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Application of the Pentagonal Flap with Pedicle on the Back of the Divided Fingers in the Surgical Treatment of Syndactyly of the Ten Fingers in Both Hands

Zhou Qin [1, 2, #], Zunian He [1, 2, #], Qunqiang Luo [1, *], Dinggui Lu [1, *]

[1] Department of Orthopedic Surgery, The Affiliated Hospital of Youjiang Medical University for Nationalities, Baise, Guangxi, China
[2] Graduate School, Youjiang Medical University for Nationalities, Baise Guangxi, China

*** Corresponding author:** Qunqiang Luo (Email: lqqgxbs@126.com), Dinggui Lu (Email: ludinggui@163.com)

# These authors contributed equally to this study

Abstract: Objective: This study aims to explore the application and efficacy of the pentagonal pedicled flap in the surgical treatment of syndactyly. **Methods:** A 16-year-old patient with syndactyly of all ten fingers for over 10 years, treated at the Orthopedic Department of the Affiliated Hospital of Youjiang Medical University for Nationalities in July 2024, was selected as the research subject. A pentagonal pedicled flap was meticulously designed during the surgery to perform precise separation of the fingers, web reconstruction, and wound repair. **Results:** Postoperative observations showed that the flap survived well, with no complications such as necrosis or infection. Follow-up after one month revealed that the shape of all ten fingers had returned to normal, with good flexion and extension function, and the patient expressed high satisfaction with the surgical outcome. **Conclusion:** The use of the pentagonal pedicled flap for the treatment of syndactyly effectively avoids the occurrence of webbing and linear scarring on the palmar side of the fingers, reducing the incidence of web creep and finger flexion contracture, with satisfactory results achieved in the short term.

Keywords: Surgical Flap; Syndactylia; Hand Deformity; Restorative Surgery.

1. Introduction

Congenital syndactyly is a relatively common congenital deformity affecting the hand. It is characterized by a pathological connection of the skin and soft tissue between two or more adjacent fingers, which can lead to the absence of webbing. In more severe cases, this condition may involve the fusion of bones and abnormal development of nerves, blood vessels, and tendons. While the precise causes of syndactyly remain unclear, it is widely believed to be associated with genetic factors, abnormal embryonic development, and external environmental influences during the embryonic stage. Treatment for syndactyly typically involves surgical procedures aimed at separating the fingers, reconstructing the webbing, and repairing wounds to restore both the normal function and aesthetic appearance of the fingers.

2. Typical Case

2.1. Patient Information

The patient is a 16-year-old male who presented to our hospital in July 2024 with a long-standing condition of syndactyly affecting both hands, which has been evident since birth. According to the patient's father, the syndactyly was first observed at birth, but as the patient did not experience any pain or discomfort at that time, no treatment was initiated. Now, the patient is seeking surgical intervention to improve both the appearance and functionality of his hands. His past medical history is unremarkable, and there are no significant diseases reported in the family; he also denies any history of infectious or genetic disorders. Upon specialized examination, both hands exhibit a constricted deformity at the thenar eminence, with an approximate opening of 60 degrees. The thumb demonstrates adequate flexion and extension. However, the index, middle, ring, and little fingers of both hands are syndactylous, with webbing that extends to the proximal interphalangeal joints. The separation between the fingers is limited, and both flexion and extension are restricted, although the blood supply to the fingers remains normal (Figure 1).

2.2. Operative Method

Under general anesthesia, a procedure was performed to widen the web space and separate the fingers. Once the anesthesia was successfully administered, the patient was positioned supine, and a pneumatic tourniquet was applied to the proximal left upper arm to control bleeding. The forearm and hand were disinfected using iodine, and sterile drapes were placed to maintain a clean environment.

The pneumatic tourniquet was then inflated to achieve hemostasis. A pentagonal flap was designed between the left thumb and index finger, incorporating two dorsal skin flaps and three palmar skin flaps at the web space. Guidelines were drawn to outline the web space and the connections between each finger. Following this, pentagonal pedicled skin flaps were crafted for the dorsal and palmar sides of the index, middle, ring, and little fingers, ensuring that the distal corners of the flaps were positioned at the midpoint of the proximal phalanges. The angles of the flaps were aligned with the midpoint plane of the metacarpophalangeal joints, with the apex of the lateral angles extending to the dorsal edge of the fingers. The bases of the flaps were set at the midpoint of the dorsal side of the adjacent metacarpophalangeal joints. Serrated incisions were designed between the fingers, where the proximal end of the dorsal incision connected to the distal corner of the flap, and the proximal end of the palmar serrated incision was located at the midpoint between the two fingers

(Figure 2).

Figure 1. 16-year-old male patient with bilateral tiger mouth contracture deformity

Figure 2. Preoperative design of split finger dorsal pentagonal flap

A 15 scalpel was utilized to make incisions along the predetermined lines, meticulously dissecting through the layers until reaching the extensor tendon sheath. The skin flaps were carefully elevated from both sides toward the center, gradually separating the subcutaneous tissue toward the proximal end while exploring the dorsal digital arteries and the communicating branches of the palmar digital arteries, ensuring these branches were preserved. The skin between the two fingers was then separated as planned, taking care to avoid any damage to the digital arteries and nerves. The five skin flaps were sutured together in an interlaced fashion using 4-0 absorbable sutures, effectively widening the web space to approximately 90 degrees and separating the index, middle, ring, and little fingers. After deflating the tourniquet, good blood flow to the fingertips was confirmed, followed by a light sterile dressing applied to the surgical site. Similarly, the flaps for the right hand were designed, separating the web space of the right hand and each finger (Figure 3). The postoperative assessment indicated that the hand anesthesia was effective, with an estimated intraoperative blood loss of about 25 ml.

Figure 3. Immediately after the surgery of the split finger dorsal pentagonal skin flap

All eight digital webs of both hands were reconstructed in a single stage without requiring skin grafts. The flaps exhibited no early complications such as infection or necrosis, and all flaps survived completely. Two to three weeks after the procedure, the sutures absorbed and fell off naturally, with all wounds healing by primary intention. A month later, follow-up assessments revealed that the skin color of the eight reconstructed web spaces was comparable to that of other areas of the fingers, and the shape of the web spaces aligned with that of peers of the same age. The extension and flexion movements of all ten fingers were normal, successfully restoring the function of each finger (Figure 4).

3. Discussion

Congenital syndactyly is one of the more common congenital hand deformities, second only to polydactyly[1]. Current research indicates that during embryonic

development at 7 to 8 weeks, the physiological necrosis of the interdigitated mesenchymal cells decreases, which can lead to a local halt in the differentiation of the fetal fingers, resulting in the occurrence of congenital syndactyly[2]. The phenotypes of syndromic and non-syndromic syndactyly are diverse, with most cases being inherited in an autosomal dominant manner, while some are inherited in an autosomal recessive or X-linked recessive manner[3]. Some chromosomal loci and pathogenic genes associated with syndactyly have been identified, but there is still much unknown to discover in genetics[4]. As research on congenital syndactyly progresses, more pathogenic mechanisms, loci, genes, and types of syndactyly may be discovered.

Figure 4. One month after surgery, the extension and flexion of 10 fingers were normal, and the function of each finger was restored

The clinical phenotype of congenital syndactyly is characterized by the pathological connection of two or more adjacent or non-adjacent fingers and their tissue components, with the absence of webbing. This can involve soft tissue connections along the entire length of the fingers or bony fusion, or only partial connections, with the middle and ring fingers being the most commonly fused[5]. Simple syndactyly presents only as a soft tissue connection, while complex syndactyly involves bony fusion and abnormal development of nerves, blood vessels, and tendons[6]. The range of active and passive flexion-extension and abduction-adduction of the fused fingers is reduced, severely affecting finger function. However, the occurrence of syndactyly involving all ten fingers is extremely rare; in the family of the one case, we treated with ten-finger syndactyly, no family history was found. Due to the close association and similarities in embryology, morphology, and clinical presentation between syndactyly and toe syndactyly, both are often studied and discussed together in clinical and genetic contexts. Syndactyly generally occurs in isolation but can also be part of syndromes, occurring in over 300 syndromes including Poland syndrome, Apert syndrome, Down syndrome, and band-like syndromes[3]. Multiple finger syndactyly is commonly seen in Poland syndrome, characterized by short fingers, and can be considered a special type of syndactyly[7].

For patients with congenital syndactyly, surgical treatment is typically employed. Surgical methods for congenital

syndactyly can be broadly categorized into: web space reconstruction, separation of the finger bodies, separation of the distal phalanges and nails, separation of vascular and nerve bundles, and lateral skin grafting of the finger bodies[8]. Although traditional rectangular or triangular flaps can adequately cover the web space, they cannot effectively repair the wound at the base of the fingers, which requires skin grafting or tension suturing for repair. However, tension suturing in the base area can lead to web creep, scar hyperplasia, or contracture[9]. In recent years, cloverleaf-shaped flaps or dorsal pentagonal flaps have been used to reconstruct the web spaces of syndactyly in the hand. The dorsal pentagonal flap involves cutting the lateral angles of the flap wings to cover the lateral side of the finger base, but the length of the lateral angles is limited, restricting the capacity for the reconstruction of the lateral finger base, making it mainly suitable for cases of incomplete syndactyly or those with larger skin tissue capacity[10]. The dorsal pentagonal flap method for reconstructing congenital syndactyly allows for a wider lateral angle, effectively covering both the finger base and web space[11].

In summary, congenital syndactyly is relatively common in clinical practice, but congenital syndactyly involving all ten fingers is very rare. Based on the syndactyly condition between each pair of fingers in the patient, we designed a modified pentagonal flap to achieve a wider lateral angle, effectively covering the lateral finger base and web space, resulting in satisfactory outcomes. During surgery for syndactyly, it is essential to assess the tension of the connected skin and optimize the choice of donor skin area to avoid tension sutures, thereby preventing the development of scars that severely affect the appearance and function of the hand postoperatively.

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