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Outcomes of V-Y Dorsal Metacarpal Artery Perforator Flap for Web Space Reconstruction in Simple Syndactyly

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Abstract

Background: New web space formation is the most challenging in the treatment of syndactyly, and the choice of the ideal reconstructive technique is still controversial. Syndactyly repairs using skin grafts increase the risk of graft-related complications. The V-Y dorsal metacarpal artery perforator flap offers a method of syndactyly release that can eliminate the need for skin grafts. In this study to allow for further progress of the flap, we guarantee free dissection of the dorsal metacarpal vessels.

Objective: To evaluate the outcomes of simple syndactyly web space reconstruction with V-Y dorsal metacarpal artery perforator flap.

Method: Surgically treated 14 patients diagnosed with simple syndactyly were included in the study. Postoperative results were clinically evaluated by two independent surgeons as regards early postoperative infection, hematoma, congestion, flap necrosis, and long-term results such as web creep grade, finger deformity, Vancouver scar scale (VSS), contracture, range of motion, and parents "or patients" visual analogue scale (VAS) for aesthetic satisfaction.

Results: All 14 flaps survived well apart from two flaps that showed distal tip necrosis. All cases had normal MCP range of motion, and only two cases had extension lag. Flexion deformity was found in two cases only. As regards web creep, seven cases developed web creep grade I, five cases were grade II, and two cases were grade III. The total median value of the scar quality on the Vancouver Scar scale (VSS) was 5.43 [range 4-7]. The average total satisfaction of patients/caregivers was 8.14 [range 5-10].

Conclusion: The V-Y dorsal metacarpal artery perforator flap is a reliable option for web space reconstruction in simple syndactyly.

Key Words: *Simple syndactyly – Webspace reconstruction – Dorsal metacarpal artery flap.*

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Ethical Committee: The study was approved by the Ethical Committee of the Institutional Review Board (IRB), Mansoura Faculty of Medicine (MS.22.03.1918). Informed consent was obtained from the patients.

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Introduction

Syndactyly is a common congenital hand abnormality with variable degrees of fusion of the hand's bone and soft tissues. It could be categorized as incomplete or complete based on the grade of skin bridging and as simple or complex based on the lack or existence of bone fusions **[1]**. This deformity is hypothesized to be the outcome of a failure of programmed cell death during the first six to eight weeks of development **[2]**.

The syndactyly release is obtained by covering the recently separated digits with supple skin which doesn't induce restriction of the motions and by adjusting the size, shape, and position of the web space. So, the flap reconstruction of web space should create a proper neo-commissure similar to the other interdigital webs and normal web space characteristics **[3]**.

The surface area of separated fingers is always more than that of syndactylized fingers. As a result, such lack of skin is traditionally covered by skin graft, which is time-consuming and has many complications such as hair growth, hyperpigmentation, graft failure, web creep, contracture scar, reduced range of motion, and may lead to finger deformity **[4]**.

On the other hand, graftless approaches have recently been defined to manage these complications by utilizing a local skin flap from the hand's lax dorsal surface **[5]**.

The dorsal metacarpal artery perforator (DMAP) flap is an island flap raised on the dorsum of the hand for coverage of phalangeal and metacarpal soft tissue defects and web space reconstruction. It was first described by Quaba and Davison in 1990 as the distally based hand flap [6]. It relies on the distal cutaneous perforator of the dorsal metacarpal artery that arises at the level of the metacarpal neck in the second to fourth intermetacarpal spaces [7].

Other authors applied this flap as an island V-Y advancement flap [8] or as a transpositional flap [1] to correct syndactyly. The former technique may have limited advancement because the pedicle was not freely dissected in all cases. The later design may have some vascular complications as the flap is rotated 180°; however, the authors reported no postoperative flap problems. In this study, we ensure free dissection of the dorsal metacarpal vessel to give more advancement of the flap. Moreover, we are seeking an objective evaluation of the outcomes.

Patients and Methods

Institutional review board approval was obtained (IRB code: MS.22.03.1918) for a prospective study on a case series of fourteen patients with incomplete or complete simple syndactyly from March 2022 to February 2023 in a University Hospital.

The study included stable patients with simple syndactyly either complete or incomplete. We excluded patients with complex or complicated syndactyly, syndactyly of the first web space, brachysyndactyly, and other syndromes, and patients with medical comorbidities contraindicated to have general anesthesia.

History taking and adequate clinical examination were done. Routine laboratory investigations were requested. Each patient/caregiver received a detailed explanation about the procedure, the site of the scar, and possible complications. Informed consents were obtained from all cases or caregivers.

Surgical technique:

The procedure was performed under general anesthesia with the patient in a supine position. Localization of perforators was done using a handheld Doppler guided by the anatomical background of normal sites of perforators which lie at the neck of the metacarpal between the dorsal perforating branch of the palmar metacarpal artery and the dorsal metacarpal artery. Flap dimensions were marked according to the new anatomical web space design (Fig. 1-A).

Afterward, the tourniquet was inflated, and Skoog's zigzag incision was used to separate the fingers (Fig. 1-B). At the intermetacarpal area, a flap was created based on the dorsal metacarpal artery perforator located 0.5 to 1cm proximal to the metacarpophalangeal joint. The flap was designed with a distal concave edge and a proximal triangular tip. The length of the flap ranged from 1 to 2cm depending on the patient's age. The flap was narrowed in the center to fit easily into the released web. A transverse slightly convex line was designed at the level of the new web on the palmar surface to accommodate the flap's distal concave edge (Fig. 1-C). To aid in the visibility of the neurovascular bundles of the fingers, total exsanguination was avoided.

The dorsal metacarpal artery flap was then carefully undermined from the sides until the perforator vessels supplying the flap were visible (Fig. 1-D). This vessel is typically located just distal to the intertendinous connection of the corresponding intermetacarpal space. The pedicle was freely dissected, and the skin was advanced with the flap being undermined. Some of the superficial veins draining the flap were maintained. The flap was then moved distally, and the defect was directly closed primary (Fig. 1-E). A deeper web space release was performed to account for possible creeping of the web skin as the child grows. The monocryl® sutures were used for skin closure [8].

Postoperatively, to prevent flap compression fingers were placed in abduction using interdigital sterile gauze dressings for two weeks. A volar splint was used for 1 week to maintain the wrist and fingers extended. Light dressing over the flap with an open window was applied to allow flap monitoring. All patients/caregivers were advised to keep the limb elevated for 1 week to improve venous return. They were advised to take antiedematous medications and oral antibiotics for one week. The first dressing was done after 24 hours then they were discharged. After wound healing, active and passive physiotherapy was started and continued for 4 weeks.

Postoperative evaluation:

All patients were assessed for early postoperative complications in terms of venous congestion, hematoma, infection, wound dehiscence, and partial or total flap necrosis. Long-term results were evaluated by two plastic surgeons over 12 month follow-up period using the Withey score for postoperative success including web creep and deformity [9].

Web creep was evaluated by a 5-point-scale system (Fig. 2).

The deformity was subdivided into flexion extension deformity (grade 0 Normal digit, grade 1 Finger cannot be hyperextended, grade 2 Finger has a fixed flexion deformity), Lateral flexion de-

formity (grade 0 Absent, grade 1 Present), and Rotation deformity (grade 0 absent, grade1 present).

Scar quality was assessed according to the Vancouver scar scale **[10]**. This is a standardized scale that describes several aspects of the scar (pigmentation, vascularity, pliability, and height) (Table 1).

The postoperative range of motion of the metacarpophalangeal (MCP) joint was detected by a goniometer held parallel to a longitudinal axis of the metacarpal bone to measure flexion and extension lag angles as the normal value (0°/90°). The interdigital abduction angle was measured by a goniometer as it is considered normal if 25°-30° **[10]**.

The patients/caregivers' satisfaction regarding the aesthetic outcomes (scar quality, digital function, web space, finger contour, and overall satisfaction) was noted by using a visual analogue scale (VAS), and an average total score was made between 0 to 10 representing complete dissatisfaction and full satisfaction, respectively **[11]**.

Statistical analysis:

Statistical analysis was performed using the Statistical Package for the Social Sciences software version 22 (IBM SPSS Inc., Chicago, IL) for Windows 10. Categorial variables were expressed as percentages and continuous variables were expressed as means ± SDs (range).

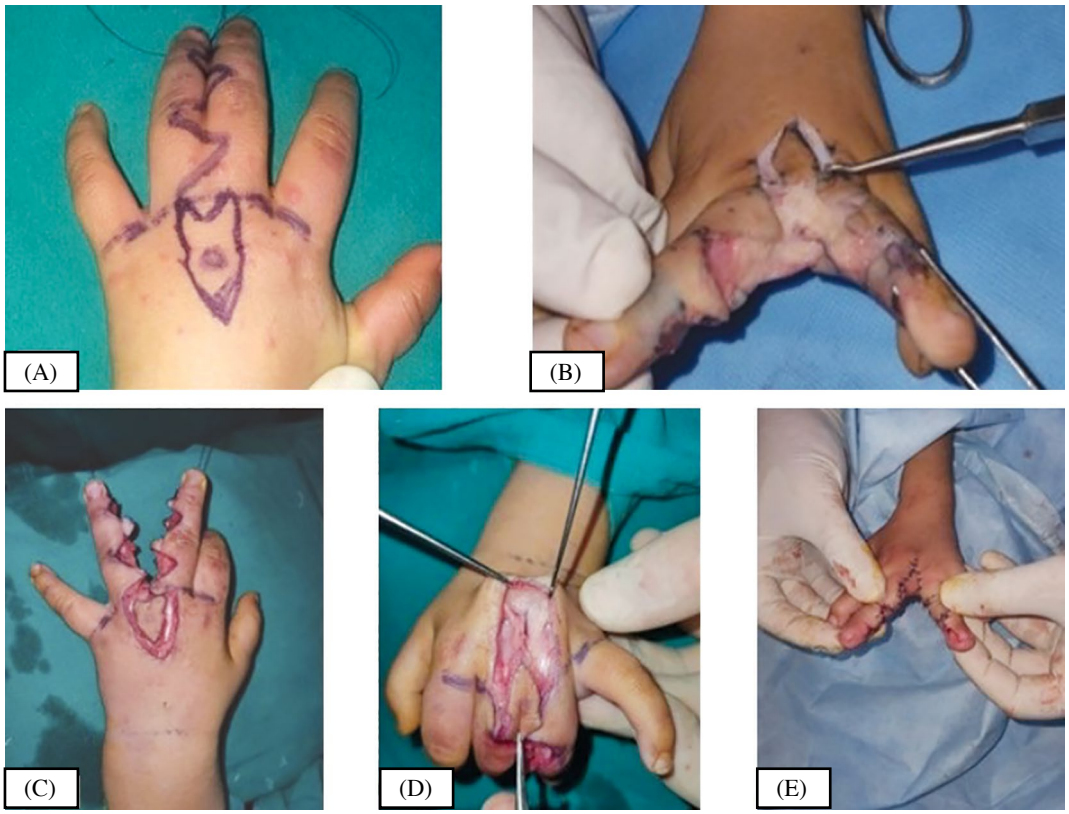

Fig. (1): (A) Preoperative identification of DMAP and marking of DMAP flap (B) Finger separation by Skoog's zigzag incision (C) The DMAP flap was created based on the dorsal metacarpal artery perforator situated between 0.5 and 1cm from the MCP joint proximally. The flap was designed with a triangular tip at the proximal end and a distal concave edge. (D) Flap elevation and DMAP identification. (E) Flap inset and new web formation.

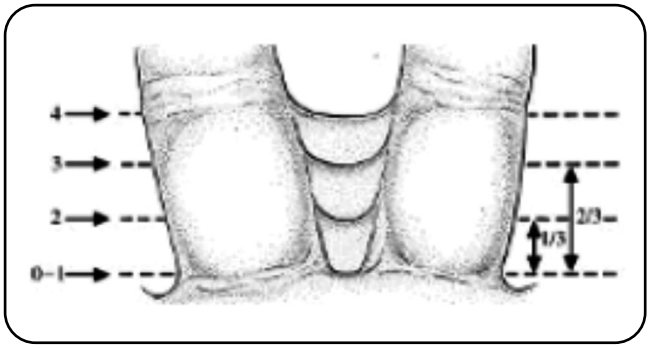

Fig. (2): Web creep categorization by Withey et al., **[9]**. (grades 0–4: Soft webs, abduction mirrors the adjacent web or equivalent web, grade 1–4: No web advancement, but a thickening of the web with the reduced span, grade 2–4: Web creep to 1/3 of the distance between the web base and PIPJ (proximal interphalangeal joint) crease, grade 3-4: Creep of the web to 2/3 of the distance between the base of the web and PIPJ crease, grade 4: Web creep to the PIPJ crease).

Results

Fourteen patients (six males and eight females) with simple syndactyly either complete or incomplete underwent syndactyly release and new web reconstruction by DMAP flap, the mean age of the studied cases is 3.43 ranging from 1 to 26 years, (57.1%) are females and (42.9%) are males (Table 2).

Seven flaps were based on the 3rd DMAP (50%), four flaps were based on the 2nd DMAP (28.6%), and three flaps were based on the 4th DMAP (21.4%). The mean flap dimensions were 3.8*1.4cm [±.75*.24] And syndactyly release with web reconstruction was executed within 84.6 minutes [±9.90] on average (Table 2).

Early postoperative follow-up revealed that four cases (28.6%) developed wound infections that resolved with oral antibiotics, three cases (21.4%) showed temporary congestion that disappeared after 48 hours with limb elevation, hot fomentation, and thrombex gel®, two cases (14,3%) had 2mm distal tip flap necrosis It was managed by conservative treatment and four cases had distal tip flap maceration which was completely healed in next follow-ups (Table 2).

Long-term follow-up (12 months) revealed that seven cases (50%) developed web creep grade I, five cases (35.7%) grade II, and two cases (14.3%) grade III, and the average grade was 1.64 [±0.72] (Table 2).

Among fourteen cases, twelve cases (85.8%) had no flexion deformity, one case (7.1%) had middle finger flexion deformity and another case (7.1%) had little finger flexion deformity at the MCP joint.no rotational /lateral deformity was noted. scar contracture was noted in two cases causing finger flexion deformity (Table 2).

According to the Vancouver Scar Scale (VSS) (10) five cases (35.7%) developed scar with a score 5, three cases (21.4%) had a score 4, three cases (21.4%) had a score 6, and three cases (21.4%) were scored 7 (Table 2) And the total median value was 5.43 [±1.05]. The scores for the individual sub-scales are 1.14 [±0.52] for pigmentation, 1.29 [±0.45] for vascularity, 1.79 [±0.56] for pliability, and 1.21 [±0.41] for scar height.

As regards MCP range of motion, all cases had a normal extension, only two cases (14.3%) had extension lag (10°/90°). MCP Flexion angle was distributed as follows; three cases (21.4%) showed (0°/90°), five cases (35.7%) showed (0°/70°) and four cases (28.6%) had (0°/80°) and the mean flexion angle was 80.71° [±7.99]. Abduction degree was as follows; five cases (35.7%) showed 40°, five cases (28.6%) showed 30°, 4 cases showed 45 and the mean abduction angle was 37.86° [±6.19] (Table 2).

The average total satisfaction of patients/caregivers was 8.14 [±1.36].

Table (1): Grading of scar quality according to the Vancouver scar scale **[10]**.

Score	Pigmentation	Vascularity	Pliability	Scar height
0	Normal	Normal	Close to normal	Flat
1	Hypopigmented	Pink	Supple	<2mm
2	Mixed	Red	Yielding	2-5 mm
3	Hyperpigmented	Purple	Firm	>5mm
4	–	–	Banding	–
5	–	–	Contracture	–

Table (2): Demographic data, perioperative, functional, and aesthetic outcome of web reconstruction by V-Y DMAP flap.

Case	Sex/age (y)	Type of syndactyly*	Affected web space*	Flap dimensions *(cm)	Operative time per web*	Complications*	Web creep grade*	Deformity*	VSS score*	MCP ROM* (extension lag/flexion)	Abduction angle*	Aesthetic satisfaction* (VAS)
1	M/26	Complete	Lt 3rd	5.7*2	100	2 mmdistal tip necrosis, temporary congestion	1	No	7	(0°/90)	45°	8
2	F/1	Complete	Lt 3rd	3.5*1	90	No	1	No	4	(0°/80)	45°	9
3	F/2	Complete	Lt 4th	4*1.5	90	No	1	No	5	(0°/70)	40°	9
4	M/1	Complete	Lt 3rd	3*1.2	85	Infection, temporary congestion	3	Middle finger flexion deformity	6	Extension lag (10°/90)	30°	5
5	F/1	Incomplete	Rt 3rd	4*1.5	70	No	1	No	4	(0°/70)	40°	9
6	M/1.5	Complete	Lt 2nd	3.7*1.5	80	No	2	No	7	(0°/80)	30°	8
7	F/2.5	Complete	Rt 2nd	4.6*1.7	90	2mm distal tip necrosis	2	No	6	(0°/90)	45°	8
8	F/1.5	Complete	Lt 3rd	3.5*1.3	95	Infection	1	No	5	(0°/80)	40°	9
9	M/2	Incomplete	Lt 4th	4.3*1.2	60	No	1	No	5	(0°/70)	40°	9
10	M/1	Complete	Rt 3rd	3*1.5	90	No	2	No	5	(0°/80)	30°	9
11	F/1.5	Complete	Rt 2nd	3.5*1.5	90	Infection	2	No	7	(0°/70)	30°	8
12	M/2	Incomplete	Rt 3rd	3*1.2	80	No	1	No	4	(0°/90)	40°	9
13	F/2	Complete	Rt 4th	4.5*1.5	80	Infection, temporary congestion	3	Little finger flexion deformity	6	Extension lag (10°/90)	30°	5
14	F/1.5	Complete	Lt 2nd	3*1.3	85	No	2	No	5	(0°/70)	45°	9

M: Male. Rt: Right. VSS: Vancouver scar scale.
F : Female. Lt: Left. VAS: Visual analogue scale.
MCP ROM: Metacarpophalangeal joint range of motion.

Fig. (3): An example of a Case: 1.5-year-old male patient with incomplete simple syndactyly ( ) the left middle and ring fingers. (A) pre-operative dorsal view (B) pre-operative ventral view (C) 1-year post-operative dorsal view (D) 1-year post-operative ventral view.

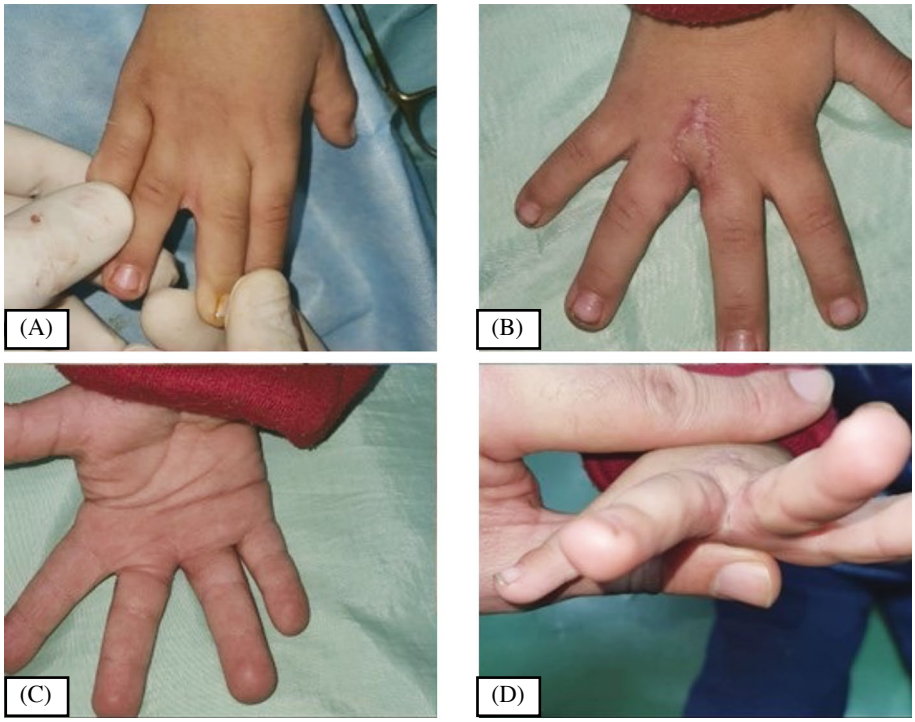

Fig. (4): An example of a Case: 2-year-old male patient with incomplete simple syndactyly ( ) right middle and ring fingers. (A) pre-operative dorsal view (B)1-year post-operative dorsal view (C) 1-year post-operative ventral view (D) 1-year post-operative anterior view.

Discussion

The most important and difficult aspect of treating syndactyly is normal neo-web space reconstruction. Many different web reconstruction methods have been developed. Each technique has its advantages and disadvantages. In the repair of congenital syndactyly, long-term stability of the newly created web space is best achieved when lined with well-vascularized native skin **[3]**.

Traditional surgical approaches for syndactyly repair have used flaps from the dorsum of the involved fingers, dorsal, and palmar interdigitating flaps. However, these flaps are dependent on the skin from syndactylic fingers which is insufficient to cover the resulting raw surface area. As a result, skin grafts have often been used to cover remaining surgical defects, but they have also been associated with suboptimal results, including skin contracture, web creep, graft loss, hyperpigmentation, hair growth, and hypertrophic scarring **[4]**.

Otherwise, the V-Y dorsal flap lines the web with skin from the dorsum of the hand rather than the proximal phalanges, which lessens the requirement for skin grafting in syndactyly repair. The flap is although well vascularized from branches of the dorsal metacarpal artery **[1,8]**.

The dorsal metacarpal artery perforator [DMAP] flap is an island flap raised on the dorsum of the hand for coverage of phalangeal and metacarpal soft tissue defects and web space reconstruction. It is an axial pattern flap based on the distal cutaneous perforator of the DMA 0.5-1cm proximal to the adjacent MCP joint. The DMAP flap is easy to harvest because dissection is superficial to the paratenon of the extensor tendon in the relatively avascular loose areolar plane **[7]**.

In our study, the V-Y (DMAP) flap was used to reconstruct fourteen web spaces in fourteen patients with complete or incomplete simple syndactyly. (Authors used objective assessment to quantify the outcomes regarding web creep, scar quality, and functional and aesthetic results.

The operative time of syndactyly separation depends on the extent and type of syndactyly, as well as on the surgical technique. The length of surgery using zigzag incisions and full-thickness skin grafts combined with web reconstruction with commissural dorsal flap varied from 40 to 120 minutes, with mean operative times of 68 minutes in simple incomplete syndactyly, and 95 minutes in simple complete syndactyly **[12]**. The reported length of simple syndactyly separation without skin grafts with metacarpal advancement flaps and zigzag incisions is shorter ranging between 44 and 86 minutes **[13,14,15]**. In our series we exclude complex syndactyly, and the separation of simple incomplete syndactyly lasted for just over an hour, in most simple complete syndactyly, it lasted for less than 2 hours which is quite close to the reported operation times with other graftless techniques.

The DMAP flap pedicle was freely dissected in this report to allow more advancement with the maintenance of some superficial veins for more venous drainage. Sherif et al., (1998) didn't freely dissect the pedicle in all cases and reported no flap loss **[8]**. Nevertheless, a systematic review reported five cases of flap necrosis **[16]**. In the recent series, there were no incidences of partial or total flap loss except for two cases of marginal tip necrosis which could be attributed to inadequate adjacent finger abduction and healed with local dressing. Also, there was no neurovascular injury. The major potential intraoperative complication is an injury to the digital artery or nerve while separating and defatting the fingers proximally. This can easily be avoided by carefully identifying and preserving the neurovascular bundle during dissection.

Postoperative infections after syndactyly release with full-thickness skin grafts occurred in 3% of the 144 syndactyly webs treated by Barabás and Pickford **[5,17]**. Greuse and Coessens (2001) and Widerberg et al (2016) using graftless technique reported that the risk of a postoperative infection was higher where 1/16 and 4/19 of patients developed an infection **[18,19]**. The early postoperative complication was observed in this series, that four cases developed a self-induced infection that healed with oral antibiotics, and three cases showed temporary congestion which disappeared after 48 hours with limb elevation, hot fomentation, and thrombex gel®.

Mericli et al., (2015) described M to V flap with skin grafting for web reconstruction in syndactyly. Found that twelve webs developed web creep which is probably caused by side wall wound contracture that pulls the reconstructed web distally **[3]**. Grahn et al., (2020) reported no scar contractures, and 2/30 hypertrophic scars **[5]**.

In our study, the mean web creep grade was 1.64±0.72. It was reported that the mean web creep score was 2.1 after using the V-Y DMAP flap in simple and complex cases **[15]**. The occurrence of web creep could be attributed to delayed wound healing due to postoperative infection, distal flap necrosis, or lack of splinting. During follow-up there were twelve cases (85.5%) had no deformity, one case had middle finger flexion deformity and one case had little finger flexion deformity which could attributed to delayed postoperative passive and active motion. These complications were treated by releasing z-plasty. In our study, the total mean VSS was 5.43±1.05, another study reported total median value for 29 web spaces was 3 points after syndactyly release with trilobed flap **[19]**. In all cases, silicone gel improved the dorsal hand scars eventually.

The mean finger abduction was 37.86±6.19 in this report. The same outcome was reported after using palmar and dorsal triangular flaps **[10]**. The mean total VAS in our study was 8.14±1.36 which was comparable to what was reported after using graftless techniques by another group in which the average VAS score was 7.9 **[11]**.

Our study had some limitations in the form of a limited number of patients and a short period of follow-up. Moreover, further comparative randomized studies are needed to allow surgeons to choose between different flap techniques. Nevertheless, this prospective study reports a detailed objective evaluation for outcomes of syndactyly release by V-Y DMAP flap.

Conclusion:

To conclude, the dorsal metacarpal artery perforator flap is an excellent option for web space reconstruction. in simple syndactyly cases. It is easily performed and versatile without the need for skin grafts. Moreover, the results are functionally and cosmetically satisfactory and comparable with other graftless techniques.

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