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Retrospective Study

Artificial dermis combined with skin grafting for the treatment of hand skin and soft tissue defects and exposure of bone and tendon

Wei Wang, Dong-Sheng Chen, Zhao-Di Guo, Dan Yu, Qin Cao, Xiao-Wei Zhu

Abstract

BACKGROUND

The recovery time of hand wounds is long, which can easily form chronic and refractory wounds, making the wounds unable to be properly repaired. The treatment cycle is long, the cost is high, and it is prone to recurrence and disability. Double layer artificial dermis combined with autologous skin transplantation has been used to repair hypertrophic scars, deep burn wounds, exposed bone and tendon wounds, and post tumor wounds.

AIM

To investigate the therapeutic efficacy of autologous skin graft transplantation in conjunction with double-layer artificial dermis in treating finger skin wounds that are chronically refractory and soft tissue defects that expose bone and tendon

METHODS

Select 68 chronic refractory patients with finger skin and soft tissue defects accompanied by bone and tendon exposure who were admitted from July 2021 to June 2022. The observation group was treated with double layer artificial dermis combined with autologous skin graft transplantation (n = 49), while the control group was treated

with pedicle skin flap transplantation (n = 17). Observe and compare the treatment status of two groups of patients, including the time between surgeries and hospital stay. The survival rate of skin grafts/flaps and postoperative wound infections were evaluated using the Vancouver Scar Scale (VSS) for scar scoring at 6 mo after surgery, as well as the sensory injury grading method and two-point resolution test to assess the recovery of skin sensation at 6 mo. The satisfaction of the two groups of patients was compared.

RESULTS

The observation group's wound healing time was significantly longer than the control group's (P < 0.05, 27.92 ± 3.25 d *vs* 19.68 ± 6.91 d); there was no significant difference in the survival rate of skin grafts/flaps between the two patient groups (P > 0.05, 95.1 ± 5.0 *vs* 96.3 ± 5.6). The observation group's interval between two surgeries (20.0 ± 4.3 d) and hospital stay (21.0 ± 10.1 d) were both significantly shorter than those in the control group (27.5 ± 9.3 d) and hospital stay (28.4 ± 17.7 d) (P < 0.05). In comparison to the control group (23.5%) and subcutaneous hematoma (11.8%), the observation group's postoperative infection (10.2%) and subcutaneous hematoma (6.1%) were considerably lower. When comparing the two patient groups at six months post-surgery, the observation group's excellent and good rate of sensory recovery (91.8%) was significantly higher than the control group's (76.5%) (P < 0.05). There was also no statistically significant difference in two point resolution (P > 0.05). The observation group's VSS score (2.91 ± 1.36) was significantly lower than the control group's (5.96 ± 1.51), and the group's satisfaction was significantly higher (P < 0.05, 90.1 ± 6.3 *vs* 76.3 ± 5.2).

CONCLUSION

The combination of artificial dermis and autologous skin grafting for the treatment of hand tendon exposure wounds has a satisfactory therapeutic effect. It provides a safe, effective, and easy to operate treatment method, which is worthy of clinical promotion.

INTRODUCTION

As the primary organ used for labor and work, the hands and arms account for the majority of work-related injuries[1,2]. Hand injuries can have a major impact on a person's social work and everyday activities, causing patients to experience both physical and financial hardship[3,4]. The opponent is greatly impacted by pressure injuries to the hand, and because of the lengthy healing period, chronic and refractory wounds are easily formed, rendering the wound incapable of being adequately treated. The inability to recover quickly makes it challenging to return to a regular functional state. Patients continue to have severe problems with the inflammatory response[5-7]. Pressure damage wounds are readily chronic and resistant if they are not treated promptly, which will have a major negative impact on the wound's ability to heal[8,9].

The inability of the skin and subcutaneous soft tissue of the body to undergo a normal, orderly, and timely repair state under the influence of internal and external factors, exhibiting a pathological inflammatory response: the trend of wound non-healing, is the complex formation mechanism of chronic refractory wounds[10,11]. The quality of life is significantly impacted by its intricate pathophysiology, which is frequently incurable, and even by secondary infections[12]. In addition, the etiology is complicated, the course of therapy is protracted, expensive, and it is likely to reoccur and cause disability. In the medical field, treating refractory wounds has never been easy[13]. Tissue engineering advancements have made it possible to treat refractory wounds with a novel approach that combines autologous skin graft with double layer artificial dermis, offering a fresh approach to fixing minor finger skin abnormalities. Hypertrophic scars, severe burn wounds, exposed bone and tendon wounds, and postoperative tumor wounds have all been repaired using it[14]. This technique can reduce harm to the skin donor area, speed up the healing process, improve the appearance of the healed wound surface, and encourage the functional recovery of the

hands and feet. It can also speed up the healing process and lower the chance of scarring and recurrence.

In this study, a prospective analysis was conducted on 68 patients with refractory hand wounds admitted to the First People's Hospital of Jiangxia District, Wuhan City from July 2021 to June 2022. Double layer artificial dermis combined with autologous skin graft has been applied to the treatment of refractory wounds and has achieved certain clinical results, as described below.

MATERIALS AND METHODS

Clinical data

Select 68 patients with chronic and refractory hand wounds who were admitted to our hospital from July 2021 to June 2022. The general information and wound situation is shown in Table 1.

Inclusion and exclusion criteria

Inclusion criteria: (1) Comply with the diagnostic criteria for hand bone and joint injuries in the "Diagnostic Standards for Orthopedic Diseases", with finger skin and soft tissue defects accompanied by tendon or bone exposure, and comply with skin flap transplantation; (2) Receive treatment 12 h after injury; (3) No severe organ and tissue diseases such as heart, brain, blood vessels, liver, kidney, lung, *etc.*

Exclusion criteria: (1) Individuals with infections in other parts of the urinary system, respiratory system, *etc.*; (2) People with diabetes, heart disease, and arterial occlusive disease of lower limbs; (3) Individuals with severe mental, neurological, immune, and hematological disorders.

Methods

After admission, the patient underwent thorough debridement to remove necrotic and degenerative skin, soft tissue, periosteum, and other tissues attached to the wound

surface, tendons, and phalanges. The necrotic tendons were removed according to the situation and the periosteum and aponeurosis were preserved as much as possible. After sufficient hemostasis, the wound surface was repeatedly rinsed with hydrogen peroxide and physiological saline.

The observation group was treated with double-layer artificial dermis combined with autologous skin graft. Artificial dermis implantation: Select a suitable model of double-layer artificial dermis (Lando, Shenzhen Qikang Medical Equipment Co., Ltd.) based on the size and shape of the wound, cut it appropriately, soak it in sterile 0.9% physiological saline, and replace it after 5 min, repeating 3 times. Use a thick needle to puncture the artificial dermis for drainage purposes. Distinguish the upper and lower layers of artificial dermis, tightly fit the wound surface with collagen surface, avoid wrinkles and gaps, and sew and fix the edges. The inner layer is covered with sterile Vaseline gauze, and the outer layer is wrapped with sterile gauze. After 3-5 d, replace the Vaseline gauze and sterile gauze, and observe the wound surface covered by the artificial dermis. If there is fluid accumulation under the artificial dermis, it can be squeezed and discharged appropriately. After treatment, continue to use Vaseline gauze and sterile gauze for wrapping. Afterwards, replace the dressing every 2-3 d and observe the condition of the artificial dermis autologous skin grafting: After 2-3 wk, when the color of the artificial dermis changes to reddish yellow or orange, the outer layer of the artificial dermis is removed. Based on the size of the patient's wound, an autologous medium thickness skin graft with a thickness of approximately 0.4 mm is taken from the normal skin (forearm). Use a thick needle to appropriately puncture the autologous skin, cover it with vascularized artificial dermis, and suture and fix it. The inner layer is padded with sterile Vaseline gauze, and the outer layer is padded with sterile gauze for wrapping. The skin supply area is covered with sterile Vaseline gauze, and sterile gauze is used for pressure wrapping. Change the dressing 7-10 d after surgery, observe the survival of the skin graft, and then change the dressing every 2-3 d. According to the survival status of the skin graft, remove the dressing and suture 12 to 14 d after surgery.

The control group was treated with pedicle flap transplantation. Abdominal pedicle flap transplantation. Design a skin flap based on the size of the finger wound and the abdomen, and the flap should extend 20% beyond the area of the finger skin defect. Layered intermittent suturing repair of the flap donor area. Place the affected finger in the appropriate position of the abdominal skin flap and intermittently suture the skin flap and the skin margin of the finger wound the flap has a broken pedicle. Four weeks after the surgery, the pedicle of the abdominal pedicle skin flap was performed.

Observation indicators

Observe and compare the treatment status of two groups of patients: (1) Compare the interval between two surgeries and hospitalization time; (2) Evaluate wound healing through complete closure and epithelialization of the wound edge; (3) Evaluate the survival rate of skin grafts by assessing the proportion of active skin fragments on the wound surface.

Observe and compare postoperative wound infections between two groups of patients: (1) Evaluate the amount of exudate through the Falange score of 4, with 1 being the minimum value; 2: Moderate; And 3: Out of control; (2) Evaluate subcutaneous hematoma based on the proportion of patients with subcutaneous hematoma.

Observe and compare the postoperative wound recovery of two groups of patients: (1) Evaluate the skin sensation recovery after 6 mo using the sensory injury grading method and two-point resolution test. Among them, the sensory injury grading method S5: completely normal sensation; S4: Complete pain and tactile sensation with two-point discrimination; S3: Complete pain and tactile sensation; S2: Pain and local touch; S1: Deep pain; S0: No sensation at all. S0 and S1 were considered poor, S2 and S3 were considered good, and S4 and S5 were considered excellent. The excellent rate and excellent rate were calculated; Two-point discrimination test, with higher scores and smaller distances indicating better finger recovery; (2) After 6 mo, the Vancouver Scar

Scale (VSS) was used to evaluate the scar condition in the receptor area, which included four aspects: color, vascular distribution, thickness, and softness, with a score of 0 to 15 points; The higher the score, the heavier the scar, and vice versa.

·Observe and compare the satisfaction of two groups of patients, and evaluate them through a questionnaire at the end of the sixth month of follow-up, with a score range of 0 to 100. The higher the score, the higher the patient satisfaction.

Statistical analysis

The data analysis was conducted using SPSS 26.0 statistical software. The chi square test is used to compare differences in categorical variables, such as postoperative wound infection and subcutaneous hematoma. For continuous variables, first perform a normality test. For variables with a normal distribution, such as exudate volume and VSS, independent sample testing is used for difference comparison and the values are reported as mean ± SD (standard deviation). $P < 0.05$ indicates a statistically significant difference.

Ethical considerations

All adult subjects were given written informed consent, and all clinical studies followed the principles of the Helsinki Declaration. Prior to analysis, all patient data was anonymous. The patient agrees in writing to use the accompanying photos in research, reports, and publications. The implementation of clinical monitoring is to monitor whether informed consent has been obtained from all selected patients, whether the treatment process has been carried out correctly, and whether the recorded data is sufficient and accurate.

RESULTS

All 68 cases of chronic and refractory wounds in the hands healed. After all patients are cured, they are discharged and followed up once a month for 6 mo.

Postoperative wound conditions of patients

Table 2 and Figure 1 show that the interval between two surgeries (20.0 ± 4.3 d) and hospitalization time (21.0 ± 10.1 d) in the observation group (artificial dermis combined with autologous skin graft transplantation) were significantly shorter than those in the control group (skin flap transplantation) (27.5 ± 9.3 d) and hospitalization time (28.4 ± 17.7 d) ($P < 0.05$), but the wound healing time in the observation group was significantly longer than that in the control group ($P < 0.05$, 27.92 ± 3.25 d *vs* 19.68 ± 6.91 d); There was no significant difference in the survival rate of skin grafts/flaps between the two groups of patients ($P > 0.05$, 95.1 ± 5.0 *vs* 96.3 ± 5.6). The postoperative infection (10.2%) and subcutaneous hematoma (6.1%) in the observation group were significantly lower than those in the control group (23.5%) and subcutaneous hematoma (11.8%). At 6 mo after surgery, the excellent and good rate of sensory recovery in the observation group (91.8%) was significantly higher than that in the control group (76.5%) ($P < 0.05$), and there was no statistically significant difference in two point resolution between the two groups of patients ($P > 0.05$); The VSS score of the observation group (2.91 ± 1.36) was significantly lower than that of the control group (5.96 ± 1.51), and the satisfaction of the observation group was significantly higher than that of the control group ($P < 0.05$, 90.1 ± 6.3 *vs* 76.3 ± 5.2).

Typical case

Figures 2 and 3 show representative cases of the natural process of skin grafts after surgery in two groups.

DISCUSSION

Exposed wounds of hand and foot tendons are extremely common in the clinical work of hand and foot surgeons and burn plastic surgeons. Due to the extremely important role of hands and feet in the daily life of patients, priority should be given to the function and aesthetic appearance of the affected limb when deciding on the repair method for such wounds[15]. Free flap transplantation is currently the most widely used

treatment method for full-thickness skin defects[16]. But as people's pursuit of beauty continues to improve, the restoration of the appearance of hand and foot wounds after injury is increasingly valued, and the main factor affecting the appearance is excessive scar hyperplasia. Studies have shown[17-19] that the main cause of scar formation is the contraction of the wound surface. Inhibiting the contraction of the wound surface helps to promote scar free regeneration, while artificial dermis, as a wound contraction inhibitor, can eliminate contraction and achieve scar minimization when used to treat soft tissue defects. Nowadays, artificial dermis has been widely used in the repair of burns, severe injuries, and non healing wounds, and has achieved satisfactory results[20-22]. However, there are few reports on the application of artificial dermis combined with autologous skin patches in exposed wounds of hand and foot tendons.

Double layer artificial dermis is a substitute for dermis, with characteristics such as biomimetic and biodegradable properties[23]. The domestically produced double-layer artificial dermis Lando is composed of a medical silicone film on the surface layer and a bovine Achilles tendon collagen and polysaccharide removed from the end peptide on the lower layer. The semi transparent medical silicone film on its surface has biomimetic function, which can play a role in breathability, controlling moisture, and blocking bacteria. It has suitable flexibility, can fit the wound surface and have mechanical strength, ensuring the sealing of the wound and reducing the risk of infection. The lower dermis has a degradable function, and its sponge like scaffold layer guides the inward migration, proliferation, and gradual maturation of vascular endothelial cells and capillaries to form new blood vessels and dermal regeneration, reducing scar formation, contracture, and restoring skin elasticity[24]. Artificial dermis is commonly used to repair burn wounds and has gradually been used in recent years to repair exposed wounds of bones and tendons[25].

Artificial dermis is divided into a silicone membrane on the surface and a collagen sponge on the bottom. The collagen sponge provides a scaffold for the orderly growth of fibroblasts and the formation of capillaries on the wound surface, constructing dermoid tissue with rich blood supply, covering exposed tendons and bone tissue,

thereby providing a good transplant bed for autologous skin graft transplantation and promoting skin graft survival. Therefore, the patient satisfaction and incidence of limb deformities in the observation group of this experiment are better than those in the control group. In addition, due to the proximity of the composition and structure of artificial dermis to natural human skin, it can guide the growth of cells and blood vessels, thereby achieving orderly regeneration and permanent reconstruction of dermis tissue[19]. After the artificial dermis is fully vascularized, remove the silicone membrane and transplant a very thin layer of autologous skin onto the newly formed granulation tissue, achieving effects similar to medium or even full thickness skin transplantation. Therefore, in this experiment, patients with exposed hand and foot tendons were treated with artificial dermis combined with autologous skin grafting. Due to the traditional free skin flap transplantation, the donor site healing time, wound surface, and scar growth in the donor site were repaired.

In this study, the observation group and the control group used Lando double-layer artificial dermis and pedicled skin flap transplantation to repair wounds, respectively. There was no significant difference in the survival rate of the skin graft/flap between the two groups after surgery. However, the observation group had shorter surgical intervals and hospital stays compared to the control group, and the postoperative appearance of the fingers was more beautiful. The skin contracture and scar formation after repair surgery are also important factors in evaluating the effectiveness of repair. We conducted a VSS score on the patient's wound surface during a follow-up of 6 mo after surgery, and the results showed that the VSS score in the observation group was significantly lower than that in the control group. This indicates that domestic Lando combined with autologous skin grafting is an effective method for repairing finger skin and soft tissue defects with bone and tendon exposure. In addition, the results of this study showed that with the prolongation of time after surgery, both groups of patients gradually recovered their finger sensation, and the observation group had a significantly higher sensory recovery score at 6 mo after surgery than the control group, indicating that the use of Lando double-layer artificial

dermis for wound repair is more effective than pedicle skin flap transplantation. Perhaps it is because newly generated fibroblasts and capillaries in the adjacent tissues after implantation of artificial dermis immerse into the pores of the collagen sponge layer, degrading to form a dermal like granulation tissue matrix. On this basis, thin skin grafting is carried out, effectively reducing epidermal contracture and scar hyperplasia, and improving finger sensation recovery and flexibility. The proportion of patients in the observation group who had a 2-point resolution of 4-6 mm was higher than that of the control group at 6 mo after surgery, despite the fact that there was no significant difference in two-point resolution between the two groups. This finding may be related to the result bias brought on by the small number of cases.

The results of this study show that compared with traditional skin flap repair methods, the application of artificial dermis in wound repair has the following advantages: (1) It can significantly inhibit scar growth and reduce skin contracture; (2) It can directly cover exposed tendons, reduce tendon adhesion, and create an excellent transplantation bed for blade thick skin grafting; (3) Increase the thickness and quality of soft tissue to achieve thinner autologous epidermal transplantation, minimizing trauma to the donor site; (4) After wound healing, the appearance is close to normal, effectively avoiding secondary scar repair; and (5) The surgical time is short, the surgery is simple and easy to perform, and the risk is low.

The results of this study indicate that thorough debridement of the wound surface is crucial before using double-layer artificial dermis, which is an important foundation for smooth vascularization of the artificial dermis[26,27]; In addition, we found that newly formed dermal tissue slowly grows inward from the outer edge of the wound, gradually covering the exposed bones and tendons until it is completely covered. Therefore, when double-layer artificial dermis is used to cover the wound, it should cover the fresh tissue at the edge of the wound to ensure successful vascularization of the artificial dermis and lay a solid foundation for later skin grafting. Infection and hematoma on the wound surface are the most common causes of failure in artificial dermis transplantation, so thorough debridement, hemostasis, and postoperative

pressure bandage are all important for postoperative efficacy[28]. We choose to open the dressing and change the dressing for the first time 3-5 d after the surgery, observe the wound condition, and if there is a hematoma or infection, the infection or hematoma can be removed in a timely manner. The remaining artificial dermis can still be successfully vascularized, and measures such as dressing with physiological saline soaked in gauze containing antibiotics such as gentamicin or combined with negative pressure drainage can be applied. During the treatment process, the treatment strategy can be adjusted in a timely manner according to the actual situation of the patient[29].

But as reported in some literature[30,31], there are also some problems with the combination of artificial dermis and autologous skin graft repair: (1) This technology inevitably involves secondary surgery, so in the experiment, the observation group patients had longer wound healing time than the control group, and there were patients in the observation group who were dissatisfied with the long treatment cycle; (2) Although artificial dermis is relatively expensive, due to the obvious scars, transfer flap surgery often requires secondary scar repair treatment, so the overall cost increase is not significant. Therefore, in order to compare the hospital stay, cost, and surgical frequency of artificial dermis combined with autologous skin flap repair with traditional skin flap repair, a cost-benefit analysis is still needed; (3) The anti infection ability of artificial dermis is poor, and the combination of artificial dermis and autologous blade thickness skin grafting requires strict aseptic procedures; and (4) The formation of hematoma is a common complication of artificial dermis and can easily lead to interruption of healing and loss of artificial dermis. Therefore, the combination of artificial dermis and autologous skin graft requires careful hemostasis and appropriate fixation.

The limitation of our research is that firstly, this graduate student is a small center study, so our sample size is limited and larger studies are needed to determine the clinical efficacy of artificial dermis combined with skin grafting treatment. Secondly, this study did not take into account factors that may affect wound recovery, such as the patient's job type, whether they smoke or drink alcohol.

CONCLUSION

In summary, it is preliminarily believed that the combination of artificial dermis and autologous skin graft has a satisfactory therapeutic effect on hand tendon exposure wounds. It provides a safe, effective, and easy to operate treatment method, which is worthy of clinical promotion.

ARTICLE HIGHLIGHTS

Research background

When paired with autologous skin transplantation, double layer artificial dermis can promote functional recovery of hands and feet, limit damage to the skin donor area, improve the appearance of the healed wound surface, speed up the healing process, and lower the chance of scar formation and recurrence.

Research motivation

Treatment of chronic and refractory skin and soft tissue defects of fingers with exposed bones and tendons.

Research objectives

To explore the clinical effect of double layer artificial dermis combined with autologous skin graft in repairing chronic refractory skin and soft tissue defects of fingers with exposed bone and tendon.

Research methods

68 chronic refractory patients with finger skin and soft tissue defects accompanied by bone and tendon exposure admitted to our hospital were selected and divided into an observation group (double layer artificial dermis combined with autologous skin grafting) and a control group (pedicle skin flap transplantation). Observe and compare

the treatment status of two groups of patients, as well as the survival rate, scar formation, recovery, and patient satisfaction of skin grafts/flaps at 6 mo after surgery.

Research results

The observation group's recovery, postoperative infection, treatment, and patient satisfaction all fared far better than those of the control group. The skin sensation recovery and skin graft/flap survival rate did not significantly differ between the control and observation groups.

Research conclusions

The combination of artificial dermis and autologous skin graft has a satisfactory therapeutic effect on hand tendon exposure wounds.

Research perspectives

The combination of artificial dermis and autologous skin grafting can be an effective method for treating hand tendon exposed wounds.

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