Section: Miscellaneous

Original Research Article

SANDWICH CROSS-FINGER FLAP/FOLDED CROSS-FINGER FLAP: FOR TREATMENT OF RING AVULSION INJURY

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ABSTRACT

Background: Ring avulsion injuries are among the most complex hand injuries encountered by reconstructive surgeons. Although microvascular replantation or revascularization remains the preferred treatment for Urbaniak Class III injuries, patient-related factors and limited access to microsurgical expertise may necessitate alternative reconstructive options. This study evaluates the use of the Sandwich/Folded Cross-Finger Flap for reconstruction of ring avulsion injuries. **Materials and Methods:** A prospective study was conducted between August 2016 and August 2017. Twelve patients with Urbaniak Class III ring avulsion injuries who were unwilling or unsuitable for microvascular reconstruction underwent reconstruction using the Sandwich/Folded Cross-Finger Flap. Demographic details, injury characteristics, flap survival, complications, functional outcomes, and patient satisfaction were assessed over a follow-up period of six months. **Results:** Twelve patients (11 ring fingers and 1 little finger) were treated using the Sandwich/Folded Cross-Finger Flap. All flaps survived completely. Partial graft loss occurred in one patient and healed with conservative management. One diabetic patient with poor glycemic control developed partial flap and graft loss, requiring secondary split-thickness skin grafting. Total Active Motion (TAM) at six months was 0–50° in 3 patients, 50–90° in 5 patients, and greater than 90° in 3 patients. Eight of the eleven patients available for final assessment were satisfied with the outcome. Cold intolerance was noted in three patients. No additional reconstructive procedures were required. **Conclusion:** The Sandwich/Folded Cross-Finger Flap is a reliable and technically straightforward option for reconstruction of Urbaniak Class III ring avulsion injuries when microvascular reconstruction is not feasible. It provides durable soft-tissue coverage with high flap survival rates, acceptable functional outcomes, and satisfactory patient-reported results.

INTRODUCTION

Ring avulsion injuries are among the most challenging injuries encountered by reconstructive hand surgeons because of their varied presentations and injury patterns.[1] Before the advent of microvascular repair, treatment options included local flaps, pedicled flaps, and split-thickness skin grafts.[2,3] The most commonly used and widely accepted classification is that of Urbaniak et al.,[4] which has been modified by Nissenbaum.[5] They are

1. **Class I** - Circulation adequate
2. **Class II**-Circulation inadequate

- **Class IIa**-Circulation inadequate (only arteries injured)
- **Class IIb** – Complex injury – injury to bone,tendon ,nerve,dorsal veins.

3.**Class III**- Complete degloving or complete amputation

The ring finger is the digit most commonly affected.This is attributed to the fact that rings are most frequently worn on the ring finger . Ring avulsion injuries typically occur when the ring becomes caught on an object, acting as a fulcrum and avulsing the soft tissues, tendons, and occasionally the bone from the digit. The progression of ring avulsion has been described by Brookes and Buntic et al.[1] (Figure 1).The importance of preserving the ring finger lies in its contribution to grip strength, maintenance of the cupped palm, hand aesthetics, and the social significance attached to the ring finger . The cross finger flap has undergone various modifications since it was first described by Gurdin & Pangman [6] based on

1. Pivot point (conventional, proximally based, or distally based)
2. Content of flap (conventional, de-epithelialized, reversed, or innervated).

MATERIALS AND METHODS

This prospective study included consecutive patients with ring avulsion injuries treated at the authors' institution between August 2016-August 2017. Clinical, operative, and radiological data were collected prospectively to characterise the injury pattern and management. Only patients with Urbaniak Class III ring avulsion injuries who were unwilling or unsuitable for microvascular reconstruction were included. [Table 1]
All procedures were performed under axillary block with pneumatic tourniquet. All patients were treated on an out-patient basis, except for three patients (seizure disorder, Diabetes mellitus and multiple injuries). The surgical technique is described below: the margin of the defect that is adjacent to the donor finger is designated "the hinge." It corresponds closely to the base of the flap, which is also called a hinge. It is similar to the pivot point of transposition flaps, in that it is a fixed reference around which tissues move. It differs in that it is a line rather than a point. A pattern of the primary defect is made and turned through 180 degrees around the hinge and applied to the dorsum of the donor finger. By adjusting the position of the hinge, the necessary flap can be derived entirely from the skin of the dorsum of the middle phalanx. The flap to be raised is folding of the flap. The vessels to the flap penetrate the more superficial part of the ligament and may be damaged unless care is taken to incise it at its depth, against the skeleton. The tourniquet is released at this juncture, and hemostasis is achieved. At this stage, split-thickness skin graft to cover the secondary defect is harvested. This is commonly taken from the same limb, usually the inner aspect of the upper forearm or arm. The skin graft is sutured to the secondary defect. The flap is folded over the primary defect in a sandwich fashion and secured with sutures. The circulation to the flap should be good, although a little blanching around the margins is common and acceptable. If the flap appears very pale and has been designed and raised correctly, it may be that the recipient finger is extending, thereby exerting undue pressure on the flap and its pedicle. This can be overcome by flexing the recipient finger until circulation returns. The fingers are dressed in situ with an interposed bolster to prevent soddening in the cleft . The hand is immobilized in a below elbow dorsal slab for 2 weeks, with the wrist in neutral and the metacarpophalangeal joints in flexion. Flap sutures are removed on the 10th day, graft sutures on 5th day and flap division at the end of 2 weeks. Thereafter, patients are advised daily wound care , flap and graft massage, and active physiotherapy for 2 weeks followed by passive physiotherapy for 2 weeks until full range of motion is achieved. [Figure 2-4]

RESULTS

12 cases of Class III Urbaniak ring avulsion injuries were treated with sandwich/folded cross-finger flap. The right hand was more commonly involved, similar to the findings reported by Adani et al. [7] , and the ring finger was most commonly affected. All flaps survived. There was partial graft loss in one patient which healed by secondary intention . One patient developed partial flap and graft loss and subsequently underwent split skin grafting to cover the residual raw area, this patient had poor glycemic control of diabetes mellitus.(Figure 5)
All patients were followed up for a period of 6 months. The Total active motion (TAM) for 12 patients were 0-50° in 3 patients, 50-90° in 5 patients and >90° in 3 patients. Of the 12 operated patients, 8 patients reported subjectively that they were satisfied with the outcome, one patient was lost to follow up after 4 months, three reported unsatisfactory outcome due to cold intolerance in the grafted site.

Recovery & Rehabilitation

All except 3 patients were treated on an out-patient basis. The duration of time away from work ranged from 4 to 9 weeks. Cold intolerance was present in three patients. No additional reconstructive procedures were required in any patient. Sensory recovery was not assessed as the follow-up period was limited to 6 months.

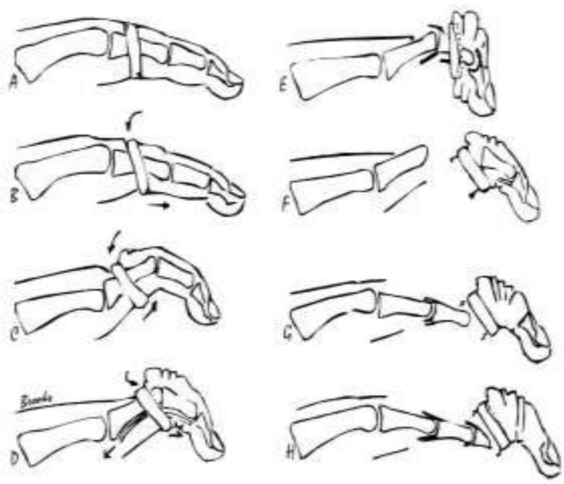

Figure 1: Sequence of avulsion

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Figure 2: (clockwise from top left): Primary defect; defect squared and planning in reverse done; flap raised from dorsum of ring finger; skin graft placed in situ and ready to receive tie-over dressing; and 4 weeks post-op picture

Figure 3: (clockwise from top left): Primary defect along with avulsed segment, replant not attempted as patient had poorly controlled seizure disorder. For the same reason, the caretakers also refused any distant flap reconstruction .

Figure 4 (left to right): Primary defect ; flap & graft in situ; postoperative period

Figure 5: Partial flap and graft loss resurfaced with secondary split-thickness skin grafting

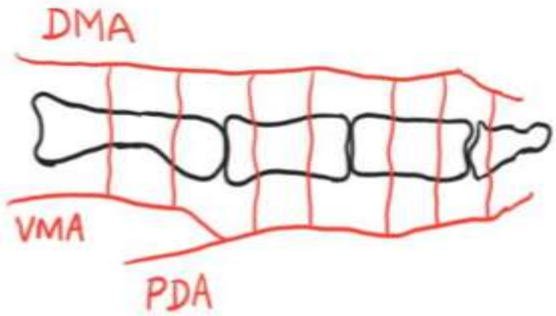

Figure 6: Schematic diagram illustrating the communications between the dorsal and palmar digital arteries.

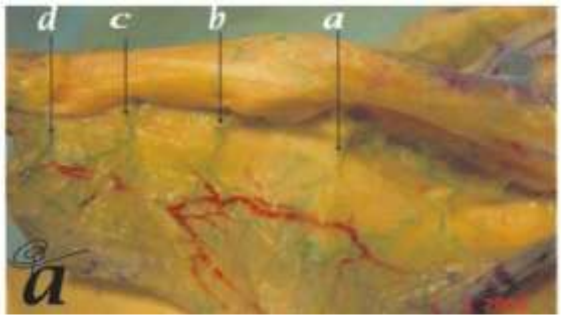

Figure 7: Cadaveric dissection demonstrating the communications between the dorsal and palmar digital arteries.

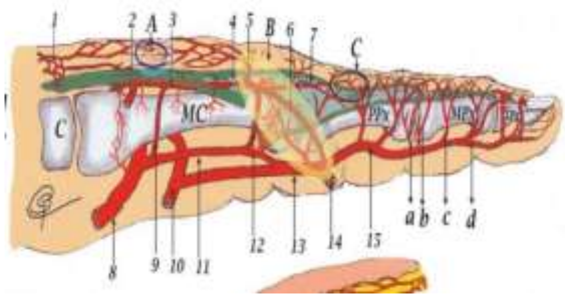

Figure 8: Diagrammatic illustration of the vascular network demonstrating the communications between dorsal and palmar arterial systems . (1) Rete carpi dorsale; (2) dorsal carpal arch; (3) dorsal metacarpal artery (DMA); (4) juncturae tendinum; (5) cutaneous perforator from DMA; (6) continuation of DMA to join the confluence of common digital artery (CDA) and digital arteries (Das); (7) lateral terminal branches of DMA anastomosing with dorsal branches of DA; (8) deep palmar arch; (9) proximal communicating perforator between DMA and palmar metacarpal

artery (PMA); (10) superficial palmar arch; (11) palmar metacarpal artery (PMA); (12) distal communicating perforator between DMA and PMA. (13) common digital artery; (14) digital artery to the neighbour finger; (15) DA to the same finger

Table 1: Demographic and Injury Characteristics of Patients

S No	Age	Sex	Side	Finger	Level of amputation	Etiology
1	23	Male	Right	Ring	DIPJ	Bus door
2	18	Male	Right	Ring	PIPJ	Printing Machine
3	36	Male	Left	Ring	DIPJ	Gate
4	27	Male	Right	Ring	MPx	Gate
5	32	Male	Right	Ring	DIPJ	Gate
6	42	Male	Left	Ring	DIPJ	Bus door
7	20	Male	Right	Ring	PIPJ	Handle bar
8	26	Male	Left	Ring	Mpx	Gate
9	39	Male	Right	Little	PIPJ	Gate
10	18	Male	Left	Ring	PIPJ	Handle bar
11	33	Male	Right	Ring	DIPJ	Gate
12	21	Male	Right	Ring	PIPJ	Gate

DIPJ-Distal Interphalangeal joint; PIPJ- Proximal interphalangeal joint; MPx- Middle phalanx

DISCUSSION

There have been two eras in the management of ring avulsion injuries, with microvascular reconstruction being the cornerstone of treatment in the modern era. Management options for finger avulsion injuries include pedicled flap cover, ray amputation, replantation and free tissue transfer. In the present study, the Sandwich/Folded Cross-Finger Flap provided dependable soft-tissue reconstruction with favourable functional results. The vascular basis of the folded component of the flap is supported by the work of Balakrishnan et al., who demonstrated communicating branches between the dorsal and palmar digital arterial systems in both clinical and cadaveric studies. [8](Figure 6-8). We believe that these vascular communications contribute to the survival of the folded portion of the flap , despite it's random- pattern configuration. The blood supply of the dorsal aspect of the finger can be divided into four zones.[9] The dorsal skin over the proximal phalanx receives its vascular supply primarily from the dorsal digital arteries. This represents the distal extent of the territory supplied by the dorsal metacarpal arteries. The remainder of the proximal phalanx and middle phalanx is supplied by branches of the palmar digital artery. These anatomical connections form the basis for the dependable vascularity observed in the folded cross- finger flap. Although replantation or revascularization remains the first-line treatment for ring avulsion injury, factors such as pre-existing medical conditions, patient unwillingness and limitations in microsurgical expertise may necessitate alternative reconstructive options .Various loco-regional flaps have been described in the literature for management of these injuries.Martin et al.[10] adapted a technique described by Foucher,[11] utilizing a reversed cross-finger flap,with its longitudinal veins used to bridge venous insuffienency. In our series , the Sandwich /Folded Cross-Finger Flap provided reliable coverage, and the technique is simple, reproducible, and does not require microsurgical expertise making it an effective alternative.

CONCLUSION

This prospective study was conducted at a teaching hospital and demonstrates that the Sandwich/ Folded Cross-Finger Flap is a reliable and effective option for the reconstruction of Urbaniak Class III ring avulsion injuries . The procedure provides durable soft-tissue coverage with satisfactory functional outcomes and high flap survival rates. Limitations of the study include a short follow-up period and incomplete long-term follow-up , as many patients were migrant workers who did not return after achieving satisfactory outcomes. Nevertheless, the technique remains a valuable alternative when microvascular reconstruction is not feasible .

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