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Evaluation of hexagonal flap for Syndactyly repair

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Abstract

Background and objective: Syndactyly is among the most commonly treated hand anomalies by plastic surgeons. Since the 1800s,over 46 corrective procedures have been described. These techniques involve using different flap designs and full-thickness skin graft or depending on graftless techniques to achieve the goals. Some articles concluded that graftless techniques have shorter operative times and fewer postoperative complications.

The aim of the study is to evaluate the use of a local "hexagonal" dorsal advancement flap (HDAF) for syndactyly repair without using a skin graft.

Methods: Between March 2021 and March 2022, we operated on 18 subjects (25 web spaces) in Rizgary and Hawler teaching hospitals in Erbil. Our study subjects were children and adults with different types of syndactyly (congenital, recurrent, and post-burn). We studied the early outcomes of using HDAF and straight-line incision for syndactyly repair.

Results: The patients' ages ranged from 1.5 to 50 years, and the mean follow-up period was 6.3 months (1-13 months). The mean operation time was 98.5 minutes (40-160 minutes). Wounds were closed primarily without skin graft in 96% of the cases. We encountered neither a flap loss nor recurrences of syndactyly. The mean abduction angle achieved was 36.5º. All patients and their caregivers were satisfied with the aesthetic outcome.

Conclusion: Syndactyly repair using a hexagonal dorsal advancement flap and straight-line separation of the fingers is a safe and straightforward technique regardless of age and syndactyly class or type. It results in a relatively short procedure with good-looking and well-functioning fingers.

Keywords: Syndactyly repair in adults; Congenital hand anomaly; Recurrent syndactyly; Post-burn syndactyly.

Introduction

Syndactyly is a fused web space between adjacent fingers.[1] It is mainly a result of the failure of differentiation in the womb, with an incidence of 1 in 2,000-3,000 newborns.[2] Usually, the digits and small joints are well differentiated by weeks 7-8 of gestation.[3]

There is an equal chance for single or bilateral limb affection with syndactyly[1] with twice as often in male than female-born babies.[1,2]

Mostly, syndactyly is sporadic, and it is familial in 10-40% of instances.[5] Syndactyly has mainly autosomal dominant inheritance.

For classification purposes, syndactyly can be described as complete, incomplete, simple, complex, or complicated.[2,6]

There has been advancement in understanding syndactyly and its causative factors; nevertheless, the management protocol is stable with minimal, if any, change over many years; notably, this management fashion is not risky.[5]

Syndactyly release as a procedure falls

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among the most commonly executed surgeries treating congenital hand deformities.[7] The discrepancy in the size of the conjoined digits influences the ideal time for surgical correction of syndactyly. Ideally, the surgical intervention could be delayed by the first to the second year of the child's life. The hand grows double in size in the first two years of life; thus, the operation is much easier with lesser complication rates after one year of age.[8,9]

In general, the goals of surgical release of syndactyly are: achieving a functional hand, creating a near-normal webspace, and tensionless wound closure.[2] Alternatively, surgical correction aims to produce independent, functional digits with the fewest possible surgeries and complications.[4]

It is good to understand the extent of available soft tissue and skin for wound coverage following surgical release of the syndactyly; by measuring the circumference of the conjoined fingers, which is 22 percent lesser than the sum of the circumference of each finger. Therefore, a gap or deficiency of skin is encountered after the surgical release. Skin flaps are better for reconstructing the webspace and over the joints.

New advances in syndactyly reconstruction involve an approach to using a graftless surgical technique; as a result, many flap designs have been described. Defatting to an appropriate extent is concluded as a valuable means of achieving this goal.[8]

The zig-zag incision is the most popular to separate the conjoined digits cited in papers. Many other incision types have been used, including curved, rectangular interdigitating, Z-plasty, and straight-line incisions.[7] Midline incisions with closure points at the mid-lateral aspect have been reported as safe with acceptable aesthetic and functional results.[10]

There is no agreement on whether the use of graft or no graft technique is ideal.[11] Nevertheless, it has been concluded, from a comparative study of using a graft vs. a no-graft technique, that the total tourniquet time is shorter for the no-graft technique, which means a shorter total operative time.[12] Reportedly, procedures depending on a graftless technique have fewer complications, including early and late ones (i.e., infection, flap necrosis, graft failure, web creep, contracture).[13]

This study evaluates the early results of using an HDAF for syndactyly repair with straight-line separation of the conjoined digits and direct closure without utilizing a skin graft, a relatively new technique in Iraq.

Aim: To evaluate a "hexagonal" flap for syndactyly release without the use of graft.

Specific Objectives: To assess outcomes based on

- Operative time
- Postoperative functional level
- Postoperative acute and long-term complications
- Postoperative web creep
- Aesthetic appearance using a visual analog scale

Methods

We conducted this prospective observational descriptive study between March 1st, 2021, and March 31st, 2022, in Rizgary and Hawler Teaching Hospitals in Erbil. This study includes all non-syndromic syndactyly cases we have received in our facilities (18 patients/ 25 webspaces). These cases included congenital, recurrent, and post-burn syndactyly, with ages ranging between 1.5-50 years (*M*13.9, ±11.3).

Only complicated or syndromic syndactylies were excluded from this study due to the involvement of abnormal bony connections and subsequent complexity in wound closure.[7] The study evaluated using an HDAF and straight midline incision coupled with defatting between the conjoined digits without using a skin graft in the closure of the wound.[10]

We analyzed the aesthetic outcome by collecting input from the participants, their caregivers, and ourselves using a visual

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analog scale (VAS) of 0-100. The value represents satisfaction with the aesthetic outcome, with zero being ugly and one hundred being beautiful.

The patients were followed up regularly with a schedule of one week, two weeks, four weeks, eight weeks, 12 weeks, and six months postoperatively.

We have documented the results using photographs of the affected hand, palmar and dorsal views, preoperatively and at each follow-up visit. We have also sent plain radiographic studies for each patient prepared for surgery for assessment and archiving purposes.

We calculated the finger abduction angle using a goniometer. For measurement, we asked the patient to lay their hand flat on the table, all the joints extended, and fingers adducted. We put the goniometer on the hand's dorsum and held it in alignment with the middle finger and the wrist. We keep one of the limbs of the goniometer fixed and move the other limb in conjunction with the finger being abducted away from the middle finger.

Ethical considerations:

Hawler Medical University's Human Research Ethics committee approved this study.All parents and patients (15 years and older) provided verbal and written informed consent for participating in the study and publishing data and pictures.

Surgical technique:

Surgery is conducted under general anesthesia in the supine position, with a tourniquet and loupe magnification. After prepping the hand and forearm with povidone-iodine, the incision lines were marked, on the dorsum, with the hand resting flat on the table. We started the markings by measuring the distance between the knuckles of the conjoined digits. Then we marked each knuckle with a dot. We calculate an equal distance and measure it starting from the point on the knuckle extending parallel to the phalanx and indicate a point at the end of this line. We repeat this for the next knuckle. The four dots form a square. The knuckle and digit points intersect equidistant from each point and are slightly shorter than the inter-knuckle distance, thus, creating an isosceles triangle at each side of the square. Then we draw the lines extending between all the points except between the knuckles forming the marking for the hexagonal flap, and we mark a straight line/doting extending from a point mid the hexagon till the end of the conjoined skin for the finger separation (Figure 1a).

On the palmar aspect, marking the straight -line incision for finger separation is continued in the same patternas above (Figure 1b). We indicated a straight horizontal line of equal measurement to that of the inter-knuckle distance at the MCP joint crease; we made a slight overcorrection to where the crease would be to mitigate web creeping.[2] We used Buck Gramco markings of triangular pulp flaps to create the nail fold when required. (Figure 1)

We carry out the dorsal incisions and hexagonal flap elevation first, then the volar incisions (Figure 2 a,b); fingers are separated in distal to proximal direction.

The defatting was done meticulously with extra care so as not to injure the neurovascular supply of the digits (Figure 2c).

Wounds were closed, starting with the hexagonal flap insetting to reconstruct the webspace. The digit wounds were closed directly in the mid-axial line (Figure 2d). We used Vicryl 5-0 suture material with simple interrupted stitches for the closure of wounds.

Vaseline-impregnated gauze, layered with fluffy gauze and a soft dressing, was used to cover the wound. The tourniquet was deflated after the completion of the dressings. We used a volar splint with the wrist in the neutral position, MP joint extended, and fingers extended with minimal abduction.

Postoperative medications included antibiotics, analgesics, Pentoxifylline tablets (twice daily for one week), and Dexamethasone ampules for the first three

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three days, with an age-appropriate dosage.

The surgeon changed the patient's first dressing on the seventh postoperative day.

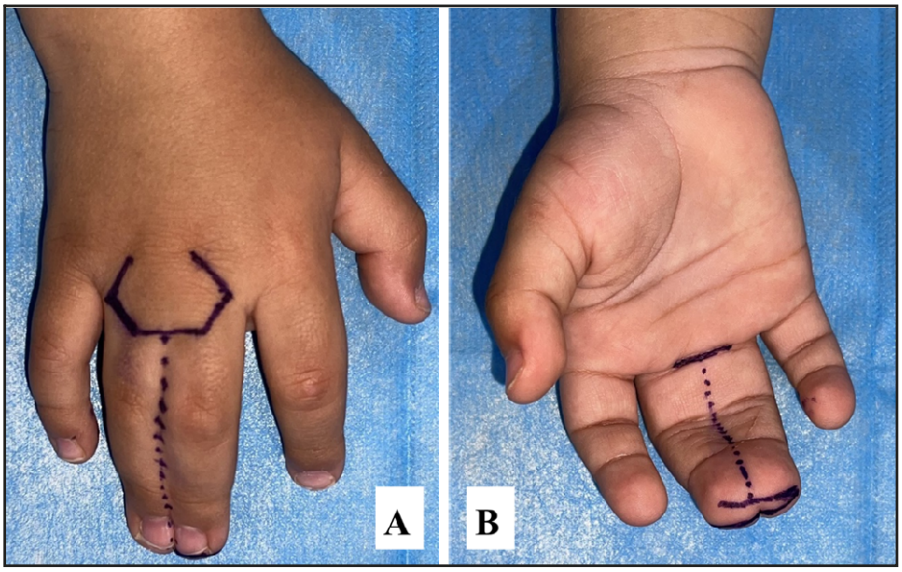

Figure 1 Markings for a case with complete complex syndactyly. (A) Dorsal marking. (B) Volar markings also showing Buck Gramcko triangular pulp flaps

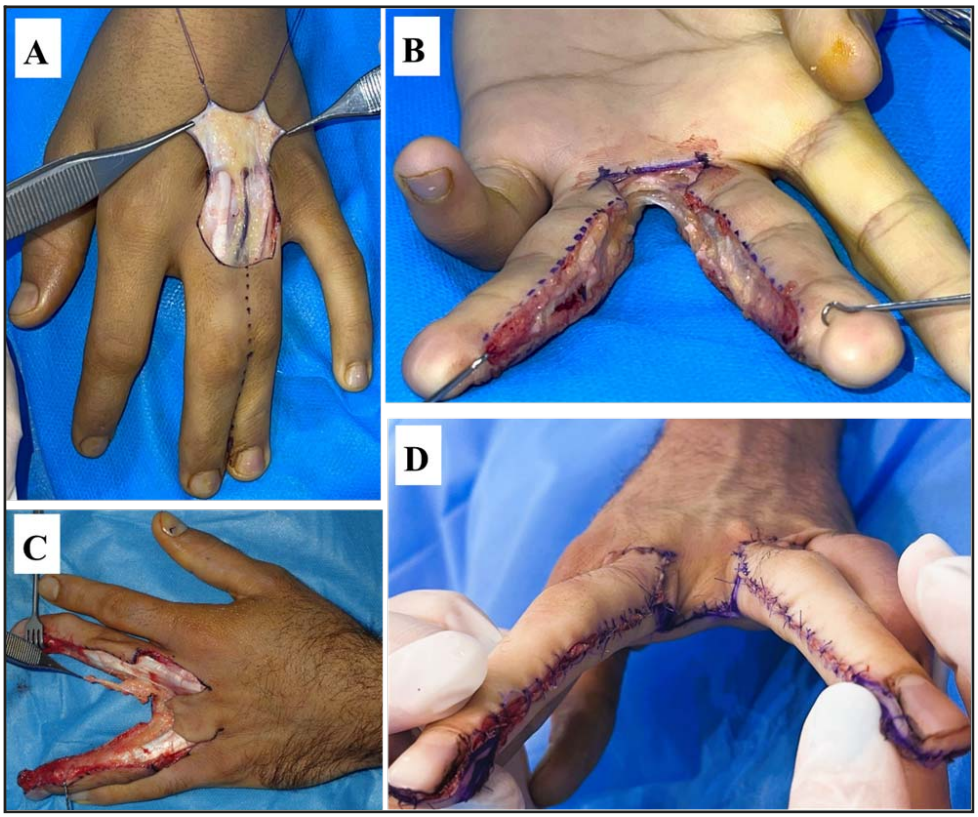

Figure 2 Operative procedure. (A) Elevation of Hexagonal dorsal advancement flap, (B) volar view after finger separation in a straight-line incision, (C) Defatting of the flaps before closure, and (D) complete closure of all wounds

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All the study participants had a questionnaire or information form filled out with a unique code per case.

Statistical analysis

We used the Statistical Package for Social Sciences (SPSS, version 25) for data analysis. One-way analysis of variance (ANOVA) was used to compare three means, and a post hoc test (LSD) was used to compare every two groups. A *P*-value of ≤0.05 was considered statistically significant.

Results

All of our patients were committed to the follow-up schedule, with a mean follow-up of 6.3 (±2.89 SD) months (range, 1-13 months). The participants' mean age (SD) was 13.9 (11.3) years, ranging from 1.5-50 years, and the median was 11 years. Males were affected more commonly (55.6%); two-thirds (66.7%) had no history of a previous operation, while 11.1% had a history of three or four operations. Refer to Table 1.

Table 1 Basic characteristics of the patients

	No.	(%)
Age		
< 6	4	(22.2)
6-11	5	(27.8)
12-17	4	(22.2)
≥ 18	5	(27.8)
Mean (SD)	13.9	(11.3)
Gender		
Male	10	(55.6)
Female	8	(44.4)
Previous operations		
None	12	(66.7)
1-2	4	(22.2)
3-4	2	(11.1)
No. of web spaces repaired		
One	12	(66.7)
Two	5	(27.8)
Three	1	(5.6)
Total	18	(100.0)

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The left third web was the most common operation site (52%). The most common class of syndactyly was the simple incomplete type (48%). The syndactyly type was congenital in 64% of the lesions (Table 2).

We did not use a skin graft for wound closure for the majority of our patients (24/25, 96%), except for one instance when a full-thickness skin graft was used (harvested from the groin).

The mean operation time for repairing congenital and recurrent syndactyly was 106.7 minutes and 105.0 minutes, respectively. These were significantly higher than the postburn syndactyly, 67.0 minutes (P = 0.005 and P = 0.033, respectively). The shortest mean operation time (84.3 minutes) was for the repair of simple incomplete syndactyly (SI), which was significantly (P = 0.014) less than that spent to repair the complex syndactyly (117.1 minutes) (Table 3).

Table 2 Characteristics of the lesions.

	No.	(%)
Affected hand and webspace		
Right 2nd web	1	(4.0)
Right 3rd web	5	(20.0)
Right 4th web	4	(16.0)
Left 2nd web	1	(4.0)
Left 3rd web	13	(52.0)
Left 4th web	1	(4.0)
Class of syndactyly		
Simple complete	6	(24.0)
Simple incomplete	12	(48.0)
Complex	7	(28.0)
Type of syndactyly		
Congenital	16	(64.0)
Recurrent	4	(16.0)
Post-burn	5	(20.0)
Total	25	(100.0)

Table 3 Mean operation time by type and class of syndactyly

Type of syndactyly	N	Mean op. time†	(SD)	*P**	LSD (groups)	*P***
Type of syndactyly						
A) Congenital	16	106.7	(27.8)		A X B	0.904
B) Recurrent	4	105.0	(12.9)	0.016	A X C	0.005
C) Postburn	5	67.0	(18.9)		B X C	0.033
Class of syndactyly						
A) Simple complete	6	105.0	(11.0)		A X B	0.124
B) Simple incomplete	12	84.3	(34.3)	0.038	A X C	0.407
C) Complex	7	117.1	(13.8)		B X C	0.014
Total	25	98.5	(28.7)		Min. 40	Max. 160

*By ANOVA test. **By LSD test. †Mean operation time in minutes.

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We encountered no serious complications, early or late, in our series, except for the following: Delayed wound healing that developed in 5 out of 25 sites (20%) and partial wound dehiscence in a single instance. Insignificant minimal web creeping (grade 1, according to Withey et al.[14]) was noted in 3/25 (12%) webs repaired. One case developed a hypertrophic scar (4%), and another developed a color change in the SG area (4%).

We depended on finger metacarpophalangeal joint (MPJ) abduction angle for evaluation of functional outcome; the results showed a mean (SD) abduction angle of 36.5º (5.3 º), ranging from 28-46º. Four patients (16%) need revision surgery due to associated finger deformities.

Assessment of the esthetic outcomes using a 100 score scale (Visual Analogue Scale), where zero means ugly (totally disfigured), and 100 means beautiful. A score of 90-100 means highly satisfied, 70-89 satisfied, 50-69 neutral, and a score of less than 50 is unsatisfied. The patients (15 years and older), their parents, and the surgeons were generally satisfied with the aesthetic outcomes (Table 4).

Discussion

The literature includes different techniques for syndactyly repair. Skin grafting, as part of the reconstruction of syndactyly repair, was first introduced in 1891 and is still used today.[15] However, skin grafting has a greater incidence of postoperative complications compared with techniques avoiding its use. These complications include web creep, hyperpigmentation, recipient site hair growth, donor site morbidity, hypertrophic scarring, and subsequent revision surgery.[13]

Zeller first introduced a dorsal V flap for web reconstruction in 1810, followed by many designs. In 1956, Cronin introduced the palmar and dorsal zig-zag incision technique (which is still popular). SG was part of the procedure covering the raw areas in all these techniques. Due to the application of skin grafts, web creep and contractures remain frequent complications of these techniques.[16]

Our series evaluated the early outcomes of HDAF and straight-line incision for syndactyly repair in children, adolescents, and adults. The adults represented 27.8% of the participants (18 years old), while 66.7% were children aged 4-18 years. In contrast to similar articles that report the results of the application of hexagonal flap for syndactyly repair, including 0% of adult participants, the oldest participant among these series is 3.5 years old (42 months).[10,15] Moreover, articles describing or comparing the results of any technique for syndactyly repair in adults are infrequent.[18,19]

Patients may present late for corrective surgery in our locality for many reasons. These may include: families residing in rural areas, which have limited or no access to adequate health education; they fear for their infants and toddlers from operative intervention at an early age; and also the lack of adequate finances to support travel to major hospitals in the city.

Reports may mention that skin elasticity and subcutaneous fat decrease with the increase in the patient's age, leading to tensioned wound closure.[15] However,

Table 4 Visual analog score (VAS) as assessed by the patients (or their parents) and surgeons.

	Mean	(SD)	Median	Minimum	Maximum
Patient/Parents' VAS	93.0	(8.7)	95.0	70.0	100.0
Surgeon's VAS	93.3	(4.0)	95.0	85.0	100.0

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regardless of age, we have not experienced difficulties achieving tensionless wound closure of our patients' hexagonal and finger flaps. We achieved tensionless closure because of proper planning, undermining, and meticulous defatting.

In our series, the mean time spent on repairing simple incomplete (SI), simple complete (SC), and complex (C) syndactyly was 73, 86, and 101 minutes, respectively. In agreement with another study using the HDAF technique, that reported a mean operative time for SI, SC, and C syndactyly to be 76, 91, and 129 minutes, respectively. It is worth mentioning that this cross-compared study included all pediatric patients under the age of four years.[10]

In contrast, a study reported the result of web space release in 39 patients with Apert syndrome. The surgeon has achieved a ten -finger repair in two stages; the operative time for the first-stage syndactyly repair of eight webs in the hands and feet averaged four hours and 11 minutes (range, 185 to 300 minutes). Furthermore, the second stage procedure for the rest of the digits averaged three hours and 49 minutes (range, 160 to 300 minutes). This cross-compared study does not provide a breakdown of operative time per web nor class of syndactyly.[17]

Many authors concluded that syndactyly repairs using skin grafts have a longer duration.[18,19]

In only one case, we used an FTSG (1/25), which was postburn syndactyly with flexion contracture of the fingers for the closure of the raw area on the fingers. However, the other three cases of postburn syndactyly (who had no contractures) in our series did not need a skin graft for closure.

We encountered wound dehiscence in a single instance due to a patient factor (he removed his stitches after one week by himself), which responded very well to dressing change and applying RepaLysyal cream.

Some authors mentioned that defatting might make the repaired fingers look thinner than unoperated fingers.[20] However, we observed no noticeable change in the finger contour compared with the non-syndactylized fingers in our cases (Figure 3). It may be because we have avoided aggressive defatting, leaving 1-2 mm thickness fat over the flaps and tensionless closure.

In the cases with multiple syndactylized fingers, we separated any two adjacent syndactylies three to four months apart.

None of our patients developed chronic pain or numbness/paresthesia in the separated digits, with no sacrifice of digital nerves or arteries. This finding is comparable to other studies.[21,22] On the other hand, several studies reported iatrogenic digital nerve injuries during the operation.[20,23] We ensured a bloodless operative field, using delicate instruments and careful dissection and tissue handling.

The patients, specifically the adults, had limited active abduction of the MCP joints. On passive abduction, the web was wide with no limitation to the movement; it may be due to late presentation to corrective surgery that leads to disuse atrophy of the small muscles of the hand. However, this finding did not affect hand function and improved with physiotherapy.

Scar contracture drags the repaired webspace distally as the sidewall heals, causing early web creep. While phalangeal expansion may lead to late web creep,[24] we have not noticed any significant creeping that affects hand function or patient satisfaction. However, in three pediatric (a 1.5-year-old boy and two 12-year-old twin sisters) cases in our series, we noticed mild creeping, grade 1 according to Whitney's classification.

One of these cases had a propensity for hypertrophic scarring following any skin wound. We noticed the creeping during calculations without the family noticing the finding. None of these cases requested revision surgery since they were very satisfied, agreeing with a study showing that the advancement flap techniques had fewer revision surgeries than techniques

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utilizing a skin graft.[13]

We relied on the visual analog score (VAS) for assessing the aesthetic outcome. The patients, their caregivers, and ourselves were very satisfied. All the participants and their caregivers answered the VAS section, and 76% of the cases scored 90–100/100, which means highly satisfied. While in 24% of the instances, the patients gave a score of 70–90/100, which means satisfied.

Those who were "satisfied" explained that they gave the score based on factors that have affected the overall aesthetics of the hand. These factors were pigmentation of the skin grafted area, associated finger deformity, and old scar of recurrent syndactyly. They had the misconception that these scars would disappear or be improved. Moreover, the finger deformity became more prominent to their attention after the correction of syndactyly. Contrary to the reported result of a comparative study of skin graft versus graftless techniques showing an aesthetic advantage of skin graft techniques over the graftless ones, with a few comparative images showing the final scars of both techniques.[12]

Ni et al.[16], Liu et al.[25], and Karamese et al.[26] reported that the dorsal advancement flaps might have conspicuous scars posing aesthetic limitations. However, we have not noted such drawbacks with our hexagonal flap. On the contrary, the dorsal hand wounds healed in a small linear scar (Figure 3 and 4), roughly visible from a 30 cm distance, and the patients and their parents were very satisfied.

This technique is versatile in its use in different age groups and syndactyly types and classes, contrary to some other graft-less techniques utilizing dorsal metacarpal flaps, which may be applicable in simple incomplete syndactyly or only web releases.[22,25] This technique is versatile; moreover, it is also straightforward to master by young and inexperienced surgeons, as opposed to complicated flap designs and techniques.[15,26]

The study results will contribute, in general, to the improved outcome in syndactyly reconstruction and, ideally, may lead to a guideline for syndactyly repair locally.

The duration of the study may be a limitation, a more extended period of 3-5 years would reveal further dimensions of this technique and its results.

Conclusion

The HDAF and straight-line separation of the fingers is a safe and straightforward technique for syndactyly repair regardless of age and syndactyly class or type. It results in a relatively short procedure with good-looking and well-functioning fingers.

We recommend that further study be conducted on a larger sample size with a more extended follow-up period (five to seven years) to evaluate the late outcome of this vital technique.

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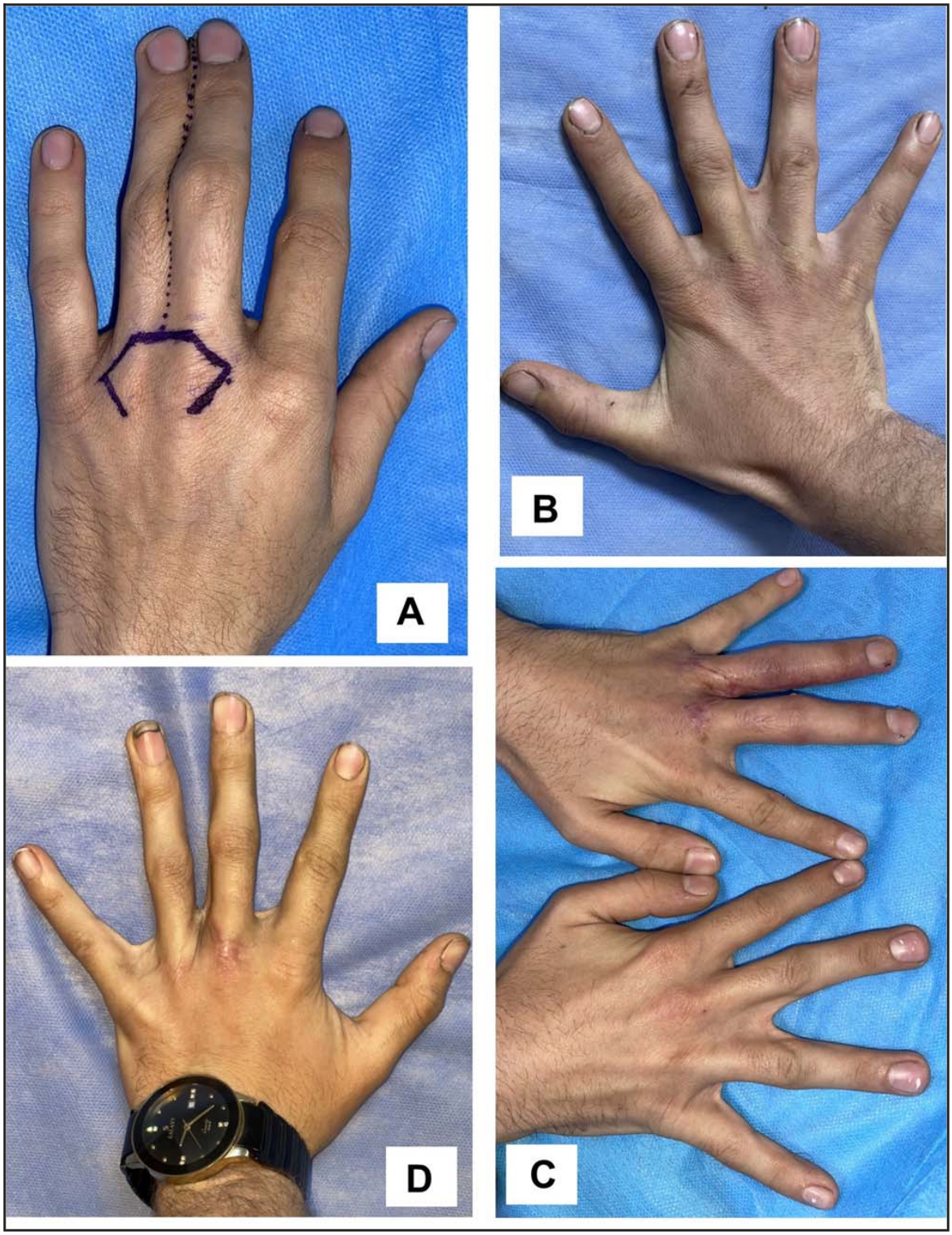

Figure 3 Twenty-year-old young man with bilateral third web space syndactyly. (A) Preoperative view of the left hand, (B) unoperated right hand, (C) left hand five weeks postoperatively compared to the unoperated hand, and (D) left hand eight months postoperatively

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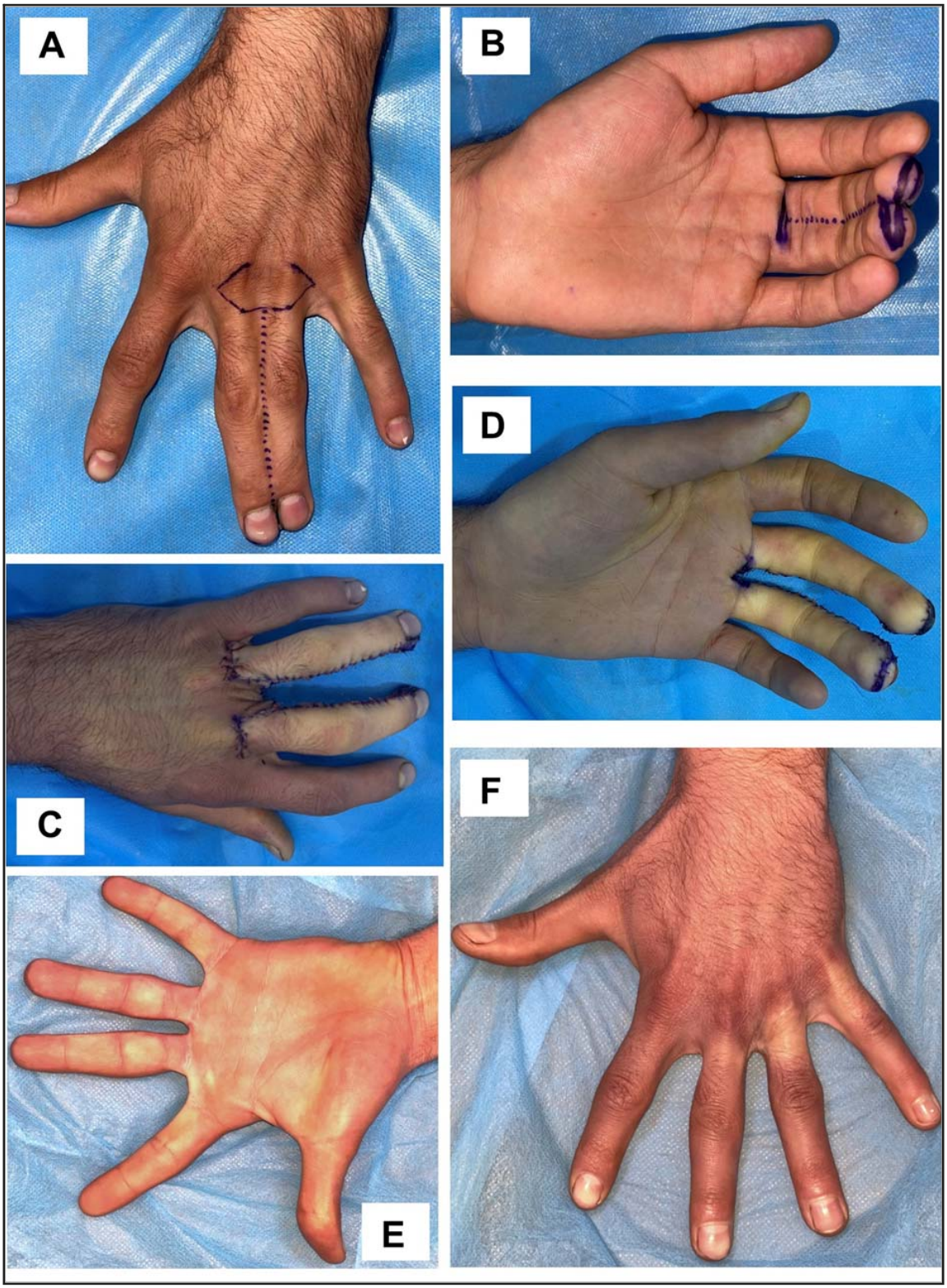

Figure 4 A 22-year-old young man with left third web space syndactyly. (A&B) Preoperative view, (C&D) immediate postoperative view, (E&F) at five months postoperatively. Note that the tourniquet is still active during photography.

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Competing interests

The authors declare that they have no competing interests.

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