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Free flap versus local flap on managing Grade III open tibial fractures: Meta Analysis Study

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Abstract

Background: Grade III open fractures of the lower extremity are solemn injuries and not easy to reconstruct and involved free flap implementation which has improved in answering the microsurgery needs. However, little to no studies on the overall performance of clinical outcomes of one flap typology particularly versus local flap. This study aimed to comprehensively evaluate benefits the effectiveness between free flap and local flap in open tibial fractures particularly in Gustilo Anderson III B/C

Methods: Following The PRISMA guidelines to perform a systematic search conducted on Scopus database namely Springer, ScienceDirect, PubMed, arxiv, and ProQuest for articles investigating free flap and local flap in open tibial fractures Gustilo Anderson III B/C whereas clinical outcomes, length of tibia reunion, and incident of infections were assessed.

Results: Seven studies were included in this review. Cohort studies, Case-control studies, but not randomized controlled trials (RCTs), showed comparation and description on success rate, incidence of infection and length to union of the tibia between free flap and local flap particularly based on donor location.

Conclusions: This study shows that free flaps outperform local flaps, from the studies shows that free flaps propose to a lesser extent donor site morbidity and stipulate greater results in both aesthetic satisfaction and better environment in reducing postoperative infection susceptibility. No significant difference results between muscle flap and fasciocutanous flap in time bone union, infection incidence and success rate.

Keywords: free flap; local flap; open tibial fracture; meta-analysis; Gustilo Anderson III B/C

1. Introduction

Gustilo grades I to IIIA in less severe open tibial fractures can be efficaciously resolved with internal fixation, closure and early wound debridement[1], but complex soft-tissue coverage, further course in handling tolls of eventual amputation, non-union, infection and protracted hospitalisation needed in Gustilo grade IIIB and IIIC fractures[2][3].

Open tibial fractures with Gustilo Grade type IIIB usually prompted by a severe trauma, involved both bone and skin element damage with wide-ranging soft tissue devascularisation. Predominantly, grade III open fractures of the lower extremity are solemn injuries and not easy to reconstruct. Moreover, ideal treatment for such injuries is still deliberated and have indistinct Management protocol.

Nowadays, implementation of free flaps has augmented as microsurgery field cultivate prevalence, there were many literatures reported possible donor sites[4]. Leading surgical methods are otherwise applied and pronounced extensively to weigh complex soft tissue defects namely muscle (M) free flaps and fasciocutaneous (FC) free flaps particularly in lower limb. Equally have been proven to be benign and effective methods in regaining functional and limb salvage. M flaps namely Latissimus Dorsi, Gracilis, and Rectus Abdominis mostly used and preferred due to aptitude to annihilate dead section and lessen the infection jeopardy by delivering blood supply efficiently for open wounds with contamination, promoting fracture healing and decreasing the infection incidence[5][6][7][8].

Both local and free tissue transfer have benefits and drawbacks[8], numerous aspects considered in taking the utmost suitable flap to use namely trauma aetiology, size and defect location, mechanism of injury, comorbidities and the vascular grade of the recipient position [2,3,5]. Moreover, suggestion of "early" flap coverage in seven days from accident happened were based on the Orthopaedic Trauma Association "Best Practices in the Management of Orthopaedic Trauma"[9][10]. Furthermore, reflective multi-centre studies advocate those patients undertaking free tissue flaps experienced less postoperative hitches, predominantly with rupture comminution [6].

Because of positive results of the FC flaps usage, many reconstructions distal lower limb open fractures case favoured it [5,6]. On one hand, free FC flaps stipulate tissue coverage with thin, supple, and cosmetically, with slight donor site morbidity. On the other hand, the anterolateral thigh (ALT) flap is the furthermost used in lower extremity microvascular reconstruction [4,5]. Hence, numerous retrospective studies conveyed specific conclusions follow-on M or FC microvascular free flaps in a comparative sight.

However, no study focus on the overall clinical outcomes performance of one particular flap typology versus local flap. Given the lack of comprehensive data on comparative studies that evaluate this issue, this study conducted a meta-analysis to critically evaluate the spectrum of reported outcomes associated with free flap versus Local flap coverage particularly on Gustilo Anderson III B/C open tibial fractures.

Methods

Prisma guidelines was used in this meta-analysis following the 2020 Preferred Reporting Items [11].

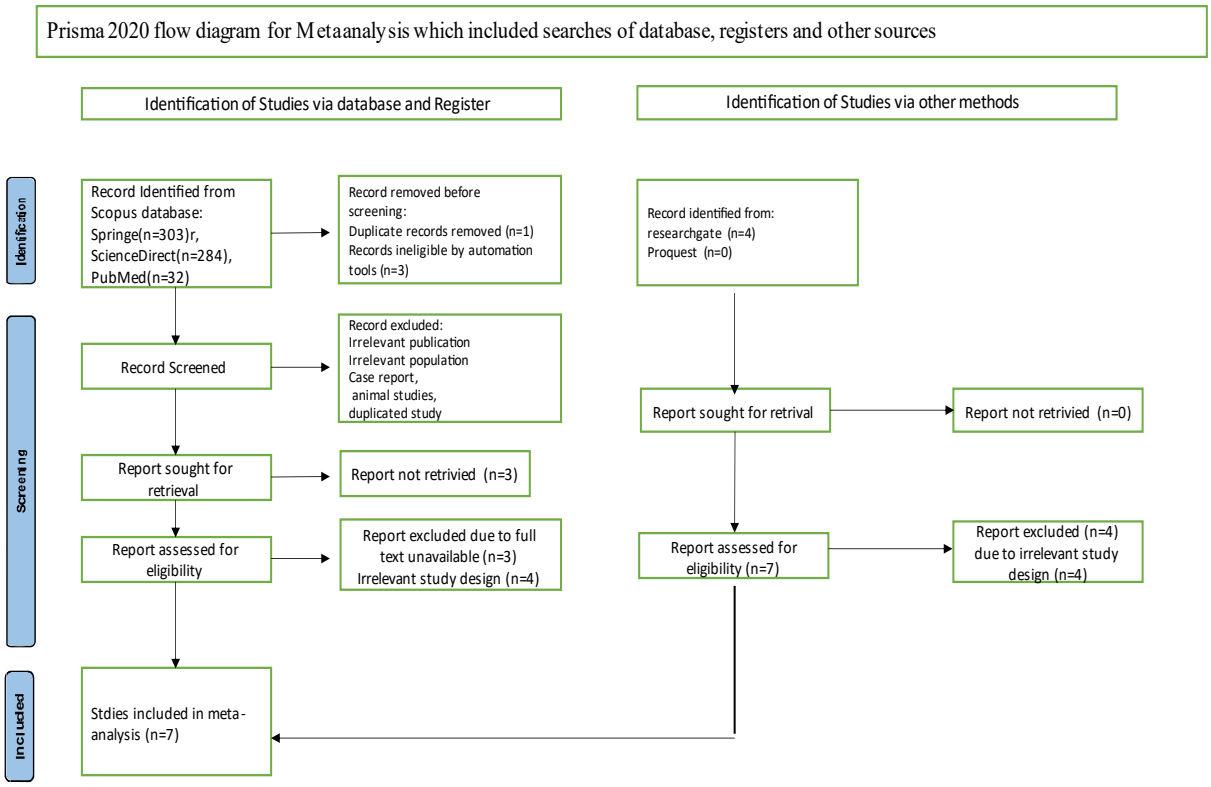

Fig. 1. PRISMA 2020 diagram chart flow for included studies

2.1 Eligibility criteria

This study included research publication in the last decades on retrospective and prospective cohort studies. The following eligibility criteria were retrieved from the titles and abstracts: reporting success rates, incidence of infection, time to union of the tibia in local flaps and free flaps in open tibial fractures Gustilo Anderson III B/C.

Relevant data were extricated from all selected paper using structured and standardized forms respectively: the name of authors, year of publication, country, study design, sample size, patients' clinical condition and age, and study outcomes as seen in figure 1.

2.2 Statistical analysis

The collected data were analysed statistically using Microsoft Excel and SPSS software (version 22.0, SPSS Inc./IBM). Correlation test of continuous data on local flap and free flap to success rate, incidence of infection and length to union of the tibia were performed by univariate analysis. T-tests were performed for the categorical data analysis to make comparation between local flap versus free flap in which P-values of <0.05 were reflected statistically significant.

3. Result

3.1 article Characteristic

The literature search yielded 7 relevant articles and sources of information on outcomes following free flaps and local flaps for tibial fracture.

Table 1 article metadata

no	First Author	article identity	study design	country	sample size
1	Weiliang Chua	Early versus late flap coverage for open tibial fractures. Journal of Orthopaedic Surgery 2014;22(3):294-8	Clinical trial comparation	Singapore	83 men and 6 female's medical records (mean age, 38 years) with Gustilo grades IIIB and IIIC and flap coverage within or after 72 hours (n=30/n=59)
2	S. Gopal, S.	Fix and flap: the radical orthopaedic and plastic treatment of severe open fractures of the tibia. J Bone Joint Surg [Br] 2000;82-B:959-66.	retrospective review	UK	84 patients with an OIIIb or OIIIc tibia
3	Ahmed Emam,	Free tissue versus local tissue: A comparison of outcomes when managing open tibial diaphyseal fractures. Injury 52 (2021) 1625–1628	Clinical trial comparation	UK	233 patients underwent reconstruction for open fracture using local flaps (n=43) or free flaps (n=180)
4	Singh J,	Single stage "Fix and Flap" gives Good Outcomes in Grade 3B/C Open Tibial Fractures: A Prospective Study. Malaysian Orthopaedic Journal 2020 Vol 14 No 1. doi: https://doi.org/10.5704/MOJ.2003.010	Clinical trial comparation	India	33 patients with severe open tibial shaft fractures.

no	First Author	article identity	study design	country	sample size
5	Y. Tropet, P.	Emergency management of type IIIB open tibial fractures. British Journal of Plastic Surgery (1999), 52, 462–470	a retrospective cohort study	France	18 (17 men and 1 woman) cases of Type III B open tibial fractures treated by emergency locked intra-medullary nailing and flap coverage in 1986 to 1995.
6	Phillip Grisdela Jr.,	Complications and timing of soft tissue coverage after complete articular, open tibial plateau fractures. Injury. journal homepage: www.elsevier.com/locate/injury doi: 10.1016/j.injury.2022.12.012	This was a retrospective cohort study	US	51 open fractures with age 45.7 (n50) and 4.3 years (n1).
7	Gianluca Canton,	Strategies to minimize soft tissues and septic complications in staged management of high-energy proximal tibia fractures. EJOST journal. https://doi.org/10.1007/s00590-019-02619-9	The study population included 24 cases control studies	Italy	23 patients, 16 males and 7 females

First Authors	Patient's clinical Condition	Patients 'age (mean)	Study Outcomes
Weiliang Chua	Fractures were treated within 6 hours (n=67) or between 6 and 24 hours (n=22). Involved motor vehicle accidents (n=63), direct crushing (n=22), fall(n=4). With fracture at proximal (n=13), middle (n=47), distal (n=26), and segmental (n=3) tibia.	38 years	Early flap coverage was associated with shorter length of hospitalization (31.4 vs. 55.8 days, p<0.01), lower deep infection rates (23% vs. 54%, p<0.01), and smaller number of surgical procedures (6.4 vs. 9.2, p=0.01). no differ significantly in time to bone union, flap failure, amputation, and the need of secondary procedures to facilitate bone union.
S. Gopal, S.	80 patients with 84 severe open fractures 79 IIIb (94%) and 5 IIIc (6%)) There were 67 men (80%) and 13 women (15%)	mean age of 37 years (3 to 89).	The rate of infection in the nailed cases was only 3%, and 74% united without a secondary procedure, shows excellent union and low rates of infection.
Ahmed Emam	A etiology - High Energy Trauma 169	41-52	No significant differences in ASA score or any associated comorbidities in both age groups ($P \geq 0.4$ for all comparisons). Free flap reconstruction higher score in high energy trauma-related injuries ($P = 0.02$), with a larger defect size (160 ± 141 v 52 ± 25 cm2 in local flaps; $P < 0.001$;). Longer operative time(400 ± 109 v 214 ± 126 min for local flaps; $P < 0.001$).

First Authors	Patient's clinical Condition	Patients 'age (mean)	Study Outcomes
Singh J, Dhillon MS, Dhatt SS	33 patients were managed by a standardized protocol of "Fix and Flap" and followed up for a minimum of 36 months; 15 were grade 3B (45.4%), and 18 were grade 3C (54.5%) open fractures.	30 men (91%) and three women (9%) with a mean age of 35.3 years (range 18-60 years).	Both deep infection and superficial infection rates results 14,33 without any statistically significant difference. 16 patients (48.4%) underwent secondary stabilization procedures (ILN, plating or Ilizarov reconstruction). 8 patients had a neurovascular deficit at initial presentation. 10 patients need Bone grafting with a fibula or iliac crest.
Y. Tropet, P.	18 patiens(17 men, 1 woman) with a high-energy trauma fractures (7 motorbike accidents, 4 car accidents, 4 pedestrians struck by a vehicle, 3 crushing injuries).	35 years old everage age with range: 18–76 years.	Local flap led to two failures and distal necrosis of the soleus muscle also followed by complex postoperative complications. The six emergency free muscle flaps healed well with average healing time 35 days, range: 21–60 days. Bone-union: 6.5 months in 18 patiens (range: 3–18.5 months) using clinical criterion, and 9 months (range: 4–27 months) using radiological criteria. Of the 18 fractures, 13 (72.2%) were primarily united. In this group, bone union was obtained within 4.6 months using the clinical criterion and 6.5 months using rigorous radiological criteria.
Phillip Grisdela Jr.	20 cases of deep infections, unplanned reoperation occurred in 26 cases. 28 fractures had initial external fixation placed, while 24 had ORIF at the initial debridement. 12 patients had a planned flap for definitive closure on average of 6.4 days (SD 3.9) after injury, 14 required a flap for wound complications.	35 patients with sustained polytrauma, age mean was 45.7 (12.3) years, 36 male patients, with follow up mean stood at 4.3 (3.8).	Early coverage within 7 days were benefit in 51 fractures with high rates of complications and deep infections. Early coverage within 24 showed no deep infection or unplanned reoperation occurrence. as guided by the judgment of experienced surgeons should be considered has important role in an acute fixation. In fractures IIB and C, rates of deep infection (5/6 vs 1/6, $p = 0.02$) and reoperation (5/7 vs 2/6, $p = 0.08$) showed higher in patients treated with flap coverage more than 7 days from injury compared to early flap coverage. There were no differences in complication rates between early (<24hrs) and delayed fixation.
Gianluca Canton,	18 Trauma modality in motorcycle accident, 3 fall from and 1 sports-related (skiing) trauma.	23 patients, 16 men and 7 women, with mean age at trauma 45 years (range 17–61). Mean follow-up was 29 months (range 8–55).	Complex fracture patterns were prevalent (AO C3 58.3%, Schatzker V–VI 79.1%), with 50% cases had severe soft tissues damage. Definitive internal fixation Mean time was 6 days, with double-plate fixation. WOMAC and IOWA mean scores as 21.3 and 82.5, respectively indicates satisfying clinical results.

Table 2 Comparation aspects

Course	aspect	n						
		article 1	**article 2**	**article 3**	**article 4**	**article 5**	**article 6**	**article 7**
Local Flap	cases	50	9	43	2	12	7	12
	Success Rate	46	6	43	2	10	7	12
	Infection incidence	4	2	1	0	3	2	1
	Time Bone Union*	13.9 Weeks	25 Weeks	12 Weeks	3.8 Weeks	16 Weeks	35.7 Weeks	40 Weeks
Free Flap	cases	39	75	180	17	6	24	5
	Success Rate	32	74	178	17	6	24	5
	infection incidence	4	2	2	0	0	4	1
	Time Bone Union*	12.5 Weeks	25 Weeks	14 Weeks	3.8 weeks	16 Weeks	40.3 Weeks	40 Weeks

* some not stated explisitly

From the data in comparation aspect in the table 2, it can be concluded that free flaps success rate is higher than local flap, slightly higher in time bone union, but not significantly bit lower in infection rate. The data then analysed statically to seek further comprehensive results.

2.2 Statistical outcomes

Corelation test and Comparison using T-test between free flap and local flap in term of success rate, incidence of infection and length to union of the tibia.

Correlations

		Σ	Success Rate	infection incidence	Time Bone Union
Local Flap	Pearson Correlation	1	.996**	0.478	-0.299
	Sig. (2-tailed)		0	0.278	0.515
	N	7	7	7	7
Free Flap	Pearson Correlation	1	.999**	0.198	-0.243
	Sig. (2-tailed)	1	0	0.67	0.599
	N	7	7	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

Comparation Group Statistics

	Flap	N	Mean	Std. Deviation	Std. Error Mean
Success Rate	Local Flap	7	18.29	18.209	6.882
	Free Flap	7	48	61.89	23.392
infection incidence	Local Flap	7	1.86	1.345	0.508
	Free Flap	7	48	61.89	23.392
Time Bone Union	Local Flap	7	21.571	14.1389	5.344
	Free Flap	7	21.657	14.0745	5.3197

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Success Rate	Equal variances assumed	3.874	0.073	-1.219	12	0.246	-29.714	24.384	-82.841	23.413
	Equal variances not assumed			-1.219	7.03	0.262	-29.714	24.384	-87.321	27.892
infection incidence	Equal variances assumed	8.774	0.012	-1.972	12	0.072	-46.143	23.398	-97.122	4.836
	Equal variances not assumed			-1.972	6.01	0.096	-46.143	23.398	-103.382	11.096
Time Bone Union	Equal variances assumed	0	0.984	-0.011	12	0.991	-0.0857	7.5404	-16.5148	16.3434
	Equal variances not assumed			-0.011	12	0.991	-0.0857	7.5404	-16.5148	16.3434

Based on the results of the independent sample T-test analysis displayed on the table, it was explained that the average success rate for local flaps was 18.29, lower than free flaps at 48.00. However, the results of the analysis in the independent sample test column interpret that the significance values at 0.246 and 0.262, are bigger than 0.01, Hence, no substantial difference amid the two flaps. Meanwhile, the incidence of local flap infection average stood at 1.86, while the free flap was at 48.00. This mean that the incidence of free flap infection is higher compared to local flaps. However, the significance values stood at 0.072 and 0.096, which were

greater than 0.01. Hence, it can be interpreted that there is no significant difference between the two flaps.

In the average of time bone union, the local flap showed 21,571, while free flaps showed higher scored 21,657. However, the results of the analysis in the independent sample test column interpret that the significance value of 0.991 which is higher than 0.01, hence, there is no substantial difference between the two flaps.

Based on the statistical analysis using SPSS which has been described previously, it can be drawn that the free flap has more advantages compared to the local flap in terms of success rate where the statistics show that there is a correlation, which means there is a relationship between the influence of the free flap on the success rate, likewise the free flap shows superiority. in the speed of bone union even though statistics show there is no correlation between the two. Meanwhile, free flaps in the incidence of infection show higher rates compared to local flaps, but statistically there is no correlation between the two and there is no significant difference between the two flaps, so free flaps are still superior to local flaps.

4. Discussion

Open tibial fractures with Gustilo grade IIIB and IIIC are related with complications such as deep infection, non-union, osteomyelitis, flap failure, and amputation. Grade 3 open fracture is a high-energy wound[12], which may portend the life of the patient. According to the British Orthopaedic Association guideline, protocol in handling Gustilo grade IIIB and IIIC open tibial fractures covered swift debridement, fixation, and flap coverage for suitable patients as possible[1].

The most common open fractures with grade 3B/C injuries is tibia, which mostly intricate by soft tissues degloving, vascular injuries and dirty contamination, and poor outcomes in a lot cases. The administration verdict oscillates between limb salvage and amputation. An immediately radical wound debridement outside the injury zone with profuse lavage, using biological AO techniques to stabilize skeletal with appropriate anatomy fracture's implant, and definitive soft-tissue cover with a vascularised muscle flap with a split-skin graft immediately were the protocol of a grade-IIIb injury. Whereas choice between a pedicle and a free muscle flap depends on the anatomy of the injury to the soft tissue[13].

From meta-analysis, severe open tibial fractures patients tend to have multiple injuries[14]. In Gustilo grade-IIIB open tibial fractures, immediate skin closure with single-stage 'fix and flap' measures managed by orthopaedic and plastic surgical services collaboration[13], achieved

good results in bone union time length or amputation risk [1][15], with flap failure rate was 3.5% and 9.5% for the deep infection rate [1][13].

The microvascular surgical techniques for free tissue transfer represents the state-of-the-art reconstruction and is tedious for the salvage of lower extremities in orthopaedic trauma or extensive tumour resection, which encourage plastic surgeons to consider more challenging cases to improved outcomes of soft tissue defects[16]. Understandably, local flaps designated in some circumstances and workhorse flaps persists only if resource and operating time was limited as well as in extremely underprivileged physiological reserve cases because local flaps have a shorter operative time and no need micro-surgery techniques. However, local flap tends to involve adulterated tissue and in fasciocutaneous flaps, skin grafting at the secondary defect cannot be avoided[15][7]. Hence, a higher number of patients receiving free flap reconstruction in high energy trauma-related injuries ($P = 0.02$), with a larger defect size ($P < 0.001$)[15].

Furthermore, one of the studies showed that M and FC free flaps were equally effective in restoring lower limb role after trauma, infection, and oncological resection. M flaps more likely present higher rates than FC flaps in donor site morbidity and total flap loss significantly. The study shows that no significant difference results between muscle flap and fasciocutanous flap in time bone union, infection incidence and success rate[16].

All in all, the analysis of results shows that free flaps are more unswerving than pedicle flaps. In one of the studies showed six free flaps engendered a simple post-operative course, which five fractures out of the twelve covered with a pedicle flap developed to more difficult fractures to handle. This situation happened because of three main reasons. Firstly, when there is substantial muscle contusion, a local flap will not be impeccably healthy and have trophic qualities like a free flap. Secondly, local devascularisation after muscle removal happened. Thirdly, the soft tissue defect covered with the least vascularised distal part of the pedicle flap, thus, bone union is likely to be delayed[17].

5. Conclusion

Study shows that free flaps outperform local flaps particularly success significantly in the aspect of success rate, slightly in infection rate and time bone union. The study indicates that the flap might be chosen based on the level of soft tissue defects, for middle and proximal fractures, local flaps were used, and free flaps were used for distal fractures. However, no significantly different results in time bone union, infection incidence nor success rate between muscle flap and fasciocutanous flap. Hence, free flaps offer a smaller amount donor site morbidity significantly and stipulate both greater aesthetic fulfilment and improved

environment to reduce postoperative infection susceptibility. Yet, the meta-analysis results should be interpreted with thoughtfulness and further studies should be made to establish meta-analysis result.

Ethic Statements

This study was approved with letter number 885/0823/Kepeg/RSUP by RSUP IGNG Ngoerah General Hospital committee, Denpasar, Indonesia, since the study complied with the ethical guidelines, no patient's disclosure, the methodology encompassed a comprehensive assessment using literature and meta-analytic review.

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