Techniques for Treatment of Severe injuries and Quality of Medical Care

How to successfully use artificial dermis
In-depth emergency procedure by which improvement in quality of wound can be expected

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An artificial dermis, PELNAC (GUNZE Limited), was developed to heal injuries accompanied by deep skin defects, severe burn, and full-thickness defects after excision of tumors, nevi or scars.

While the artificial dermis is used mainly in plastic surgery, it is also used in the emergency procedure for patients with severe injuries with exposed bone and tendon, who were transported by ambulance to an orthopedic ward or an emergency and critical care center. In such cases, since the artificial dermis will be gradually replaced by dermis-like granulation tissue, it can contribute to the improvement of the quality of patients’ lives including functional recovery after surgery and cosmetic outcome.

This time, we had the privilege of interviewing Dr. Masato Kurokawa, Head of Department of Plastic Surgery, Takarazuka City Hospital, Adjunct professor of Plastic Surgery, Osaka City University Hospital and Shiga University of Medical Science Hospital about the advantages and disadvantages of using artificial dermis and how to make good use of artificial dermis, focusing on the treatment of severe injuries.

Artificial dermis is effective against deep skin defects

First, could you tell me for what purposes the artificial dermis is used? Previously, the skin graft or flap had been carried out in the treatment of deep skin defects due to severe injuries or third-grade burn. In recent years, the artificial dermis has emerged as a medical material for healing the wounds in deep skin defects. The artificial dermis has a bilayer structure comprised of collagen sponge and silicon sheet. The main feature of this artificial dermis is that the fibroblasts and capillaries enter the collagen sponge adhered to the surface of the wound to regenerate the self-collagen and then the collagen sponge is degraded, and finally the dermis-like granulation tissue is formed. After the dermis-like granulation tissue is formed in 2 to 3 weeks, the silicon sheet is removed, followed by ultra-thin split-thickness skin grafting (Figure 1). Because the dermis-like tissue has already been formed as a bed, the degree of postoperative contraction, which occurs in the case of conventional skin graft, is smaller, and the skin with fine texture can be reconstructed.

Dermis-like tissue can be formed on exposed bone or tendon, allowing skin grafting

Could you tell me the advantages and disadvantages of the treatment using artificial dermis? The main advantage is that the degree of postoperative contraction of skin graft is small. Since the skin grafting can be achieved by ultra-thin split-thickness skin grafting, the donor site for skin grafts is less invaded and can be epithelialized rapidly, with the formation of hypertrophic scar being minimized. The treatment using artificial dermis can also improve the skin texture and cosmetic outcome. Even on the exposed bone or tendon where the skin graft is difficult to survive, the dermis-like granulation tissue is formed and skin grafting can be performed.

In the case of deep skin wounds, due to the inability to perform skin grafting, the flap transfer should be considered. If the flap cannot be obtained from near the wound, a free flap should be harvested from other parts of the body to be transferred. This is considerably invasive to the flap donor site and requires long surgical duration. On the other hand, in the case of artificial dermis, all you need are the debridement of wound site and the application of artificial dermis onto the debrided area. These procedures can reduce the invasion to the donor site, the time required for excision and grafting of skin, and the total number of surgeries including treatments for contracture or complications. Since the dermis-like tissue is formed in the artificial dermis, even when employing the mesh skin graft as a secondary one, the scarring is slight and the joint function is also preserved.

The main disadvantage is that two surgeries have to be carried out because a secondary skin grafting is usually required in the case of artificial dermis. In addition, since this is an artificial material, it is undeniable that it is susceptible to infection,
Artificial dermis is an effective means of emergency treatments for severe injuries.

Could you tell me in detail how to use artificial dermis and its advantages when applying it to severe injuries?

When patients who are involved in traffic accidents and transported to emergency and critical care center are taken as an example, if they have severe injuries accompanied by deep skin defects on the extremities, requiring rescue measures, a life-saving treatment should be the top priority, but the closure of skin defects is also required as an emergency procedure. In such cases, the debridement of the extremities is performed and, for example, lyophilized porcine skin and silicon-nylon composite membrane are used as wound dressings for wound closure. It is true that dressing enables temporal closure of wounds, but a secondary reconstruction is required. If artificial dermis is used instead of dressing, the dermis-like tissue is formed during a period of time when the most urgent and crucial treatment is being performed in advance. Therefore, a secondary skin grafting requires a thinner graft and an invasion to donor site is less significant. In addition, actually, the postoperative quality of patients’ lives is better than that when a secondary reconstruction is employed.

I think that artificial dermis may become an effective treatment means for wounds in emergency room. Although the efficacy of artificial dermis in such situations has been less well recognized, I think it is worthwhile to review it, when considering from the standpoint of quality of patients’ lives. One of the advantages of artificial dermis is that even when the graft fails to survive due to certain reasons including infection, the invasion to donor site can be less significant in the case that artificial dermis is employed.

In addition, if an artificial dermis with mesh reinforcement is applied to wound areas after trauma, the drainage effect by which effusion can be discharged is also expected, by means including punching holes. In the case of trauma, since hematoma may be formed due to excessive bleeding, it is also important to prevent its formation.

Severe injuries are often accompanied by deep skin defects with exposed bone and tendon. Could you tell me how to use artificial dermis in such cases?

Artificial dermis can be effectively applied to various wound surfaces, especially to skin defect area with exposed bone and tendon. Skin grafts usually do not adhere to exposed bone and tendon. After artificial dermis is applied to exposed bone and tendon, the so-called “bridging phenomena” take place in collagen sponge. Specifically, surrounding fibroblasts and capillaries enter collagen sponge, recovering a blood flow, and dermis-like granulation tissue is formed.

Case 1 is an eight-year-old boy, who was run over by a truck when he was on his bicycle and had a crush wound on the left lower thigh and a compound fracture of the tibia. Approximately two-thirds of the skin of the lower thigh was exfoliated and skin defects were also observed on the feet and the part of the lower thigh. The exfoliated skin was put back in original place as much as possible, and PELNAC was applied to the raw area. On Day 16 after the injury, a secondary skin grafting was performed in conjunction with debridement of the necrosed skin. At four years after surgery, the outcome is good, without any scar or contracture (Figure 2).

If skin is directly grafted on exposed muscle or tendon, adhesions may be formed owing to the lack of dermis layer or soft tissue, resulting in contracture. In the case of artificial dermis, because of the existence of thick dermis-like tissue composed of collagen, it is stiff at first but gradually becomes soft, and the flap-like texture can be achieved.

Treatment of fingertip injuries can be simplified by using artificial dermis with good functional and cosmetic outcomes.

It is said that fingertip injuries represent a substantial portion of all wounds. Could you tell me how you use artificial dermis for fingertip injuries?

Fingertip injuries commonly occur during work or household activities. Since the fingertip is an important area, careful consideration should be given to the reconstruction both functionally and cosmetically. For treating fingertip injuries, cerclage, while skin grafting, flap transfer, and open therapy are used commonly, we are currently employing the transfer of reverse digital artery flap, aluminum foil treatment, and treatment using artificial dermis. Especially, a method using artificial dermis is relatively simple and is producing good results. This method is indicated for fingertip injuries distal to the DIP joint. We are employing the treatment using artificial dermis regardless of the site of injury, depth of injury, or whether the distal tip of bone is exposed or not.

The artificial dermis is applied to an injured site and secured with sutures or tapes. Approximately two weeks later, the silicon sheet is removed and the conservative treatment with ointment will be continued without skin grafting until epithelialization is achieved. This method can minimize finger deformity and is producing good results both functionally and cosmetically.

For the treatment of a large wound in the finger pad, etc., however, the transfer of reverse digital artery flap will be employed due to the lack of soft tissue.
I hear that you once conducted a comparative study of aluminum foil method (a conservative treatment) and treatment with artificial dermis. Could you tell me the results?

We compared 43 fingers treated with artificial dermis with 20 fingers treated with aluminum foil method. The results showed that although the number of days required for epithelialization was approximately five days greater than that in patients with aluminum foil method, the hemostatic effect and pain relief effect were better in patients treated with artificial dermis. In cases treated with artificial dermis, the morphological outcome after wound closure was relatively good, and especially in cases with nail bed defects, no deformities were observed in the nails. The quality of patients’ lives was also excellent with the same level as in cases treated with flap transfer.

Case 2 is a 24-year-old man, who cut his distal middle finger diagonally when using a slicer. Because he did not bring the severed fragment, PELNAC was promptly applied to the raw area. Two weeks later, the silicon sheet was removed and an ointment treatment was started instead. Epithelialization was achieved in 35 days. The morphological outcome at one year after surgery is favorable (Figure 3).

Finally, could you tell me what kind of feeling do you get from the clinical experience with PELNAC, an artificial dermis?

I think that PELNAC is characterized by a 3 mm-thick collagen layer and the compact and highly flexible collagen sponge. It can adhere firmly to curved wound surface and wrap around the tube shapes such as fingers comfortably. Therefore, the following can also be pointed out as the features: firstly, since it adheres firmly to wound surface, hematoma is hardly formed; and secondly, due to its softness, the physical irritation and patient’s pain can be reduced. In addition, because the mesh reinforced type is also available, we are using this type of artificial dermis, when it will be fixed using a stapler or sutured, or will have holes punched. Although PELNAC is required to be immersed in normal saline before use, I occasionally use it without immersion. Although a secondary skin grafting is required in the treatment using artificial dermis, I consider that the abilities to reduce the total number of surgeries, to alleviate the contracture, to achieve favorable cosmetic and functional outcome, and to help to improve the quality of patients’ lives are the main advantages of artificial dermis in the treatment of severe injuries.