CASE REPORT

Microvascular “on-top-plasty”: An Alternative for Thumb Reconstruction in Constriction Band Syndrome

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Constriction band syndrome affecting the hand and importantly the thumb may require reconstruction to improve function. This case report presents a patient with auto-amputation through the proximal phalanx of the middle, index, and thumb. Microvascular reconstruction was used to perform an on-top-plasty with the remaining index finger to the thumb. The case also involved skin graft coverage, venous grafting, and tendon reconstruction. The patient presents with 12 months follow up after index procedure and 3 months after revision. She has the ability to grasp large objects. Sensation remains present in pulp of new thumb. Cosmesis subjectively improved per patient’s family and physician. Strength continued to improve and reached 2 Kg of grip strength by 12 months. Microvascular on-top-plasty is a possible option for improving function in constriction hand syndrome affecting multiple digits.

Keywords: microvascular; on-top-plasty; thumb; reconstruction; constriction band

Introduction

Constriction band syndrome can yield devastating deformities to limbs. It is estimated to affect 1 in 15,000 live births in the United States [1]. The etiology of congenital constrictive band syndrome is controversial with several theories. Regardless of etiology there is a significant predilection for hands, reported in up to 90% of cases [2]. Treatment is catered to the severity and location of the deformity. Associated syndactyly often requires single vs staged z-plasty or W-plasty to improve cosmesis and function of remaining digits [1, 3–5]. Amputation through the thumb is less common then other digits [2]. When the thumb has been deformed the patient may undergo a lengthening procedure, pollicization, second toe transfer or hallux transfer [6, 7]. Toe transfers are a reliable and effective option but, when contraindications are present, transposition of index finger with on-top-pasty has also been described [8].

The thumb is indispensable with an estimated 40% of overall hand function with fundamental attributes as tactile function, exclusive position, and unique mobility [2, 9]. The anatomic characteristics that allow thumb function are related to the palmar pulp, length, deep web space, thenar muscles and first carpo-metacarpal (CMC) joint. In this case, that patient has lost and unlikely to develop many of the key thumb characteristics. Surgical intervention was indicated to lengthen the thumb and deepen the first web space while maintaining the pulp function and CMC joint.

Patient and Methods

The patient is a five year old female with constrictive band syndrome with amputation of her left thumb, index, and long fingers at the level of the proximal portion of the proximal phalanx (Figure 1). She lives with her parents, she is an active child and attending school. Patient had no family history of similar conditions and no diagnosis of genetic syndromes. Prior to evaluation at our institution, the patient underwent a z-plasty to release constrictive bands on the ring finger of the left hand. Initial evaluation showed a normal small finger. The ring finger was of normal length and maintained functional ability for grasping; status post z-plasty release of constrictive bands at base of proximal phalanx. Syndactyly was present between then remaining index and middle digit as well as between the thumb and index. Patient had stable 1st CMC joint and was able to perform pinch between thumb and index stumps (Figure 2). The remnant thumb also maintained its ability to flex, extend, and oppose, indicating presence and function of intrinsic and extrinsic muscles. This work is being reported in line with the SCARE criteria [10].

Surgery 1

The surgery was performed by the first author of this paper (JBP), with assistance of the second author, the senior author (PCC) helped with surgical technique indication (GME). Under general anesthesia, with partial tourniquet exsanguination, the flaps were designed around the 2nd MCP joint with extension proximally in zigzag fashion (Figure 3). A single dorsal vein was identi-
fied and marked along with extensor tendon and intermetacarpal artery. On the volar surface, the neurovascular bundle and superficial palmar arch were located. The flexor tendon and 1st interosseous muscle (volar and dorsal) for the index finger were identified. The volar and dorsal thumb flaps were then elevated. The EPL and FPL were identified and insertion found. The nerve was dissected free proximally. Attention was turned back to the 2nd metacarpal. Volar vascular pedicle for the 2nd metacarpal was dissected proximally but its length remained restrictive for transfer due to branch from deep palmer arch. At this point it was decided to perform an on-top-plasty with revascularization using greater saphenous vein graft to the dominant common digital artery from the deep palmar arch to the 2nd ray. The artery was temporarily ligated. Surrounding tissue released and an osteotomy of the 2nd metacarpal was performed. The dorsal veins remained intact in the redundant dorsal tissue. It was possible to transfer the nerve via proximal dissection without transection. Bony fixation of the 2nd metacarpal

Figure 1: Pre-operative clinical assessment of hand.

Figure 2: Pre-operative gripping ability and x-ray.
to the proximal phalanx of the thumb was performed with 90/90 cerclage. A kirschner wire was then placed between the 1st and 3rd metacarpal to keep the first web space open. An additional kirschner wire was used to capture the thumb metacarpal and the transferred 2nd metacarpal.

The extensor digitorum communis for the 3rd finger was transferred with weaving through the remnant of the extensor mechanism of the transferred index finger at the level of the MCP joint and attachment to the APL in hopes of creating an abduction moment. The flexor tendon was repaired with interweaving Pulvertaft technique after being passed inside the first dorsal interosseous muscle to obtain adequate vector.

Ten centimeters of the greater saphenous vein was harvested from the ipsilateral leg. The graft was connected end-to-end distally via a smaller venous branch (better anatomic fit) to the ligated common digital artery of the 2nd ray and end-to-side proximally to the dorsal branch of the radial artery in the region of the anatomic snuffbox (Figure 4).

The volar aspect of the thumb required a three by five centimeter full thickness skin graft. The web space was deepened by disarticulating the third MCP and by transfer of the second ray on top of the remnant thumb. The finger showed brisk capillary refill at the end of the procedure (Figure 5). The patient was placed in a long arm cast.

**Post-Operative**

Initial follow up x-rays after removal kirschner wire provided maintained position of thumb and MCP joint. The patient developed first web space scar contracture which limited her ability to abduct her thumb and prohibited normal pincer action (Figure 6). During grasping and pincer motion the patient continued to have retropulsion at her MCP joint which forced her to use her thenar palm (Figure 7). There was also concern for thinning skin over the distal tip of the distal phalanx with prominent bone. The patient was still having problems with skin breakdown at the tip of the thumb and referred difficult with grasping. The Revision surgery was discussed with patient and family and agreed to undergo first web space deepening, scar revision, distal phalanx tip revision, and thumb extensor tenotomy.

**Surgery 2**

General anesthesia was used. The dorsal based flap was elevated; the initial vein graft was visualized and protected. Tissue was mobilized with excision of hypertrophic scar up to the level of the 1st metacarpal to deepen the web space. Attention was then turned toward the exten-
sor tendon. Tenotomy of the thumb extensor tendon was performed to improve balance and ability to flex through MCP joint. The joint was stabilized by pinning the proximal phalanx to the metacarpal. Fluoroscopy was then used to determine the level of distal phalanx tip excision. Needle perforation was used in posterior to anterior direction with removal of 4mm of bone. The skin of the thumb pulp was contoured and closed without excessive tension.

To keep the first web space open, a pin was passed from 1st to 3rd metacarpal. With the thumb in stable position, the dorsal flap was advanced volarly to deepen the first web space (Figure 8).

Figure 4: Index Procedure: microvascular arterial anastomosis with vein graft.

Figure 5: Index procedure: immediate post-operative.
Results

The transfer was successful with maintained vascularization to the transferred digit, bony healing, and adequate soft tissue coverage. Cosmetic appearance per patient’s family and physician was improved (Figure 9). Sensation to light touch was present on dorsum and pulp of finger. The length of the thumb is 70% the length of the remaining ring digit. At 12 months from initial procedure and 3 months from second, the patient’s 1st MCP had minimal active and passive flexion. After the second procedure, the MCP retropulsion was nearly eliminated and clinical ability to grip had improved (Figure 10). Passive and active opposition at 3 months from initial procedure was 30/5 degrees, which remained the same at 12 months.
At 12 months from initial procedure and 3 months from second the patient's passive and active abduction was 45/5 degrees, respectively. The patient was able to use thumb and ring finger to complete 3 buttons within 35 seconds. Pinch and grip strength were measured using standard pinch and grasp meters. Three trials were performed for each strength test. At 3 months, the key pinch pressure was 1.5 lbs (contralateral side 9 lbs). Tip pinch pressure was not testable. Grip strength was 1 kg (contralateral side 10 kg). At 12 months, the key pinch was unchanged but her grip strength was 2 kg (contralateral side 10 kg).

Discussion

This case of a five year old female with congenital constrictive band syndrome with auto-amputation of the middle finger, ring finger, and thumb at the level of the proximal portion of the proximal phalanx had few reconstruction options. It is commonly agreed that toe transfer is a successful procedure when indicated. A toe transfer was not possible for our patient as she had concomitant syndactyly of her toes (Figure 11) and due to the parents unwillingness to use toes for transfer. Akin has previously described the use of microvascular free on-top plasty in mutilated hands with anastomosis between digital arteries [11]. Kelleher described an on-top-plasty with intact neurovascular pedicle in a 13 year old with constrictive band syndrome in 1968 [8].

Due to restrictions from the short index finger pedicle, a vein graft was required to perform the microvascular transfer, which to our knowledge has not been described in the literature. Our patient had successful thumb lengthening with left index to thumb on-top-plasty with arterial microanastomosis using a vein graft and dorsal vein transferred.
on a pedicle fashion. The first web space was deepened by excision of 3rd ray proximal phalanx and by the transfer of the 2nd metacarpal on top of the remnant thumb. In attempt to improve stability and extension of the 1st ray, a transfer of the long finger extensor digitorum communis was done to the transferred thumb extensor tendon. In retrospect, this created a retropulsion force at the thumb metacarpophalangeal joint and compromised the grip function, hence the reason for the tenotomy during the second procedure. Also, the authors believe the index procedure could have been improved if we had begun with a free on-top-plasty with vein graft to the artery with pedicled transfer of the dorsal vein. Our attempt to transfer the artery in a pedicled fashion only added time to the index procedure. Fortunately, during the index procedure, the nerve was transferred on a pedicle fashion with proximal release, but a nerve anastomosis could also be done, with the use of a nerve graft, as needed.

Classically, it is believed that structures proximal to constrictive band develops normally. Knowing this, it is assumed that the 1st ray in our patient has normal intrinsic and extrinsic muscles with the ability to provide adequate function to the thumb. The native stump of the thumb did develop in the normal anatomic position.

Figure 9: Second procedure: clinical follow up.

Figure 10: Second procedure: Intra-operative X-ray and grip function.
which is described at approximately 47 degrees from other digits, abduction 40 degrees, pronation 120–140 degrees, and extension 15 degrees [12]. The length of the thumb was 70% of the ring digit which is comparable to a normal 2/3 of the long digit. The grip strength for our patient was 2 kg (19.6N) which is below that of a normal 5 year old female average of 55.1N ± 4.4N (Hager-Ross 2002). The average lateral pinch and average tip pinch in a normal 5 year old left hand was found to be 22.7N and 11.6N, respectively (Ager et al., 1984) [13]. Staines et al performed a study to evaluate strength after pollicization for thumb aplasia in 10 patients with an average age of 5.2 years (2.8 year follow up). They found the operative side to have less than fifty percent strength when compared to the non-operative side. Lateral pinch was found to be 9.81N, jaw pinch was 8.82N, and grip was 19.61N [14]. Pinch strength in adults was also been found to be 50% of contralateral side with a toe to thumb transfer (Lin et al., 2011) [15]. Schenker et al evaluated the precision grip function in children with toe transfer for hypoplastic digits and with those children with intact CMC joints and presumed intact intrinsic muscle function had equal to or greater than the contralateral side [16]. With only 12 months follow up, 3 months from revision procedure, it is difficult to provide an adequate comparison to these previously reported numbers but with our 1 year strength scores we anticipate continued progression.

The results and early function regained in our patient provides an enthusiastic outcome but are difficult to quantify. There are very few reports of standardized functional scores with on-top-plasty or thumb pollicization. Zlotolow et al did evaluate different parameters that impress good outcomes for pollicization and found the strongest correlation with range of motion of the MCP and IP joint along with the sticker test (peeling a sticker). These functions were vital for small object acquisition. Our patient at 12 months from index procedure and 3 months from second procedure had limited active ROM with her thumb and continued to favor her native fingers for functions requiring dexterity. With our early outcome measures we are anticipating continued development and matured use of the hand and thumb.

**Conclusion**

This case report of constriction band syndrome presents a complex problem with auto-amputation through the proximal phalanx of the middle, index, and thumb. In hopes of creating a stable thumb a microvascular reconstruction with vein graft and deepening of first web space was used to perform an on-top-plasty with the remaining index finger to the thumb. At 12 months status post index procedure and 3 months after a revision procedure, the patient had a stable thumb that could aid in grip strength. Despite stability and maintained pulp sensation the patient did continue to have difficulty with dexterity and pinch action which we anticipate improving with time. Therefore, the surgical technique used in this case report can be considered as a valuable alternative for thumb reconstruction when the toe transfer technique is not an option.

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**Competing Interests**

The authors have no competing interests to declare.

**Author Contributions**

Panattoni Surgeon, Ebbersole Manuscript, Cavadas suggested the procedure.
Guarantor
Joao Panattoni is the guarantor.

References


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