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Original Research Article

Clinical and Functional Outcomes of Congenital Syndactyly Release Using Dorsal Web Reconstruction and Zig-Zag Digital Incisions: A Prospective Observational Study

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Abstract

Background: Congenital syndactyly is a common congenital hand anomaly characterized by fusion of adjacent digits. Surgical treatment aims to restore hand function, reconstruct a functional web space, and achieve satisfactory cosmetic outcomes. Dorsal web reconstruction with zig-zag digital incisions is a widely accepted technique for minimizing scar contracture and improving postoperative results.

Objective: To evaluate the clinical and functional outcomes of congenital syndactyly release using dorsal web reconstruction with zig-zag digital incisions at a tertiary care centre.

Materials and Methods: A prospective observational study was conducted over 12 months in the Department of Plastic Surgery at PMCH, Patna. Thirty patients with congenital simple syndactyly underwent surgical release using dorsal web flap reconstruction and zig-zag digital incisions. Demographic characteristics, operative details, functional recovery, cosmetic outcomes, and postoperative complications were assessed during scheduled follow-up. Data were analysed using SPSS version 26.0, with a p-value of <0.05 considered statistically significant.

Results: Thirty patients involving 42 web spaces were included. The mean age was 3.9 ±2.1 years, and 60% were males. The third web space was most commonly affected (42.9%). Full-thickness skin grafting was required in 36.7% of patients. At six months, 83.3% achieved excellent functional outcomes and 13.3% had good outcomes. Mean total active finger motion improved significantly from 198.6 ±18.2° preoperatively to 247.4 ±11.6° postoperatively ($p<0.001$). Cosmetic outcomes were excellent or good in 90% of patients. Minor complications included hypertrophic scarring (6.7%), web creep (3.3%), and superficial wound edge necrosis (3.3%).

Conclusion: Dorsal web reconstruction with zig-zag digital incisions is a safe and effective technique for congenital syndactyly release, providing excellent functional recovery, satisfactory cosmetic outcomes, and a low complication rate.

Keywords: Congenital Syndactyly, Dorsal Web Reconstruction, Zig-Zag Incision, Hand Surgery, Functional Outcome, Plastic Surgery.

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Introduction

Congenital syndactyly is one of the most common congenital anomalies of the hand, accounting for nearly 20% of all congenital hand deformities, with an estimated incidence of 1 in 2,000–3,000 live births [1–4]. It occurs due to incomplete separation of the fingers during the sixth to eighth weeks of embryonic development because of failure of normal programmed cell death between the developing digits [2,4]. Syndactyly may be classified as simple, involving only the skin and soft tissue, or complex, when bones, tendons, joints, nerves, or blood vessels are also fused. It may further be classified as complete or incomplete depending on the extent of fusion [4–6]. The condition is more common in males and is bilateral in approximately 40–50% of patients. The third web space is most frequently affected, followed by the second and fourth web spaces. Although syndactyly often occurs as an isolated deformity, it may also be associated with syndromes such as

Apert syndrome, Poland syndrome, Carpenter syndrome, and amniotic band syndrome [2,4,9]. If left untreated, it can interfere with normal finger growth, hand function, grip strength, and fine motor development, resulting in both functional and cosmetic problems [4,9,10].

The primary aim of surgery is to separate the fused digits, reconstruct a deep and stable web space, preserve the digital neurovascular structures, restore finger movement, and achieve a good cosmetic outcome [5,6]. Over the years, several surgical techniques have been described; however, dorsal web reconstruction with zig-zag digital incisions remains one of the most commonly used methods because it provides adequate soft tissue coverage, reduces scar contracture, and decreases the risk of postoperative web creep [1,3,7].

The zig-zag incision pattern helps prevent linear scar contracture by distributing wound tension, while the dorsal rectangular or triangular flap recreates a natural web space with good long-term stability. When primary closure is not possible, full-thickness skin grafts are commonly used to cover residual defects because they provide better colour match and less secondary contraction than split-thickness grafts [1,7,8]. Although graftless techniques have recently been introduced, dorsal web flap reconstruction with selective skin grafting continues to be the preferred technique in many hand surgery centres due to its reliable functional and cosmetic outcomes [1,3,8,11–13].

Successful treatment depends not only on wound healing but also on restoration of finger movement, maintenance of web space depth, good scar quality, and patient or parent satisfaction. Complications such as web creep, hypertrophic scarring, flexion contracture, and graft loss may still occur despite advances in surgical techniques [1,7,11,14]. Previous studies have reported favourable outcomes following dorsal web reconstruction, although results may vary depending on patient age, severity of deformity, surgical technique, and postoperative rehabilitation [7,11,15–18].

Despite advances in hand surgery, prospective studies on congenital syndactyly from Indian tertiary care centres remain limited. Therefore, the present prospective observational study was undertaken to evaluate the clinical and functional outcomes of congenital syndactyly release using dorsal web reconstruction and zig-zag digital incisions at a tertiary care centre. The study assessed functional recovery, cosmetic outcomes, web space reconstruction, parent satisfaction, and postoperative complications to determine the effectiveness and safety of this surgical technique.

Materials and Methods

Study Design: This prospective observational study was conducted in the Department of Plastic Surgery at a tertiary care teaching hospital, PMCH Patna over a period of 12 months (April 2024 to March 2025) after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from the parents or legal guardians of all participants.

Study Population: Thirty consecutive patients with congenital simple syndactyly involving 42 web spaces were included in the study. Children aged 6 months to 12 years undergoing primary surgical correction were enrolled. Patients with complex or syndromic syndactyly, previous syndactyly surgery, major associated congenital upper limb anomalies, or those medically unfit for surgery were excluded.

Before surgery, all patients underwent detailed clinical evaluation, including demographic details, type of syndactyly, number of affected web spaces, side involved, associated anomalies, and assessment of finger movements. Standardized preoperative clinical photographs were obtained for documentation.

Surgical Procedure: All procedures were performed under general anaesthesia with pneumatic tourniquet control by the same surgical team. A dorsal rectangular flap was designed to reconstruct the web space, and zig-zag digital incisions were marked over the dorsal and palmar aspects of the involved fingers according to standard surgical principles [1,5,6]. Careful dissection was carried out while preserving the digital neurovascular bundles. After complete separation of the digits, the dorsal flap was inset to create a new web space. Full-thickness skin grafts harvested from the groin were used whenever primary closure was not possible [7,8]. The hand was dressed with a non-adherent dressing and immobilized in a below-elbow plaster splint.

Follow-up and Outcome Assessment: Patients were reviewed at 2 weeks, 1 month, 3 months, and 6 months after surgery. During each visit, wound healing, flap viability, graft uptake, range of finger motion, web space depth, scar quality, cosmetic appearance, and postoperative complications were assessed. Functional outcome was graded as excellent, good, fair, or poor based on finger movement, web reconstruction, and hand function. Cosmetic outcome was evaluated according to scar quality, web contour, finger alignment, and overall appearance using previously described assessment methods [1,11,13].

Statistical Analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean ±standard deviation, while

categorical variables were presented as frequencies and percentages. The paired Student's t-test was used to compare preoperative and postoperative continuous variables, whereas the Chi-square test or Fisher's exact test was used for categorical variables. A p-value of <0.05 was considered statistically significant.

Results

A total of 30 patients with congenital simple syndactyly involving 42 web spaces underwent surgical correction during the study period. All patients completed the scheduled six-month follow-up and were included in the final analysis. No patient was lost to follow-up.

Baseline Demographic Characteristics: The mean age of the study population was 3.9 ±2.1 years (range: 10 months–10 years). The majority of patients (40.0%) were between 1 and 3 years of age. There were 18 (60.0%) males and 12 (40.0%) females, resulting in a male-to-female ratio of 1.5:1.

Table 1: Baseline demographic characteristics (n = 30)

Variable	Frequency	Percentage (%)
Age (years)		
<1	3	10.0
1–3	12	40.0
4–6	9	30.0
>6	6	20.0
Gender		
Male	18	60.0
Female	12	40.0

The mean duration of symptoms before presentation was 3.8 ±1.9 years.

Clinical Profile: Unilateral syndactyly was observed in 18 patients (60.0%), whereas 12 patients (40.0%) had bilateral involvement. Among the 42 affected web spaces, the third web space was most commonly involved (42.9%), followed by the second web space (33.3%). Incomplete syndactyly was more frequent than complete syndactyly.

Table 2: Clinical characteristics of syndactyly

Variable	Frequency	Percentage (%)
Laterality		
Unilateral	18	60.0
Bilateral	12	40.0
Type of syndactyly		
Incomplete	17	56.7
Complete	13	43.3
Affected web spaces (n = 42)		
First	2	4.8
Second	14	33.3
Third	18	42.9
Fourth	8	19.0

Operative Findings: The mean operative time was 74.6 ±11.8 minutes per web space. Primary closure without skin grafting was achieved in 19 patients (63.3%), while 11 patients (36.7%) required full-thickness skin grafting because of residual soft tissue defects after separation of the digits. Complete flap survival was observed in all cases.

Complete graft take was achieved in 10 of the 11 grafted patients (90.9%), whereas one patient developed a small area of partial graft loss that healed with conservative management.

Table 3: Operative details

Variable	Value
Mean operative time (minutes)	74.6 ± 11.8
Mean hospital stay (days)	2.8 ± 0.7
Primary closure	19 (63.3%)
Skin graft required	11 (36.7%)
Complete graft take	10 (90.9%)
Complete flap survival	30 (100%)

Functional Outcome: At the six-month follow-up, a significant improvement in digital mobility was observed. The mean total active finger motion increased from 198.6 ±18.2° preoperatively to 247.4 ±11.6° postoperatively ($p < 0.001$). Similarly, the mean web-space adequacy score improved significantly from 2.1 ±0.6 before surgery to 3.8 ±0.4 at the final follow-up ($p < 0.001$).

Table 4: Comparison of functional parameters

Parameter	Preoperative	Six months	p-value
Total active finger motion (°)	198.6 ± 18.2	247.4 ± 11.6	<0.001
Web-space adequacy score	2.1 ± 0.6	3.8 ± 0.4	<0.001

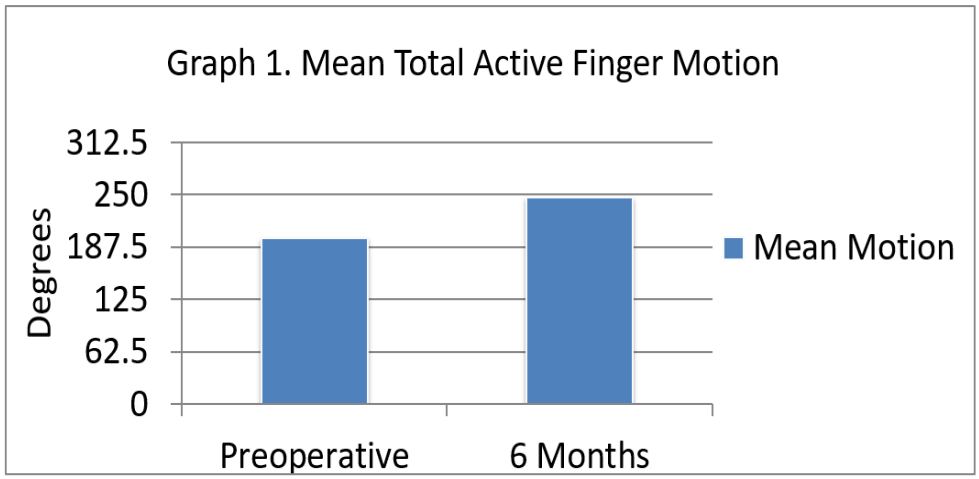

Figure 1: Comparison of Mean Total Active Finger Motion Before Surgery and at Six Months Postoperatively.

Functional Outcome Grading: At the final follow-up, 25 patients (83.3%) achieved excellent functional outcomes. Four patients (13.3%) had good outcomes, while one patient (3.3%) had a fair outcome because of mild postoperative web creep. None of the patients had poor functional results.

Table 5. Functional outcome at six months

Outcome	Frequency	Percentage (%)
Excellent	25	83.3
Good	4	13.3
Fair	1	3.3
Poor	0	0

Overall, 96.6% of patients demonstrated excellent or good functional recovery.

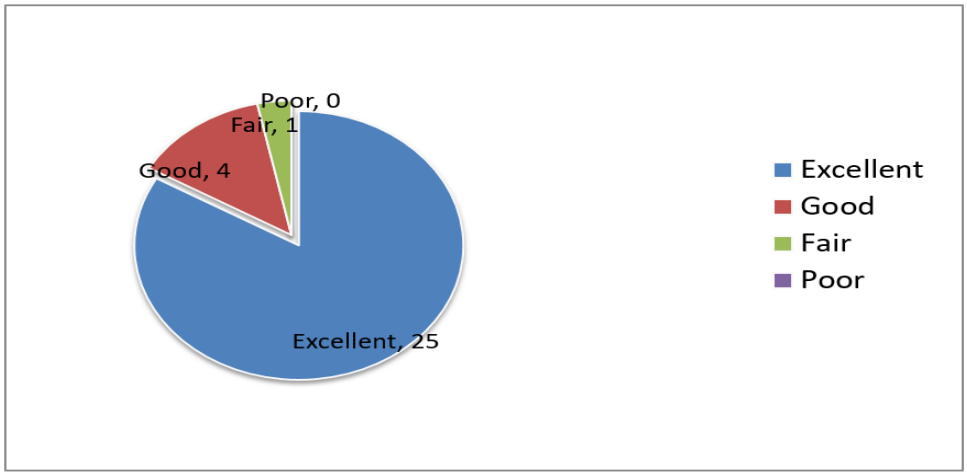

Figure 2. Distribution of Functional Outcomes at Six Months Following Syndactyly Release.

Cosmetic Outcome: Cosmetic assessment demonstrated satisfactory web-space contour and scar quality in the majority of patients. Excellent cosmetic results were observed in 21 patients (70.0%), while 6 patients (20.0%) had good cosmetic outcomes. Only 3 patients (10.0%) had fair cosmetic appearance due to hypertrophic scarring or mild web flattening.

Table 6: Cosmetic outcome

Cosmetic grade	Frequency	Percentage (%)
Excellent	21	70.0
Good	6	20.0
Fair	3	10.0
Poor	0	0

Postoperative Complications: The overall complication rate was low. Hypertrophic scar formation occurred in 2 patients (6.7%), superficial wound edge necrosis in 1 patient (3.3%), partial graft loss in 1 patient (3.3%), and mild web creep in 1 patient (3.3%). No patient developed flap necrosis, deep surgical-site infection, neurovascular injury, or digital ischemia.

Table 7: Postoperative complications

Complication	Frequency	Percentage (%)
Hypertrophic scar	2	6.7
Web creep	1	3.3
Partial graft loss	1	3.3
Superficial wound edge necrosis	1	3.3
Flap necrosis	0	0
Deep infection	0	0
Neurovascular injury	0	0
Digital contracture	0	0

Parent Satisfaction: At the final follow-up, 22 parents (73.3%) reported being very satisfied, while 6 (20.0%) were satisfied with the surgical outcome. Only 2 parents (6.7%) expressed neutral satisfaction, and none reported dissatisfaction.

Table 8: Parent satisfaction

Satisfaction level	Frequency	Percentage (%)
Very satisfied	22	73.3
Satisfied	6	20.0
Neutral	2	6.7
Dissatisfied	0	0

Discussion

Congenital syndactyly is one of the most common congenital hand anomalies requiring surgical correction during childhood. The main objectives of surgery are to separate the fused fingers, reconstruct a stable web space, restore finger function, and achieve a satisfactory cosmetic outcome [1,4,5]. In the present study, dorsal web reconstruction with zig-zag digital incisions provided good functional recovery, favourable cosmetic results, and a low rate of postoperative complications, supporting the effectiveness of this technique.

The mean age of patients in our study was 3.9 ±2.1 years, with most children undergoing surgery between one and six years of age. Early surgical correction is generally recommended to prevent growth-related deformities and to improve hand function [2,4,5]. Similar age distribution has been reported by Braun et al. (1) and Wang et al. [3], who also observed good outcomes when surgery was performed during early childhood.

Male patients were more common than females, and unilateral involvement was seen more frequently than bilateral disease. The third web space was the most commonly affected, followed by the second web space. These findings are consistent with previous studies describing the typical clinical pattern of congenital syndactyly [2,4,9,10].

In the present study, all patients underwent syndactyly release using dorsal web reconstruction and zig-zag digital incisions. This technique is widely accepted because it helps create a stable web space, reduces scar contracture, and lowers the risk of postoperative web creep [1,5,6]. Complete flap survival was achieved in all patients, and no case of flap necrosis or digital vascular

compromise was observed, indicating that the procedure is safe and reliable. Full-thickness skin grafts were required in 36.7% of patients. Previous studies have shown that full-thickness skin grafts provide better colour match, less secondary contraction, and improved long-term results than split-thickness grafts [7,8].

Only one patient in our study developed partial graft loss, which healed with conservative treatment, comparable to the low graft-related complication rates reported in earlier studies [7]. A significant improvement in finger movement was observed after surgery.

Mean total active finger motion increased from 198.6 ±18.2° before surgery to 247.4 ±11.6° at six months ($p < 0.001$). Overall, 96.6% of patients achieved excellent or good functional outcomes. These findings are comparable with those reported by Yu et al. [11] and Braun et al. [1], who also demonstrated excellent functional recovery following dorsal web reconstruction.

Cosmetic outcomes were equally encouraging. In our study, 90% of patients had excellent or good cosmetic results, with satisfactory web space depth and acceptable scar appearance. Similar observations have been reported by Jose et al. [17], who highlighted the importance of proper web space reconstruction in achieving good aesthetic outcomes.

The overall complication rate was low. Hypertrophic scarring was the most common complication, while web creep and partial graft loss were observed in only a small number of patients. No patient developed deep infection, flap necrosis, or neurovascular injury.

Similar low complication rates have been reported in previous studies using dorsal flap techniques [1,7,18]. Careful surgical planning, preservation of neurovascular structures, and appropriate postoperative rehabilitation may have contributed to these favourable outcomes.

The main strengths of this study include its prospective design, use of a uniform surgical technique, and regular postoperative follow-up. However, the study was conducted at a single centre with a relatively small sample size and a follow-up period of only six months. Therefore, long-term complications such as recurrent web creep or growth-related deformities could not be assessed. Larger multicentre studies with longer follow-up are needed to further evaluate the long-term functional and cosmetic outcomes of this technique.

Conclusion

Dorsal web reconstruction with zig-zag digital incisions is a safe and reliable technique for the surgical management of simple congenital syndactyly. It provides good functional recovery, satisfactory cosmetic outcomes, and a low rate of postoperative complications. The technique allows effective reconstruction of the web space while preserving finger function and appearance. Based on the findings of the present study, this method can be considered a suitable option for routine management of congenital simple syndactyly. Further multicentre studies with larger sample sizes and longer follow-up are recommended to assess long-term outcomes.

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