Egypt, J. Plast. Reconstr. Surg., Vol. 46, No. 1, January: 37-43, 2022

A Retrospective Comparative Study between Muscle Flaps and Fasciocutaneous Flaps in Reconstruction of Chronic Osteomyelitis Related Wounds of the Lower Limb in the Adult Population

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ABSTRACT

Introduction: Chronic osteomyelitis cases are challenging, as they require a multidisciplinary approach for reconstructive soft tissue coverage and orthopedic management. Proper debridement, stable coverage and effective antibiotic therapy are mandatory before application of flap coverage.

Patients and Methods: We performed a retrospective comparative study between muscle and fasciocutaneous flaps used for coverage of chronic osteomyelitis related wounds of the lower limb. It included thirty patients who finished a 12 months of follow-up to assess the complications rate and the outcome of surgery. Color match, texture match and aesthetic satisfaction were compared between the 2 groups.

Results: Thirty-one flaps including six free flaps and twenty-five local flaps were used to treat these cases. Complications included fluid collections in one case, sinus formation in two 2 cases, partial flap loss in one case. These complications were managed by prolonged antibiotic therapy and dressing changes. Cases in group B had higher scores (mean: 9.5±1.34) in comparison with cases in group A (mean: 7.25±1.29). Yet, there were no statistically significant differences between the 2 groups (*p*-value: 0.27).

Conclusion: A multidisciplinary team is needed for management of cases with chronic osteomyelitis related wounds. Flap coverage can be achieved with either muscular or fasciocutaneous flaps with comparable successful rates.

Key Words: *Osteomyelitis – ALt flap – Gracilis.*

Disclosure: The authors do not have any financial disclosures / Conflicts of interest to report.

Ethical Committee Approval.

INTRODUCTION

Osteomyelitis is a progressive condition induced by the depreciate effects of micro-organisms on the osseous tissues through inflammatory and infectious actions **[1]**. Once the infection recurs after recovery or persists for over than one month, we may consider the condition as "chronic" **[2]**.

Tibial osteomyelitis is usually complicated by fracture nonunion, presence of bony sequestrate, extensive scarring and fewer options for stable soft tissue coverage **[3,4]**. Some experimental animal models found that muscle flaps have been superior to skin coverage in initiating the repair of devascularized tibial cortex **[5]**. Other studies empathized on the decrease in fibrotic cavities using muscle flap and improve blood flow, which leads to suppress bacterial contamination **[6,7]**.

Other clinical studies have addressed the efficacy of the use of muscle flaps for coverage of chronic osteomyelitis wounds **[8,9]**. Recent studies have found that fasciocutaneous flaps are more effective than muscular flaps in the reconstruction of acute trauma to the lower limbs **[10,11]**. However, another study investigated the use of fasciocutaneous flaps in reconstruction of the chronic lower limb osteomyelitis **[12]**.

In this study, we aimed at comparing muscular and fasciocutaneous flaps used for coverage of chronic osteomyelitis wounds of the lower limb in terms of indications, complications and surgical outcome.

PATIENTS AND METHODS

We performed a retrospective study in which patients with chronic osteomyelitis who required flap coverage by plastic surgeons from March 2014 to March 2020 in our institution were included. The patients' files were reviewed after the study had been accepted by the local institutional board review.

Our inclusion criteria included patients with chronic osteomyelitis who had bone exposure and infection for more than one month or when the infection and soft tissue disruption recurred after bone coverage. Patients with fistula, purulent discharge, pain or compromised soft tissue coverage at the site of old fractures were included. These

cases were managed by a multidisciplinary team consisted of a plastic and an orthopedic surgeons

We excluded cases with extreme of age (younger than 10 years or older than 70 years). Cases with sever medical impairments including hepatic failure, renal failure or uncontrolled Diabetes were excluded.

We found 30 cases who matched our inclusion criteria who were divided into 2 main groups:

1- Group A (muscle flaps): In which we used pedicled or free muscle flaps This group consisted of 16 patients in which 17 muscular flaps were performed including 7 gastrocnemius flap, 9 soleus flap and one free gracilis muscle flap Fig. (1).

2- Group B (fasciocutaneous flaps): In which we used pedicled or free fasciocutaneous flaps. This group consisted of 14 patients in which 14 fasciocutaneous flaps were performed including 8 posterior tibial artery perforator flaps, one peroneal artery perforator flap and 5 free anterolateral thigh (ALT) flap Fig. (2).

Fig. (1): A 13 years male patient with osteomyelitis of the lower third tibia managed by free gracilis muscle flap. (A): Pre-operative view. (B): Immediate Postoperative view, (C): 6 months Post-operative view.

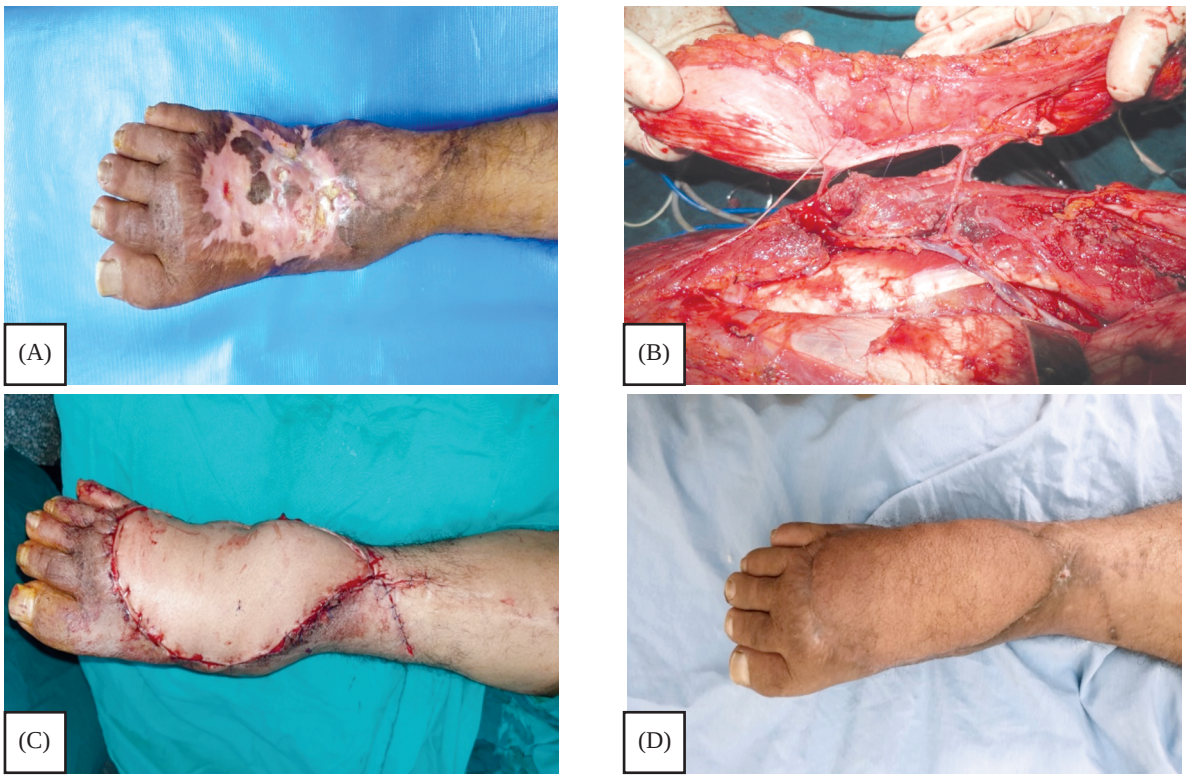

Fig. (2): 40 years old male patient presented with chronic osteomyelitis in ankle joint, managed by free ALT free flap. (A): Pre-operative view. (B): Intraoperative view, (C): Immediate Postoperative view, (D): 12 months Post-operative view.

Treatment protocol:

A brief description of our treatment protocol is explained. We started by surgical debridement and bone biopsy followed by systemic antibiotic therapy and wet dressing changes. Improvement of the general conditions of the patient were done, including correction of anemia, hypoalbuminemia, and vitamin deficiencies. An analysis of the lower limb defects were obtained. It included:

- *Bone defect analysis:* Included type, site and the level of fracture, type of fixation and the length of bone defect. Routine radiological evaluation was done. We used the Cierny-Mader grading system (Table 1) to classify our cases of chronic osteomyelitis.
- *Soft tissue analysis:* Included the site and depth of the wound or sinus opening, the availability of local flaps, the availability of recipient blood vessels and complete neurological examination of the lower limb.

According to the results of this analysis a decision was made regarding the orthopedic interference including bone debridement (removal of necrotic bone, bone decortication, reaming of the medullary cavity or irrigation with local antibiotics) with or without change of the type of fixation. The role of the plastic surgeon was to provide the exposed osseous tissues with a stable soft tissue flap coverage.

Table (1): Cierny-Mader classification.

Stage	Description
A- *Anatomic stages:*	
Stage 1 (Medullary)	Osteomyelitis confined to medullary cavity
Stage 2 (Superficial)	Osteomyelitis confined to cortical bone
Stage 3 (Localized)	Osteomyelitis confined to both cortical and medullary bone. However, bone is stable
Stage 4 (Diffuse or infected nonunion)	Osteomyelitis involves the entire thickness of the bone with instability
B- *Host stages:*	
A	Normal host with no systemic or local comorbid conditions
B	Systemic comorbidities (bs): malnutrition, hepatic or renal impairments, dm, malignancy, hypoxic lung diseases, extreme of ages, immune deficiency or depression.
	Local comorbidities (Bl): lymphatic, venous, arterial or sensory compromise, extensive scarring or radiation dermatitis or smoking
	Systemic and local comorbidities (Bls)
C	Sever comorbid condition that radical treatment is associated with high unacceptable risks

Analysis of the surgical outcome:

Patients who finished one year of follow-up were subjected to the following assessment tools:

- Exclusion of signs of osteomyelitis recurrence (Pain, sinus formation, purulent discharge).
- Aesthetic outcome (we asked each patient about thickness match, texture and aesthetic appearance of the flaps). We asked patients about each item. A score from 1 to 5 was formulated for every item where 1 refer to no satisfaction and 5 refers to full satisfaction.

Statistical analysis:

We used the Statistical package for the social sciences (SPSS) version 20 (SPSS Inc., Chicago, IL, USA) for the analysis of our results. We compared the mean values between the two groups. We considered that the probability value (*p*-value) was significant when it was less than 0.05.

RESULTS

In our study, there were 30 cases: 27 male (90%) and 3 female (10%), with age ranging from 15 to 55 years (Mean: 29.83±12.2 years Standard Deviation). We divided our cases in group A (muscle flap) which included 16 patients (14 male and 2 female). Group B (fasciocutaneous flaps) which included 14 patients (13 male and 1 female). Patients' demographic data were shown in Table (2).

The primary cause of injury was related to traffic accidents (28 cases), while the other two cases were related to pathological fractures. The mean period of delay between the initial trauma and the treatment was 20 months (ranged from 3 months to 20 years). The mean and standard deviations of the size of the soft tissue defects in group A and B were 63±28 and 53±37 cm^2 respectively. There were no statistically significant differences

between the defect sizes between the 2 groups. See Tables (3,4).

Post-operative complication were reported in 4 cases. In group A, complications included one case with serosanguineous collection who was managed by repeated aspiration and prolonged antibiotic therapy, one case with sinus formation (Fig. 2) and one case with partial necrosis of the flap was who was managed conservatively. In group B only one case who showed sinus formation and was managed conservatively.

Table (2): Patients' demographic data.

	Age	Sex	Cause	Operation	Complication
1	40	Male	Post cellulitis	ALT	
2	9	Male	Neglected RTA	ALT	
3	13	Male	Chronic sinus after RTA	Gracilis	Sinus formation
4	16	Male	RTA, Neglected	Gc. & sol.	Serosnagionus collections
5	25	Male	Chronic sinus after failed free flap	PTAP Flap	
6	40	Male	Neglected RTA	PAPF	
7	55	Male	Neglected RTA	Sol.	
8	33	Male	Neglected RTA	PTAP	
9	16	Male	Neglected RTA	PTAP, Skin graft	
10	38	Male	Neglected RTA	Sol.	
11	12	Male	Neglected RTA	PTAP	Partial necrosis
12	20	Male	Failed IMN	Sol.	
13	34	Male	Neglected RTA	ALT	
14	26	Male	Neglected RTA	Gc.	
15	40	Male	Neglected RTA	Sol.	
16	30	Male	Neglected RTA	Sol.	
17	35	Female	Neglected RTA	Gc.	
18	26	Male	Neglected RTA	Gc.	
19	16	Male	Neglected RTA	Sol.	
20	26	Male	Neglected RTA	Sol.	
21	30	Male	Neglected RTA	Gc.	
22	40	Male	Neglected RTA	Gc.	
23	28	Female	Neglected RTA	Sol.	
24	24	Male	Neglected RTA	Sol.	
25	12	Male	Neglected RTA	ALT	
26	35	Male	Neglected RTA	Gc.	
27	55	Male	Neglected RTA	Sol.	
28	29	Male	Neglected RTA	ALT	Sinus formation
29	44	Female	Neglected RTA	Gc.	
30	48	Male	Neglected RTA	Sol.	

U: Upper. Gc: Gastrocnemius muscle flap. PAPF : Peroneal artery perforator flap.
L: Lower. Sol: Soleus muscle flap. PTAPF: Posterior Tibial Artery Perforator Flap.
M: Middle. ALT : Anterolateral Thigh Flap.

Table (3): Defect size dimensions in group A.

Serial	Area	Length in centimeters	Width in centimeters	Area in square centimeters
1	L 1/3 tibia	12	8	96
2	U& M 1/3 tibia	25	7	175
3	M 1/3 tibia	5	7	35
4	M 1/3 tibia	6	8	48
5	M 1/3 tibia	5	7	35
6	U 1/3 tibia	5	8	40
7	M 1/3 tibia	7	4	28
8	U 1/3 tibia	8	4	32
9	U 1/3 tibia	7	9	63
10	U 1/3 tibia	6	7	42
11	U 1/3 tibia	8	6	48
12	M 1/3 tibia	4	9	36
13	M 1/3 tibia	9	7	63
14	U 1/3 tibia	4	5	20
15	M 1/3 tibia	7	6	42
16	M 1/3 tibia	5	8	40
Mean		7.69	6.88	53
Standard deviation		5.06	1.54	37

Table (4): Defect size dimensions in group B.

Serial	Area	Length in centimeters	Width in centimeters	Area in square centimeters
1	Foot	15	7	105
2	L 1/3 tibia	8	8	64
3	L 1/3 tibia	7	6	42
4	L 1/3 Tibia	5	6	30
5	L 1/3 tibia	6	10	60
6	Ankle joint	10	4	40
7	L 1/3 Tibia	14	6	84
8	L 1/3 Tibia	6	8	48
9	L 1/3 Tibia	8	5	40
10	L 1/3 Tibia	5	6	30
11	L 1/3 Tibia	10	7	70
12	L 1/3 Tibia	9	7	63
13	L 1/3 tibia	8	9	72
14	Foot	16	8	128
Mean		9.07	6.93	63
Standard deviation		3.6	1.59	28

In order to compare the outcome of surgery of the 2 groups, a total score for every case was calculated after finishing 12 months postoperative follow-up. Color match, flap texture match and aesthetic satisfaction were compared between the 2 groups Table (5). Cases in group B had higher scores (mean: 9.5±1.34) in comparison with cases in group A (mean: 7.25±1.29). Two-Sample *t*-test were used, there were no statistically significant differences between the 2 groups (*p*-value: 0.27). Finally, an algorithm was formulated to guide the choice of the type of flap coverage Fig. (3).

Table (5): The results of outcome assessment.

	Aesthetic outcome							
	Thickness match		Texture match		Aesthetic		Total score	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
	4	3	2	4	3	3	9	10
	2	4	2	3	2	3	6	10
	3	4	3	3	3	4	9	11
	2	3	3	3	3	4	8	10
	3	3	2	3	3	3	8	9
	2	4	2	3	3	3	7	10
	3	3	2	3	2	4	7	10
	2	4	2	3	2	3	6	10
	2	3	3	4	2	3	7	10
	3	2	3	2	3	2	9	6
	2	2	2	3	3	2	7	7
	1	4	3	3	2	3	6	10
	2	3	2	3	2	4	6	10
	3	3	3	4	3	3	9	10
	2		2		3		7	
	2		1		2		5	
Mean	2.38	3.21	2.31	3.14	2.56	3.14	7.25	9.5
Standard Deviation	0.72	0.7	0.6	0.53	0.51	0.66	1.29	1.34
p-value	0.25		0.89		0.37		0.27	

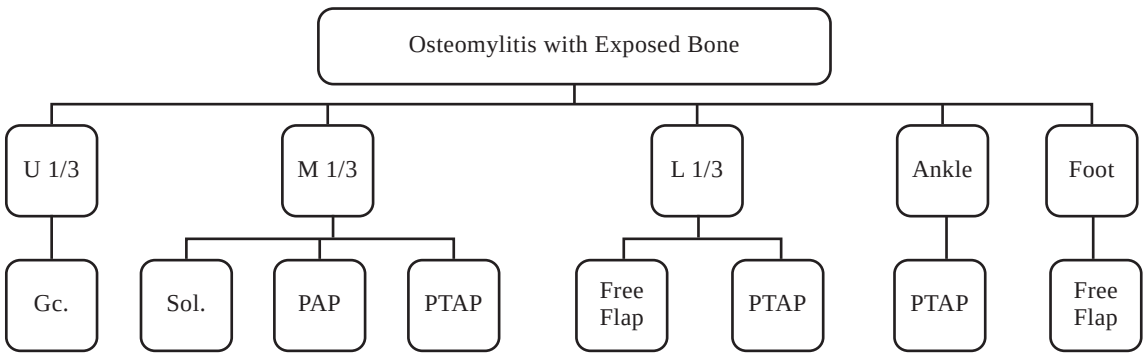

Fig. (3): Algorithm of flap coverage in our patient group. U/3: Upper third tibia; L/3: Lower third tibia; M/3: Middle third tibia; Gc: Gastrocnemius muscle flap; Sol: Soleus muscle flap; PAP: Peroneal artery perforator flap; PTAP: Posterior Tibial Artery Perforator Flap.

DISCUSSION

We have reviewed the argument about whether muscular or fasciocutaneous flaps are better for wound coverage in cases with chronic osteomyelitis in the literature. The use of pedicled muscle flap was mentioned as a surgical treatment for chronic osteomyelitis after compound fractures **[8]**. Muscle flaps exhibited a safe and competent coverage in long bone and pelvic osteomyelitis after initial debridement and momentary antibiotic treatment **[7]**. De Souza reported excellent results after the use of gastrocnemius muscle over infected knee injuries **[13]**.

Some studies were advocated that microsurgical flaps were a successful option that allowed surgeons to deal with more extensive wounds. Using latissimus dorsi, rectus abdominis and radial forearm as free-tissue transfer in chronic osteomyelitis

allowed tibial nonunion and bone defect to heal following resection and bone transport using a callus distraction technique **[15]**.

On the other hand, fasciocutaneous flaps like the ALT flap is now considered a workhorse flap for lower limb reconstructions, requiring free tissue transfer. It has short operation time as the patient does not need to be repositioned during the surgery, two-team approach can be implemented and requires less blood transfusion compared to muscle flap in the perioperative period **[16]**. Early management by an orthoplastic team with early soft-tissue coverage with a free flap in grade III B/C tibial fractures will decrease the infection rate and consequently decrease the cost of osteomyelitis treatment **[17]**.

Previous studies favored the use of local muscle flaps in the coverage of infected wounds because of its power to enhance the vascularity of the infected wounds, bringing immune cells to wound bed and they are sprightly in the management of lower extremity osteomyelitis **[18]**. However, recent studies favored free fasciocutaneous flaps especially in foot and ankle reconstruction **[19]**.

Doi used free vascularized osteocutaneous grafts in treatment of infected tibial wounds **[20]**. Other authors favored the use of free anterolateral thigh flaps in the reconstruction of chronic osteomyelitis related wounds. It was successfully used to combat infection and bring stability to wounds with chronic osteomyelitis when antibiotic beads and secondary bone graft procedures were performed **[21,22]**.

Khan et al., used free radial forearm flaps. The major benefits of free fasciocutaneous flaps over muscle flaps were superior aesthetic outcome and improved sensory recovery with no added recipient site complications including seroma or hematoma **[23]**.

Several protocols described the management of post-traumatic osteomyelitis using a single stage approach for management of chronic osteomyelitis related wounds **[24-26]**. On the other hand, Buono and his team implement two stages approach for the management of chronic osteomyelitis. In the first stage, they did radical debridement, bone sampling and application of gentamicin poly methyl methacrylate beads for three months and a second stage for definitive flap coverage **[27]**.

The concept of lower extremity reconstruction using an orthoplastic approach speeds up and enhance the quality of care for patient who require collaborative integration between two specialties with aggressive debridement of the devitalized bone and soft tissues, rigid skeletal fixation, effective antimicrobial treatment and durable soft tissue coverage **[28,29]**.

Some limitations of our study are the limited cases and short follow-up. The authors recommend further prospective collaborative research and long term follow-up.

In our study, we emphasize on the importance of a multidisciplinary team for management of chronic osteomyelitis related soft tissue defects in the lower limb. The strategy of prolonged antibiotic therapy, bone debridement, soft tissue reconstruction and coverage was successful in curing the condition. In fasciocutaneous group, we found less complication rate and better scores for patients' satisfaction. However, there were no statistically significant differences between the two groups.

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