

RECONSTRUCTION OF DEEP BURNS OF THE KNEE USING GASTROCNEMIUS FLAP

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ABSTRACT

PURPOSE: The objective of this paper was to share our surgical experience and discuss the application of the gastrocnemius flap in the reconstruction of deep burns of the knee.

MATERIAL AND METHODS: We reported a reconstructive work using gastrocnemius flap in six patients with deep burns of the knee joint. The application of flap surgery was determined by the size and the depth of the defect without considering the etiology of the burn. Five patients were treated with the medial head and the sixth one was treated with the lateral head of the gastrocnemius muscle.

RESULTS: Complete tissue coverage of the wounds was obtained. In one patient, partial split-thickness skin graft was lost, however, secondary healing of the wound occurred. Primary healing occurred in the donor areas. Full mobility and good aesthetic results were obtained in all the patients.

CONCLUSION: The gastrocnemius flap is a valuable surgical method in the reconstruction of the deep burns of the knee joint. The final functional and aesthetic outcome is very good. Having considered the advantages of the technique, we believe that its application is appropriate in many cases of deep burns of the knee presenting with exposed bone and tendon.

Key words: *deep knee burns, surgical flaps, fasciocutaneous flaps, gastrocnemius muscle*

INTRODUCTION

Deep burns of the lower extremities involving the knee joint are associated with exposure of bones, tendons or ligaments. These severe wounds represent a considerable challenge for reconstructive surgery. The main reason is that after the excision of the dead tissues, there could be no viable

wound bed to which skin grafts can be applied. Skin grafts alone placed over a granulating bed may lead to unstable soft tissue coverage and contracture. In addition to the wound coverage, stabilizing of the joint, restoration of its mobility and complete joint function are required, too. In such cases the method of choice is a flap which may be pedicled or free (20). The gastrocnemius flap defined as type I according to Mathes and Nahai's classification is a feasible option (16). Its application is possible either as a muscle flap covered with a split-thickness skin graft, or as a composite myocutaneous flap.

MATERIAL AND METHODS

We report our clinical experience of reconstructive work with gastrocnemius flap in six patients with deep burns of the knee joint. The indications for flap application were defined according to

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the size and the depth of the defect, however, without taking into account the etiology of the burn. Five patients were treated with the medial head of gastrocnemius muscle and the sixth one was treated with the lateral head.

The surgical technique involved a vertical incision from the crease of the popliteal fossa to the middle of the leg. Then the deep fascia was incised vertically and retracted so as to expose the surface of the gastrocnemius muscle. Both muscle heads were separated in the midline by blunt dissection. Mobilisation of the medial or lateral head started at the lower musculo-tendinous junction. The dissection continued proximally. Depending on the choice of the muscle head to be used, a subcutaneous tunnel was formed medially or laterally over the upper tibia. The flap was transferred to the knee through the subcutaneous tunnel and it was spread over the knee joint. It was fixed to the wound edges by simple interrupted stitches. The muscle was covered with a split-thickness skin graft. Primary wound closure was performed on the donor site.

RESULTS

Complete tissue coverage of the wounds by gastrocnemius flap was obtained. In one patient, partial split-thickness skin graft was lost but secondary healing of the wound occurred. Primary healing occurred in the donor areas. Full mobility and good aesthetic results were obtained in all the patients without functional deficit of donor site.

CASE REPORTS

Case 1

A 59-year-old male sustained an electrical burn of the right knee joint (Fig. 1a). Upon debridement, the burn was found to involve the periosteum and the lower medial part of the patella. The



Fig. 1a. An electrical burn of the knee

teum and the lower medial part of the patella. The patellar tendon was partially damaged. The patella was medially fenestrated with a power drill and fixed to the intact part of the tendon and the procedure provided stability to the joint (Fig. 1b).



Fig. 1b. Medially burred patella fixed to the intact part of the tendon

The reconstruction was performed with a flap from the gastrocnemius medial head. A split-thickness skin graft meshed at a 2:1 ratio was used for covering the muscle. The wound healed completely and the result was stable coverage and good function of the joint (Fig. 1c).



Fig. 1c. Complete knee joint recover one year after the reconstruction

Case 2

A 59-year-old male sustained flame burns to both lower extremities. The patient underwent early excision with skin grafting. His left knee burns were deep, the periosteum of the patella was destroyed and the tendon was exposed (Fig. 2a). The medial



Fig. 2a. Burns of the knee

gastrocnemius flap was elevated to cover the exposed patella (Fig. 2b) and it was covered with skin grafts. The patient recovered completely (Fig. 2c).



Fig. 2b. Medial gastrocnemius flap covering the exposed patella



Fig. 2c. Healed flap and partial lesion of the free graft

Case 3

A 77-year-old female sustained a thermal hot surface contact burn to the knee and lower extremity. Upon necrectomy, the burn was found to involve the periosteum of the patella and the tendon was exposed (Fig. 3a). The patient underwent reconstruction with the lateral gastrocnemius flap (Fig. 3b) followed by skin grafting (Fig. 3c). The final result consisted in restored function of the knee.



Fig. 3a. Deep thermal surface contact burns of the right knee joint



Fig. 3b. Lateral gastrocnemius flap



*Fig. 3c. Healed flap with skin graft
Lateral gastrocnemius flap*

DISCUSSION

The aim of the reconstructive work around the burned knee joint is to obtain adequate functional and aesthetic results with minimal donor site morbidity. The various treatment approaches depend on the location, size and depth of the defect related to the knee joint. Inappropriate treatment can lead to contractures, malfunction and unpleasant aesthetics results. In cases of complete destruction of the skin alone, the debridement followed by skin grafting is the most common method of treatment. When burns extend deeper and result in bone devoid of periosteum and exposure of tendons, traditional skin grafting is not suitable. In the past, granulation tissue growth was stimulated by fenestrations into the bone

and split-thickness skin grafts were applied to these granulating beds. Nowadays many clinicians use negative-pressure therapy with vacuum-assisted closure system (VAC; KCI, Inc., San Antonio, TX, USA) to treat wounds with exposed bones and tendons (8).

The objective of this therapy is to reduce the amount of tissue edema, to improve local blood flow, decrease bacterial counts and facilitate coverage of exposed bone and tendon with granulation tissue (24). Once that occurs, a skin graft can be placed to cover the wound. The granulation process and patient's recovery is shortened by using VAC, however, skin grafts alone applied directly over bone or tendon do not provide any stable long-term coverage and mechanical stability.

Bioengineered skin replacements that minimize scar contraction and optimize the quality of the reconstructed skin represent another modern option for treatment of deep burns. Dermal templates such as Integra® (Integra Life Sciences Corp., Plainsboro, NJ, USA) and Matriderm® (Skin and Health Care AG, Billerbeck, Germany) are used for the treatment of burns in reconstructive surgery (14).

The dermal matrix of Integra Bilaminare is composed of bovine collagen and shark chondroitine-6-sulfate. The epidermal component is a thin layer of silicone. It is usually vascularized in 2 to 4 weeks prior to coverage with skin grafts. VAC system is used in clinical practice in conjunction with Integra as several good results have already been reported in the medical literature (18,19). The advantage of the simultaneous use of Integra with VAC is the quick vascularization of the dermal substitute which allows grafting as soon as 4 days after Integra placement. The method is quite efficient, but it is a two-step procedure compared to the one-stage skin graft or flaps.

The dermal Matriderm template is the recent innovation in plastic surgery (6). It is made of 3-dimensional dermal matrix consisting of bovine dermal collagen - I, III, V and elastin hydrolysate. Matriderm allows one-step application of both procedure - the dermal substitute and the skin grafting, which considerably shortens the recovery period (22). The bioengineered skin replacements are successfully used to reconstruct many hard-to-heal defects, including wounds with poorly vascularized beds (i.e., bone, tendon, and joint), burn contractures, keloids

as well as extensive body surface area burn (4). Furthermore, patients with substantial hemodynamic changes resulting from severe burn may prove to be poor candidates for treatment with flaps. In such cases, bioengineered skin replacement is the feasible and appropriate alternative since they are far less traumatic compared to flap surgery. However, as far as the mobility of the knee joint is concerned, flaps are the better option because they provide full functionality (11). A recognized advantage of the artificial skin replacements is, however, wound coverage with higher elasticity of the soft tissues compared to skin graft alone. Therefore, in certain cases, they are the preferred method of choice in reconstructive surgery. The limitations of bioengineered skin are that it attaches a 5-mm thickness which does not provide sufficient coverage in deep wounds and thus the obtained aesthetic outcome is not satisfactory enough. However, in very deep tissue loss or in certain situations in which cosmetics is important, second or successive layers might be very worthwhile (12). Besides, the high cost of the product is another reason why we have not used it in cases with deep burns crossing the knee joint.

Inadequate treatment of burn injuries around lower extremity joints associated with exposure of bones and tendons may result in debilitating post-burn contractures. The clinical experience shows that early excision of all non-vital tissue followed by soft tissue coverage with local or free flaps prevents the development of contractures. It provides stability of the joint and restores its full functionality. Free flap transfers can provide good coverage in one stage (26). However, the disadvantages associated with the application of free flaps are donor-site morbidity, long operating duration, and necessity of a highly specialized surgical team. Free flaps are suitable in cases when the availability of local flap coverage is limited in some patients with deep burns with surrounding tissues necrosis (22).

Local flaps such as fasciocutaneous flaps or muscle flaps are an alternative in cases of deep burns of the knee with exposed bones, tendons, ligaments or joint and intact surrounding tissues. Some good results from the application of fasciocutaneous flaps in deep burn of the knee joint with exposed patella without periosteum were reported (3). The usage of

this flap if the defect is small and if bone or tendons are exposed as well as the usage of a musculocutaneous flap (medial or lateral gastrocnemius) for covering large defects was recommended (25,27). Proximal defects up to the level of the superior patellar pole were treated with a combination of medial gastrocnemius and fasciocutaneous flaps to avoid the morbidity associated with a free tissue (21).

In cases with exposed bones and tendons, damaged patellar tendon, or open knee joint, the gastrocnemius muscle flap provides a well-vascularized tissue and stable coverage. This flap was first described by Ger in 1971 as a muscle flap (10). Nowadays it is widely used in covering the defects of the knee, proximal shank and thigh (1,5,13). The lateral gastrocnemius flap is used more rarely than the medial one because it is shorter and narrower (2). The other reason for the scarce usage of the lateral gastrocnemius is the smaller arc of muscle rotation and the potential risk of peroneal nerve palsy caused by the surgical procedure itself (7,23). The medial head of the gastrocnemius muscle part being most commonly used meets all the criteria for a successful muscle flap (15). We prefer the medial to the lateral gastrocnemius head because, as our experience shows, the muscle is of a larger volume and length as well. The application of the lateral head is preferred in cases of wounds in the proximal part of the tibia and the lateral surface of the knee.

Here we presented six cases of deep burns of the knee joint treated with gastrocnemius flap. Patella without periosteum and tendons were exposed in all the three patients. In one case, there was a partial damage of the patellar tendon. The medial gastrocnemius transposition flap was the appropriate choice for five patients. The sixth one was treated with lateral gastrocnemius muscle flap. All the flaps healed without complications and full knee functionality was restored. Good aesthetic results were achieved.

The main disadvantage of the muscle flap is the deformation of the donor area. Myocutaneous gastrocnemius flap first proposed by Mc Craw *et al.* in 1978 (17) and popularized by Feldman *et al.* in the same year (9) requires coverage of the donor site with skin graft which additionally damages the donor area. For that reason, we prefer the application of the muscle flap alone covering the free skin graft.

The advantages of the gastrocnemius flap prevail over its disadvantages. The surgical technique is relatively easy to perform and the operative time is much shorter compared to the free tissue transfer. In addition, it is one-step procedure compared to the two-step Integra Bilaminate treatment. Moreover, the gastrocnemius flap provides better tissue coverage, greater stability of the knee joint and full range of movement in cases of exposed bones, ligaments and tendon in comparison with all the types of bio-engineered skin.

CONCLUSION

The gastrocnemius flap is a valuable surgical method in reconstructive work of deep burns of the knee. The surgical intervention is comparatively simple and short-lasting. It does not require any special microsurgical skills and equipment. The final functional and aesthetic outcome is very good. Having considered the advantages of the gastrocnemius flap, we believe that its application is appropriate in many cases of deep burns of the knee with exposed bone and tendon.

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