

Keystone Flap: Suitable Option for Coverage of soft Tissue Defect over Tendo Achilles following Open Repair

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Abstract:

Introduction: Wound complications are not uncommon following operative Tendo Achilles repair. Patients presented in Plastic surgery department with soft tissue defect on Tendo achilles region with exposed Tendon. The paucity of tissue and poor blood circulation are main challenges for the reconstructive surgeon. The study aimed to evaluate the Keystone flap for soft tissue coverage of defects following Tendo achilles repair.

Methods: This prospective study was conducted on January 2021 to December 2022 in Plastic surgery department of Rajshahi Medical College Hospital and all 12 cases were done by single surgeon. All patients had history of repair for ruptured Tendo Achilles and were presented with defect over Tendo achilles near or at its insertion, where the defect length was larger than width. Keystone flap type IIA was done for each defect.

Introduction:

Tendo Achilles (TA) is the strongest Tendon in the body and is prone to injury in the adult population, specially in the third and fourth decade of men.¹

Operative treatment for TA ruptures leads to good recovery and low re-rupture rates; but, it is not beyond complications.²⁻⁴ Sharing force during movement, superficial location of Tendon, poor blood supply, and traumatic local soft tissue loss are the factors for wound healing and are the factors for relatively high wound complication rate after surgical treatment.⁵ Regardless of the technique of open repair, a wound complication rate of 7 to 13% and an infection rate of 2 to 4% have been reported.⁶ Cases are presented with soft tissue defects over Tendoachilles and even calcaneum at its

Results: Mean age of the study patients was 43.42 ±9.79 years. The highest dimension of wound was 36.80 (8 X 4.6) cm² and flap was 66 (10 X 6.6) cm². The range of advancement of flap was 3- 4.6 cm (mean: 3.43 ±0.54 cm) in transverse axis of leg. Mean duration of operative time was 53.58± 10.06 minutes. Follow up period was 3 months to measure outcome the flap.

Conclusion: The keystone flap has high survivability rate with low complications rate providing with good functional outcome of joint. So, keystone flap is a suitable option for coverage of soft tissue defects following operative Tendo Achilles repair.

Key words: Keystone flap; defect on Tendo achilles region.

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insertion with exposed dead Tendon. Characteristics of such defects are having longitudinal scar proximal to defect and length larger than width.

The paucity of suitable local tissue makes it challenging for reconstructive surgeons to coverage of such defects. Free flaps and reverse sural artery flaps are for large wounds of the distal leg.⁷ Perforator-based propeller flaps can provide good coverage of such defects with minimal donor site morbidity but have the concerning rate of flap loss.⁸⁻¹⁰

Keystone flap, first described as Keystone design perforator island flap by Behan¹¹ may be one of the solutions to such challenges of “Like with like” local tissue arrangement, high success rate, tension-free

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closure without skin graft, and avoiding sharing force related wound dehiscence with quick healing and operative time. The study aimed to evaluate the Keystone flap for soft tissue coverage of defects following Tendo Achilles repair.

Methods and Materials:

This prospective study was conducted on January 2021 to December 2022 in Plastic surgery department of Rajshahi Medical college Hospital and all 12 cases were done by a single surgeon. 9 patients were male and 3 were female and age range was 27- 56 years. All the included patients had history of repair for ruptured Tendo achilles and were presented with defects over TA near or at its insertion. The length was larger than width and exposed Tendon were the common criterion of all the defects. Simmond's calf squeezing test was done in each patient. Proper written informed consent was taken and permission was also taken for pre and postoperative photos. Data were analyzed in Microsoft Excel 2015 and Level of significance was determined at 5% ($p < 0.05$) for comparing outcomes and complications among the cases. Standard statistical test was done for comparing to other studies.

Operative technique:

All patients were operated under subarachnoid anesthesia. After identifying the posterior tibial artery perforators by Hand-held Doppler, tourniquet was applied. All cases were done in prone position and the ankle was in the neutral position. After all aseptic precautions, wound excision was done. Then keystone flap was designed at posterior tibial artery perforator's territory according to the wound dimension. For its unique design and contour, such flaps were named as Keystone designed perforator flap. Here the last limit of flap medial border was along tibial medial border. Flap and wound measurements were documented. Then, the incision was made along the flap borders and subfascial undermining was done on both sides of the line of perforators without visualizing them preoperatively. Both great saphenous vein and nerve were avoided to injury. After harvesting, flap was ready for advancement. After withdrawal of tourniquet, flap viability was checked. 2-0 cutting prolene was used for stay sutures at the corners and rest of the sites were closed with 3-0 cutting prolene. No skin graft was required for donor

site coverage. Penrose drain was applied and long leg anterior splint was applied in ankle neutral position.

Postoperative care and follow-up:

In the postoperative room, patient was in a prone position and the operated limb was elevated. The flap was monitored regularly through the window made during preoperatively. Patients were discharged by 4-6th postoperative day with ensuring viability of flap and splint in situ. All patients were advised to elevate the affected lower limb and to come to follow-up clinic at the 2nd and 3rd, 6th and 12th postoperative week. All sutures were removed by 3rd week following the operation and splint was removed on 3rd to 4th postoperative week. Measurement Passive Range of ankle movement was noted in 6th and 12th postoperative week.

Results:

Mean age of the study was 43.42 ± 9.79 years. Among 12 cases, Tendo achilles was ruptured mostly (58.33%) due to toilet pan injury and only case was repaired for closed rupture. Infection was the commonest (41.67%) causative factor for soft tissue defect followed by skin necrosis (33.33%). Mean interval time was 23.33 ± 16.21 days between the repair of Tendo Achilles and presentation to our Plastic surgery department. Other demographic features were shown in Table-1. All were keystone type IIA flaps. The highest dimension of wound was $36.80 (8 \times 4.6) \text{ cm}^2$ and flap was $66 (10 \times 6.6) \text{ cm}^2$. The range of advancement of flap was 3- 4.6 cm (mean: 3.43 ± 0.54 cm) in the transverse axis of leg. Mean duration of operative time was 53.58 ± 10.06 minute. All flaps were survived only 1 (8.33%) case had marginal necrosis. 2 cases had wound complications (case no2 and 5). Case no2 had both wound dehiscence and infection and another one had only infection. The complications rate was 16.66%. Mean hospital stay after flap coverage was 4 ± 4.3 days. Healing time was 3 ± 0.93 weeks. The functional outcome was measured by ankle joint range of movement (ROM). As Tendo Achilles was lost either completely or partially, the passive movement was taken in all cases. Here ROM of dorsiflexion and plantar flexion was classified as Fair (restriction $>10^0$); Good (restriction 5^0-10^0) and Excellent (restriction $<5^0$). 8 patients had excellent dorsiflexion and 10 patients had excellent plantar flexion (Table-4).

Table-I

<i>Demographic distribution</i>		
Variables		Frequency
Sex	Male	9 (75%)
	Female	3 (25%)
Age	Range	27- 56 years
	Mean (SD)	43.42 (\pm 9.79) years
Etiology of tendon rupture	Accidental	2 (16.67%)
	Sharp weapon	2 (16.67%)
	Toilet pan injury	7 (58.33%)
	Closed rupture	1 (8.33%)
Factors for defect on TA region	Infection	5 (41.67%)
	Suture granuloma	3 (25%)
	Skin necrosis	4 (33.33%)
Interval between repair and admission to Plastic surgery department	Mean (SD)	23.33 (\pm 16.21) days
Operation time	Range	40- 75 min
	Mean (SD)	53.58 (\pm 10.06) min
	Mean (SD)	4 (\pm 0.43) days
Hospital stay following surgery	Mean (SD)	4 (\pm 0.43) days

TA: Tendo Achilles

Table-II

<i>Dimension of Defect and Flap</i>			
Variables		Range	Mean (SD)
Defect dimension	Length	4-8 cm	6.29 (\pm 1.39) cm
	Width	3- 4.6 cm	3.43 (\pm 0.54) cm
	Area	12- 36.80 cm ²	22.09 (\pm 7.79) cm ²
Flap dimension	Length	6-10 cm	8.25 (\pm 1.34) cm
	Width	4.5- 6.6 cm	4.67 (\pm 0.74) cm
	Area	27- 66 cm ²	39.23 (\pm 11..51) cm ²
Range of advancement		3.1-4.6 cm	3.43 (\pm 0.54) cm

Table-III*Outcome and complications of flaps*

Variables		Frequency	p-value*(<0.05)
Survivability of flaps	Completely survived	11 (91.67%)	0.611NS
	Marginal loss (.05- 1 cm)	1(8.33%)	
	Partial loss (>1 cm)	0	
Complications	Infection	2 (16.67%)	0.074NS
	Wound dehiscence	1 (8.33%)	
Total no. of cases having complications		2 (16.67%)	

*= Chi-square test with yate's correction; NS= Non-significant

Table-IV*Functional outcome*

Ankle joint Movement	Fair	Good	Excellent
Passive Dorsiflexion	1	3	8
Passive Plantar flexion	0	2	10

(Restriction of movement: $<5^0$ = Excellent; $5-10^0$ = Good; $>10^0$ = Fair)



Figure 1: a. Soft tissue defect on Tendo Achilles region with exposed dead tendon. b. After wound excision. c. Immediate post-operative photo.



Figure 2: a. Soft tissue defect on Tendo Achilles region with exposed dead tendon. b. After wound excision with Keystone flap marking and × were marking of posterior tibial artery perforators identified by Hand-held Doppler. c. Immediate post-operative photo. d. At 6th post-operative week

Discussion:

Operative treatment is a good option for Tendo Achilles rupture but complications rate is not less. Skin healing-related complications rate was reported 8.2- 14.6%.^{2-5,12} So, many patients have soft tissue defects over Tendo Achilles region following repair. Though only one patient had a closed rupture, other 11 cases had open rupture and all were repaired. Patients presented with soft tissue defect in Plastic surgery department following repair of Tendo achilles and mean interval time between repair and presentation was 23.33 ± 16.21 days in this study. Infection (41.67%) was the prime factor for such defect followed by skin necrosis due to relatively poor blood supply in the midline over Tendo Achilles Tendon region.¹³

Durable coverage for such soft tissue defect is required not only for reconstruction of Tendo Achilles but also for its cushion and smooth gliding movement which is not possible in skin graft.¹⁴ As TA is the strongest Tendon in the body, soft tissue coverage should have the property to resist sharing force and can prevent Tendon pressure and friction by footwear during ambulation. So, secondary healing may cause an unstable scar in this highly mobile area.¹⁵

So flap is the best option for such durable coverage of this type of defect with facing challenges like paucity of local tissue, relatively poor vascularity, and tight

compartment compared with proximal part of the leg.

With the advance of knowledge of vascular distribution of leg since Taylor's angiosome concept, Perforator based flap has become popular to combat all such challenges for coverage of distal leg.¹⁶ Behan¹¹ first described a curvilinear-shaped perforator-based double V-Y advancement flap named as keystone designed perforator island flap for coverage of different parts of the body for soft tissue defect. In our study, 12 keystone flap type II A were done to cover the soft tissue defect following Tendo Achilles repair where defect length was larger than width. All flaps were based on posterior tibial artery perforators escaping peroneal perforators for future reconstruction of the distal leg. Mean wound area was $22.09 \pm 7.79 \text{ cm}^2$ ($6.29 \times 3.433 \text{ cm}^2$) ranging from 12 cm^2 ($3 \times 4 \text{ cm}^2$) to 36.8 cm^2 ($8 \times 4.6 \text{ cm}^2$) and mean flap dimension was $39.23 \pm 11.51 \text{ cm}^2$ ($8.25 \times 4.69 \text{ cm}^2$) ranging from 27 cm^2 ($6 \times 4.5 \text{ cm}^2$) to 66 cm^2 ($10 \times 6.6 \text{ cm}^2$). The highest advancement of this study was 4.6 cm from medial to lateral direction on posterior surface of leg and mean advancement was $3.43 \pm 0.54 \text{ cm}$. Average operating time was 53.58 ± 10.06 minutes. All flaps were survived completely except one that had marginal necrosis due to wound infection causing wound dehiscence. Besides this case another case developed infection. All complications were managed conservatively and healed well. So, flap success rate of this study was 91.67% with complications rate was only

16.67%. Huang⁹ showed in their Systemic review study, only 5 cases had either complete or partial loss of keystone designed perforator island flap for coverage of lower limbs and the success rate was 98.23% with complications rate was 9.6%. success rate and complication rate of our study is statistically similar to this systemic review study. Sarkar¹⁰ showed in their study, 83.37% success rate of propeller flap for coverage of distal leg and ankle joint and Jammula¹⁷ showed 83.33% success rate among 6 propeller flaps for coverage of exposed Tendo Achilles. Bekara⁸ reported 78.60% success rate of propeller flaps for lower extremity soft tissue defect and the complications rate was 2.77%. So, Perforator based propeller flap gives great freedom to plastic surgeons but complications rate is higher than keystone flap.

Mean hospital stay after flap coverage was 4 ± 0.43 days. Here we measured functional outcome by passive range of motion of ankle joint. As Achilles Tendons were lost their continuity either completely or partially during wound excision, it was difficult to measure ankle plantar flexion. 66.66% and 83.33% of cases had excellent ankle passive dorsiflexion and plantar flexion respectively 3rd month following coverage. It indicates that keystone flap can provide good wound healing and prevent sharing force during ambulation. Pelissier¹⁸ proved that keystone flap distributed tension force to a wider area and distant point from flap.

Conclusion:

Keystone flap has a high survivability rate with low complications rate and has the merits of tension free closure, combating sharing force and easy to harvest in contrast to other perforator based flaps. It can provide good functional outcome of joint. So, keystone flap is the suitable option for coverage of soft tissue defect following operative Tendo Achilles repair.

Conflict of Interest

There is no conflict of interest regarding the research, authorship and publication of this article.

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