Our experience of Posterior interosseous bone flap reconstruction of segmental defects of hand and distal forearm.

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ABSTRACT

Objective: To determine the functional and radiological outcome of posterior interosseous bone flap in reconstruction of intercalated defects of the hand and distal forearm.

Methods: This descriptive study was conducted in Millat Orthopedic and Trauma Surgery Hospital Sargodha from 23rd March 2015 to 23rd June 2019.All patients of segmental bone loss in the hand and distal forearm fulfilling the inclusion criteria were treated with posterior interosseous bone island pedicle flaps for filling of defects. Donor site wounds were directly closed. The patients were assessed clinically for viability of the flap and hand functions and radiologically for transferred bone union.

Results: The total number of patients were 6 with mean age 33.3 years(range 19 to 48 years).All patients were male. Right side was involved in 4(66.6%) and left in 2(33.3%).The aetiology was gunshot injury in 3(50%), saw cut in 2(33.3%) and infection in 1(16.6%) patient. First metacarpal bone defect was present in 2 (33.3%) patients, second and third metacarpal in 1(16.6%),third metacarpal in 1(16.6%) proximal phalanx of the thumb in 1 (16.6%) and distal radius in 1 (16.6%) patient. Posterior interosseous osteocutaneous flap were used in 4(66.6%) and osseous flap in 2(33.3%).The mean length of bone transported was 4.3 cm(range 2.5 to 5.5 cm). All flaps survived completely without any untoward sequelae. No donor site morbidity regarding fracture and cosmesis was reported. The transported bone in all cases were incorporated successfully without any resorption. All the patients were able to use their hands for daily activities without any major functional impairment.

Conclusion: The intercalated defects of the hand and distal forearm treated with posterior interosseous bone flap resulted in acceptable functional and radiological outcome. In an injured hand with composite bone defects of metacarpals or proximal phalanges if there is no biological spare part available then the use of posterior interosseous bone island flaps should be the preferred choice for reconstruction.

Keywords: Intercalated bone deficits, Posterior interosseous bone island pedicles, Reconstructive surgical procedure.

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INTRODUCTION

The management of the large complex skeletal defects of the hand and distal forearm requires a sophisticated management strategy with a significant challenge for a hand surgeon. Factors determining the restoration and salvage of hand function in such injuries are the severity of the soft tissue damage, the level of injury and the viability of the digit including occupation, physical demands, and expectations as patient factors.[1]Treatment of these devastating injuries with a distant pedicle flap and non-vascularized corticocancellous bone graft have substantial problems with graft resorption and fatigue fracture, even after many years of the surgical procedure. Whereas, vascularized bone grafts have

been shown to reduce the risk of subsequent fracture, provide more rapid bone union and have the capacity to remodel under physiologic load.[2,3]

Possible strategies for management of these segmental defects by vascularized bone grafts can be (1) use of severely damaged but viable parts of the hand(Vascularized Spare Parts) (2) vascularized forearm pedicled bone grafts, and (3) free vascularized pedicled bone grafts.[4,5] Free vascularized bone transfer requires microvascular anastomoses, experienced operative team and prolonged operative time and increased morbidity at donor site. When the nature of injury has not led to any functionally useless parts of hand, then the only reliable alternative left is vascularized forearm bone graft pedicles reconstruction.[6-8] Vascularized forearm bone graft pedicles are moved with their reverse flow of blood supply to an injured area of the hand.It has the advantage of reconstructing all the defects in a single stage comprising of soft tissues, nerves and bone while preserving as much function as possible. Most common vascularized forearm bone pedicle flap options are radial forearm flap (RFF)[9,10]and posterior interosseous flap (PIF).[11,12]

Sever hand trauma patients are usually treated with amputations or salvage procedures and these patients then suffer life long disability and loss of profession or job. This is not only due to lack of experts of hand reconstruction surgery but also unwillingness of the patients for prolonged and staged procedures of hand reconstructions. The objective of our study was to determine the functional and radiological outcome of posterior interosseous bone flap in reconstruction of intercalated defects of the hand and distal forearm. Our results would encourage other hand surgeons to avoid amputations and opt for posterior interosseous bone island pedicle flap in sever hand trauma patients. Moreover the public will get awareness that reconstruction and restoration of hand functions are possible in complex hand trauma.

METHODS

This study was conducted in Millat Orthopedic and Trauma Surgery Hospital Sargodha from 23rd March 2015 to 23rd June 2019.The study protocols were approved by the Ethical Committee of the hospital. Informed consent was taken from all the participants of study.Patients of either gender and any age with segmental bone loss in the hand and distal forearm were included. Patients of polytrauma with other injuries requiring surgical intervention, completely transected fingers or hand requiring transplantation and those patients in whom reconstruction with biological spare parts could be done were excluded from the study.All patients of segmental bone loss in the hand and distal forearm were treated with posterior interosseous bone island pedicle flaps(osteo-cutaneous or osseous) for filling of defects.All the surgeries were done under general anaesthesia and tourniquet control. In all cases a variable portion of the proximal ulna with intact blood supply and part of extensor pollicis longus muscle was harvested for filling the defects. K wires were used for stabilizing the transferred bone. In some cases abdominal flap were used for coverage before the definitive pedicle flap.(fig. IA to IF) Traumatic tendon deficits were replaced with tendon transfers in selected cases. Donor site wounds were directly closed. Post operatively the hand and forearm was immobilized in a splint for two weeks.In follow up visits the patients were assessed clinically for viability of the flap and hand functions(grasping, pinching) and radiologically for transferred bone union. K wires were removed after bone healing. The data was analyzed with SPSS version 20. Important quantitative variables were represented as mean while qualitative as frequencies and percentages.Some data presented in table as summary.

RESULTS

In our study the total number of patients were 6 with mean age 33.3 years(range 19 to 48 years).All patients were male. Right side was involved in 4(66.6%) and left in 2(33.3%).The aetiology was gunshot injury in 3(50%),saw cut in 2(33.3%) and infection in 1(16.6%) patient. First metacarpal bone defect was present in 2 (33.3%) patients, second and third metacarpal in 1(16.6%),third metacarpal in 1(16.6%) proximal phalanx of the thumb in 1 (16.6%) and distal radius in 1 (16.6%) patient.Posterior interosseous osteocutaneous flap was used in 4(66.6%) and osseous flap in 2(33.3%). The mean length of bone transported was 4.3 cm(range 2.5 to 5.5 cm).The transferred bone was united in an average 3.4 months(range 2.5 to 5.5 months). No delayed resorption of ulna segment bone graft was seen at recipient site. The mean follow up was 6.5 months(range 3.5 to 11 months) All flaps survived completely without any untoward sequelae. No donor site morbidity regarding fracture and cosmesis was reported. All the patients were able to use their hands for daily activities(grasping, pinching) without any major functional impairment. No patient required prolonged immobilization or

further bone grafting. All patients were satisfied with the reconstructed site and were back to their jobs. The donor ulnar site healed in all patients without any further intervention. No patient was lost to follow up. (fig. II & III) Treatment summary of our study participants is shown in table I.

Fig IA: A saw cut injury to the dorsum of the right hand in a 32 year old man. **IB**: Thumb was fixed in lengthened position with an axial K-wire and soft tissue coverage was provided with an abdominal flap. **IC:** After healing of flap wound an osseous posterior intraosseous island pedicle flap was harvested with a 5.5 cm proximal ulna segment and fixed with K-wire. **ID:** Transferred bone union at 3 months. **IE & IF**: Functional outcome with pinch and grasp functions.

Fig IIA & B: A 25-year-old man with gunshot injury to the dorsum of his left hand stabilized with bayonet k wire after debridement. **IIC & D:** When the wound was clean, an osteo-cutaneous posterior intraosseous island pedicle flap was fashioned. The transferred ulna was used to fill the gap and stabilized with a k wire. Lost extensor tendon was reconstructed with Extensor Indicis Proprious transfer. **IIE:** At two months there was complete healing at recipient site.

Fig IIIA: Gunshot wound on the dorsum of proximal phalanx of the thumb in a 41-year-old man. **IIIB:** After cleaning of wound, an osteo-cutaneous posterior interosseous island pedicle flap was made and transferred to the defect. The transferred portion of ulna had filled the bony defect and stabilized with an axial K-wire. **IIIC:** At two months there was complete healing at the recipient site and the wire was ready to be removed.

Table I: Treatment summary of our study participants.

Case No.	Sex	Age (years)	Mechanism of injury	Location of bone defect	Type of PIF used	Length of bone graft (cm)	Donor area	Bone healing (months)	Duration of follow-up (months)
1	M	48	Saw-cut	1st metacarpal	Osseous PIF	5.5	Direct closure	3	3.5
2	M	38	firearm	2nd & 3rd metacarpal	Osteo-cutaneous PIF	4.5	//	3	6
3	M	36	Saw-cut	1st metacarpal	//	4.0	//	2.5	5
4	M	28	firearm	3rd metacarpal	//	4.0	//	4	11
5	M	31	firearm	proximal phalanx Thumb	//	2.5	//	5.5	9
6	M	19	postop infection	Distal radius	Osseous PIF	5.5	//	2.5	5
Summary	All Male	19 to 48 Y, average-33.3 Y	Firearm-3, Sawcut-2, Infection-1	Metacarpal 1st-2, 2nd-1, 3rd-2 Phalanx thumb Proximal-1 Distal radius-1	Osseous-2 Osteo-cutaneous-4	Range 2.5 to 5.5 Average 4.3	Primary healing in all cases	Range 2.5 to 5.5 average 3.4	range 3.5 to 11 (average 6.5)

DISCUSSION

In our study reconstruction of hand defects with posterior interosseous bone island pedicle flaps had achieved the goals of one stage bridging of bone defects with vascularized bone grafts. No donor site morbidity or revision procedures were required and all patients had returned to their previous job. The filling of defects of distal radius and proximal phalanx of thumb with posterior interosseous bone island pedicle flap were an unexpected mind-stricken idea that have expanded the indications for reconstruction with reverse flow posterior interosseous flap.

Because of being vascularized bone with intact pedicle of blood supply in the flap,the transferred bone achieved union without requiring any additional surgical procedures. The healing rates at bone graft junctions is enhanced without any resorption of vascularized bone segment than non-vascularized

free bone grafts[13-15]. As a result, early institution of occupational rehabilitation program gives better results. After Bostwick[15]first discovery of flaps with "Retrograde Blood Supply" or distally based island flaps, their utilization in hand and forearm reconstruction has expanded the indications when local solutions are not available. Because of their excellent outcome and easy transfer as we found in our series, they can be indicated for primary reconstruction of alone or composite defects of forearm and hand.[4,16-19]

The Radial Forearm Flap(RFF) is the most commonly performed forearm flap because it can be transplanted together with a segment of radius[3-5,20], nerves and tendons.[3,4,21] Biemer and Stock[3] reported one stage osteoplastic reconstruction of thumb with radial forearm osteo-cutaneous flap after traumatic amputation. Matev[19] and Chacha[2] have reported thumb intercalated defects reconstruction as a single stage procedure. Although the Radial Forearm Flap (RFF) is most widely used in hand reconstruction it has many complications and the most common is compromising the radial artery and weakening of distal radius and ultimate fracture.[5,22]

The Posterior Interosseous Bone Flap is uncommonly described in literature and less commonly used. Costa[11] used this flap for terminal thumb reconstruction in two clinical cases and suggested that this flap was an excellent alternative to any other lengthening procedure and had no donor site morbidity.

There are many advantages of Posterior Interosseous Bone Flap. Firstly, this flap is based upon a very small artery and the major blood supply of the hand is not disturbed. Secondly, if the radial or ulnar artery or the palmar arch is injured even then this flap can be fashioned because this flap receives blood in a retrograde manner from an anastomoses between anterior and posterior interosseous arteries at the level of wrist joint. [8-12,23-25]

Thirdly, the proximal portion of ulna is triangular and broad and a good portion of it can be excised without any fear of donor site fracture.[8-12] Considering the above advantages perhaps was the reason that we started using posterior intraosseous bone pedicle flap. Costa[7] noted that since proximal ulna has musculoperiosteal blood supply and distal ulna has fascioperiosteal, the proximal ulna can offer some part of Extensor Pollicis Longus muscle.[8-9] Selcuk[24] reconstructed metacarpal defects with posterior interosseous flap in five cases as osteo-cutaneous pedicles while we used posterior interosseous flap as osteo-cutaneous in four and osseous in two cases for reconstruction of segmental bone defects of hand and distal forearm and results were very good.

Free osteo-cutaneous flaps for coverage of hand defects are well described in literature with variable results. [2-3,22,25-27] These procedures require microsurgical expertise, prolonged operative time and our setup was not having requisite resources for this kind of surgery. Furthermore, our patients were reluctant to use distant parts of body as donor.

Our sample size was small and the possible reasons may be that complex hand trauma patients are usually treated with salvage procedures at local hospitals because of lack of expert hand surgeons and the patients were reluctant for prolonged and repeated surgeries. Secondly we were not able to provide a specific and uniform physiotherapy protocol for rehabilitation. We therefore, recommend further well designed studies with larger sample size and specific rehabilitation protocol to confirm the effectiveness of posterior interosseous bone flap.

CONCLUSION

The intercalated defects of the hand and distal forearm treated with posterior interosseous bone flap resulted in acceptable functional and radiological outcome. In an injured hand with composite bone defects of metacarpals or proximal phalanges if there is no biological spare part available then the use of posterior interosseous bone island flaps should be the preferred choice for reconstruction.

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