

# Study of Paraumbilical Perforators in a Normal Population Group and its Clinical Correlation with Paraumbilical Perforator Based Abdominal Flaps in South Indian Population

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## Abstract

**Aim:** To analyse the perforators around umbilicus in a normal population group. To assess the clinical versatility of paraumbilical perforator based abdominal flaps.

**Materials and Methods:** Doppler analysis of site of paraumbilical perforators was done in 50 individuals of varying age groups, with normal abdominal wall. 32 patients having upper limb defects were reconstructed with paraumbilical perforator based abdominal flaps, in the Department of Burns, Plastic and Reconstructive Surgery, Kilpauk Medical College, Chennai, during the period of two years 2016 and 2017, and analysed.

**Discussion:** The perforators in paraumbilical region, were Dopplered in normal individuals. The paraumbilical region was divided into 4 zones and the perforator pattern was studied. The clinical study was done in the case series of the paraumbilical perforator based abdominal flaps, done in the department. The flaps were based on the perforators in all the zones of paraumbilical region studied.

**Results and Conclusion:** The commonest position of the paraumbilical perforator was analysed. It was found that the paraumbilical perforator based abdominal flaps can be harvested in any zone, in any direction. The versatility of flap design, with comfortable and amiable positioning of the upper limb with abdomen, makes these flaps reliable and a "user-friendly" option in the reconstruction repertoire of the upper limb defects.

**Key words:** Paraumbilical perforator based abdominal flaps, Umbilical perforator zones.

## INTRODUCTION

The anterior abdominal wall extends from xiphoid process above to pubis below. The anterior abdominal wall is made of skin, subcutaneous tissue – scarpa's fascia and Camper's fascia, rectus sheath enclosing rectus muscle in the center and three-layered muscles – external oblique, internal oblique and transverse abdominis muscles in

the periphery of the abdomen. The abdomen is richly vascularized with superior and inferior epigastric vessels in the center and lateral intercostal arteries in the periphery. There is anastomosis between the epigastric vessels and intercostal arteries which varies from above to below, above the umbilicus having rich anastomosis and below the umbilicus having sparse anastomosis.<sup>[1]</sup>

Based on the perforator of the superior epigastric artery, skin flap was first described by Hallock.<sup>[2]</sup> Based on superior epigastric perforator flap, few case series were published.<sup>[3-6]</sup> The vascular basis of superior epigastric artery perforator flap was analyzed by computed tomography angiographic study in two case series.<sup>[7,8]</sup> In another study, which was a cadaveric study, analysis of vascularity of the abdominal wall was done.<sup>[9]</sup>

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The anterior abdominal wall provides versatile skin flaps for the reconstruction of upper limbs. Although there are studies to analyze the blood supply of the abdominal wall, there are not many clinical studies to incorporate the knowledge of the angiosomes of the abdominal wall around the umbilicus in the clinical setup.

The institution Kilpauk Medical College Hospital is one of the largest tertiary burn care and plastic and reconstructive care in India and the largest one in South India. Here, the treatment is given to persons who are in all ethnic groups and in all age groups predominantly from South India. The purpose of this study is to analyze the perforators around the umbilicus by Doppler study in the normal population and to assess the clinical versatility of paraumbilical perforator based abdominal flaps in the reconstruction of the upper limb defects.

## MATERIALS AND METHODS

### For Doppler Study Group

A total of 50 volunteered individuals having normal abdominal wall were taken up for Doppler study group. Inclusion criteria include persons in all age groups and both sexes and persons with all ethnic groups. Exclusion criteria include persons having previous surgeries or scars in the abdomen and persons having other intra-abdominal pathology including hernia.

After an extensive search in research articles, it was found that there is no proper classification of the blood supply around the umbilicus described. In this study, the abdominal wall around the umbilicus was divided arbitrarily into four zones, and these zones are named as paraumbilical perforator (PUP) zones of the paraumbilical region. The upper limit of the paraumbilical region is midway between xiphoid process and umbilicus. The lower limit of the paraumbilical region is midway between umbilicus and pubis bone. The lateral extent is the lateral end of rectus muscle which is identified clinically [Table 1]. All these zones were present both above and below the umbilicus and in both sides [Figure 1].

Doppler study was done in all these 50 volunteered individuals around the umbilicus in all these four zones using the 8 MHz hand-held Doppler probe. The Doppler signals with biphasic flow denoting the perforators around the umbilicus were noted in all the four PUP zones. The number of perforators detected and its distance from the umbilicus was noted in all the persons included in this study. Statistical analysis of these recorded data was performed [Figures 2 and 3].

### For Clinical Study Group

This was done as a retrospective study during the period of 2 years starting from January 2016 to December 2017.

32 patients with upper limb defects were treated with pedicled paraumbilical perforator based abdominal flaps during this period. In eight cases, double paraumbilical perforator based abdominal flaps were done for defects in the upper limb. A total of 40 paraumbilical perforator based abdominal flaps were done. It was found that these flaps were done for in all age groups from pediatric to adult in both sexes [Figure 4]. 40% of the patients who underwent paraumbilical flap reconstruction were male. The age distribution of the patients was also studied [Figure 5].

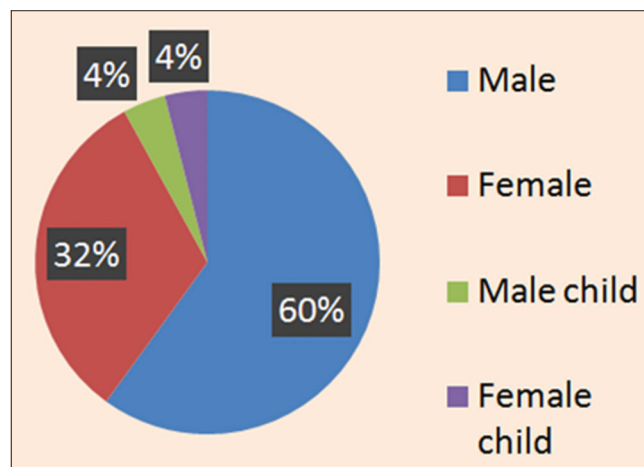
**Table 1: The PUP zones of paraumbilical region**

Zone of Anatomical area	
PUP	
Zone 1	Paraumbilical region above the umbilicus and to the right side
Zone 2	Paraumbilical region above the umbilicus and to the left side
Zone 3	Paraumbilical region below the umbilicus and to the left side
Zone 4	Paraumbilical region below the umbilicus and to the right side

PUP: Paraumbilical perforator



**Figure 1: Marking for the paraumbilical perforator zones of the paraumbilical region**



**Figure 2: Pie chart showing the distribution of both sexes and distribution of adults and children in the Doppler study group**

The cause for the defects for which the paraumbilical perforator based abdominal flaps was done include post-traumatic raw area, post-electric burn raw area,

post-burn scar contracture, and post-burn raw area [Figure 6].

The number of patients who had single paraumbilical perforator flap and double paraumbilical perforator flaps was also analyzed [Figure 7].

## RESULTS

The number of perforators detected around the paraumbilical region in all zones and its distance from the umbilicus was recorded. Statistical analysis of the recorded data was performed. A total of 672 perforators were identified through Doppler study in the 50 volunteered individuals. Among these 672 perforators, 629 perforators (93.6%) were found in all zones within 5 cm from the umbilicus [Table 2]. Statistical analysis was performed using the paired Chi-square test regarding the number of

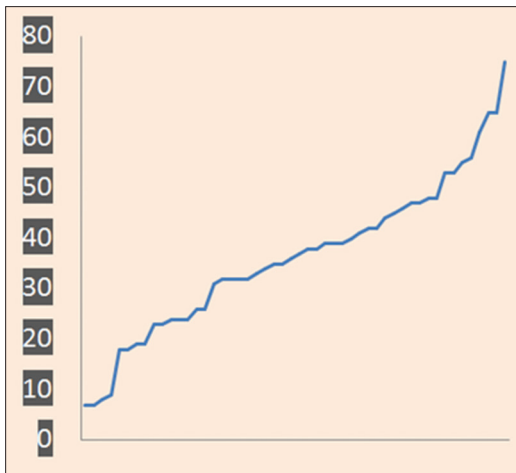


Figure 3: Line chart showing the distribution of persons in all age groups in the Doppler study group – X-axis in years

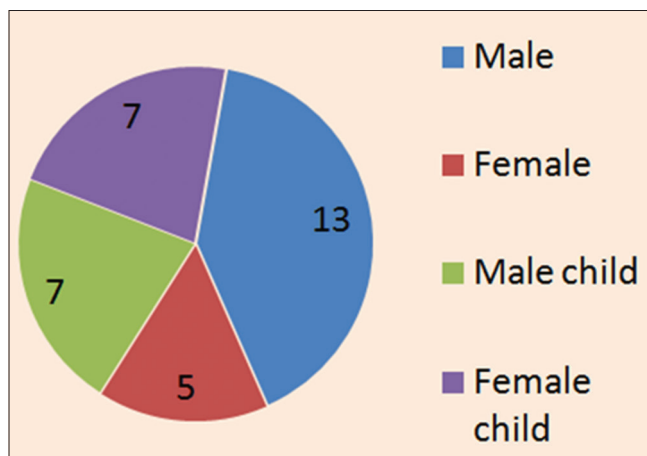


Figure 4: Pie chart showing the distribution of both sexes and distribution of adults and children in the clinical study group.

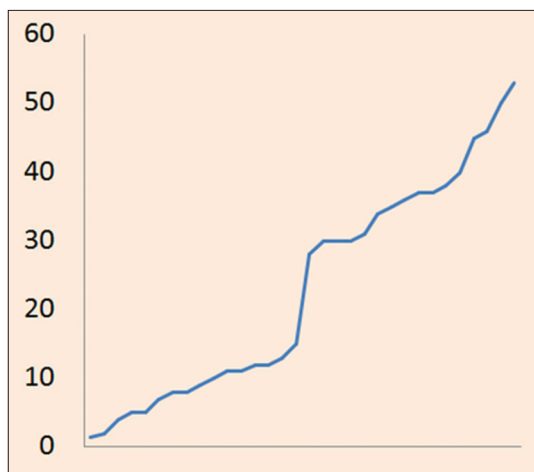


Figure 5: Line chart showing the distribution of persons in all age groups in the clinical study group – X-axis in years

Table 2: The number of perforators in all four zones with respect to the distance from the umbilicus

Perforator distance from umbilicus	PUP Zone1	PUP Zone 2	PUP Zone 3	PUP Zone 4
1 cm	20	20	21	14
2 cm	23	23	35	38
3 cm	29	25	48	42
4 cm	31	38	49	47
5 cm	16	21	39	50
6 cm	1	9	7	15
7 cm	2	1	4	4

PUP: Paraumbilical perforator

Table 3: The statistical analysis by Chi-Square test regarding the number of perforators in all zones with respect to its distance from the umbilicus

	Chi-square tests		
	Value	df	Asymp. Sig (2 sided)
Pearson Chi-square	26.095*	18	0.098
Likelihood ratio	28.239	18	0.059
Linear-by-linear association	12.526	1	0.000
No of valid cases	672		

Table 4: The number of individuals having a different number of perforators in different zones of the paraumbilical region and its average

Number of perforators	Zone 1	Zone 2	Zone 3	Zone 4
1 Perforator	4	2	0	0
2 Perforators	23	16	0	0
3 Perforators	20	25	7	8
4 Perforators	3	7	34	25
5 Perforators	0	0	8	15
6 Perforators	0	0	1	2
Total	50	50	50	50
Average	2.44	2.74	4.06	4.22

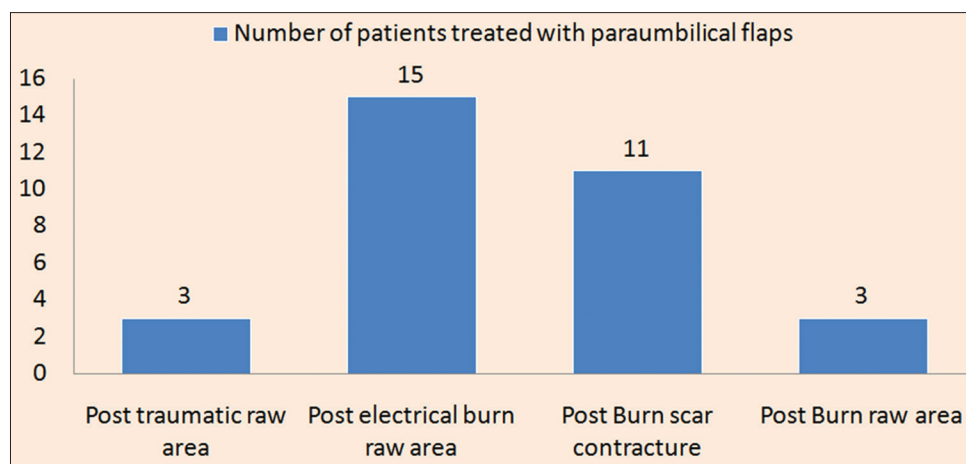


Figure 6: Bar diagram showing the various etiologies for which the paraumbilical perforator based abdominal flaps were done

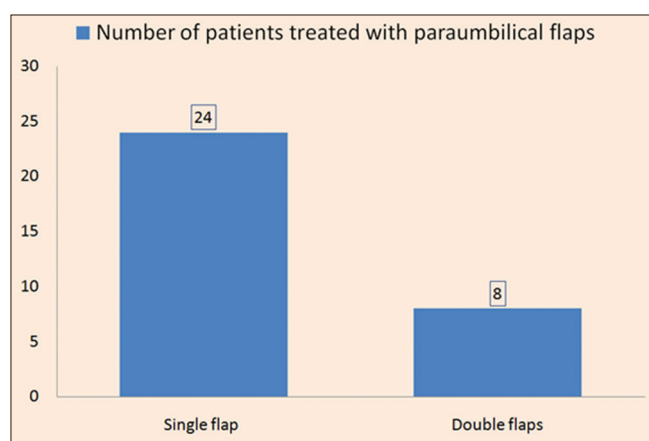


Figure 7: Bar diagram showing the number of paraumbilical perforator based abdominal flaps done



Figure 8: The para umbilical perforator zone 1 flap for right thumb web contracture

perforators and their distance from the umbilicus in all zones and it was found that  $P = 0.098$  which is  $>0.05$  and hence statistically not significant [Table 3]. This implies that the number of perforators is equally distributed in all zones with respect to distance from umbilicus.

Table 5: The Chi-square test for the number of individuals having a different number of perforators in different zones

	Chi-square tests		
	Value	df	Asymp. Sig (2 sided)
Pearson Chi-square	133.249*	15	0.000
Likelihood ratio	160.768	15	0.000
Linear-by-linear association	98.357	1	0.000
No of valid cases	200		

Table 6: P values for the perforators around umbilicus with respect to different age groups and sex

	Zone 1	Zone 2	Zone 3	Zone 4
Age	$P=0.373$	$P=0.427$	$P=0.236$	$P=0.404$
Sex	$P=0.717$	$P=0.794$	$P=0.906$	$P=0.084$

Statistical analysis of the number of individuals having a different number of perforators in different zones was performed. It was found that 43 out of 50 members were having 2 or 3 perforators in zone 1, 41 out of 50 members were having 2 or 3 perforators in zone 2, 42 out of 50 members were having 4 or 5 perforators, and 40 out of 50 members were having 4 or 5 perforators [Table 4]. Statistical analysis by paired Chi-square test was performed.  $P = 0.00$  is statistically significant. This implies the number of perforators in zones 1 and 2 will be 2 or 3 and the number of perforators in zones 3 and 4 will be 4 or 5 [Table 5].

The average number of perforators in each zone in this study denotes 2.44 in zone 1, 2.74 in zone 2, 4.06 in zone 3, and 4.22 in zone 4 [Table 4].

Statistical analysis of the perforators in each zone in respect to different age groups and sex was done. In all





Figure 9: The paraumbilical perforator zone 3 flaps for the reconstruction of the left-hand defect following electrical burn injury



Figure 10: The paraumbilical perforator zone 4 flaps for reconstruction of right-hand defect following camphor burn



Figure 11: Paraumbilical perforator zone 1 and zone 2 flaps for the reconstruction of left upper limb defect following trauma

cases,  $P > 0.05$  is statistically not significant. This implies that the perforators were equally distributed in all zones in respect to different age groups and sex and hence it is



Figure 12: Paraumbilical perforator zone 3 and zone 4 flaps for the reconstruction of the right hand and forearm defects following electric burn injury



Figure 13: Paraumbilical perforator zone 1 and zone 4 flaps for the reconstruction of right fingers and thumb following electric burn injury

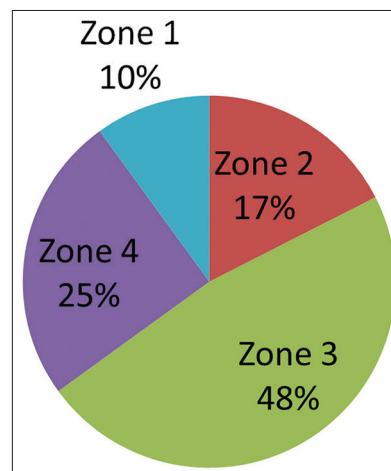


Figure 14: Pie chart shows the distribution of the paraumbilical perforator based abdominal flaps in each zone of the paraumbilical region

safe in raising the flaps in different zones with respect to different age groups [Table 6].

**Table 7: The indication of paraumbilical perforator based abdominal flaps in each zones**

Para umbilical Perforator Zone	Indication for use of paraumbilical perforator
PUP Zone 1	Dorsal defects in right forearm/right hand/right thumb web space
PUP Zone 2	Dorsal defects in left distal forearm/hand in double flaps
PUP Zone 3	Dorsal defects in left forearm/left hand/left thumb web space
PUP Zone 4	Dorsal defects in right distal forearm/hand in double flaps
	Volar defects of left fingers/left hand/left palm/left wrist/left forearm
	Near circumferential defect of left forearm with intact skin in the dorsal aspect
	Volar defects of right fingers/right palm in double flaps
	Volar defects of right fingers/right hand/right palm/right wrist/right forearm
	Near circumferential defect of right forearm with intact skin in dorsal aspect
	Volar defects of left fingers/left palm in double flaps

PUP: Paraumbilical perforator

**Figure 15: The comfortable position of the upper limb with the abdomen**

## DISCUSSION

In this study, 32 patients with upper limb defects were treated with paraumbilical perforator based abdominal flaps. The distribution of these flaps include in all zones of the paraumbilical region [Figures 8-13]. In 10% of cases, flaps were harvested from PUP zone 1. In 17% of cases, flaps were harvested from PUP zone 2. In 48% of cases, flaps were harvested from PUP zone 3. In 25 % of cases, flaps were harvested from PUP zone 4 [Figure 14].

The dimensions of these 40 flaps included in this study range from 3 cm × 4 cm to 8 cm × 12 cm. In all cases the length-breadth ratio is >1:1 and it ranges from 1:1.3 to 1:2.2. The maximum dimension of these flaps is 8 cm–12 cm. In zones 3 and 4, the flaps were taken to anterior superior iliac bone. In most of the cases, the donor site was closed primarily and in some cases where large dimensions of the flap were taken, donor site was closed with a skin graft.

The flap division was done from 16 to 21 days of flap harvest in all cases. In one case of thumb reconstruction following post-electric burn injury, the tubed paraumbilical

flap was taken from zone 4 and in that case, flap delay was done.

In all 40 flaps, there is no report of flap necrosis. Complication includes partial wound dehiscence in 3 cases, and they were managed conservatively.

The main advantage of these paraumbilical perforator-based flaps is safe and reliable since there are multiple perforators in all zones which make these flaps having a robust blood supply. The other advantages of these flaps include easy to harvest, no need for microsurgical setup needs less expertise, and fast learning curve. The other main advantage of these flaps is that the positioning of the hand with abdomen is comfortable and amiable to the patients. This is more particular to the pediatric age group who can maintain this position comfortably [Figure 15].

The disadvantages of these flaps include that these flaps are staged procedure and they produce scars in the abdomen. These are the main limitations of these procedures.

Analyzing these flaps, it was found that the defects in the right upper limb were treated with paraumbilical perforator based abdominal flaps harvested from PUP zone 1 and zone 4. The defects in the left upper limb were treated with these flaps harvested from PUP zone 2 and 3. For the defects in the volar region of the upper limb, the ideal zones from which these flaps were harvested include PUP zone 3 and zone 4 and for the defects in the dorsal aspect of the upper limb, the ideal zones from which these flaps were harvested include PUP zone 1 and 2 [Table 7].

## CONCLUSION

In this study, it was found that the PUP based abdominal flaps can be harvested in any zone, in any direction. It is safe and reliable in all age groups. There are multiple perforators in all zones. By this study, it was found that the number of perforators in zone 1 and zone 2 include

2 or 3 perforators and the number of perforators in zone 3 and zone 4 includes 4 or 5 perforators. The versatility of flap design, with comfortable and ease of positioning of the upper limb with the abdomen, makes these flaps reliable and a “user-friendly” option in the reconstruction repertoire of the upper limb defects.

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