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Coverage of exposed hardware after lower leg fractures with free flaps or pedicled flaps

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Abstract. – OBJECTIVE: The placement of osteosynthetic materials in the leg may be complicated by hardware exposure. Successful soft tissue reconstruction often provides a critical means for limb salvage in patients with hardware exposure in the leg. Free flaps are currently considered the standard surgical procedure for soft tissue coverage of the wounds with internal hardware exposure. However, to date, no conclusive literature shows the superiority of a specific type of flap.

MATERIALS AND METHODS: The current review compares data from the literature concerning outcomes and complications of free and pedicled flaps for exposed osteosynthetic material preservation in the leg.

RESULTS: A total of 81 cases from twelve different articles presenting internal hardware exposure of the leg were analyzed in our study. Thirty-two patients underwent immediate reconstructive surgery with pedicled flaps, while forty-nine patients underwent free flap reconstruction. The overall survival rate for pedicled flaps was 96.77%, while for free flaps it was 97.77%. The overall implant preservation rate was 78.12% for pedicled flaps and 53.33% for free flaps. With reference to postoperative complications, the overall complication rate was 46.87% for pedicled flaps and 10.20% for free flaps.

CONCLUSIONS: No significant difference was found in terms of overall flap survival. However, a significant difference was found regarding successful implant preservation (78.12% in the pedicled flap group *vs.* 53.33% in the free flap group). In particular, the first observation appears to be in contrast with the current trend of considering the free flaps the first choice procedure for soft tissue coverage of the wounds with internal hardware exposure. Nevertheless, a higher occurrence of postoperative complications was observed in the pedicled flap group (46.87% *vs.* 10.20%). The choice of the most appropriate reconstructive procedure should take into account several issues including the size of the wounds with internal hardware exposure, the possibility of soft tissue coverage with pedicled flaps, the availability of recipient vessels, general conditions of the patients (such as age, diabetes, smoking history), patients' preference and presence of a microsurgical team. However, according to the results of this review, we believe that pedicled flap reconstruction should be reconsidered as a valid alternative procedure for skin tissue loss with hardware exposure whenever it is possible.

Key Words:
Hardware exposure, Soft tissue coverage, Leg, Free flap, Pedicled flap.

Introduction

The placement of osteosynthetic materials is a common procedure for the open reduction internal fixation (ORIF) of fractures in the leg[1]. However, this procedure may be complicated by exposure of the hardware[2,3]. Traditionally, the postoperative management of wound dehiscence with hardware exposure consists of wound irrigation and debridement, antibiotic administration and, possibly, removal of the hardware and its replacement with external fixators. Soft tissue reconstruction is usually performed in a later stage. However, several studies have shown the possibility of a single-stage procedure consisting of wound debridement and soft tissue reconstruction either with pedicle or free flaps without internal hardware removal[4-7]. Free flaps are currently considered the standard surgical procedure for soft tissue coverage of the wounds with internal hardware exposure. However, to date, there is no conclusive literature that shows the superiority of a specific type of flap.

The following review includes case series of patients affected by wound dehiscence with hardware exposure in the leg that underwent soft tissue reconstruction with free or pedicled flaps and aims at investigating which of these flaps is best suited for tissue coverage.

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Materials and Methods

A literature review on soft tissue reconstruction for wound dehiscence with hardware exposure in the leg was performed using PubMed search engine. The aim of our investigation was to compare the efficacy of pedicled flaps *vs*. free flaps in preserving the hardware.

Inclusion criteria for article selection were: papers published no more than 15 years ago, presenting cases of hardware exposure on the leg without hardware removal, and soft tissue reconstruction with either pedicled or free flaps.

The keywords used for the research were: Internal hardware exposure, immediate reconstruction, leg fracture, pedicled flaps, free flaps. The search words were entered in PubMed central and appropriate abstracts reviewed. Relevant full text articles were retrieved and perused. Cross references from these articles were also reviewed. Articles presenting alternative methods of wound closure without hardware removal were also included. Review articles were excluded.

Bibliographies were reviewed to identify additional articles relevant to the topic.

Results

A total of 81 cases from twelve different articles presenting internal hardware exposure of the leg were analyzed in our study[8-19].

Thirty-two patients underwent immediate reconstructive surgery with pedicled flaps, while forty-nine patients underwent free flap reconstruction. Eleven cases underwent Vacuum-Assisted Closure (VAC) therapy preoperatively.

Details of reconstructive procedures are shown in Tables I and II.

In particular, recovery time ranges from 20 days to 18 months. The overall survival rate for pedicled flaps was 96.77%, while for free flaps it was 97.77%. The overall implant salvage rate was 78.12% for pedicled flaps and 53.33% for free flaps.

With reference to postoperative complications, the overall complication rate was 46.87% for pedicled flaps and 10.20% for free flaps (Table I). In particular, the following complications were recorded for reconstructions with pedicled flaps: 1 case of total flap necrosis (3.12%), 4 cases of partial flap necrosis (12.5%), 7 cases of fistula (21.87%), 2 cases of infection (6.25%), 2 cases of dehiscence (6.25%), 7 cases required hardware removal (21.87%). Patients reconstructed with free flaps presented the following complications: 1 case of total flap necrosis (2.04%), 2 cases of thrombosis (4.08%), 2 cases of infection, one of which consisting of a submuscular abscess (4.08%), 2 cases required hardware removal (4.08%), one of which underwent later amputation, and 6 cases required amputation (12.24%).

Discussion

Successful soft tissue reconstruction often provides a critical means for limb salvage in patients with hardware exposure in the leg. The use of well-vascularized flaps provides soft tissue coverage, obliterates dead space, and controls the infection[20]. Free flaps are currently considered the standard surgical procedure for soft tissue coverage of the wounds with internal hardware exposure[8,21]. However, to date, there is no conclusive literature that shows the superiority of a specific type of flap. The location of the defect plays a role in the choice between a pedicled or free transfer.

Several free flaps have been used for coverage of wounds in the lower extremities. The *latissimus dorsi* muscle flap and the gracilis muscle flap[14,20] provide a large mass of well-vascularized tissue, especially when dead space presents. The anterolateral thigh fasciocutaneous flap can provide a large skin paddle nourished by a long and large-caliber pedicle[22], and is now used more than the foearm fap (Figure 1 A-B).

However, free flaps may have some disadvantages such as the bulkiness and the possible donor-site morbidity. Moreover, all free flaps have the common drawback of the difficulty of choosing the recipient vessels because of the poor local wound condition in the lower extremity.

There are also many pedicled flaps for soft tissue reconstruction in lower extremities, such as local fasciocutaneous flaps (as described by Ponten), the sural flap or reverse sural flap (Figure 2 A-B), the gastrocnemius flap, the saphenous fasciocutaneous flap, the soleus or hemisoleus flap, and the lateral supramalleolar flap, and the perforator-based propeller flap[23-29]. However, the selection of the flaps depends on the availability of the donor sites, which are mainly located around the injured area.

Table I. Comparison of post-operative course after free/pedicled flap cover of exposed osteosynthetic material in the distal leg

	Number of patients and type of pedicled/free flap cover	Complications	Duration of post-primary surgery to wound breakdown	Duration of post-wound breakdown to flap cover	Duration of post-primary surgery to flap cover	Further surgeries	Eventual flap survival	Success/ failure of implant preservation
Verhelle et al[7]	4 – Gracilis flap							
	1 – Medial adipofascial flap	1 fistula				1 hardware removal		1 Failure
Vaienti et al[8]	4 – Sural fasciomiocutaneous flap	1 fistula 1 dehiscence partial necrosis	3-20 days (mean 12.66)		30 days	1 hardware removal	4 yes	3 Success, 1 failure
Vaienti et al[9]	7 – Sural fasciomiocutaneous flap	3 fistula 1 dehiscence 1 partial necrosis	5 months (mean)	8 months (mean)	13 months (mean)	1 debridment 1 hardware removal	7 yes	6 success, 1 failure
	3 – Medial gastrocnemius flap	1 fistula				1 hardware removal	3 yes	2 Success, 1 failure
	1 – Soleus flap	1 fistula				1 hardware removal	1 yes	1 Failure
	1 – Perforator flap	1 total necrosis				1 sural fasciocutaneous flap	1 no	1 Success
	1 – ALT flap						1 yes	1 Success
Temmen et al[10]	3 – Gracilis flap	1 thrombosis 1 flap ischemia	4 weeks-20 years			2 harvest of proximal gracilis	3 yes	3 Success
Wen et al[11]	7 – VAC + reversed saphenous neurocutaneous perforator flap	1 partial necrosis		7-26 days			7 yes	7 Success
Zhang et al[12]	1 – Musculocutaneous flap of the saphenous nerve and great saphenous vein + medial gastrocnemius flap + soleous flap	3 days					yes	Success
Viol et al[13]	1 – ALT flap						1 yes	1 yes
	1 – LD flap	1 Submuscular abscess	1 year			1 debridment and hardware removal followed by amputation for continued infection	1 no	1 no
	1 – VAC + LD flap						1 yes	1 Yes

Table continued

Table I *(Continued)*. Comparison of post-operative course after free/pedicled flap cover of exposed osteosynthetic material in the distal leg

	Number of patients and type of pedicled/free flap cover	Complications	Duration of post-primary surgery to wound breakdown	Duration of post-wound breakdown to flap cover	Duration of post-primary surgery to flap cover	Further surgeries	Eventual flap survival	Success/ failure of implant preservation
Pu1[4]	3 – VAC + combined medialgastrocnemius and medial hemisoleus muscle flap				Within 10 days		3 yes	3 Success
Tan et al[15]	2 – Free gracilis flap	1 infection	2-44 days (mean 16.83)	6-30 days (mean 14.66)	8-63 days (mean 31.5)	1 hardware removal	2 yes	1 Failure, 1 Success
	4 – Sural flap	2 infection				2 hardware removal	4 yes	2 Failure, 2 Success
Yazar et al[16]	1 – Groin flap		21 days				yes	Success
Patel et al[17]	21 – Rectus abdominis flap					5 late amputation	34 yes	14 Failure, 7 Success
	7 – Gracilis flap							3 Failure, 4 Success
	4 – ALT flap							2 Failure, 2 Success
	1 – Lateral arm flap							1 Success
	1 – Radial forearm flap							1 Success
Ribuffo et al[18]	1 – Radial forearm flap	Venous thrombosis				1 skin graft	yes	Success

Table II. Details of reconstructive procedures.

	Operative time	Duration of hospital stay	Recovery time	Full weight bearing	Lenght of follow-up (months)
Verhelle et al[7]	3-4:25 hours (mean 3:40) – gracilis flap 1:15-2:05 (mean 1:35) – medial adipose-fascial flap	10-31 days (mean 16) – gracilis flap 7-12 days (mean 10) – medial adipose-fascial flap			16-38 (mean 26) – gracilis flap 19-47 (mean 30) – medial adipose-fascial flap
Vaienti et al[8]			20-60 days (mean 32.5)	10-40 days (mean 23.5)	7-24 (mean 12.5)
Vaienti et al[9]					
Temmen et al[10]			9-18 months	9 months	12-18
Wen et al[11]			4-6 months (mean 4.7)		8-14 (mean 10.6)
Zhang et al[12]					5
Viol et al[13]					12-24
Pu[14]		5 days			60
Tan et al[15]					14.7-51.4 (mean 26.08)
Yazar et al[16]				16 months	36
Patel et al[17]					0.3-7 years (mean 3.2)
Ribuffo et al[18]					

According to the literature, soft tissue necrosis after internal fixation with the conventional plate-screw system is a common complication[2]. The main risks of internal hardware exposure are infections, osteomyelitis and non-unions.

According to Viol et al[30], important prognostic factors for the success of management of exposed hardware are the duration of exposure and the duration of infection. In particular, better results are achieved when debridement and soft-tissue coverage are performed within 2 to 3 weeks after exposure of the hardware and higher rates of hardware salvage are observed if the infection occurred within 2 weeks of the original operation.

In case of infection, the vacuum-assisted closure (VAC) can be used before surgery in order to obtain a more favorable preoperative condition[11]. The use of the VAC therapy may reduce the need for flap coverage, alter the type of flap required or even eliminate the need for soft tissue coverage with flaps.

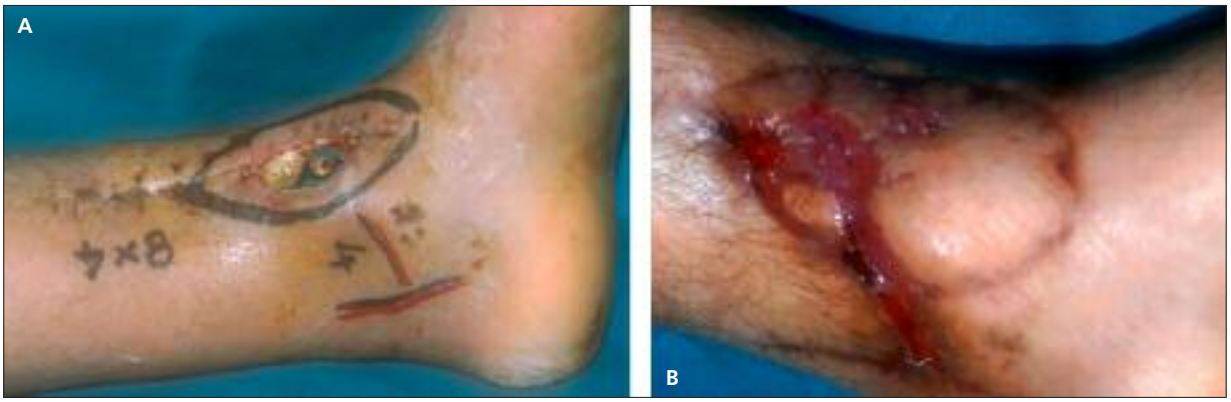

Figure 1. ***A,*** Trauma to the lower leg with hardware exposure. ***B,*** Reconstruction with a free forearm flap, which suffered from marginal necrosis.

Figure 2. ***A,*** Trauma to the lower leg with hardware exposure. ***B,*** Reconstruction with a sural flap.

The most important data emerging from our review are two: the higher implant preservation rate in the pedicled flap group compared to the free flap group (78.12% *vs*. 53.33%) and the higher prevalence of postoperative complications in the pedicled flap group (46.87% *vs*. 10.20%). In particular, the first observation appears to be in contrast with the current trend of considering the free flaps the first choice procedure for soft tissue coverage of the wounds with internal hardware exposure. This is probably due to the fact that the choice of a pedicled flap is reserved for less complicated cases with limited tissue loss. Nevertheless, the choice of the more appropriate surgical procedure should be evaluated singularly according to the general and local conditions of the patient, keeping in mind that the two are both valid options for soft tissue coverage in case of hardware exposure.

Conclusions

The exposure of ostheosynthetic material with skin tissue loss is a common complication that plastic surgeons encounter. Reconstructive strategies mainly consist of a pedicled or free flap reconstruction. The current review compares data from the literature in terms of outcomes and complications of each procedure. No significant difference was found in terms of overall flap survival. However, a significant difference was found in terms of successful implant preservation.

With reference to postoperative complications, patients reconstructed with pedicled flaps experienced a higher number of complications. On the other hand, operative time and hospital stay are definitely higher for free flap reconstruction, with an increase in costs.

The choice of the most appropriate reconstructive procedure should take into account several issues including the size of the wounds with internal hardware exposure, the possibility of soft tissue coverage with pedicled flaps, the availability of recipient vessels, general conditions of the patients (such as age, diabetes mellitus, smoking history), patients' preference and presence of a microsurgical team. However, according to the results of this review, we believe that pedicled flap reconstruction should be reconsidered as a valid alternative procedure for skin tissue loss with hardware exposure whenever it is possible.

Conflict of Interest

The Authors declare that there are no conflicts of interest.

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