Correction of Congenital Syndactyly of the Hand with Minimal Full-Thickness Skin Graft from the Weight-Bearing Midline Plantar Area

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Background: Traditional skin grafts for syndactyly often cause color mismatches and unsightly donor sites, whereas no–skin graft methods leave noticeable dorsal hand scars. This study presents a plantar full-thickness skin graft (FTSG) from the weight-bearing midline area for syndactyly repair, a novel approach not previously reported in the literature.
Methods: The study included 3 groups of patients with congenital syndactyly of the hand who underwent primary operations with plantar FTSG ($n = 70$), groin FTSG ($n = 20$), and no–skin graft techniques ($n = 22$). Postoperative outcomes were evaluated by an assessment panel, and guardians' satisfaction scores were measured. Color similarity between the graft and surrounding skin was assessed using a three-dimensional color space.
Results: The plantar FTSG group demonstrated a significantly higher likelihood of receiving an excellent rating compared with the groin FTSG group, with an odds ratio of 6.30 ($P < 0.001$). Color difference analysis showed that plantar FTSG more closely matched surrounding skin color than groin FTSG (6.33 versus 22.57; $P < 0.001$). Guardians reported greater satisfaction with outcomes on the hand in the plantar FTSG group compared with the groin FTSG and no–skin graft (7.16 versus 5.05 and 4.36; $P < 0.001$) groups. Satisfaction with donor sites was also significantly higher in the plantar FTSG group than in the groin FTSG group (8.23 versus 6.30; $P < 0.001$).
Conclusion: Correction of congenital hand syndactyly using midline plantar FTSG from the weight-bearing area can reduce scarring on the hand dorsum, ensure superior color similarity with surrounding skin, and offer inconspicuous donor sites compared with no–skin graft or groin FTSG techniques. *(Plast. Reconstr. Surg.* 155: 96e, 2025.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, II.

Surgical techniques for syndactyly correction have advanced to achieve optimal function and appearance of webspaces. However, postoperative scars may permanently stigmatize the congenital deformity of the children and parents. Skin grafts, previously used on the digits, often result in hyperpigmentation with different textures and noticeable scars in the donor sites.[1–7] Recent trends have focused on avoiding skin grafts in treating simple complete or incomplete syndactyly of the hand by using various designs of dorsal flaps that use skin from the dorsum of the hand for webspace reconstruction.[8–10] Interestingly, despite noticeable scars on the dorsum of the hand shown in postoperative photographs, authors and parents assessed the scars as satisfactory, pleasing, or even invisible[11–14] (Fig. 1).

Since 2014, our institute has implemented a weight-bearing midline plantar full-thickness skin graft (FTSG) technique to correct congenital syndactyly. Following syndactyly division using the

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Fig. 1. A patient who underwent a no–skin graft technique for complete simple syndactyly of the third webspace of the hand, performed by the senior author (W.S.H.), is shown at 34 months postoperatively. There are conspicuous scars on the dorsum of the hand, extending beyond the original boundaries of syndactyly. To circumvent the need for a skin graft, borrowing skin from the dorsum of the hand is inevitable.

dorsal rectangular and volar triangular interdigitating flap, we use minimal skin grafts from the midline plantar area. This study aimed to demonstrate that the plantar FTSG yields superior postoperative outcomes, including better color matching with the surrounding skin and higher levels of patient satisfaction, as evidenced by postoperative results.

PATIENTS AND METHODS

This study received approval from the institutional review board (P01-202302-01-033). Guardians of the pediatric patients provided written informed consent before enrollment. Patients with congenital syndactyly of the hand who underwent primary surgery from 2014 to 2021 were included in the study. All types of syndactyly, either simple or complex, and complete or incomplete, were included. Patients were divided into 3 groups based on the surgery performed: plantar FTSG ($n = 70$), groin FTSG ($n = 20$), and no–skin graft ($n = 22$). Graftless syndactyly division was considered in cases with fusion less than one-half to two-thirds of the digit length.[15] If any tension was observed, plantar FTSG was used. The group of patients who underwent groin FTSG was sourced from multiple external institutes, with procedures performed by board-certified pediatric hand surgeons. Patients were excluded if they had associated syndromes such as Poland or Apert syndrome. Cases with a follow-up period of less than 1 year, or those lacking postoperative photographs at least 1 year after the operation, were also excluded. Demographics, clinical information, and data on postoperative complications and secondary surgery were collected from medical records.

Assessments and Statistical Analysis

Categorical variables were analyzed using the Fisher exact test, and numerical variables were analyzed using analysis of variance to compare patient characteristics between 3 types of surgery (plantar FTSG, groin FTSG, and no–skin graft). Postoperative outcome evaluation for 2 groups who received skin graft (plantar FTSG and groin FTSG) was done by an assessment panel. The panel included 12 people, including 6 hand fellowship–trained plastic and orthopedic surgeons and 6 nurses. They evaluated the scars in postoperative photographs while blinded to the graft type. Photographs of surgical sites for all patients were captured using consistent camera settings and under uniform lighting conditions in the clinic against a blue background. Grading was done with a system reproduced by Yuan et al. based on the Manchester Scar Scale after instruction.[16] It contained categories including color, surface shine (or matte), and skin distortion which classified the scar into 4 categories: excellent, very good, good, or poor. The grading evaluation was done with a binary outcome; excellent versus non-excellent (very good, good, or poor). There was a total of 1080 data points (12 raters × 90 patients = 1080). The overall agreement among raters, measured by the Fleiss kappa, was 0.247 to 0.248, indicating fair agreement, with a significance of $P < 0.001$. The intraclass correlation coefficient for all 12 raters was 0.929, indicating excellent reliability ($P < 0.001$). The values suggest a consensus among the raters across all ratings. A logistic regression model was used to examine the correlation between grading and each patient characteristic. Then, multivariable logistic regression was performed with random effect using surgery type as the single covariate while controlling for those patient characteristics that had significant associations with each grade.

For objective comparison of color similarity between the skin graft site and the surrounding skin, postoperative photographs in 2 groups (plantar FTSG and groin FTSG) were evaluated with color quantification by the International Commission on Illumination (CIE).[17,18] The

CIELAB space is a three-dimensional space designed to approximate human vision. The color is presented using 3 values: L* for perceptual lightness and a* and b* for the 4 colors (red, green, blue, and yellow). The colors it defines are device-independent and accurately reflect perceived changes in color. A square sized as large as possible was marked on the skin graft area in the photograph. Three identical squares were marked to capture random surrounding skin around the skin graft. These squares in the surrounding skin were then sliced to match the size of the square on the skin graft, and a median combined square image was created. Colors in two squares (skin graft, and median combine of surrounding skin) were converted from its original space to CIELAB with standard equations from the International Color Consortium. The differences in color between the skin graft and surrounding skin were computed using the following equation, which represents the Euclidean distance in L*a*b* values of the color:

$$D\,(distance) = \sqrt{\left(L_1^* - L_2^*\right)^2 + \left(a_1^* - a_2^*\right)^2 + \left(b_1^* - b_2^*\right)^2}$$

The most frequent value of Euclidean distance was used as the representative color difference (D_f) for the patient. The D_f values of all patients in the plantar and groin FTSG groups were drawn out in the histogram after normalization because of differences in total frequency. The average color difference between 2 groups was calculated and compared using a *t* test.

Finally, guardians of patients of all 3 types of surgery were asked to evaluate their satisfaction with surgical outcomes in terms of both aesthetics and function for the affected hand and the donor site. The satisfaction score was measured with a visual analogue scale, with 0 as total dissatisfaction and 10 as ultimate satisfaction at every outpatient visit. The final score was used for evaluation. The average satisfaction scores for surgical outcomes in both the hand and the donor site were calculated using analysis of variance and *t* tests. Statistical analyses were performed using IBM SPSS statistics 27 (IBM Corp., Armonk, NY). *P* values less than 0.05 were considered to indicate statistical significance.

Surgical Technique

For digit separation, the dorsal rectangular flap and long, narrow volar interdigital triangular flaps were used.[19–21] (**See Video [online]**, which demonstrates the comprehensive procedure of syndactyly division and harvesting of plantar FTSG from the weight-bearing midline plantar area.) The base of the dorsal rectangular flap was marked 1 to 2 mm proximal to the neighboring webspaces, avoiding extension to the knuckle to prevent scarring on the dorsum of the hand, while ensuring that the length of the flap matched the height of the hand webspace. Careful flap elevation was undertaken to preserve neurovascular integrity and ensure flap viability. Meticulous defatting of the flap was performed to facilitate approximation, reduce tension, and minimize the need for excessive skin graft harvest, ensuring the use of minimum skin grafts.[22] Interdigital triangular flaps were strategically arranged and sutured to confine skin defects strictly to the interdigital webspace, thereby reducing the visibility of scars on the dorsum of the hand. Careful efforts ensured that the intentional skin defects did not exceed a maximum width of 1 cm. The total width and length of defects were recorded. In cases of syndactyly with synonychia, Buck-Gramcko pulp flaps were designed to create nail folds.[23]

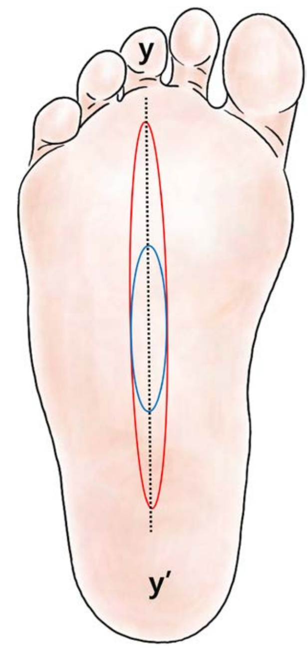

Fig. 2. The plantar FTSG was designed longitudinally with its central axis from the third toe (*y*) to the central heel (*y′*) along the midline plantar region. For smaller grafts, the excision followed the midline plantar area (*blue line*), whereas larger grafts required extending the incision toward the distal plantar region (*red line*). The width was kept under 1 cm to enable primary closure.

An elliptical FTSG was harvested from a weight-bearing midline plantar area (Fig. 2).[24] It was designed longitudinally to be centered over a line connecting the third toe to the central heel, and the width did not exceed 1 cm. The FTSG was

Table 1. Comparative Demographics and Clinical Features of Patients in 3 Surgery Types

	Plantar FTSG	Groin FTSG	No–Skin Graft	*P*
Total no. of patients	70	20	22	—
Syndactyly type (%)				0.541[a]
Complex, complete	11 (15.1)	1 (5.0)	1 (4.5)	
Complex, incomplete	1 (1.4)	1 (5.0)	0 (0)	
Simple, complete	16 (22.9)	4 (20.0)	4 (18.2)	
Simple, incomplete	42 (60.0)	14 (70.0)	17 (77.3)	
Sex (%)				0.364[a]
Male	50 (71.4)	11 (55.0)	16 (72.7)	
Female	20 (28.6)	9 (45.0)	6 (27.3)	
Laterality (%)				0.214[a]
Right	27 (38.6)	12 (60.0)	11 (50.0)	
Left	43 (61.4)	8 (40.0)	11 (50.0)	
Webspace (%)				0.031[a]
Second	9 (12.9)	8 (40.0)	5 (22.7)	
Third	48 (68.6)	7 (35.0)	15 (68.2)	
Fourth	13 (18.6)	5 (25.0)	2 (9.1)	
Complications (%)				
Immediate problems	2 (2.9)	1 (5.0)	0 (0.0)	0.527[a]
Scar contracture	17 (24.3)	9 (45.0)	7 (31.8)	0.203[a]
Web creep	11 (15.7)	3 (15.0)	4 (18.2)	0.934[a]
Donor-site complications	2 (2.9)	1 (5.0)	—	0.534[a]
Secondary surgery (%)				
No. of patients[b]	13 (18.6)	8 (40.0)	6 (27.3)	0.124[a]
Scar contracture release	11	9	5	—
Web creep correction	6	8	4	—
Scar revision/scar resection	1	8	1	—
Nail deformity correction	3	1	0	—
Corrective osteotomy	5	3	0	—
Mean age at first operation conducted ± SD, mo	16.9 ± 20.7	20.2 ± 14.2	18.9 ± 12.2	0.755[c]
Mean age at last follow-up ± SD, mo	42.1 ± 31.6[d]	112.1 ± 68.1[e]	44.6 ± 17.5[d]	<0.001[c]
Mean length of follow-up ± SD, mo	24.7 ± 20.9[d]	91.5 ± 67.5[e]	25.2 ± 17.2[d]	<0.001[c]

[a]Fisher exact test.
[b]The sum of procedures exceeds the no. of patients as some patients underwent multiple interventions during a single secondary surgery session.
[c]Analysis of variance test.
[d,e]Values marked *e* are significantly higher than those marked *d*, as analyzed by Scheffe post hoc test.

defatted as much as possible using Metzenbaum scissors. If the graft still appeared thick or if stretching was difficult because of its small size, it was immersed in saline for 5 to 10 minutes for additional defatting. Then, multiple slit incisions were made on the graft using a no. 11 scalpel blade. After bleeding control, plantar FTSGs were inset using resorbable 5-0 polyglactin sutures (Vicryl Rapide; Ethicon, Somerville, NJ).

The donor site was closed primarily without undermining of the edges, using an everting horizontal mattress suture technique with resorbable 5-0 polyglactin sutures. The plantar wound was rigorously dressed with a self-adherent, silicone-coated absorbent pad and multiple layers of gauze, secured with a cohesive elastic bandage and a non-adhesive foam heel dressing. A custom-made short leg splint was then fitted to ensure that the dressing remained intact. Guardians were educated to minimize the child's weight-bearing and encourage foot elevation for the first 4 to 5 days. Medical staff carefully monitored the integrity of the dressing.

After 2 weeks, remnant stitches were removed at the outpatient clinic. After an additional 2 to 3 days, dressings and splints were taken off, and patients were permitted to wash the operated area under running water. By the third week postoperatively, patients were allowed to bathe and to walk and stand without any special protective devices. Guardians began scar care immediately by gently massaging with silicone-containing cream, continuing for 3 to 4 months.

RESULTS

A total of 112 patients were included in the study across 3 groups (Table 1). Syndactyly

Table 2. Univariate Analysis of Factors Affecting Grade

Variables	OR of Getting an Excellent in Grade Rating (95% CI)[a]	P
Graft type		
Plantar FTSG	3.80 (2.57–5.60)	<0.001
Groin FTSG[b]	1	
Syndactyly type		
Complex, complete[b]	1	
Complex, incomplete	2.17 (0.81–5.81)	0.125
Simple, complete	2.42 (1.44–4.09)	<0.001
Simple, incomplete	3.16 (1.92–5.06)	<0.001
Sex		
Female	1.49 (1.14–1.95)	0.003
Male[b]	1	
Laterality		
Left	1.17 (0.91–1.52)	0.224
Right[b]	1	
Web space		
Second	1.59 (1.03–2.46)	0.035
Third	1.99 (1.40–2.85)	<0.001
Fourth[b]	1	
Complications		
Immediate problems		
Yes	0.89 (0.43–1.82)	0.740
No[b]	1	
Scar contracture		
Yes	0.60 (0.44–0.80)	<0.001
No[b]	1	
Web creep		
Yes	1.04 (0.74–1.48)	0.808
No[b]	1	
Donor-site complications		
Yes	0.77 (0.37–1.62)	0.490
No[b]	1	
Secondary surgery		
Yes	0.80 (0.59–1.08)	0.149
No[b]	1	
Length of follow-up		
<12 mo[b]	1	<0.001
≥12 mo	1.83 (1.37–2.45)	

[a]ORs of getting an excellent result were calculated from mixed logistic regression models with random intercept for each reconstruction with a single covariate.
[b]Reference group.

Table 3. Multivariate Analysis of Factors Affecting Grade

Variables	Adjusted OR of Getting an Excellent Grading (95% CI)[a]	P
Graft type		
Plantar FTSG	6.30 (4.06–9.76)	<0.001
Groin FTSG[b]	1	
Syndactyly type		
Complex, complete[b]	1	
Complex, incomplete	1.84 (0.55–6.12)	0.319
Simple, complete	2.12 (1.2–3.74)	0.010
Simple, incomplete	3.60 (2.08–6.24)	<0.001
Sex		
Female	2.51 (1.78–3.53)	<0.001
Male[b]	1	
Webspace		
Second	2.01 (1.23–3.30)	0.005
Third	1.75 (1.19–2.58)	0.004
Fourth[b]	1	
Complications		
Scar contracture		
Yes	0.77 (0.54–1.10)	0.145
No[b]	1	
Length of follow-up		
<12 mo[b]	1	
≥12 mo	2.07 (1.50–2.86)	<0.001

[a]ORs of getting an excellent result were calculated from mixed logistic regression models with random intercept for each reconstruction with a single covariate.
[b]Reference group.

affecting the third webspace was most commonly observed in both the plantar FTSG and no–skin graft groups. Patients in the groin FTSG group had a significantly longer follow-up and were older at their last follow-up compared with the other 2 groups. Syndactyly type, sex, laterality, and age at surgery did not differ significantly between groups. Immediate problems included partial graft loss ($n = 1$) and wound infection ($n = 1$) in the plantar FTSG group, and wound dehiscence ($n = 1$) in the groin FTSG group. Secondary operations occurred at comparable rates, with the main procedures being scar contracture release, web creep correction, scar revision, nail deformity correction, and corrective osteotomy. Notably, in the groin FTSG group, scar resection involved the removal and replacement of hyperpigmented skin grafts.

Table 2 shows the results of univariate analysis for identifying factors associated with an excellent versus non-excellent grading (very good, good, and poor). The analysis revealed significant associations between achieving an excellent grading and several variables: graft type, syndactyly type, patient sex, webspace, scar contracture, and follow-up length. The odds ratio of getting an excellent grading in patients who received plantar FTSG compared with groin FTSG was 3.80 ($P < 0.001$) (Table 2). Following adjustment for significant variables identified in the univariate analysis, the multivariable analysis revealed that patients who underwent plantar FTSG had a significantly higher adjusted odds ratio for achieving an excellent grading compared with groin FTSG (6.30 versus 1; $P < 0.001$) (Table 3).

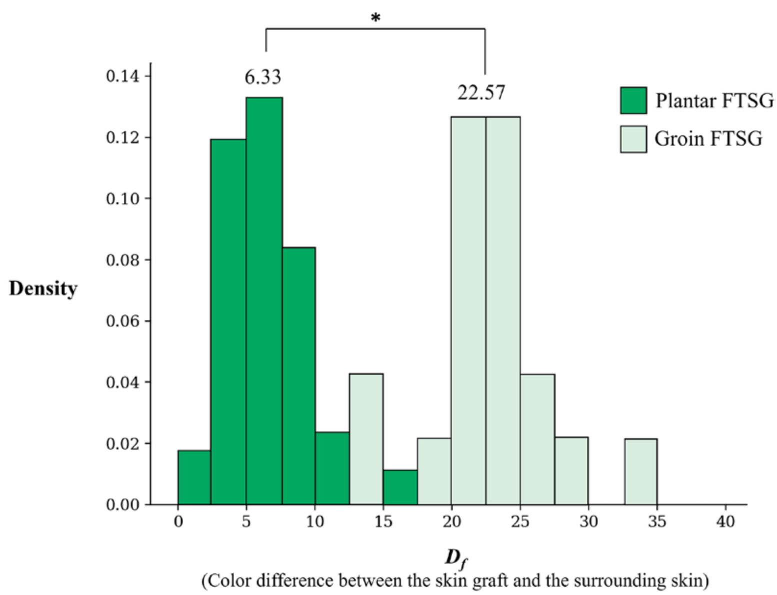

Fig. 3. The histogram compares the color differences between the skin graft and surrounding skin (D_f) in the plantar FTSG and groin FTSG groups. The results indicate significantly less color difference in the plantar FTSG group (average D_f value, 6.33) compared with the groin FTSG group (average D_f value, 22.57), demonstrating a superior color match achieved with the plantar FTSG technique (*$P < 0.001$).

The color difference between the skin graft and the surrounding skin (D_f) of patients in the plantar FTSG and groin FTSG group followed a normal distribution in the histogram (Fig. 3). The average D_f value was significantly larger in the groin FTSG group compared with the plantar FTSG group (22.57 versus 6.33; $P < 0.001$). The numerical results show that, similar to visual observation, the groin FTSG is significantly darker than the surrounding skin, whereas the plantar FTSG closely resembles the surrounding skin (Fig. 4).

The satisfaction score of the guardians showed significantly higher scores with the surgical outcomes on the hand in the plantar FTSG group compared with the groin FTSG and no–skin graft groups: 7.16 versus 5.05 ($P < 0.001$) and 7.16 versus 4.36 ($P < 0.001$) (Fig. 5). Also, the donor site in the plantar area showed significantly higher satisfaction scores compared with the groin area (8.23 versus 6.30; $P < 0.001$).

DISCUSSION

Syndactyly division is performed with the Bauer dorsal rectangular flap[20] and the Cronin zigzag incision[21] as the basic framework. The mathematical difference in circumference between 2 separate digits and 2 conjoined digits is 22%,[3] rendering skin grafting a crucial procedure. Numerous authors have underscored the importance of skin grafts, particularly in instances of complete syndactyly.[5,6] However, there has been a preference to avoid using skin grafts to prevent complications such as hyperpigmentation, hair growth, and donor-site morbidity, even for complete syndactyly.[14,25–27] Various flap designs that minimize or eliminate the need for skin grafts have been introduced.[25–28] Postoperative figures in published literature often depict significant dorsum of the hand scars; however; they are described as pleasing or satisfactory, potentially overlooking unspoken concerns of patients and their parents. Using skin grafts should not be considered a shortcoming for the surgeon, nor does it appear to negatively impact patient satisfaction.[16,29] A shorter operation time without skin grafts cannot outweigh the burden of a life-long scar on the dorsum of the hand. If there is even a slight suspicion that problems such as compromised flap or sutures under tension will occur, using skin grafts can facilitate wound closure and healing, and enhance the cosmetic outcome of the final scars.[16,30–32]

Various donor sites have been mentioned for hand reconstruction. Although useful for glabrous reconstruction, the hypothenar eminence is limited in supply and can leave a painful scar when harvested from the slightly palmar side of the glabrous-skin border.[4] Wrist fold and

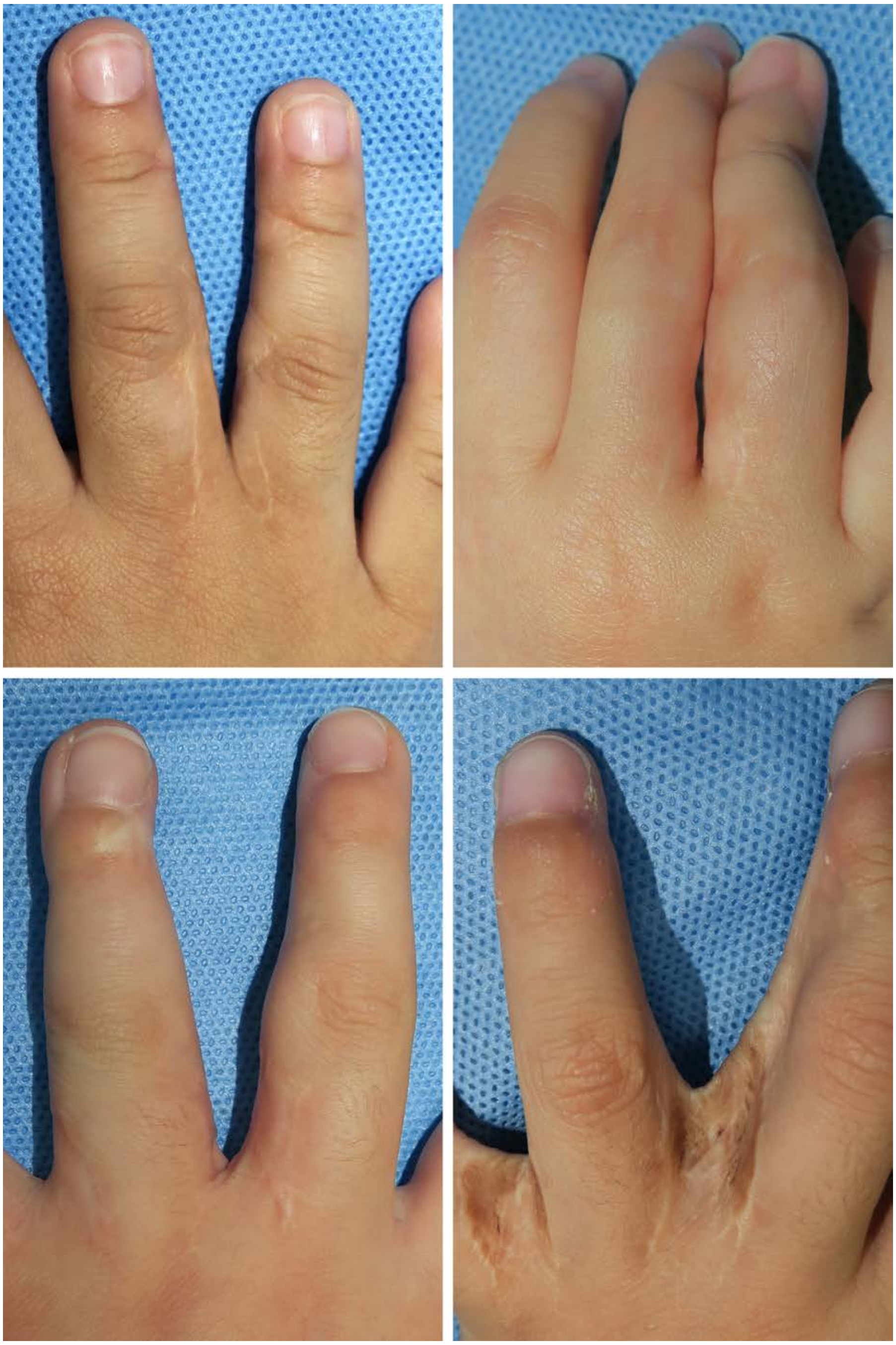

Fig. 4. (*Above*, *left*; *above*, *right*; *below*, *left*) Postoperative images using plantar FTSG for syndactyly correction show a hypopigmented linear scar with a color-matched skin graft blending with the surrounding skin. (*Below*, *right*) In contrast, a groin FTSG presents a noticeably hyperpigmented skin graft scar due to the stark contrast between the darker groin skin and the lighter skin on the dorsum of the hand.

antecubital fossa have been described because of their similarities in skin color. However, they may result in conspicuous scarring, which could have negative psychological impacts on patients with suicidal ideation (Fig. 6).[2,6,7] The groin FTSG, commonly used because of its availability in large amounts, extensibility, and relatively concealed scar, has been associated with issues such as hyperpigmentation and hair growth. To address these concerns, it has been suggested to harvest the graft from the lateral third of the groin area rather than the medial aspect.[1,5]

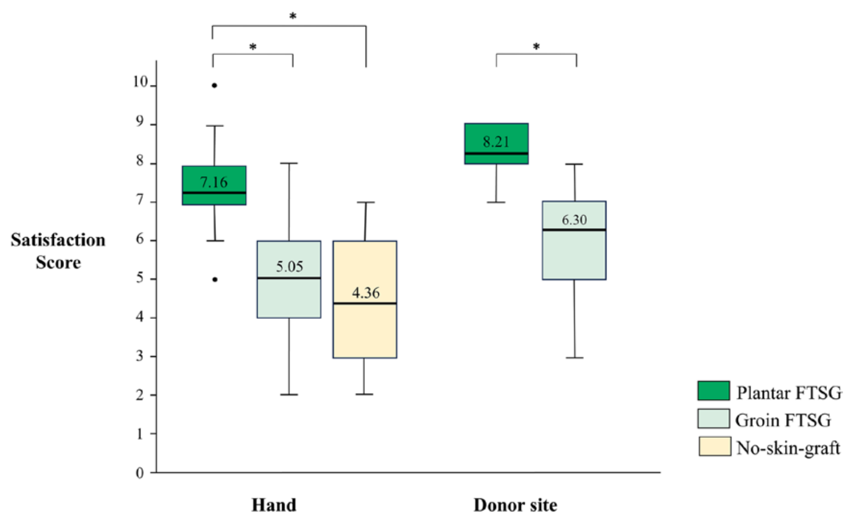

Fig. 5. This histogram shows the average satisfaction scores for the hand and donor site by the guardians across 3 groups: plantar FTSG, groin FTSG, and no–skin graft. The plantar FTSG group achieved significantly higher satisfaction scores for surgical outcomes on the hand and the donor site than the other groups (*$P < 0.001$).

Fig. 6. Unattractive scars are observed on the wrist and antecubital fossa following their use as FTSG donor sites in the syndactyly correction of a 5-year-old girl.

The medial plantar region was first illustrated as a donor site for palmar defects in 1956,[33] leading to its recognition as an option for hand reconstruction. Subsequently, it was reported to be used for syndactyly release in 1989,[34] and further studies have investigated its effectiveness for treating hand burn injuries and flexion contractures.[35–38] Histologically, the plantar skin shares many similarities with palmar skin, including a thick epidermal layer with a well-defined stratum corneum and stratum lucidum.[39] The corium layer, which needs to be revascularized for graft take, is similar or thinner in thickness than in grafts from other areas[36,38] and is less elastic and compact to withstand shearing forces.[39] Both plantar and palmar skin are hairless,[40] possess numerous Pacinian corpuscles important for sensibility,[41] and have abundant sweat glands that contribute to rapid healing.[42]

The pigmentation of skin grafts is related to epidermal melanocytes in the skin graft, which undergo biological stages in melanogenesis after transplantation.[43] Over time, the melanocyte within the graft increases in number and size of melanosomes, with dendritic cellular processes extending into the keratinocyte layer.[44] Notably, the lightness of the donor-site skin is the primary factor influencing the lightness of the skin graft.[45] The plantar and palmar areas have a 5 times lower melanocyte density than that of nonglabrous areas. This can be attributed to the high-level expression of an inhibitor for the canonical signaling pathway, which suppresses the growth and pigmentation of melanocytes.[46] Thus, the plantar area is an excellent choice as a donor site for hand resurfacing, from both histologic and visual standpoints.

Despite commonalities between plantar and palmar skin, reservations about donor-site problems have limited the use of plantar skin grafts. Previous studies have reported harvesting grafts from non–weight-bearing areas such as the “medial pedal” and “instep”[33–35,37,42] to avoid discomfort during weight-bearing activities.[37,38] However, such practices have frequently resulted in hypertrophic scarring and prolonged healing in donor sites.[33,34,42] To tackle these issues, plantar dermal grafts have been introduced to cover the donor site with the superficial layer of the graft

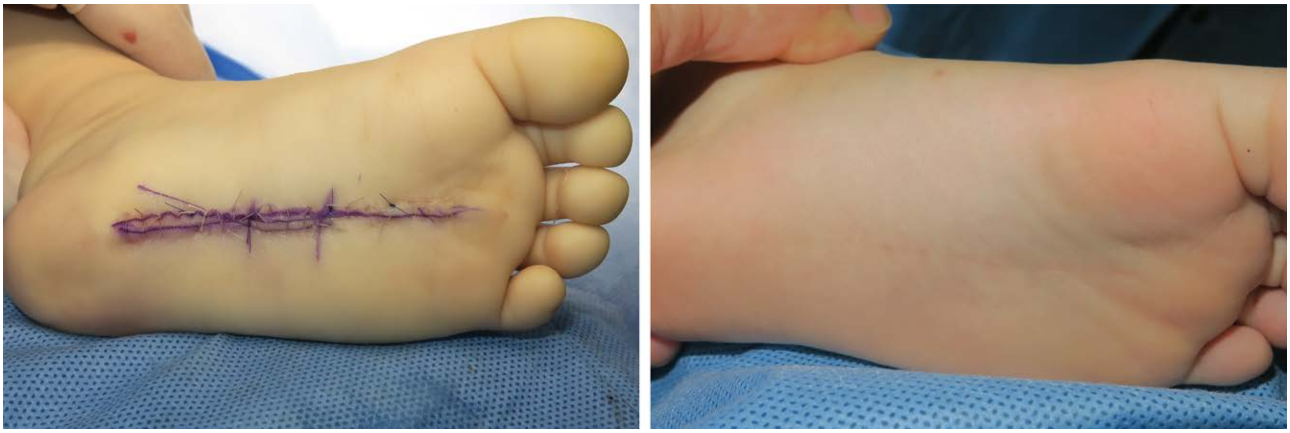

Fig. 7. The donor site on the foot in a case of bilateral complete syndactyly is shown (*left*) immediately after the operation and (*right*) 20 months postoperatively.

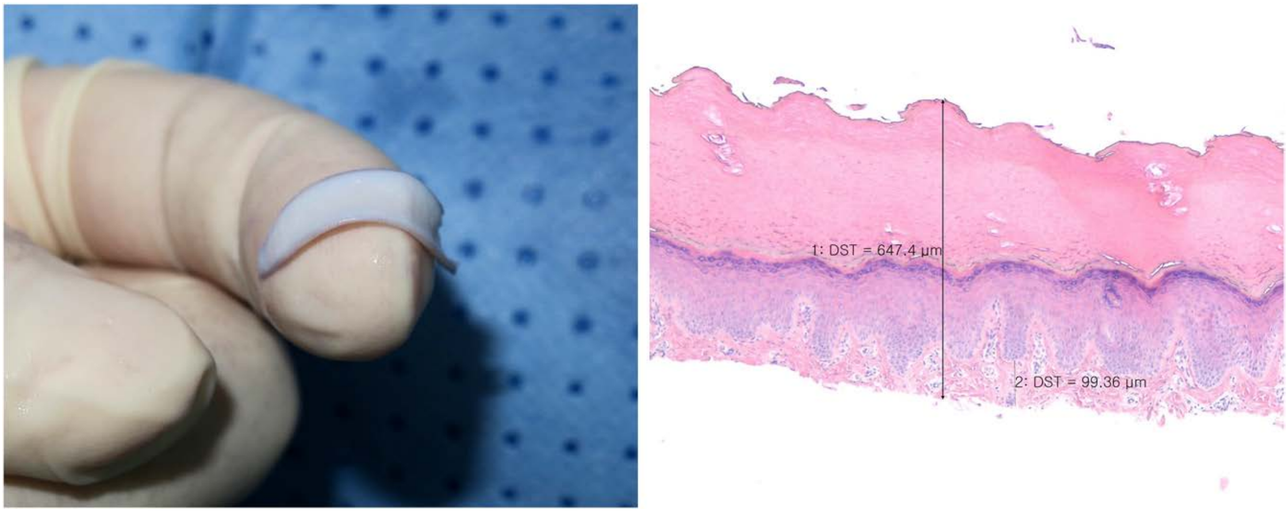

Fig. 8. (*Left*) The photo shows defatted plantar skin ready to be applied to the defect. (*Right*) The thickness of the defatted plantar skin from a 14-month-old child is 647.4 µm, measured from the top of the stratum corneum to the base of the dermis. Hematoxylin and eosin stain; × 40 magnification.

for improved healing.[47,48] In contrast to these approaches, our study strategically placed the donor site on the weight-bearing area, perceiving this as an advantage rather than a concern. The application of pressure to prevent and treat hypertrophic scars is a standard principle in plastic surgery.[49–51] Our experience has demonstrated that scars at the donor site progressively improve over time, with long-term outcomes revealing only minimal scarring and high patient satisfaction (Fig. 7). The donor-site complications observed were 2 cases of wound disruptions because of early spontaneous removal of absorbable suture material, primarily caused by sweating in pediatric patients. These incidents did not hinder wound healing, with both cases resolving satisfactorily. Long-term follow-up revealed no reports of discomfort or compromised function in standing or walking attributable to the donor site.

The authors herein report several characteristics of midline plantar FTSG for syndactyly correction. First, despite concerns regarding the excessive thickness of midline plantar skin, histologic examinations of remnant skin grafts from 13 patients displayed a thickness range of 600 to 800 µm, with a mean value of 682.25 µm (Fig. 8). This falls in line with the textbook definition of FTSG thickness.[52] Next, harvesting sufficient skin from one foot is possible for patients with bilateral complete syndactyly (Fig. 9). Among a total of 28 cases of complete syndactyly, all patients underwent plantar FTSG harvested from a single foot. However, it is still imperative to keep the graft width less than 1 cm to ensure primary donor-site

Fig. 9. (*Above*) The preoperative view shows a 13-month-old girl with complete, complex syndactyly affecting both hands. (*Below*) This is the postoperative view at 80 months following syndactyly division and plantar FTSG. Corrective osteotomy is scheduled for correction of bone deformity.

closure. Lastly, hypopigmentation can rarely occur in individuals with a darker dorsum of the hand, as observed in 5 of 70 patients (7.14%) in our study (Fig. 10). However, this issue is not a significant concern given the limited visibility of the graft from the dorsum, as our surgical approach prioritizes graft placement within the interdigital webspace.

Several limitations should be acknowledged in this study. First, there was a discrepancy in the number of cases among the groups, and cases in the groin FTSG group were sourced from external institutions. Efforts were made to mitigate this limitation by involving multiple raters for evaluation and generating substantial data points. Next, the evaluated photographs were not standardized with time after operation. To overcome the shortcomings of digital photography and red, green, and blue color space, L*a*b* color space was used, as it is well suited to displaying color changes. Lastly, prospective studies are needed to confirm the histologic thickness of plantar skin to precisely determine the age limitation for the use of plantar FTSG. An examination of a plantar skin sample from an adult revealed that the full thickness of the skin, inclusive of both the epidermis and dermis, exceeds 1200 μm. Despite its limitations, this study provides a long-term outcome using plantar FTSG for syndactyly division and demonstrates satisfactory results in hand and donor site as assessed by raters and guardians.

Based on the results of this study, 3 key points need to be emphasized in syndactyly treatment. First, placing the scar in the interdigital webspace should be prioritized over borrowing skin from the dorsum of the hand (Fig. 11). The dorsum of the hand is the second aesthetic zone following the face. Especially, the knuckle of the hand is a critical area of significant aesthetic importance that is constantly visible and unclothed.[53] Rather than being overly concerned with avoiding

Fig. 10. Two brothers, born with complete syndactyly, were photographed postoperatively after 4 and 11 years, respectively. The older brother (*hand on the right*) underwent a groin FTSG at an external institute, while the younger brother (*hand on the left*) received a plantar FTSG at our center. Although hypopigmentation is visible in the younger brother’s hand, the guardian expressed greater satisfaction with the results compared to those of the older brother's hand. Additionally, the outcomes were more favorably rated by evaluators.

Fig. 11. Postoperative views following incomplete syndactyly division and plantar FTSG show scarcely visible scars on the knuckles and dorsal aspect of the digits at 38 months postoperatively.

skin grafts, focus should be on using a minimal amount of skin graft through strategic design and flap defatting. The defatting technique can decrease digit circumference and facilitate the transposition of skin from redundant to deficient areas, thereby reducing the amount of skin graft needed.[22] Second, ensuring color-matching with the surrounding skin is crucial when selecting a donor site for skin grafts. In this regard, the use of plantar FTSG leads to high color similarity, as perceived by the naked eye, resulting in superior aesthetic and pleasing outcomes. Lastly, one should not settle for scars in "less" visible donor areas as a satisfactory outcome. The weight-bearing midline plantar area can be an optimal selection, offering effective camouflage for scars and enhancing patient satisfaction.

CONCLUSIONS

The purpose of hand syndactyly treatment is to achieve aesthetic separation for function. To correct congenital syndactyly of the hand, surgical division of the digits, followed by the placement of minimal FTSG from the weight-bearing midline plantar area at the interdigital webspace, can minimize scars on the hand dorsum, deliver color-matched skin to the surrounding area, and result in satisfactory donor-site scars.

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DISCLOSURE

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