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Reconstructive

Reconstruction of Upper Extremity Defects by Random Pedicle Abdominal Flaps: Is It Still a Valid Option?

Samir Jabaiti, MBBS, MSc*
Muayyad Ahmad, PhD†
Saif Aldeen AlRyalat, MD‡

Background: Traumatic soft tissue defects of the hand and upper extremities are common and may be challenging to the reconstructive surgeon. Several reconstructive procedures such as use of local, regional, distant, and free flaps have been described. This study aimed to report the techniques, outcomes, and complications of pedicle abdominal flaps in reconstructing hand and upper extremity defects.

Methods: In this retrospective study, we included patients with different traumatic defects in the hand and upper extremities who underwent reconstruction by random pedicle abdominal flaps between 2002 and 2017 at Jordan University Hospital, Jordan. Data were collected and analyzed, and the variables studied included patient age and sex, etiology and size of the defect, complications, outcomes, and the need for further revision procedures. Appropriate statistical analysis was used to examine the potential factors affecting flap survival.

Results: We included a total of 34 patients with a mean age of 22.2 years, ranging from 1 to 54 years. Finger degloving was seen in approximately half of the patients. Flap survival rate was 85.3%. A small area of defect was the only risk factor that significantly affected the flap failure rate.

Conclusions: Thin pedicle abdominal flaps are a valid, affordable, and safe option in upper extremity traumatic defects, especially in situations where microsurgical techniques are unavailable or contraindicated. Extra care should be taken when the defect surface area is small. *(Plast Reconstr Surg Glob Open 2020;8:e2687; doi: 10.1097/GOX.0000000000002687; Published online 18 March 2020.)*

INTRODUCTION

Traumatic soft tissue defects of the hand and upper extremities are common and may be challenging to the reconstructive surgeon, especially when they are severe and associated with exposed vital structures such as the tendons, nerves, bones, and joints.[1,2] Although these defects are rarely lethal, they are invariably resource-demanding and a source of significant long-term disability.[3] Several reconstructive procedures have been described to cover the soft tissue defects of the hand and upper extremities, including local, regional, distant, and free flaps. Traditionally, pedicle abdominal flaps, whether axial or randomly based, have been considered as the standard procedure for successful upper limb reconstruction.[4–14] With the introduction of microsurgery in the 1970s, microsurgical free tissue transfers have become the gold standard for upper extremity functional reconstruction.[15,16] Free flaps and other microsurgical techniques have been used to achieve early, functional, and custom-tailored reconstructive solutions for upper limb injuries.[17] However, despite the superiority of free flaps, this option may not be always accessible, especially in developing countries, owing to the high cost and technical demands.[18] Moreover, free tissue transfer may be contraindicated in many circumstances.[13,19] In such situations, pedicle abdominal flaps may once again become an alternative option for safe and effective upper extremity reconstruction.[20] This study aimed to report our experience in using random pedicle abdominal flaps, based on the indications, complications, outcomes, and evaluating factors affecting the flap survival rate.

*From the *Department of Plastic and Reconstructive Surgery, Jordan University Hospital, The University of Jordan, Amman, Jordan; †Department of Clinical Nursing, The University of Jordan, Amman, Jordan; and ‡Department of Special Surgery, The University of Jordan, Amman, Jordan.*

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METHODS

This retrospective study was approved by the institutional review board (10/2017/1631), conducted in concordance with the latest update of the Helsinki Declaration, and registered on clinicaltrials.gov (ID: NCT04007497). Moreover, this work has been reported based on the Strengthening the Reporting of Cohort Studies in Surgery criteria.[21] Data of patients with different traumatic defects in the hand and upper extremities who underwent reconstruction by random pedicle abdominal flaps at our tertiary hospital (Jordan University Hospital, Jordan) between 2002 and 2017 were collected. Patients' medical records were reviewed. Data were collected and analyzed. The variables studied included patient age and sex, etiology and size of the defect, complications, outcomes, and the need for further revision procedures.

Operative technique:

Patients and/or their parents were counseled preoperatively. The procedure and its benefits and disadvantages were thoroughly explained. All procedures were performed under general anesthesia. Preoperatively, the flap was designed on the abdominal wall in a relatively loose area, orientated along minimal skin tension lines to facilitate the primary closure of the secondary defect (Fig. 1A–C). By applying the principle of reverse planning, the donor site was chosen in an area that provides maximum comfort to the patient and allows the patient to exercise the elbow and shoulder joints. Intraoperatively, flaps were raised and thinned to suitable thickness adjusted according to the needs of the defects (Fig. 1D, 1E). The donor site was closed primarily. The flap was then inserted into the defect and sutured with 3-0 Nylon sutures (Fig. 1F). The upper limb was strapped to the abdominal wall using an adhesive tape, leaving the part of the flap exposed for inspection. Postoperatively, patients were immobilized in bed for 2–3 days. After that, mobilization was encouraged. All patients were encouraged to exercise the shoulder and elbow joints. Flap division was carried out 3 weeks later. During flap division, flap maturation was tested by applying a tourniquet (rubber catheter) to the pedicle for 10 min while observing the color of the flap. When the flap was mature, it was divided.

Statistical analysis:

The SPSS version 25.0 (Chicago, USA) was used in our analysis. Continuous variables (eg, age) were described using the mean (± SD), with count (frequency) utilized to describe other nominal variables (eg, gender). The Mann–Whitney *U* test was performed to analyze the difference between survived and nonsurvived flaps. All underlying assumptions were met unless otherwise indicated. *P* value ≤ 0.05 was considered as statistically significant.

RESULTS

A total of 34 patients with various traumatic defects in the hand and upper extremities were included in the study. The patients' mean age was 22.2 years, ranging from 1 to 54 years. Furthermore, 31 patients (91%) were male. Degloving injury of the fingers occurred in almost half of the cases (n = 16, 47.1%). The median surface area of the defects was 44 cm^2, ranging between 12 and 162 cm^2, with 12 cases (35.3%) having a surface area of 12 cm^2. Table 1 summarizes the statistical description of the study variables.

Flaps survived successfully in 29 cases (85.3%) (Fig. 2). One case of complete flap failure (2.9%) was encountered in a 27-year-old man, a cigarette smoker, who was involved in an avulsion crushing injury to his index finger 2 months before referral to our hospital. Examination of the injured finger showed exposed phalanges, denuded of its periosteum, and looked ischemic. The remaining soft tissue of the finger was deficient with ischemic changes (Fig. 3A). A random pedicle abdominal flap was performed as a salvage procedure. Postoperatively, the flap looked retracted and grossly necrotic (Fig. 3B).

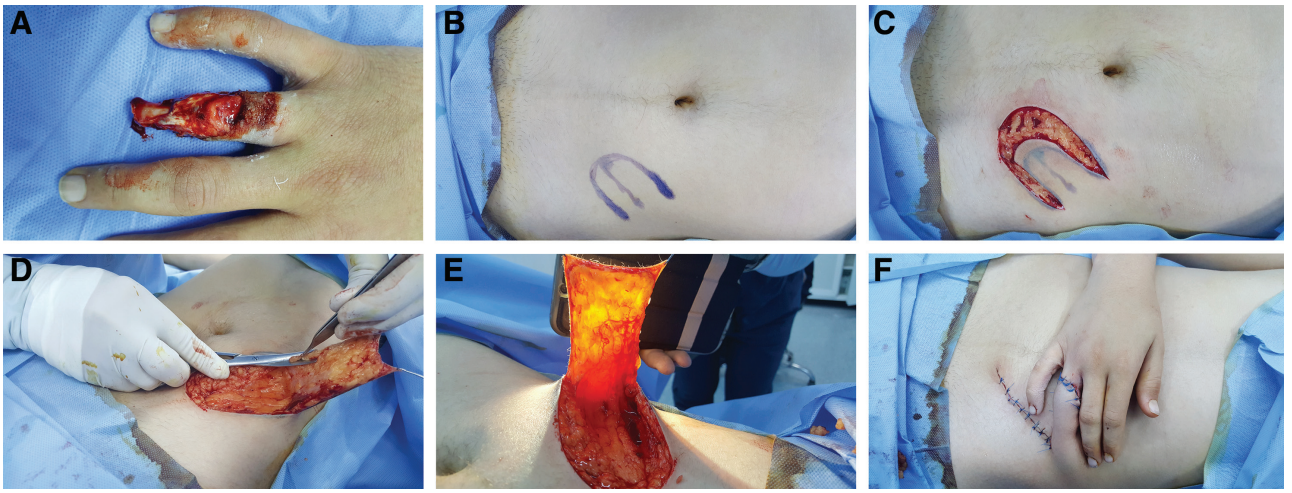

Fig. 1. Surgical technique. A, 15-year-old boy with degloving injury of right ring finger. B, Design of the flap in left iliac fossa area, along skin tension lines. C: Raising of the flap. D, Intraoperative thinning of the flap with scissors. E, Flap after appropriate thinning. F, Flap covering the defect, donor site closed primarily.

Table 1. Description of the Study Variables (N = 34)

Variable	n	%
Age (Mean = 22.2, SD = 12.9) (Range, 1–54 years)		
Sex		
Male	31	91.2
Female	3	8.8
Etiology of the defect		
Road traffic accidents	10	29.4
Deep thermal and electrical burns	8	23.5
Degloving injuries	16	47.1
Site of the defect		
Elbow	3	8.8
Forearm	9	26.5
Finger	16	47.1
Dorsum of the hand	6	17.6
Flap survival		
Survival	29	85.3
Nonsurvival		
Partial survival	4	11.8
Complete failure	1	2.9
Flap thinning and minor revision		
No	24	70.6
Yes	10	29.4

In 4 patients (11.8%), the distal part of the flap was noticed to be partially necrotic postoperatively (Fig. 4), and an additional surgery was performed. The flap was revised with the excision of the necrotic part and reinserted into the defect. These flaps survived and were divided as usual 3 weeks later.

Postoperatively, 1 patient (54 years) developed shoulder joint stiffness, which improved after 2 months of physiotherapy. No wound infections or hematomas were noted in the flaps or donor sites. None of the patients experienced sensory loss in the abdominal wall or lower limbs and had deep vein thrombosis or other life-threatening conditions.

The follow-up duration ranged from 2 to 17 years. All flaps were viable and healthy during the follow-up. Flap thinning was required in 5 cases (14.5%). Finally, the effect of potential factors on the flap survival was examined. The examined factors were the following: age and etiology, site, and surface area of the defect. For the purpose of the statistical analysis, we defined flap survival as those who maintained adequate vascularity from the first day postoperatively until its division. Flaps that were totally or partially necrotic postoperatively were considered to have not survived. When comparing flap survival with flap nonsurvival with the study variables (age and etiology, site, and surface area of the defects), we found that only the variable "surface area" was significant. The larger the surface area, the higher the chance of flap survival (U = 32.0; $P = 0.044$).

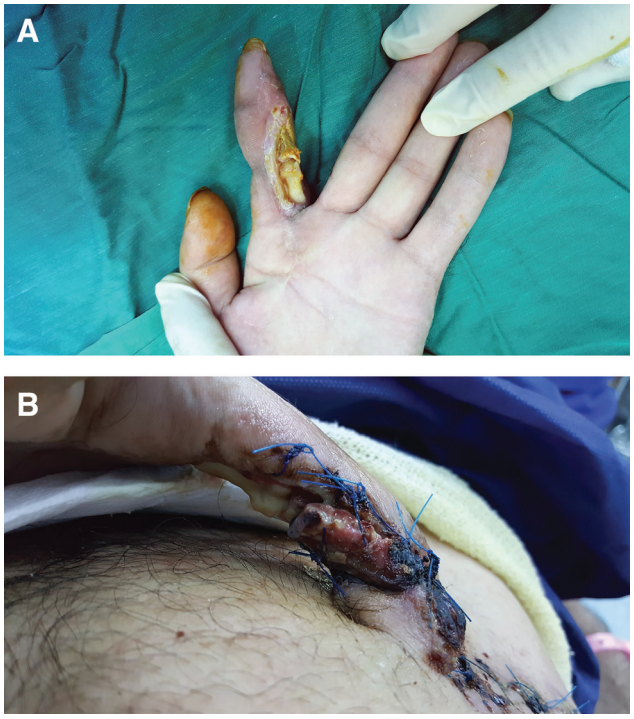

Fig. 3. The case of flap failure. A, Avulsion crushing injury in left index finger showing exposed phalanges, denuded of its periosteum, and ischemic changes. B, Total flap necrosis in left index finger traumatic defect.

DISCUSSION

We described the long-term outcome of reconstructing hand and upper extremity traumatic defects by thin random pedicle abdominal flaps, a viable and affordable

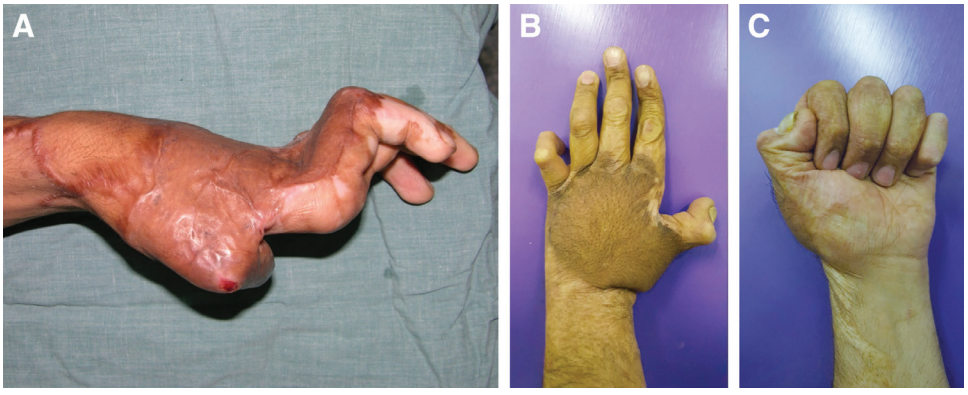

Fig. 2. Postoperative results. A, Preoperative view of a 17-year-old boy with postburn hand contracture. B, Postoperative view: full range of hand extension. C, Full range of hand flexion.

Fig. 4. Partial flap necrosis of degloved ring finger.

option in limited resources settings. With only 1 flap failure (2.9%) and 4 flaps with partial necrosis (11.8%), the overall success rate was 85.3%. No mortality or life-threatening conditions were noted. The only factor associated with graft survival was the surface area of the defect, where the larger the surface area, the higher the chance of flap survival. Early appropriate soft tissue coverage of traumatic wounds of the upper extremities is crucial in achieving acceptable functional and esthetic outcomes.[1,2,11,16] Various types of flaps have been described for hand and upper extremity reconstruction depending on the general condition of the injured patient, mechanism and severity of the injury, and local condition of the wound and the neighboring tissues.[2,3]

Local and regional flaps have been used for upper limb reconstruction.[1–3] However, their use may not be always applicable because the donor tissues may lie within the zone of the injury. Therefore, their use may result in significant functional deficits in an already compromised limb. Furthermore, the use of these flaps is limited by the small area they can cover and their restricted arc of rotation.[2,11]

The technique of groin flaps described in detail by McGregor and Jackson in 1972 was a milestone in the history of the reconstruction of soft tissue defects of the hand.[4] Groin and random pedicle abdominal flaps and their modifications have remained the standard procedure for successful upper limb reconstruction for a long time.[4–14] With the advent of reconstructive microsurgery in the 1970s, microsurgical free tissue transfer has become the gold standard for soft tissue reconstruction of the upper extremities.[1–3,15–17,22] Free flaps may offer the potential for early, functional, and esthetic reconstruction of complex upper extremity defects in a 1-stage procedure.[16,17,22] They can provide custom-tailored reconstructive solutions to suit the requirements of the injured upper limb through transferring various composite soft tissues, innervated muscles, and vascularized bone.[2,17,22] Despite the superiority of free flaps in upper limb reconstruction, they are time-consuming and technically demanding procedures that require high cost and technical resources that are not always accessible, particularly in several centers in developing countries.[5,10,14,18,23]

Furthermore, free tissue transfer may be contraindicated in certain groups of patients such as cigarette smokers, diabetics, immunosuppressed, and those with significant chronic illnesses or in cases of absent suitable recipient vessels in severely injured limbs.[19] Free flap is a multihour surgical procedure that may be unadvised in a critically ill patient.[11]

Considering these limitations, traditional pedicle abdominal flaps continue to be a valid and safe option for upper limb reconstruction even in centers with microsurgical facilities.[3,5,11,20] Recently, Al-Qattan et al. defined the indications of using pedicle abdominal flaps in the era of microsurgical facilities, based on literature review and their own experience.[20] Our flap necrosis rate of 14.7% (including 11.8% salvageable flaps) is comparable with the results of the other authors who reported flap necrosis rate between 3.4% and 27.3%.[5,7,8,11] Our results, along with the absence of mortality and life-threatening complications, would support the principle of using abdominal flaps in certain situations and indications.[20] Decreased survival associated with a small defect area may be explained by the minimal contact with the recipient site, as 4 out of 5 flap failures were encountered in cases of degloved fingers.

Pedicle abdominal flaps have been classified as axial pattern flaps based on an anatomically known arteriovenous system running along its long axis and random pattern flaps based on the subdermal vascular plexus.[24] Compared with the random flaps, the axial flaps have better vascularity and wider arch of reach due to their specific vascular pedicle.[4] However, the donor site of the groin axial flaps may be constrained by their anatomical vascular pedicle.[24] On the contrary, random pedicle abdominal flaps based on subdermal vascular plexuses can utilize

Table 2. Mann–Whitney U Test Comparing Flap Survival against Study Variables (N = 34)

Variables	Survival n	Nonsurvival n	Mann–Whitney *U* Test	Significance
Surface area of the defect	29	5	32.0	0.044
Age	29	5	68.0	0.826
Etiology of the defect				
Road traffic accidents	9	1		
Burns	8	0	48.5	0.208
Degloving injuries	12	4		
Site of the defect				
Elbow	3	0		
Forearm	8	1	70.0	0.896
Finger	12	4		
Dorsum of the hand	6	0		

almost any area of the abdomen as the donor tissue.[24] This allows the surgeon to choose redundant areas of the abdominal wall as potential donor sites that could be closed primarily, avoiding the need for skin grafting which was usually required in groin flaps.[4–7] In groin flaps, persistent loss of sensation in the upper lateral thigh caused by injury to the lateral femoral cutaneous nerve during flap dissection is possible, and it was reported in 50% in 1 study.[8] None of our patients had such complication, since there was no need to dissect that area in random pedicle abdominal flaps.

The bulkiness of abdominal pedicle flaps and the need for secondary thinning procedures have been considered as a drawback.[5,7,11] Intraoperative attempts of thinning the axial groin flaps may be unsafe due to the lack of knowledge of the depth of the vascular pedicle in the subcutaneous tissue.[4] On the other hand, random pattern pedicle abdominal flaps are based on the subdermal vascular plexuses, giving the surgeon the freedom to thin the flap intraoperatively to suit the need of the defect.[25,26] Over the past few decades, several authors applied the principle of intraoperative flap thinning to create thin and even superthin pedicle abdominal flaps to fit the requirement of the defect.[12,14,27,28] Yamada et al. reported the use of thin abdominal pedicle flaps for immediate coverage of multiple degloved fingers in 3 patients.[12]

Decreased survival associated with a smaller area of a defect may be explained by minimal contact with the recipient site. This is demonstrated in the case of degloved fingers, which made up 4 out of the 5 failed flaps. These flaps were inset on bare bones. Furthermore, in the resurfacing of the degloved fingers, flap failure may be explained by the relatively inadequate width-to-length ratio required for random flaps.[24] In addition, our attempt to cover the degloved fingers with suprathin flaps to match the skin of fingers could have jeopardized the vascularity of the flaps and contributed to their relative failure.

One of the 5 flaps failed completely; this random pedicle abdominal flap was performed on avulsed index finger (Fig. 3A). The cause of flap failure may be attributed to the grossly ischemic, denuded bone of the reconstructed finger, and possible hidden bone infection that may be caused by long-standing neglected bone exposure. Furthermore, the ischemic soft tissues of the finger may have also contributed to the flap failure. Finally, cigarette smoking might be an additional factor for flap failure as the adverse effects of smoking on flap necrosis were demonstrated by clinical and experimental studies.[29,30]

Gousheh et al. applied the same principle and used superthin abdominal random pedicle flaps to resurface the dorsal hand burn scars in 34 patients. Their results were esthetically and functionally good without the need for subsequent defatting procedures.[14] Urushidate et al. reported the use of thin abdominal flap (glove flap) to resurface 7 hands of 5 patients involved in burns; all the flaps survived with good functional and esthetic outcomes.[27] Wang et al. reported the coverage of 9 hand dorsa with suprathin abdominal pedicle flaps, with only 1 flap undergoing partial necrosis.[28] In our series, the flaps were raised in an optimal thickness that matched the needs of the defect. This was particularly valuable in successful resurfacing of degloved fingers and the dorsum of the hand with thin flaps.

A major disadvantage of the pedicle abdominal flaps is being a 2-stage procedure with a period of inconvenient upper limb immobilization with the potential risk of persistent restricted movements of the shoulder and elbow joints.[2] Gousheh et al. found that the majority of patients accepted the procedure and its associated lifestyle inconvenience because of its benefits after the surgery.[14] All patients tolerated the procedure. This may be attributed to adequate preoperative counseling and an explanation of the benefits of the technique.

Graf and Biemer reported restricted shoulder mobility in 4 out of 24 patients (17%) aging 50 years and above who underwent groin flaps for upper limb reconstruction.[8] The low rate of joint stiffness in our series (only 1 patient) may be caused by the relatively younger age of our patients and encouragement of routine exercise on the involved joints.

In developing third-world countries, the infrastructure, surgical tools, and/or resources needed to perform sophisticated microsurgical procedures may not be available. In this setting, more conservative procedures such as distant pedicle flaps remain suitable options for covering defects of the upper extremity.[23] Our results with random abdominal flaps would support this opinion. Random pedicle abdominal flaps have several advantages. The procedure is simple, requires neither expensive resources nor extensive experience, and can be achieved without prior knowledge of the specific vascular anatomy. Furthermore, these flaps can be safely thinned intraoperatively as needed without jeopardizing the vascular pedicle. Additionally, the donor sites can be closed primarily. The main limitation in our study is our small sample size although we included all patients referred to our center. Future studies should consider comparing the outcome between pedicle abdominal flap and newer approaches for upper limb reconstruction, along with a cost-effective analysis between the approaches.

CONCLUSIONS

In conclusion, thin pedicle abdominal flaps may be considered a valid, affordable, and safe option in patients suffering from upper extremity traumatic defects, especially in cases where microsurgical techniques are unavailable or contraindicated. They remain a valid choice in the armamentarium of the reconstructive surgeon embarking on upper extremity reconstruction. Surgeons in the developing countries are encouraged to use it, alongside their effort to acquire the skills and resources of the microsurgical techniques.

Although there are some disadvantages, the benefits outweigh the drawbacks.

Saif Aldeen AlRyalat
Department of Special Surgery
The University of Jordan
Amman, Jordan
E-mail: saifryalat@yahoo.com; S.alryalat@ju.edu.jo

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