



The homodigital neurovascular antegrade island flap for fingertip reconstruction in children

Bingqi WANG, Lei CHEN, Laijin LU, Zhigang LIU, Zhixin ZHANG, Liangsong SONG

From The First Hospital, Jilin University, Changchun, PR China

We describe a homodigital neurovascular island flap for fingertip reconstruction in children and review the appearance and function of the reconstructed fingertips.

Eleven children, with a mean age of 4 years (range : 2-7), who had sustained a fingertip injury with total or subtotal pulp loss were treated with a homodigital neurovascular island flap between 2007 and 2009. The flaps were harvested based on a single digital neurovascular bundle without further shortening of the distal phalanx. The average follow-up period was 15 months (range : 10-32 months). The clinical outcome evaluations included the defect size of the flap, the static two-point discrimination, total active motion (TAM) of the PIP and DIP joints and time to return to daily activities. Patient satisfaction with function and cosmesis were also evaluated.

All of the flaps survived without any painful scar formation, hypersensitivity or cold intolerance and no interphalangeal joint contractures were noted. The average two point discrimination ranged from 3 to 4 mm, with an average of 3.4 mm. All the patients were satisfied with the function and appearance of the involved finger.

Our study suggests that the homodigital neurovascular is a reliable choice of treatment for children fingertip defects.

Keywords : homodigital neurovascular island flap ; finger-pulp defect ; microsurgery ; children.

INTRODUCTION

Injury of the fingertip is common in children ; reconstruction requires advanced surgical techniques. Cases with pulp loss to the middle level of the nail bed can be safely treated in the majority of cases with palmar V-Y advancement flaps (2). When the defect is more extensive, a regional flap like thenar, cross-finger flap or neurovascular island flap may have to be considered (4,8). However, these methods immobilize the fingers in unnatural positions with resultant joint stiffness and give poor recovery of sensibility.

Between May 2007 and December 2009, 11 homodigital neurovascular island flaps were performed for fingertip reconstruction in children and

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- Bingqi Wang, MD, PhD, Hand Surgeon.
 - Lei Chen, MD, PhD, Professor of Hand Surgery.
 - Laijin Lu, MD, PhD, Professor of Hand Surgery.
 - Zhigang Liu, MD, PhD, Professor of Hand Surgery.
 - Zhixin Zhang, MD, PhD, Professor of Hand Surgery.
 - Liangsong Song, MD, Hand Surgeon.
 - *Department of Hand Surgery, The First Hospital, Jilin University, Changchun, PR China*
- Correspondence : Lei Chen, Laijin Lu, Department of Hand Surgery, The First Hospital, Jilin University, 1 Xinmin Street, Changchun 130021, PR China. E-mail : leichenjlu@qq.com (Lei Chen), laijinlujlu@qq.com (Laijin Lu)
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have produced satisfactory functional and cosmetic results. This study reviews the results with this technique in 11 children.

PATIENTS AND METHODS

Between May 2007 and December 2009, 11 children (9 boys and 2 girls) were treated with homodigital neurovascular island flap. In all cases, replantation was considered to be impossible. Ages at the time of operation ranged from 2 to 7 years (mean : 4 years). The aetiologies of finger tip amputation included crush injury with heavy object (6), door entrapment (6), and avulsion type (4). The injuries involved the index finger in 6 cases, the middle finger in 2 cases and the ring finger in 3 cases. According to Allen's classification, the injuries were classified as type II in 2 cases, type III in 7, and type IV in 2 cases. The defect size ranged from 8 mm × 6 mm to 15 mm × 12 mm (mean 10 mm × 8 mm). In all cases, reconstruction was achieved using the homodigital neurovascular island flap. All operations were performed by two surgeons, and the examiner was not involved in the surgery. All 11 patients were invited for clinical review at an outpatient's clinic. Written records and photographic documentation of all 11 patients were performed. Standardised assessment of outcome in terms of the defect size of the flap, the static two-point discrimination, total active motion (TAM) of the PIP and DIP joints, time of return to daily activities and subjective assessment (satisfactory, good and very good) was completed.

Surgical technique

The operation was carried out under general anaesthesia, with a tourniquet applied. After wound debridement, the size and shape of the defect was measured. A V-shaped flap a little larger than the defect and orientated toward the volar surface on the contralateral side to the obliquity of the wound was marked (Fig. 1A). To dissect the pedicle of the neurovascular flap, a Bruner or hemi-Bruner incision was used (Fig. 1B). The flap included the end of the neurovascular bundle and skin with the underlying tissue. The flap was dissected under loupe magnification. The skin incision began with the flap and was continued midlaterally to the level of the metacarpophalangeal (MP) joint. The neurovascular pedicle was included in the flap by freeing it from Cleland's ligaments, allowing the bundle to be elevated off the tendon sheath. Care was taken to leave sufficient fat tissue around the neurovascular pedicle to ensure adequate

venous drainage of the island. After complete dissection of the neurovascular bundle, the flap was advanced into the pulp defect and sutured with 4-0 non-absorbable sutures. The flap was advanced in a V-Y fashion and there was no need to use skin grafts to cover additional residual defects (Fig. 1C-D). The sutures were removed on the 12th day postoperatively. The flap healed rapidly.

Follow-up evaluation

All patients were followed up for a mean of 15 (range : 10-32) months. The outcome was assessed for defect size, recovery of sensibility (two point discrimination in children older than 6 years at final follow-up), total active motion (TAM). Parents were asked to rate their opinion as "satisfactory", "good" and "very good". They were also asked to assess any cold intolerance or pain and estimate the time taken till the finger was used for daily activities.

RESULTS

All 11 flaps survived ; primary healing was achieved within 2 weeks after operation. Eleven children were followed up for an average of 15 months (range : 10-32 months). The average size of the flaps ranged from 8 mm × 6 mm to 15 mm × 12 mm (mean : 11 mm × 8 mm). There were no complications such as flap congestion, haematoma or infection and no pain from neuroma. The average time interval before normal use of the hand for children's daily activities was 5 weeks (range : 4-6). Stiffness developed in none of the digits treated. Sensory testing with static two-point discrimination was difficult to evaluate in children under 6 years old and in small flaps (3). Thus, sensibility evaluation was performed only in 5 children. The average static two-point discrimination of the flaps was 3.4 mm (range, 3-4 mm). The average TAM was 185° (range : 170°-200°). The flaps were characterised by rich blood supply, cold resistance, suitable thickness and good texture. None of these flaps required thinning or any revisions. All parents were satisfied with the cosmetic and functional outcome of the surgery. Flap size, total active motion (TAM) of the PIP and DIP joints, complications, static two-point discrimination, time before normal use of the hand, objective outcome and subjective outcome of the long-term follow-up are summarised in Table I.

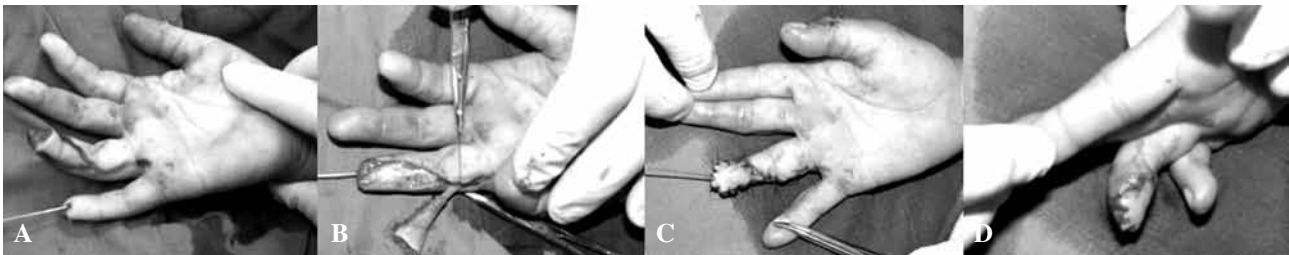


Fig. 1. — (A) A V-shaped flap is marked ; (B) the flap is dissected ; (C-D) the flap is advanced into the pulp defect and sutured with 4-0 non-absorbable sutures.

Table I. — Objective and subjective assessments at long-term follow-up

Patient No.	Age at Surgery (y)	Digit	Defect Size (mm)	Allen's classification	TAM (°)	S2PD (mm)	Time to normal use of the hand (weeks)	Subjective assessment
1	4	Index	8 × 7	II	II200	3	5	very good
2	3	Middle	10 × 6	III	190	–	6	very good
3	6	Ring	8 × 7	III	180	4	4	very good
4	7	Index	15 × 12	IV	170	3	6	very good
5	2	Ring	8 × 6	III	190	–	4	very good
6	3	Index	12 × 11	III	190	–	5	very good
7	4	Ring	10 × 8	III	180	–	4	very good
8	5	Index	14 × 12	IV	180	3	6	very good
9	4	Middle	9 × 6	II	190	–	6	very good
10	5	Index	13 × 11	III	180	4	4	very good
11	3	Index	11 × 6	III	180	–	5	very good

S2PD, static 2-point discrimination.

TAM : for fingers = (active PIP joint + DIP joint flexion) – (PIP joint + DIP joint extension deficit).

Illustrative case

A 4-year-old boy presented with right middle finger-pulp defect following a crush injury. There was a 10 mm × 8 mm pulp defect (Allen's III) (Fig. 2A). The homodigital neurovascular island flap was designed with a size of 10 mm × 20 mm and was brought over the defect (Fig. 2B). The flap was advanced in a V-Y fashion and there was no need to use skin grafts to cover additional residual defects (Fig. 2C). The wounds healed uneventfully and the flap survived completely (Fig. 2D). The length of the injured finger was preserved. The parents were satisfied with the function and appearance of the reconstructed finger-pulp (Fig. 2E-H).

DISCUSSION

A stable, mobile and sensate fingertip is important to the overall function of the hand. In addition, the face and hand are the most looked at parts of our body. Children are undergoing a growth period in which functional and aesthetic fingers are particularly important to them. There are unique features and needs of this population that should be taken into account, including smaller vessel size, lack of cooperation, social and emotional constraints, and the potential for limb growth abnormalities (8). When we deal with children's pulp loss, we should first consider whether it can be sutured directly. If the defect cannot be sutured directly or skin grafts



Fig. 2. — (A) 10 mm × 8 mm right ring finger-pulp defect ; (B) the flap is advanced in a V-Y fashion ; (C) after tourniquet release, the flap received a good blood supply ; (D) the flap survived completely ; (E-H) the function and appearance of the reconstructed finger-pulp, 14 months postoperatively.

cannot achieve a satisfactory repair, we must use a flap to repair the defect.

Depending on the size of the defect, the pulp can be reconstructed using various advancement flaps, regional flaps and free tissue transfers. Advancement flaps, however, often display limitations in size and arc of rotation as well as persistent cold intolerance. Regional flaps such as the thenar flap or the cross-finger flap require a 2-stage procedure, insensate nonglabrous skin is used, digits are held in an awkward position and immobilized for 2 to 3 weeks, and there is a risk of donor site morbidity (6). The homodigital, laterodorsal fasciocutaneous flap (11) based on the dorsal branch of the proper palmar digital artery is an ideal alternative to reconstruct the finger-pulp for single-stage reconstruction without sacrificing the proper palmar digital artery and nerve, but it is not suitable for children by reason of their small vessels. Free tissue transfers not only require significant microsurgical expertise but also subject the patient to prolonged surgery (7).

Surgery in the hand should aim at preservation of adequate and functional length of the digits, immediate coverage of the wound, preservation of sensibility at the distal pulp, adequate distal interphalangeal joint motion, a painless scar, short hospital stay and morbidity and early return to work and

other daily activities (9). In addition, we think when the flaps are applied in children we should consider the following issues : avoid damage to the donor site, so as to avoid adverse impact on children's growth ; children are vibrant and poorly cooperative, 1-stage procedure without immobilization is preferable ; if possible, choose the flap that does not require vascular anastomosis, because vascular anastomosis not only extends the operation time but also increases the possibility of vascular crisis.

The homodigital neurovascular island flap is based on that described by Venkataswami and Subramanian (10) and modified by Adani *et al* (1). From our experience, the homodigital neurovascular island flap, which is based on the lateral digital artery, would be recommended as the flap of choice for covering children digital pulp defects. Satisfactory results have been achieved. None of the children in this series were found to be intolerant to cold. Normal sensation was achieved in all children. The average two-point discrimination at final follow-up was 3.4 mm, which is better than adults (4 mm) (1). Normal motion was well preserved. The average TAM was 185°, which is much better than adults (177°) (6). Three children in our series developed mild nail beaking, and this deformity may develop because of inadequate bone and

soft tissue support for the distal edge of the nail bed (5). According to our experience, the functional and cosmetic result of this flap applied in children is far better than in adults, and this difference may be related with their increased capacity for growth and regeneration (12).

The advantages of the homodigital neurovascular island flap applied in children include : resurface fingertip with finger skin and pad virtually similar in appearance, texture, and sensibility as the skin that was lost ; quick and simple to perform and without immobilization ; it has the potential for the treatment of finger-pulp defect in a single-stage procedure ; it avoids unnecessary trauma to otherwise uninjured digits ; the donor site can often be closed directly ; the interphalangeal joints have recovered their total mobility and flexibility without any stiffness ; reducing cost and time taken till the finger was used for daily activities.

In conclusion, the homodigital triangular neurovascular island flap is an ideal surgical option for fingertip reconstruction in children, offering satisfactory functional recovery, and has acceptable patient satisfaction rates in terms of physical appearance and surgical outcome.

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