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LATEST ARTICLES

The Application of MatriDerm in Soft Tissue Defects with Bone Exposure.

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Abstract

Background: Treatment of patients with post-traumatic severe and chronic wounds poses many challenges. A large number of dermal analogs have been invented in an effort to overcome these challenges. Matriderm®, a biosynthetic dermal analog, is made from bovine collagen and elastin. The aim of our study was to prove the effectiveness of MatriDerm® combined with skin grafting versus skin grafting alone in these difficult-to-heal wounds.

Material and Methods: Twenty-two patients with post-traumatic defects with bone exposure and chronic wounds treated in the Clinic of Plastic Reconstructive and Aesthetic Surgery of the University Hospital "St. George" were included in this prospective study. The mean age of the patients was 58 years. The patients were divided into two groups: the experimental and the control group. The patients in the experimental group received a Matriderm® appliance and a split-thickness skin graft, while those in the control group received only a split-thickness skin graft. All patients gave their informed consent to participate in the study.

Results: The hospitalization period in the experimental group was 3 weeks and 5 days and in the control group 8 weeks. The period of complete healing was shorter in the experimental group patients (5 weeks) compared with control group patients (9 weeks) with a difference reaching statistical significance ($P<0.05$). Matriderm® enables effective healing and improves elasticity in the treatment of patients with post-traumatic severe and chronic wounds.

Conclusions: With our study, we confirm the evidence of the clinical use of MatriDerm® technology in the healing of soft tissue wounds and prove the effectiveness of combining MatriDerm® and skin grafting for the first time. Moreover, we observed a reduction in wound contraction and an improvement in elasticity, quality of scar tissue, and dermal architecture.

Keywords: Dermal substitute, Post-traumatic wounds, Skin grafting

Introduction

Post-traumatic wounds with bone exposure and chronic nonhealing wounds can be designated as a silent pandemic affecting a large segment of the world population. It is estimated that 6% of the global population is afflicted by these types of chronic wounds. The International Diabetes Federation predicts that a lower limb is amputated every 30s, globally. One of the most serious complications in post-traumatic wounds is bone exposure, and in metabolic or trophic wounds is the development of local infection with gangrene and subsequent amputation of the lower leg [1].

Damage to this type of wound is in many cases complex and therefore a multifactorial approach is needed [2]. Correction of peripheral vasculopathy, and adequate surgical

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treatment of the wound, including control of infection, are the key steps in the treatment of post-traumatic and chronic wounds. If the tissue defect is superficial, a simple wound dressing may be sufficient. However, if the wound is deep enough, with a lesion of adipose tissue, muscle, and bone exposure, it is mandatory to close the wound with a free graft or local/distant flap [3].

Skin grafting is a relatively simple procedure, but there are limitations, including a high probability of graft skin loss and low resistance to friction and pressure. On the other hand, valve surgery is effective and durable in deep ulcers, but has a narrow spectrum of patients and is associated with severe post-operative complications, including flap necrosis. The aim of this study was to investigate the effectiveness of Matriderm (Skin Health, Billerbeck, Germany), an artificial dermis, compared to a skin graft in the treatment of post-traumatic wounds with bone exposure and chronic difficult-to-heal wounds [4, 5].

Materials and Methods

The study included 22 patients (14 males, 8 females), with a mean age of 58 years (range from 35 to 72 years) with post-traumatic defects with bone exposure and chronic non-healing skin defect and a postoperative follow-up period of 8.8 months (range from 6 to 12 months) treated in the Clinic of Plastic Reconstructive and Aesthetics Surgery of the University hospital "St. George" between 01.2021 and 01.2022. All wounds were localized on the inferior limbs (Table 1).

Characteristics	**Patients treated with skin grafts**	**Patients treated with Matriderm® and skin grafts**
Number of patients	11	11
Sex (male/female)	8/4	6/4
Age	35-72	50-72
Initial size of wounds (cm2)	10-250 cm^2	10-200 cm^2
Wound with bone expose	11	11
Patients with post-traumatic defect	5	3
Patients with chronic non-healing defect	8	6

Table 1. Clinical characteristics of patients.

Exclusion criteria were severe arterial wounds and patients with renal failure and sepsis. In our study, 11 patients were treated with MatriDerm® combined with an autologous skin graft, and 11 patients received only an autologous skin graft. Our protocol for patient selection was based on clinical evaluation, wound examination, swab culture, and instrumental examination (echo–color-Doppler) of the lower limbs. Each patient was examined for chronic diseases and possible concomitant pathology.

The wound examination included the wound area (cm3), wound bed, wound margins, and the surrounding tissue. Microbial culture was performed to evaluate any microbiological infections and to find the appropriate antibiotic therapy for treatment. Echo–color-Doppler was performed in the lower limbs to achieve a complete evaluation of local vascular circulation.

All procedures were performed in a complete asepsis ambiance with general anesthesia. The surgical treatment included debridement (removing all non-viable tissues), controlling infection (based on the results of bacterial culture), and maintaining a balanced moist environment. The curettage of damaged areas and the dermal substitute application in combination with a split-thickness autograft in a one-step procedure (Table 2).

Postoperative evaluation	**Patients treated with skin grafts**	**Patients treated with Matriderm® and skin grafts**
Hospital stay	8 weeks	3 weeks and 5 days
Complete healing period	9 weeks	5 weeks
Completely healed ulcer (%/patients)	60/7	81/9

Table 2. Postoperative characteristics of ulcer.

All patients gave their informed consent to participate in the study.

Material and Methods.

Proper wound bed preparation was performed before the study, including debridement (removing all non-viable tissues), controlling infection (based on the results of bacterial culture), and maintaining a balanced moist environment. Inclusion criteria were type 2 diabetic patients with a chronic foot ulcer, venous wounds, and post-traumatic defects with bone exposure, lasting more than four weeks after appropriate management, wound size bigger than 1 cm2, and formation of healthy granulation tissue after proper wound bed preparation. Exclusion criteria were a wound depth of Wagner grade 3 or a wound with severe vasculopathy [6,7]. After that the 22 patients were divided equally into two groups: a control group (n=11), receiving a skin graft only, and an experimental group (n=11), receiving the Matriderm® appliance combined with a skin graft.

Surgical technique. In both groups, adequate debridement was performed until healthy tissue was exposed with pinpoint bleeding. After debridement, Matriderm® was applied, soaked with normal saline, and a split-thickness skin graft was performed in one stage in the experimental group (Fig. 1). Only a split-thickness skin graft was performed in the control group (Fig. 2). Wet-to-

dry compressive dressing was administered until the grafted skin had been taken in both groups. After the grafted skin had been taken, ointment (Bactigras®) and dry dressing with controlled compression were applied daily.

Assessment. For the comparison of the two groups, three factors were measured.

1) The length of the hospital stays;

2) The length of complete wound healing;

3) The number of completely healed patients during the postoperative period for 12 weeks.

Complete healing was defined as complete wound closure without any transudate or exudate from the wound [9]. SPSS ver. 12.0 was used for the statistical analysis.

The data were analyzed with the Chi-square test. Significance was set at a value of $P \leq 0.05$.

Results

A summary of the demographic details of the control and experimental groups, including age, wound size, and wound depth, is shown in Table 1. In 11 patients treated with skin grafting combined with MatriDerm®, we observed complete healing of the wound and 81% epithelialization in 9 patients.

Minimal or absence of skin grafting contracture was observed in these patients.

The percentage of living tissue was evaluated to be 95% of the wounds in patients treated with MatriDerm® combined with skin grafting, whereas it was almost 70% in the wounds treated with skin grafting alone. In almost all patients treated with skin grafting only, we observed contracture of the graft. The length of the hospital stay was shorter in the experimental group, lasting 3 weeks and 5 days, while in the control group it was 8 weeks. In addition, the time for the wound epithelialization was shorter in the experimental group (5 weeks), than in the control group (9 weeks).

The number of completely healed patients in the 12 postoperative weeks was greater in the experimental group, with 9 patients (93,5%) than in the control group with 6 patients (60.5%) ($P<0.05$). The elasticity ratio of the affected lesion and contralateral region at the complete wound epithelialization point was higher in the experimental group.

A summary of the outcomes of these factors is shown in Table 2. There was no occurrence of complications, such as a rejection response to the artificial dermis, infection, bleeding problems, or loss of graft skin. Also, during the follow-up period, there was no recurrence in either group.

Case 1; A 52- year-old male with post-traumatic wound with bone exposure on the medial side of the right great toe. Debridement with curettage and VAT (vacuum assisted therapy) was performed primarily, followed by application of Matriderm® and a split-thickness skin graft. The patient stayed in the hospital for four weeks and the wound epithelialization lasted six weeks (Fig. 1 a, b, c, d, e, f).



Figure. 1(a, b, c, d, e, f). A 52- years-old male patient with post-trauma with bone expose soft tissue defect, at the beginning and end of surgical treatment using Matriderm® and a split-thickness skin graft.

Case 2; A 72-year-old female with chronic venous insufficiency suffered from an unhealed venous foot ulcer up to 6 months on the anterior part of the right leg after after trauma.

Debridement with excision of wound margins was performed primarily, followed by application of Matriderm® and a split-thickness skin graft.

The patient stayed in the hospital for two weeks and the wound epithelialization took four weeks. (Fig. 2, a, b, c).



Figure 2 (a,b,c). A 72-year-old female with chronic venous wound treated with Matriderm® and a split-thickness skin graft.

Discussion

Post-traumatic and chronic wounds with bone exposure is not simply a problem of soft tissue defects; it also degrades the quality of life of patients and can cause complications, such as amputation and sepsis. Therefore, surgical treatment for this severe type of wounds with primary closure, skin graft, and flap application is important [10].

Primary closure is possible only for small wounds, and skin grafting is easy to perform; however, the latter does not take well in deep wounds and has low durability. Flap application can overcome the limitations of skin grafting; however, it is burdened with the risk of complications, such as flap necrosis, especially in the cases of common diabetes with a poor vascular state and chronic venous insufficiency. In 2000, the use of a collagen–elastin matrix for the treatment of burn wounds in a one-stage grafting model was described by *Van Zuijlen et al.* [11]. This is a highly porous, 1-mm-thick membrane, fully biodegradable, three dimensional, composed of native bovine collagen fibers I and V, coated with elastin hydrolysate derived from bovine ligamentum nuchae in a concentration of three weight-to weight ratio, and the matrices were treated with gamma-irradiation (1000 Gy) and stored at room temperature.

In the past 10 years, dermis, collagen, and elastic fibers have emerged as important components of wound healing. *Cuono et al*. [12], presented a synthesized functional dermal tissue with elastic fiber that had excellent resilience for prevention of scar formation. Matriderm®, which was used in our study, is a three-dimensional matrix composed of collagen fibrils and elastin fibers for support of dermal regeneration in one stage.

It induces dermis regeneration as a scaffold and decreases scar tissue formation. It also provides optimal dermal wound bed preparation as regenerated skin with extensive formation of rete ridges and capillary loops but with the absence of skin appendages and is ready for relatively thinner subsequent skin grafting [12].

Collagen is obtained from the bovine dermis and contains dermal collagen types I, III, and V. Elastin is obtained from the bovine nuchal ligament by hydrolysis. In addition, Matriderm® has excellent hemostatic properties and thus reduces the risk of hematoma formation under grafted skin.

In our study, the experimental group treated with Matriderm® showed a shorter length of hospital stay and length of complete wound closure and showed a higher elasticity ratio of the affected lesion.

We concluded that Matriderm® induced dermal regeneration and facilitated the graft take. Patients with chronic wounds like diabetic foot ulcers seem to hope for an especially quick return to their daily lives, which was possible in the experimental group. We applied a meshed Matriderm® and meshed split-thickness skin graft to facilitate graft take [13].

We expect that meshed Matriderm® would also be effective on wounds with a bleeding tendency, such as those associated with liver cirrhosis or chronic renal failure with dialysis. In our study, elasticity was the most important component for data analysis, considering the predictive factors for recurrence [14, 15] [19].

As we continue to do follow-up with the patients, we expect lower recurrence in the experimental group, given its higher elasticity, than the control group with a lower elasticity. In each patient, the dermal substitute, MatriDerm®, showed positive effects in accelerating the improvement of the quality and the functionality of skin reconstruction.

Dermal substitutes may act as a barrier for vascular ingrowths and hamper diffusion of nutrients by increasing the distance between the wound bed and the graft, for this reason, it was postulated that survival of the overlying skin graft could be at risk after dermal substitution. Furthermore, the skin elasticity parameters of wound areas treated with MatriDerm® were significantly improved in less time when sheet auto grafts were used [12].

The experimental group showed a shorter hospital stay. According to these results, we believe that Matriderm® can be an effective treatment for post-traumatic with bone exposure and chronic non-healing wounds.

Discussion

Wound healing is an evolutionarily conserved complex multi-cellular process that aims at restoring the skin barrier. This process involves coordinated efforts of several cell types including keratinocytes, fibroblasts, endothelial cells, macrophages, and platelets. The migration, infiltration, proliferation, and differentiation of these cells will culminate in an inflammatory response, the formation of new tissue, and ultimately wound closure. This complex process is executed and regulated by an equally complex signaling network involving numerous growth factors, cytokines, and chemokines [17,18]. This has been available in Europe since 2004 (MatriDerm®; Dr Suwelack, Skin and Health Care AG, Billerbeck, Germany).

Conclusions

Our study demonstrates the role of MatriDerm® in combination with skin autologous graft in tissue regeneration and wound closure with a significant reduction in healing time to 15 days in post-traumatic wounds with bone exposure and chronic wounds. On the basis of our clinical practice, we consider MatriDerm® and skin autologous graft as the key element to improve functional and aesthetic outcomes. This association guarantees a temporary barrier with multiple functions: hemostatic, reduction of contracture wound, infection, maintenance of skin elasticity and dermal architecture, and better appearance of the scar. Furthermore, the minimally invasive technique is well accepted by patients with a noteworthy improvement in quality of life along with cost reduction due to the fewer number of medications. In conclusion, our results show that the integration of different disciplines such as cell therapy, bioengineering, and biomaterials sciences is an effective support to successful surgical treatment and definitely healing of post-traumatic with bone exposure and chronic wounds.

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