the surgery, which provides 45° of web slope. Donor sites are covered using FTSGs.

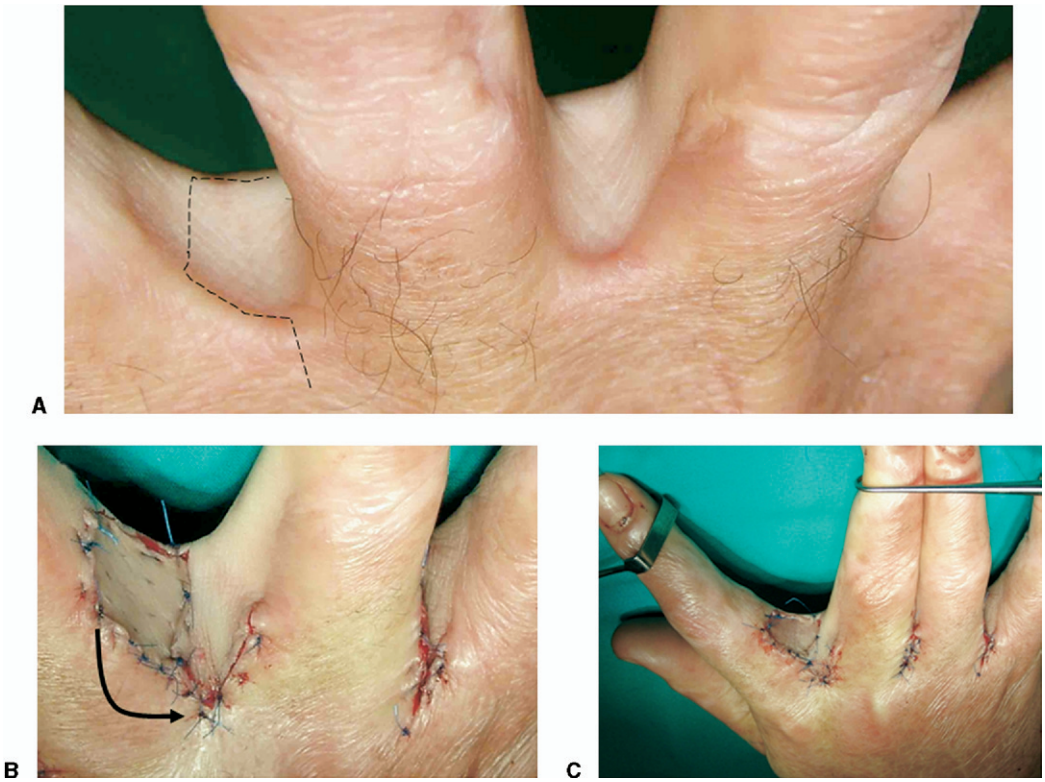

Figure 5. Dorsal web contracture. A rectangular-shaped flap on the side of the digit is designed (A), a longitudinal incision is made (B), and the flap is rotated (C).

skin incisions to remove some of the diseased skin (Fig. 8C). These incisions are each made at 60°. The full-thickness skin grafts used to cover the defects do not cross the flexion creases longitudinally (Fig. 8D). An example of palmar burn contracture released using this technique is shown in Figure 9 4 years after the surgery.

Interdigital (Syndactyly-Type) Web Contractures

This type of contracture is characterized by syndactyly-type fusion that is usually incomplete. Because lateral borders of the finger rarely are affected by flame burns and are never affected by contact burns, these contractures almost always are seen after hot liquid burns. The treatment is similar to congenital syndactyly correction because 2 skin flaps with z-plasty incisions are created on the migrated web skin to reconstruct the rectangular base of the web space, using full thickness skin grafts (FTSGs) for lateral defects (Fig. 10).

Discussion

The surgical techniques presented in this report are based on the anatomic location of the contracture, which is dependent on the mechanism of injury and

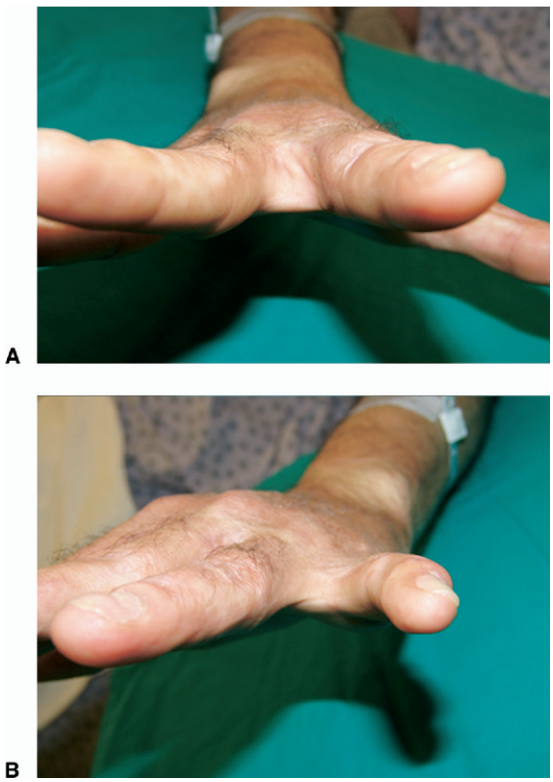

Figure 6. Complete restoration of the web depth, slope, and shape are shown in 2nd (A) and 4th (B) web spaces.

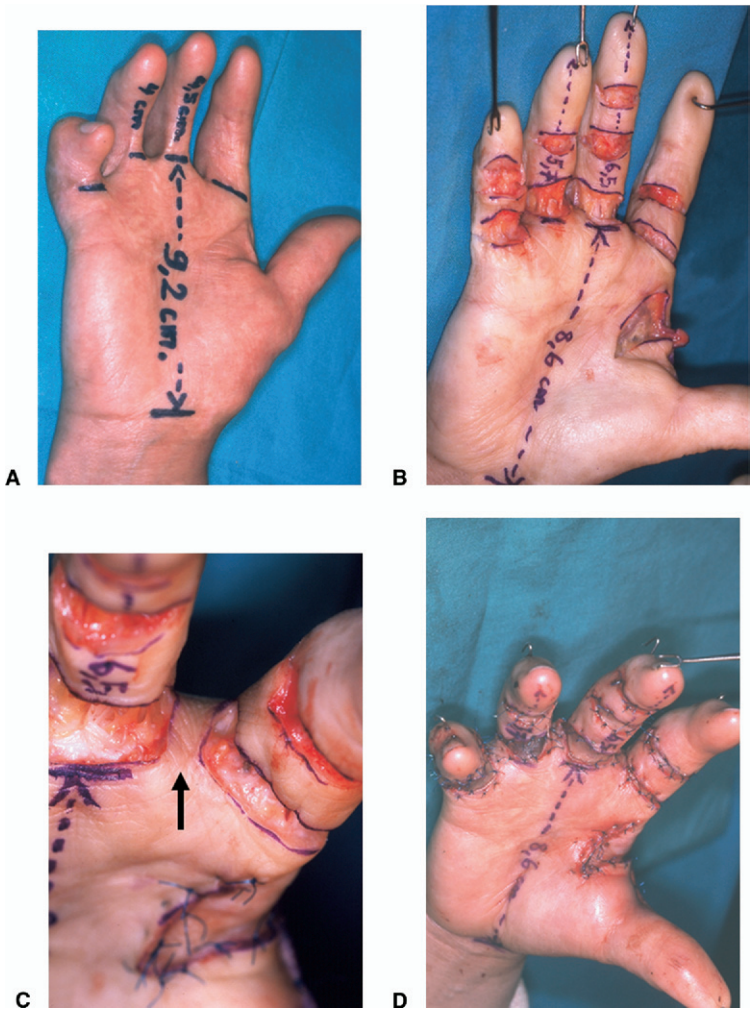

Figure 7. A 28-year-old man who sustained a flame burn injury and developed a palmar burn contracture as seen in (A). (A) Before incisions were made, the palm-to-middle-finger-length ratio was measured as 9.2/4.5 = 2.04. As is seen in a majority of palmar contractures, this increased ratio makes the palm of the hand look longer than it is relative to the middle finger. (B) After the release of all palmar contractures at the proximal, middle, and distal digital creases, the normal ratio was established (8.6/6.5 = 1.3). (C) The release of the contracture at the proximal digital crease was circumferential and 270°, whereas only 180° of release was needed at the middle and distal digital creases. The arrow shows 270° of release around the MCP joint, which ensures a complete release and a rectangular flap at the bottom of the web. (D) Overall appearance of the hand after placement of FTSGs.

the position of the hand at the time of the injury. Contact and flame burns usually affect one side of the hand, whereas hot liquid and electric burns create a more widespread injury. In dorsal contractures, the burn injury not only affects the dorsal surface of the hand, but also affects the entire interdigital space including the lateral sides of the digits, rectangular-shaped web, and commissure. In palmar contractures, however, the palmar surface is burnt, but interdigital space, especially the rectangular area, is relatively preserved. This may be due to the interdigital web space slope because 45° of elevation at the palmar border protects the rectangular area from an injury perpendicularly directed toward the palm. In dorsally directed injuries, the dorsal surface and the interdigital area are widely exposed, resulting in contracture. The practical implication of this basic difference is that dorsal contractures require not only a contracture release, but also need a resurfacing and reshaping of the web space. Thus, for dorsal contractures, the lateral surfaces of the digit are the areas of first choice because rectangular-shaped flaps are present. In palmar contractures, however, circumferential release around the proximal digital crease allows the tethered interdigital web skin to recede back to its original level, creating a rectangular-shaped

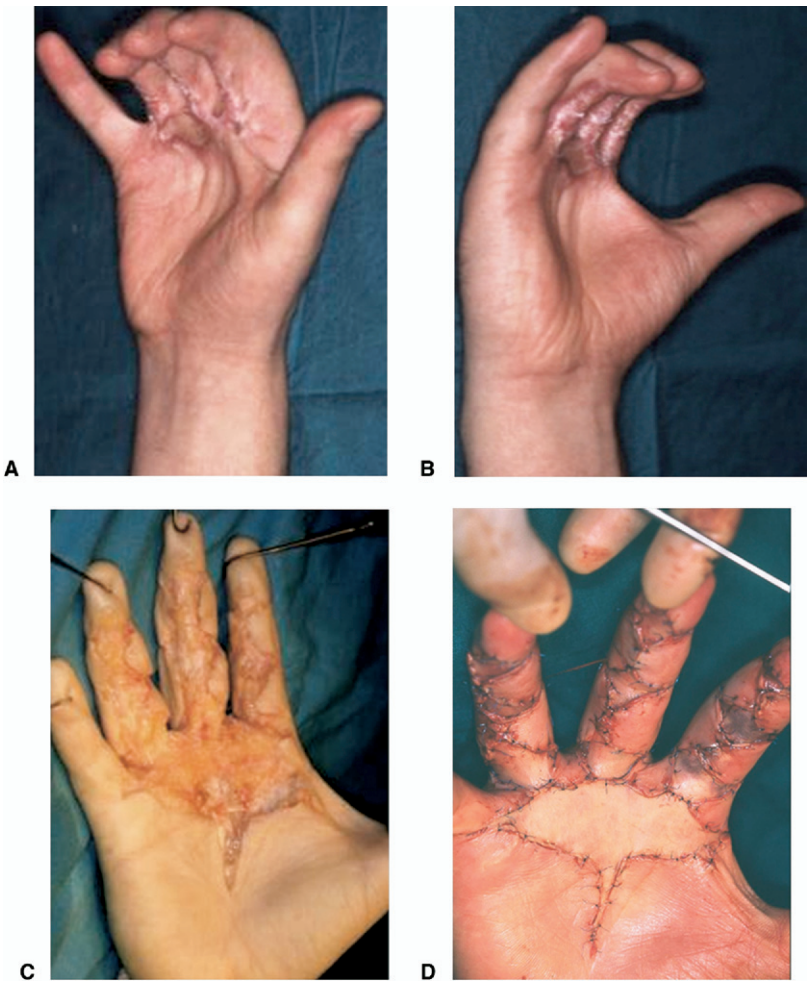

Figure 8. A 22-year-old man sustained an electrical burn injury 9 months before surgery. (A, B) Severe cord-like flexion contracture of the skin in the palm and fingers. (C) Zigzag incisions are preferred because of the extensive scarred area, with poor quality of skin between the flexion creases of the digits. Some of the diseased skin also is excised in addition to simple z-plasty incisions. (D) After placement of FTSGs, normal palm-to-middle-finger-length ratio was established with rectangular skin islands at the interdigital web spaces. Complete resection of the skin is indicated only if the quality of the existing burn skin is inferior to the skin graft.

web with normal slope. In palmar contractures, the amount of release at the proximal, middle, and distal digital creases varies. At the proximal digital crease, a circumferential 270° incision releases the tethered interdigital skin, thereby enabling lateral motion of the digit. At the middle and distal digital creases, 180° of release (midline ulnar, palmar, midline radial) usually is enough because motion is in the flexion/extension plane only.

Not all burn-induced web contractures require skin grafts. Z-plasties or their modifications such as the 5-flap technique are used commonly for relatively narrow bands and provide a smaller area of reconstruction.[5–8] Syndactyly treatment after release (STAR) plasty, described for dorsal contractures and 3-square flip-flap reconstruction for palmar contractures, offers the advantage of not using a skin graft; however, these are limited by a small area of reconstruction and are not recommended for moderate to severe contractures. Although there is no quantitative measure reported in the literature regarding the severity in burn injuries, in our experience only a limited number of contractures can be released without a skin graft. An extensive area of involvement almost always requires a wide division of the scar at multiple levels, which requires skin grafting.[8]

During normal development, separation of the digits occurs from a distal to proximal direction. Failure of this separation results in various types of congenital syndactyly. In burn contractures, the web space fuses from a proximal to distal direction. In particular, in interdigital syndactyly, the web depth, shape, and sur-

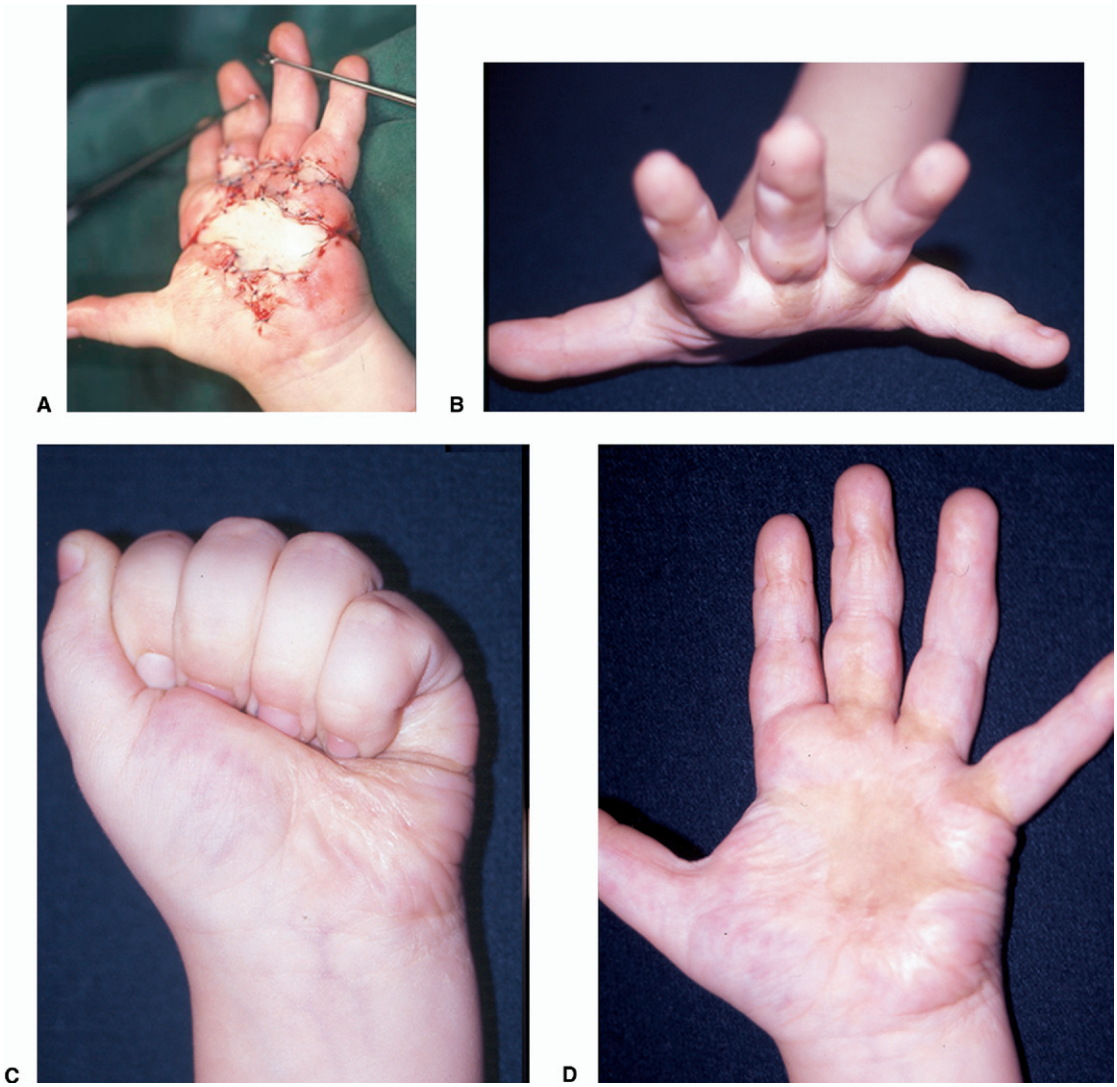

Figure 9. Long-term result of a 10-year-old with a palmar burn contracture. Placement of FTSG at the palmar aspect of the digital flexion creases and the distal palmar crease are shown (A). Four years after the surgery the patient shows full range of motion, no recurrence of the deformity (B), normal palm-to-middle-finger-length ratio (C), and slope of the web (D).

face reconstruction can be performed using techniques described to correct congenital syndactyly.

From a technical standpoint, careful dissection is of utmost importance to protect the digital neurovascular bundles. Burn scar often is thick and rigid, however, and fixation of the scar to joint capsules and/or digital neurovascular bundles is uncommon because direct involvement of these structures usually results in amputation shortly after the injury. In releasing flexion contractures, we believe in gentle joint extension. Although forceful joint extension is recommended by some investigators,[6,7,9] this has the potential to increase postoperative scar formation and neurapraxia. Any resistance to extension at the PIP or DIP joints should be resolved by capsular or collateral ligament releases. In releasing contractures, we use a combination of excisions and incisions along with grafting, depending on the location of the scar and the quality of the skin. The presence of poor-quality skin over the flexion crease requires excision of the scarred skin and grafting.

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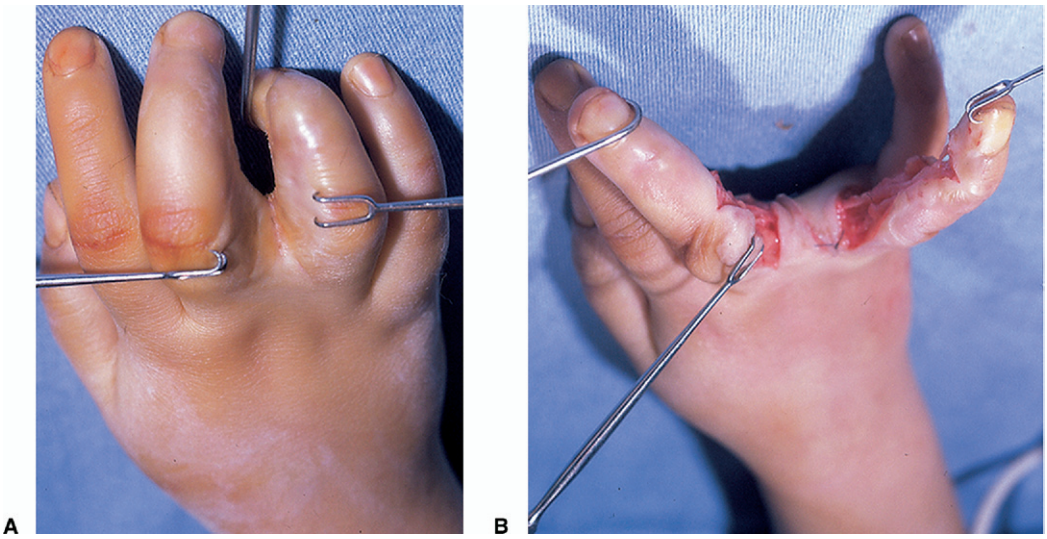

Figure 10. (A) Syndactyly type interdigital contracture with a third web space and a fourth digit flexion contracture on a 4-year-old. (B) Reconstruction of the third web space with double triangular flaps. Two triangle-shaped flaps are prepared from the lateral borders of the digits to form a rectangular web space as they meet at the center.

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