Use of Dorsal Skin Islands as Firebreak Grafts to the Palm to Reduce the Recurrence Rate of Dupuytren's Contracture

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Abstract: Dupuytren's pathologic tissue usually involves the palmar skin and rarely infiltrates into the dorsal skin. In this study, we hypothesized that transplantation of a vascularized cutaneous flap harvested from the dorsum of the hand to the palmar skin, under which the pathologic cord existed might be useful for blocking reformation of the pathologic cords and for decreasing the recurrence rate. After removal of the pathologic tissue under the palmar skin, we harvested 2 types of skin islands nourished by the dorsal digital arterial network including the dorsal perforating arteries arising from the palmar digital arteries. The skin islands were transplanted into skin defects in the palm of the fingers and hand that had been created after correction of flexion contracture of the fingers. We performed this surgical maneuver on 24 fingers in 24 patients who exhibited severe flexion contracture because of Dupuytren disease. During the mean 40-month follow-up, only 1 patient experienced metacarpophalangeal joint flexion contracture $\geq$20 degrees in the operated finger. The recurrence rate was 4.2%, which was almost similar to that for a dermofasciectomy followed by a large full-thickness skin graft.

Key Words: Dupuytren's contracture, dorsal skin island transplantation, fasciectomy, dorsal digital arterial network

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The best method for reducing the rate of recurrence of Dupuytren's contracture caused by the pathologic cord is a great concern among surgeons treating this disease. Several studies have shown that the skin overlying the pathologic cord is also invaded by the pathologic myofibrils,[1–3] and these studies have indicated that the pathologic skin may cause recurrence of the pathologic cord. To reduce the recurrence rate, some surgeons prefer to perform a fasciectomy plus removal of the entire skin overlying the pathologic fascia followed by a large full-thickness skin graft (Wolfe graft).[4–8] By contrast, others perform a fasciectomy followed by transplantation of a small skin graft to split the continuity of the pathologic palmar skin (firebreak grafts).

Wade et al[8] reported that the recurrence rate of Dupuytren disease was 3.4% over a median follow-up of 51 weeks (range, 24 to 96 wk) after dermofasciectomy followed by a Wolfe graft but was 6.8% over a median follow-up of 39 weeks (range, 16 to 72 wk) after a fasciectomy alone. The recurrence rate after dermofasciectomy plus Wolfe graft reported in other studies was about 8% with a follow-up of $>$2 years.[5,7] Ullah et al[9] compared the recurrence rate after fasciectomy with that after fasciectomy combined with firebreak grafts. They reported that over 3 years of follow-up, progressive contracture of the proximal interphalangeal (PIP) joint occurred in 5 patients (10.9%) after fasciectomy and in 6 patients (13.6%) after dermofasciectomy plus firebreak skin graft. These authors concluded that they could not identify any improvement in the rates of correction and recurrence between a fasciectomy followed by firebreak grafts and a fasciectomy alone.[9]

Dupuytren's contracture usually involves the palmar skin and has minimal effects on the dorsal skin, except in very rare cases.[10,11] We hypothesized that transplantation of firebreak vascularized cutaneous flaps harvested from the dorsum of the hand to cover the palmar skin defects might be useful for blocking recurrence of the pathologic cords and covering the palmar skin defects created after correction of the flexion contracture of the fingers. From the dorsum of the hand and fingers, we harvested pedicled vascularized cutaneous flaps nourished by small dorsal perforating arteries arising from the palmar digital arteries and the dorsal digital arterial network (DDAN)[12,13] and transplanted them into the palmar skin defects created after the fasciectomy. We performed this surgical maneuver on 24 fingers in 24 patients who had exhibited severe flexion contracture of the fingers and demonstrated a skin defect in the palmar aspect of the fingers or hands after correction of the flexion contracture. Recurrence of the pathologic cord was found in only 1 patient (4.2%) with a median follow-up for 40 months. This technique is useful for not only obliterating palmar skin defects created after correction of the contracture but also possibly reducing the recurrence rate of the disease.

ANATOMY

Like the palmar side of the hand and fingers, the dorsum of the hand and fingers also contains an arterial system.[14] These palmar and dorsal arterial systems communicate with each other through many communicating arteries. In the palm, each common palmar digital artery (a in Fig. 1) usually has 2 communicating arteries with a dorsal metacarpal artery (b in Fig. 1), one at the base and the other at the neck of each metacarpal (c in Fig. 1). In the fingers, the proper palmar digital arteries (d in Fig. 1) communicate with the dorsal digital arteries (e in Fig. 1) through many dorsal perforating arteries (f in Fig. 1). According to our experience and previous studies,[12–14] 2 significant arteries among these numerous small dorsal perforating arteries usually arise from a proper palmar digital artery at around the junctions of the proximal and middle third and the middle and distal third of each proximal or middle phalanx.

Unlike the palmar digital arteries, arteries in the dorsum of the fingers are tiny and form an arterial network comprising small dorsal arteries (e in Fig. 1) that connect the dorsal perforating arteries (f in Fig. 1) arising from the proper palmar digital arteries (d in Fig. 1) and the distal communicating

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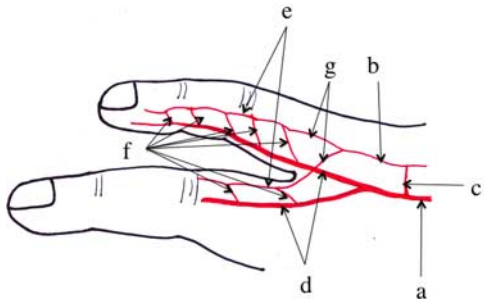

FIGURE 1. A schematic diagram of the vascular anatomy of the hand and fingers: the common palmar digital artery (a); the dorsal metacarpal artery (b); the distal communicating artery between the common palmar artery and the dorsal metacarpal artery (c); the proper palmar digital artery (d); the dorsal digital arteries (e); the dorsal perforating arteries (f); the distal communicating branches of the dorsal metacarpal artery (g). full color online

branches of the dorsal metacarpal arteries (g in Fig. 1). In the thumb, the dorsal digital arteries are well developed and form 2 independent vascular structures.

Because blood pressure and flow are lower in the DDAN than in the palmar digital arteries, vascular problems can happen when a large flap or a flap having a long vascular pedicle is harvested based on the DDAN. However, small cutaneous flaps can survive with a small amount of vascular supply from the DDAN.[12,13] Small pedicled cutaneous flaps supplied by the DDAN can be harvested from anywhere in the dorsum of the hand and fingers. To harvest skin islands from the dorsum of the hand, it is essential to design a small skin island that includes a short arterial pedicle with connections to dorsal perforator arteries of the palmar digital arteries and sufficient subcutaneous tissue and veins around the vascular pedicle.

Dupuytren disease with severe contractures can be treated by performing a fasciectomy followed by transplantation of dorsal skin islands (Fig. 2) nourished by 2 different vascular

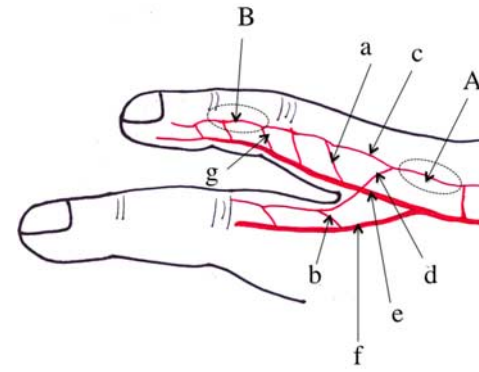

FIGURE 3. A schematic diagram showed 2 types of skin islands in the dorsum of the hand and finger. In the diagram, the upper finger is affected by Dupuytren's contracture and the lower finger was a adjacent finger. A, A skin island in the dorsal intermetacarpal space (dotted line). B, A skin island in the dorsal quadrant of a finger (dotted line). a, A dorsal perforator artery arising from the proper palmar radial digital artery of the affected finger around the finger web. b, A dorsal perforator artery arising from the proper palmar ulnar digital artery of the adjacent finger around the finger web. c and d, The distal communicating branches of the dorsal metacarpal artery. e, The proper palmar radial digital artery of the affected finger. f, The proper palmar ulnar digital artery of the adjacent finger. g, A dorsal perforating artery arising from the proper palamr radial digital artery around the proximal interphalangeal joint. The arteries a and c or those b and d compose a vascular pedicle of the skin island A. The artery g is a vascular pedicle of the skin island B. full color online

types of the DDAN (A and B in Fig. 3) to both obliterate the palmar skin defects and to reduce the recurrence rate.

INDICATIONS AND CONTRAINDICATIONS

This procedure is specifically indicated for patients demonstrating finger flexion contracture due to the recurrence of Dupuytren's pathologic cords after surgery or collagenase injection or having several factors of so-called Dupuytren

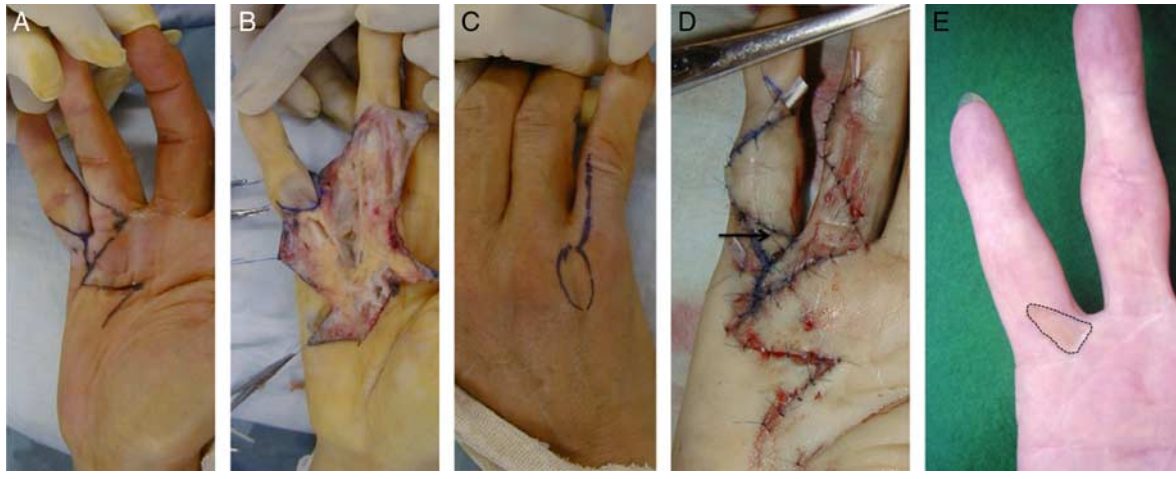

FIGURE 2. Fasciectomy and flap transplantation. A, A zigzag incision was made on the palmar surface of the hand and along the palpable pathologic cords. B, After identifying and securing the bilateral palmar neurovascular bundles of the involved finger, the pathologic structures were completely removed. C, A skin island flap was designed in the intermetacarpal space between the little and ring fingers at the level of the metacarpophalangeal joint. D, The island was passed through the subcutaneous tunnel in the interdigital space and taken out through the proximal palmar skin defect of the little finger. The skin defect was obliterated by transplantation of the skin island. E, 2 years after surgery, the flap survived and no recurrence of the pathologic cord was found. full color online

diathesis[15] including positive family history, young onset of the disease (< 50 y), smoking, considerable alcohol consumption and bilateral hand involvement, and severe finger flexion contractures that would leave skin defects after correction of the contractures. In these patients, the dorsal skin island can be interposed in the palmar skin incisions after removal of a piece of skin along the incisions even if the palmar skin is closed primarily. Contraindications include injury to the dorsal and/or palmar digital arteries of the hand and fingers, which can be nutrient vessels of the skin flaps or systemic or vascular diseases that can be anticipated to produce vascular problems in the flaps. If the dorsal perforating arteries could not be identified in the expected area by Doppler sonography, the flap design was changed because the perforating artery may have been cut during the fasciectomy.

TECHNIQUE

The patient was placed in the supine position. A tourniquet was applied to the upper arm of the involved finger. A zigzag incision was made on the palmar surface of the hand and along the palpable pathologic cords in the finger affected by the disease (Figs. 2A, B). After identifying and securing the bilateral palmar neurovascular bundles of the involved finger, the pathologic structures were completely removed. Some pathologic cords extend to the Grayson and Cleland ligaments, which encase the digital neurovascular bundles. Complete separation of the pathologic fibers from the neurovascular bindles before extension of the affected PIP joints is essential to avoid injuries to the bundles and achieve the full extension arcs of the joints. After the metacarpophalangeal (MP) and PIP joints of the finger were then fully extended, skin defects were created slightly distal to the MP joint (proximal palmar skin defect), just proximal to the PIP joint (distal palmar skin defect), or in both positions.

We used skin islands with 2 different vascular types to cover the 2 palmar skin defects mentioned above (A and B in Fig. 3). For the proximal skin defect, a skin island flap was designed in the intermetacarpal space between the affected finger and an adjacent finger at the level of the MP joint

FIGURE 4. A 57-year-old man exhibited severe flexion contracture of his left little finger. A, Before surgery. B, Two skin defects were created in the palmar side of the finger. C, A skin island was designed in the dorsal ulnar quadrant of the little finger. D, The distal skin defect was covered by the skin island harvested from the dorsal ulnar quadrant of the finger. E, Another skin island was designed over the dorsal intermetacarpal space. F, A full-thickness skin graft was performed at the donor site of the flap. G, A skin island harvested from the dorsal intermetacarpal space (dotted line) and that from the ulnodorsal quadrant of the finger (solid line). A 15-degree extension deficit remained in the proximal interphalangeal joint. full color online

(Fig. 2C, A in Figs. 3, 4E). When a dorsal perforator artery arising from the palmar digital artery was identified by Doppler sonography at the affected finger base (a in Fig. 3) just distal to the web, the skin incision was then extended distally from the distal end of the skin island to the dorsum of the proximal phalanx of the affected finger (Fig. 2C). When the dorsal perforator artery was not identified at the base of the affected finger but was identified in the adjacent finger (b in Fig. 3), the skin incision was extended distally to the dorsum of the proximal phalanx of the adjacent finger. The flap with a vascular pedicle, which included the dorsal metacarpal artery, the distal communicating branch of the dorsal metacarpal artery (c or d in Fig. 3), the dorsal perforating artery (a or b in Fig. 3) arising from the proper palmar digital artery of the affected (e in Fig. 3) or adjacent finger (f in Fig. 3) around the finger web, and the concomitant subcutaneous veins with the surrounding subcutaneous tissue, was elevated distally. After the elevation of the vascular pedicle to the point where the dorsal perforator artery was bifurcated from the proper palmar digital artery, the island was passed through the subcutaneous tunnel in the interdigital space and taken out through the proximal palmar skin defect (Figs. 2D, E). The donor site of the skin island is primarily closed.

To cover the distal palmar skin defect created after correction of the severe flexion contracture of a finger (Figs. 4A, B), a skin island was harvested from the dorsal quadrant of the affected finger just distal to the PIP joint (B in Figs. 3, 4C). The skin island, which included the DDAN, a dorsal perforating artery of the proper palmar digital artery around the PIP joint (g in Fig. 3), and the surrounding subcutaneous tissue and veins, was elevated just above the paratenon of the extensor tendons. The dorsal digital nerve accompanying the DDAN was transected at the distal end of the skin island flap and was included in the flap. The skin island was turned palmarly and proximally to cover the distal skin defect (Fig. 4D). The donor site of the skin island was covered by a full-thickness skin graft harvested from the ipsilateral medial forearm (Fig. 4F). Patients exhibiting a huge skin defect after correction of the flexion contracture underwent transplantation of these 2 skin islands (Fig. 4G).

POSTOPERATIVE REHABILITATION

The PIP joint was fixed in the fully extended position for 2 weeks using a 1.2-mm K-wire. After that, hand therapy including active and passive exercises of the operated fingers was performed to increase the range of motion of the fingers. The patients were encouraged to move the fingers in the daytime and wore a splint to keep the fingers extended overnight for 3 months postoperatively.

EXPECTED OUTCOMES

We treated 30 fingers in 24 patients who displayed flexion contracture caused by Dupuytren disease using the abovementioned technique. Seventeen patients underwent fasciectomy on 1 finger, 5 patients on 2 fingers, and 1 patient on 3 fingers. However, the skin island transplantation was performed on only 1 finger in each patient. In this study, only those fingers that received a fasciectomy and skin island transplantation were included. One patient had the proximal and distal skin defects in 1 finger, which was covered with 2 skin islands (Fig. 4). In the other 23 patients, a skin island was transplanted to the proximal skin defect of a finger. Therefore, 24 patients (20 men and 4 women) with 24 fingers having 25 flaps were included in the analysis. The fingers included 17 little fingers, 6 ring fingers, and 1 middle finger.

The age of the patients at the time of surgery ranged from 38 to 84 years (median, 60 y). The postoperative follow-up

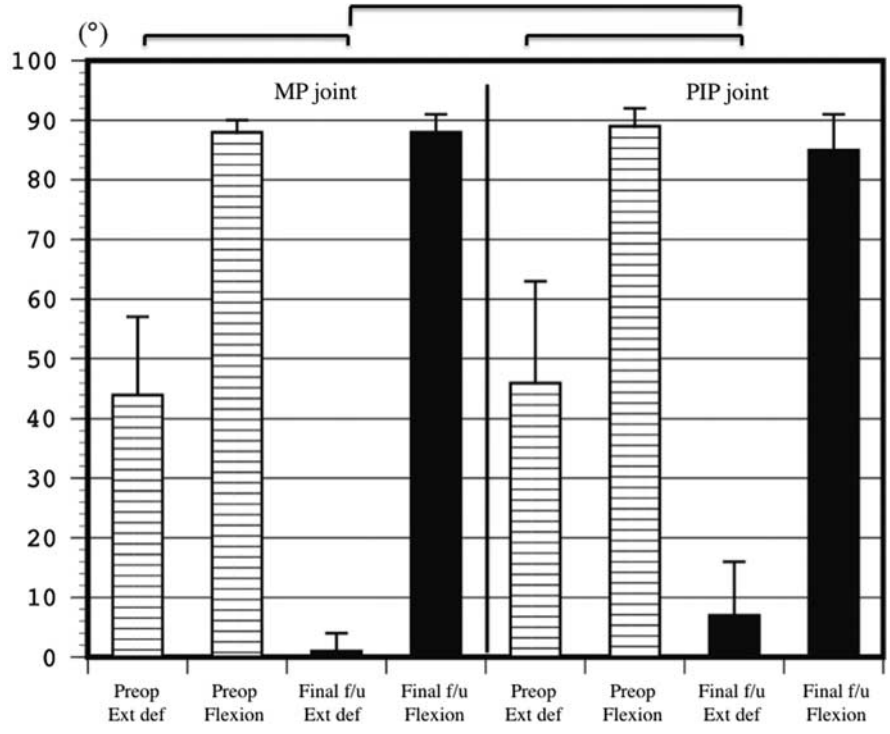

FIGURE 5. Mean extension deficits and active flexion of the MP and PIP joints preop and at the final f/u. The brackets indicate statistical significance ($P < 0.05$). Ext def indicates extension deficit; f/u, follow-up; MP, metacarpophalangeal; PIP, proximal interphalangeal; preop, before surgery.

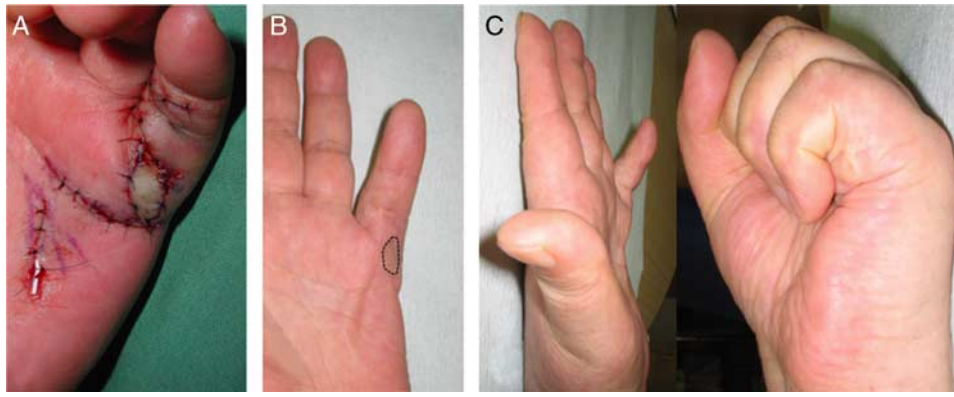

FIGURE 6. A 65-year-old woman underwent fasciectomy and dorsal skin island transplantation in her left little finger. A, A skin island harvested from the dorsal web space between the ring and little fingers was transplanted to a palmar skin defect. B, A pathologic cord was first palpated 24 months after surgery and gradually became thicker and shifted the skin island (solid line) ulnarly. C, The lack of extension was 25 degrees in the proximal interphalangeal joint and 0 degree in the metacarpophalangeal joint 47 months after surgery (left). Full flexion was possible (right). full color online

period ranged from 22 to 94 months (median, 37 mo; mean, 40 mo). Retrospective analysis of the patients' physical records showed that 6 patients were receiving treatment for diabetes mellitus at the time of surgery, 7 had a history of habitual smoking, and 4 were engaged in manual labor. Only 1 had a family background of Dupuytren disease. All skin islands were elliptical, and the longer and shorter axes ranged from 1.5 to 3.5 cm (mean, 2.1 cm) and from 0.8 to 2 cm (mean, 1.6 cm), respectively.

The patients underwent goniometry to determine the degree of the extension deficits and active flexion of the MP and PIP joints of each affected finger before surgery and at the final follow-up. Paired *t* tests were used to compare the extension deficits and active flexion ranges of the PIP and MP joints before surgery with those at the final follow-up. The patients' visual analog scale scores for satisfaction (0, least satisfied to 10, completely satisfied) and recurrence of the contracture were also analyzed at the final follow-up. Recurrence of finger contracture was defined as a loss of ≥ 20 degrees in extension of the MP or PIP joints caused by palpable pathologic fascial cord formation. The committee for medical ethics of our university approved this study.

The extension deficits of the MP joints ranged from 16 to 71 degrees (mean, 44.1 degrees) before surgery and 0 to 25 degrees (mean, 1.3 degrees) at the final follow-up. The active flexion angles of the MP joints ranged from 84 to 92 degrees (mean, 87.9 degrees) before surgery and from 84 to 95 degrees (mean, 88.4 degrees) at the final follow-up (Fig. 3). The extension deficits of the PIP joints ranged from 20 to 90 degrees (mean, 46.2 degrees) before surgery and from 0 to 28 (mean, 7.4 degrees) at the final follow-up. The preoperative and postoperative active flexion angles of the PIP joints ranged from 84 to 95 degrees (mean, 88.4 degrees) and from 73 to 100 degrees (mean, 84.6 degrees), respectively. The mean extension deficits of both MP and PIP joints decreased significantly after surgery (both $P \leq 0.0001$). The mean extension deficit was significantly greater in the PIP joints than in the MP joints at the final follow-up ($P = 0.0006$), whereas there was no significant difference between them before surgery ($P = 0.318$). The mean active flexion angle of the PIP joints was significantly smaller at the final follow-up than before surgery ($P = 0.0001$) (Fig. 5).

At the final follow-up, the mean visual analog scale score for satisfaction was 9.1. Only 1 patient (4.2%) exhibited contracture of the MP joint caused by formation of a cord-like structure in the operated finger and palm, and met the criteria for recurrence of the disease (Fig. 6).

COMPLICATIONS

One patient showed mild symptoms of complex regional pain syndrome, which subsided after medication within 5 months after surgery. Four flaps showed evidence of venous congestion 1 week after surgery, but these healed spontaneously within 3 weeks after surgery. Flap necrosis would possibly happen, but replacement of the flap with a skin graft would rescue the flap necrosis. No flaps developed into necrosis in our series of patients.

CONCLUSIONS

Among 24 patients who underwent a fasciectomy followed by dorsal skin island transplantation, only 1 patient demonstrated the recurrence of the finger contracture at the final follow-up (4.2%). Four patients demonstrated nodular structures palpable along the operative scars, but formed no cord-like structure. Transplantation of a dorsal skin flap following a fasciectomy may be useful to prevent the pathologic cord formation and obliterate skin defects created after correction of the finger flexion contractures in patients with Dupuytren disease.

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