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Application of Autogenous Dermis Combined With Local Flap Transplantation in Repair of Titanium Mesh Exposure After Cranioplasty

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Objectives: To investigate the clinical outcome of autogenous dermis combined with local flap transplantation in the treatment of titanium mesh exposure after cranioplasty.

Methods: We studied a total of 8 patients with titanium mesh exposure after cranioplasty. After debridement of the head wound, the autogenous dermal tissue from the lateral thigh was transplanted to the surface of titanium mesh, and the local skin flap was then applied after suturing and fixation to repair the wound on the surface of the dermis. To repair the lateral thigh dermal tissue area, a local skin flap was obtained, and a blade thick skin graft was used.

Results: Both dermal tissue and local skin flap survived. In the meanwhile, the donor skin area of the lateral thigh healed well, with only slight scar hyperplasia, and the titanium mesh was preserved. There was no recurrence after 6 months of follow-up.

Conclusions: The application of autogenous dermis combined with local skin flap to repair titanium mesh exposure can effectively avoid skin flap necrosis, potential re-exposure of titanium mesh, sub-flap effusion, infection, and other problems. This method has an ideal effect, has easy access to materials, and reduces patients' economic burden. It is worth popularizing.

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INTRODUCTION

It is popular in the field to use 3-dimensional titanium mesh to repair skull defects caused by craniocerebral trauma, tumor, and other reasons. This operation method is simple and fast and able to restore the patient's appearance to the greatest extent; thus, it has been widely promoted and used in clinical.[1] However, the titanium mesh is often exposed due to infection, effusion under the skin flap, or necrosis of the skin flap and other reasons,[2] which then causes great difficulty in subsequence treatment. Once the titanium mesh is exposed, if not dealt with in time and effectively, it may not only lead to the failure of repair but also lead to intracranial infection and other serious consequences.[3] There are many treatment methods for titanium mesh exposure in clinical practice. If the exposed area is small, it can be cured by a conservative dressing change. If the exposed area is large, surgical treatment should be chosen. The traditional surgical plan is to remove the titanium mesh and repair the titanium mesh again after the wound is healed. However, repeated operations not only increase the medical expenses, life, and psychological burden of patients but also increase the risk of titanium mesh exposure (Q2) .To close the wound and effectively preserve the titanium mesh, clinicians have achieved certain efficacy through local rotating flaps, fascial flap transplantation, or free skin grafting and free flaps.[4] Researchers reported that an acellular dermal matrix can prevent titanium mesh exposure during cranioplasty and can also be used as a biological mesh to avoid direct contact between cerebrospinal fluid and surface repair tissue, which is conducive to wound repair.[5] However, the high cost of acellular dermal matrix prevents it from being widely used in clinical practice. (Q1) From January 2019 to January 2022, the authors treated 8 patients with titanium mesh exposure after skull repair. All of them were repaired with autogenous dermis combined with a local skin flap. As a result, the titanium mesh was effectively preserved, and the wound was closed in stage 1 after the operation, with a satisfactory outcome.

DATA AND METHODS

Patient Background

From December 2018 to December 2020, 8 patients with titanium mesh exposure after cranioplasty were admitted to the Burn Department of Quanzhou First Hospital, including 5 males and 3 females, aged 19 to 63 years old, with an average age of (44.0 ± 14.6) years old. The causes of titanium mesh

cranioplasty were 6 cases of craniocerebral trauma and 2 cases of benign brain tumor. The exposure time of titanium mesh was 20 days to 2 years after cranioplasty, with an average of 9 months. The exposed locations were temporal in 5 cases and frontal in 3 cases. The causes of the exposure were necrosis of the skin flap in 4 cases, atrophy of the scalp in 3 cases, and infection in 1 case. Underlying diseases: diabetes mellitus in 4 cases.(Q3)The area of lesion accounts for 2.4 cm^2 to 12.0 cm^2 of the total scalp surface area, with an average of (6.16 ± 3.26) cm^2. Pathogenic examination of 5 cases of wound secretion showed bacterial infection, including 3 cases of *Staphylococcus aureus*, 1 case of *Pseudomonas aeruginosa* and 1 case of *Escherichia coli*.

Preoperative Treatment

All 8 patients were treated with pathogenic examination and drug sensitivity test upon admission. Patients with positive bacterial cultures were treated with sensitive antibiotics for 7 to 10 days. Patients with negative pathogenic examination were treated with antibiotics in the perioperative period. After admission, according to the condition of the wound, wound debridement and dressing change were performed. Patient wound was washed repeatedly with 3% hydrogen peroxide solution, normal saline, 0.1% iodophor solution, and active factor biological dressing once or twice a day.

Surgical Treatment

Debridement

Remove the necrotic tissue, purulent secretion, and inflammatory granulation tissue of the wound in the exposed titanium mesh area, and wash the wound repeatedly with a large amount of 3% hydrogen peroxide solution, normal saline, and 0.1% iodophor solution.

Further Debridement

Along 0.5 cm to the wound margin, further remove necrotic tissue, inter ecological tissue, and wound scar tissue to the normal scalp, followed by 3% hydrogen peroxide solution, normal saline, 0.1% iodine solution, and active factor biological dressing to wash the wound repeatedly and to also stop the bleeding thoroughly.

Obtain Tissue

After routine disinfection of the lateral thigh, the electronic scalpel was first used to cut a thick blade skin (0.2 mm thick), with a cutting area 2.5 times the size of the head wound. And then, once again, use the electronic scalpel to cut the autogenous dermis tissue (0.3 mm thick) in the previous lateral thigh skin area, with an area 1.3 times the exposed titanium mesh wound. The obtained thick skin and dermis tissue were placed immediately in the growth factor solution to maintain their activity. The autogenous dermis tissue and thick blade skin were immersed in the growth factor solution.(Q5)

Prepare for Transplantation

Cut the scalp to the galea aponeurosis (Q6) layer, and then the subdermal layer of the flap was separated to form a flap. According to the shape and size of the wound area, design the local flap to transfer and repair the wound. As a result, blood leakage of the skin edge of the flap was observed, and the blood circulation of the flap was good.

Transplantation

First, confirm there was no active bleeding of the wound, then cover the surface of the titanium mesh with the autogenous dermal tissue, with the dermal tissue close to the titanium mesh, and the dermal tissue should completely cover the titanium mesh with 0.5 cm over the titanium mesh edge. Next, the dermal tissue was sutured to the skin edge with absorbable suture, and the skin flap was then transferred to the basement membrane of the dermis, and sutured with silk thread.

Fix the Transplantation

The skin flap was covered with a self-blade thick skin graft, the peripheral silk suture was fixed, the long thread was reserved, the skin surface was covered with silver ion dressing, the cotton ball was filled, and the long thread was packed in groups and fixed with appropriate pressure.

Finish the Transplantation

Transplant the self-blade thick skin graft to the self-dermis tissue supply area. After the transplantation is stable, cover the skin flap area with silver ion auxiliary material, and use dry gauze to compress properly.

Postoperative Treatment and Rehabilitation Treatment

Scalp Area

After the operation, use proper medication to improve skin flap microcirculation and to promote the survival of the skin flap. In the meantime, use sensitive antibiotics or empirically selected antibiotics for anti-infection treatment. Dressing change every day in the flap transplantation area, and closely monitor the survival condition of the skin flap. The head grafting area was unpacked 1 week after the operation.

The Thigh Skin Supply Area and Grafting Area

Should start dressing change on the third day after the operation, once every 2 days.

Rehabilitation

If the patient's condition allows, early lying in bed or getting out of bed for functional rehabilitation training is critical to prevent muscle, tendon contracture and joint stiffness, promote limb blood circulation, and prevent deep vein thrombosis.

Ethical Considerations

Written consent to publish the case report was obtained from the patient, which complies with the regulations of the Ethics Committee of Quanzhou First Hospital.

Statistical Analysis

All statistical analyses were performed with IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp.). The data are presented as mean SD. P values of <0.05 were considered statistically significant.

RESULTS

In this study group, all 8 patients' wounds were healed in stage 1, the blood supply of the head flap was good, the color of the skin flap was ruddy, the skin flap and dermal tissue all survived, and the skin grafts of the head and thigh were ruddy and survived well. The suture was removed 7 days after the operation in the head grafting area and 12 days after the operation in the thigh skin flap area. The titanium mesh was retained, and patients were discharged. In 6-month follow-up, there was no re-exposure of titanium mesh, no obvious scar hyperplasia in the operation area, and patients were satisfied with their appearance.

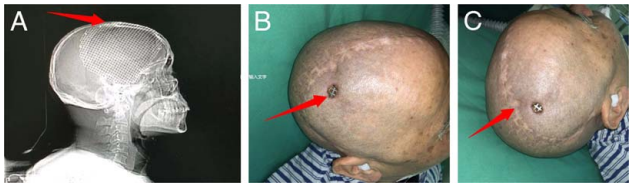

FIGURE 1. Preoperative assessment. A, skull CT showed that the titanium mesh was exposed in patient frontal region. B, the titanium mesh was exposed in patient frontal region, about 1.5 cm × 1.8 cm in size. C, There was hyperplasis of the scar in the old surgical incision area with thin local skull and shrunken local scalp.

Representative Case

A 63-year-old man was referred to our hospital due to "24 months after cranioplasty and 2 months of titanium mesh exposure at the top of the forehead". Upon physical examination, there was hyperplasis of the scar in the old surgical incision area with thin local skull and shrunken local scalp. The titanium mesh was exposed in the patient's frontal region, about 1.5 cm × 1.8 cm in size. The surface of the titanium mesh was covered with pus, and there was necrotic tissue around the wound (Fig. 1b, c). Skull computer tomography (CT) revealed that the titanium mesh was exposed in the patient's frontal region. Inflammation of surrounding soft tissue was observed (Fig. 1a).

We performed the operation of "local flap transfer + autologous dermis transplantation + skin grafting + thigh skin extraction" for the patient. We, according to the area of the titanium mesh exposed wound, determined the scope of resection and designed a local skin flap to cover the wound, marking with a line (Fig. 2d). We removed the local necrotic tissue, inter ecological tissue, and peripheral scar tissue (Fig. 2e). We cleared the wound thoroughly, removed the infection focus, and expanded the wound to the space between titanium mesh and dura mater. The wound size after the expansion was 4.5 cm × 2.5 cm (Fig. 2f, g). We cut the blade thick skin at the left lateral thigh, with a thickness of 0.2 mm and a size of 11 cm × 5.5 cm (Fig. 3h). We obtained dermal tissue at the thick skin cutting point of the left lateral thigh, with a thickness of 0.3 mm and a size of 5.5 cm × 3.0 cm (Fig. 3i). The left thigh donor area was obviously infiltrated with blood, and the self-blade thick skin and dermis tissue showed completely good activity (Fig. 3j). We cut the scalp along the design line to the cap aponeurosis layer, and separated along the lower cap the aponeurosis layer to form a local akin flap, about 5 cm × 3 cm in size, with good blood supply of the flap (Fig. 4k). The autogenous dermal tissue was

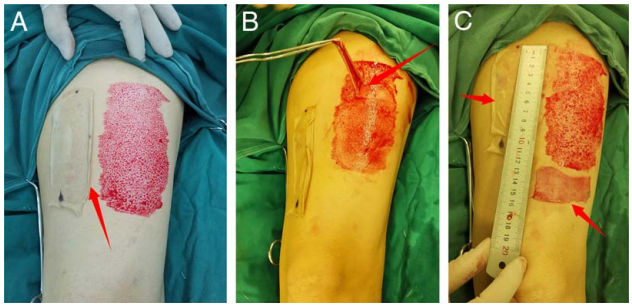

FIGURE 3. Obtain skin and dermal tissue at the left lateral thigh. H, cut the blade thick skin at the left lateral thigh, with the thickness of 0.2 mm and the size of 11 cm × 5.5 cm. I, obtain dermal tissue at the thick skin cutting point of the left lateral thigh, with a thickness of 0.3 mm and a size of 5.5 cm × 3.0 cm. J, the self-blade thick skin and dermis tissue are complete with good activity.

transplanted on the surface of titanium mesh with the dermal tissue facing down and the basement membrane facing up. The dermal tissue completely covered and exceeded the exposed titanium mesh edge by 0.5 cm, and the absorbable suture was used to close the wound on the normal skin edge (Fig. 4l-n). The local flap was transplanted to cover the dermis and seal the expanded wound of the head. As a result, the titanium mesh was completely covered (Fig. 5o, p). We used a self-blade thick skin graft to repair the head flap donor area and thigh dermal tissue donor area (Fig. 5q, r).

On the 7th day after operation, the local skin flap of the scalp survived well and there was good blood circulation. The wound was closed in stage 1 and the titanium mesh was preserved; the skin graft of the left thigh was ruddy and survived well (Fig. 6s, t). The patient was in good health 6 months after the operation; the skin grafts of the local flap, head, and left thigh survived well; the titanium mesh was not exposed; scar hyperplasia was negligible; and the appearance was good (Fig. 6u, v).

DISCUSSION

The main causes of titanium mesh exposure after cranioplasty include skin flap necrosis, skin flap thinning after incision scarring, effusion under the skin flap, infection, and other factors. At the same time, advanced age, scalp atrophy, diabetes, and other systemic diseases are also the main causes of titanium mesh exposure.[6] In this study group, there was ischemia in the skin flap after titanium mesh implantation in 4 cases. With scar contracture, the ischemia increased, then the skin flap necrosis occurred, the incision did not heal, and finally, the titanium mesh was exposed. In 3 middle-aged patients, the scalp atrophied and became thinner with aging,

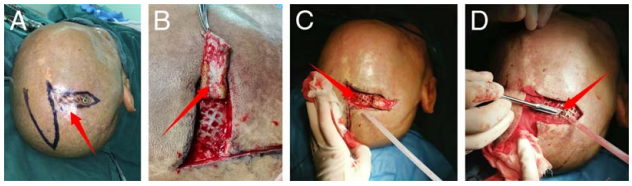

FIGURE 2. Design and preparation of the surgical area. D,according to the area of titanium mesh exposed wound, design a local skin flap to cover the wound. E, removing local necrotic tissue, inter ecological tissue and peripheral scar tissue. F, there was infection around the titanium mesh. G, clear the wound thoroughly, the wound size after expansion is 4.5 cm × 2.5 cm.

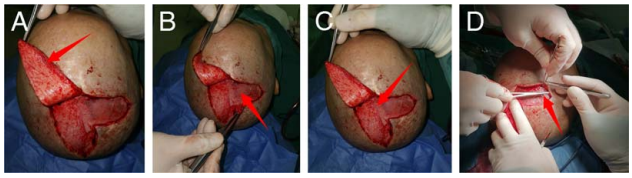

FIGURE 4. Transplantation of autologous dermal tissue onto the surface of titanium mesh. K, cut the scalp and separate along the lower cap aponeurosis layer to form a local akin flap, about 5 cm × 3 cm in size, with good blood supply of the flap. L-N, The autogenous dermal tissue was transplanted on the surface of titanium mesh with the dermal tissue facing down and the basement membrane facing up.

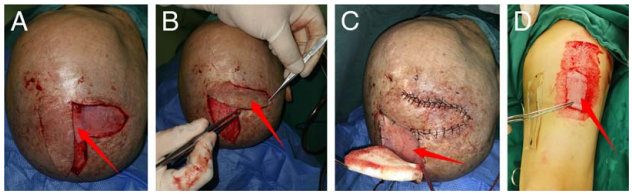

FIGURE 5. Cover the dermis and seal the wound. O,P, the local flap was transplanted to cover the dermis and seal the expanded wound of the head. Q, R, use self-blade thick skin graft to repair head flap donor area and thigh dermal tissue donor area.

leading to incision scarring, which leads to further thinner of the scalp, ischemic and broken. The wound was not healed for a long time, leading to the titanium mesh exposure. During the operation of this group of 8 patients, it was found that there was some degree of damage and contracture in the cap aponeurosis, which was also the main reason for the thinning of the scar and the exposure of titanium mesh in the incision.[7] It has also been reported that diabetic patients with poor blood glucose control, long-term smoking, and drinking are also the main reason for infection in the operation area, poor wound healing, and titanium mesh exposure.[8]

Autogenous dermis is mainly composed of reticular layer, papillary deep layer, and a few skin appendages. As the main part of dermal tissue, reticular layer contains a large number of fibers and has a special fiber arrangement structure, which contributes to the strong toughness and elasticity of dermal tissue.[9] Many experts in the field have widely used these characteristics for tissue repair, reconstruction, and plastic surgery,[10] and achieved good patient outcomes, especially in tissue strengthening, replacement, and tissue filling; it has a unique therapeutic effect.[11] Because titanium mesh is large and dense, the authors used autogenous dermis to fill the space between the head flap and titanium mesh, which is helpful to establish effective blood circulation with dura after vascularization of the autogenous dermal tissue surface and then wrap titanium mesh.[5] The autogenous dermis basement membrane surface can be connected with the local flap cap aponeurosis, which is conducive to the movement and redistribution of fascia. At the same time, the autogenous dermal filling can effectively establish a buffer zone to reduce the direct pressure on the skin flap and then avoid ischemia and necrosis of the skin flap. From the curative effect of this group of cases, it also fully confirmed the effectiveness of this method.

Skin flap transplantation has achieved good results in the repairment of titanium mesh exposed wounds. Local flap, island flap, and free flap can be used for transplantation, among which local flap transfer is the first choice.[12] Blood sugar should be strictly controlled before skin flap transplantation, the nutritional status of the body should be improved, smoking and alcohol should be stopped, and various factors that are not conducive to wound healing should be eliminated. Before the operation, we should strengthen debridement and dressing change, effectively control local infection, improve the condition of the wound base, and make full preparation for flap transplantation.[13] The cases in this group were treated by expanding the wound, removing the necrotic tissue, inter ecological tissue, and scar tissue to the scalp with good blood circulation, which is conducive to increasing the skin flap's ductility, and effectively avoid the skin flap's rupture or even necrosis caused by scar ischemia.[14] After the operation, the dressing change in the operation area should be strengthened; the necrotic tissue should be fully drained and removed in time. At the same time, the active factor silver ion adjuvant should be used for local wet dressing to strengthen local antibacterial and also to avoid skin flap necrosis caused by infection.

In this treatment plan, the following points should be paid attention to (1). The donor area of the dermis should be the part with thick skin, such as the back and lateral thigh; (2). The cutting area should be at least 30% larger than the defect area as there will be some degree of contracture after dermis cutting (3). It is better to use an electronic or pneumatic scalpel to cut the dermis so that the obtained dermis will be relatively flat and uniform in thickness; (4). The dermal tissue transplanted on the surface of titanium mesh should not contain an epidermis, and the scope of dermal transplantation should exceed 0.5 cm of titanium mesh. Also, the dermis should be fixed on the edge of the normal scalp to prevent postoperative dermal contracture, which can lead to operation failure; 5. When designing the flap, the flap should be designed to cover the wound sufficiently with 10% larger than the wound in the recipient area to avoid the influence of traction on the blood circulation of the flap.

FIGURE 6. Postoperative assessment. S,T, on the seventh day after operation, the local skin flap of the scalp survived well and there was good blood circulation. The titanium mesh was preserved; the skin graft of the left thigh was ruddy and survived well. U,V, after 6 months follow-up, the skin grafts of local flap, head and left thigh survived well, titanium mesh was not exposed, scar hyperplasia was slight, and appearance was good.

CONCLUSION

It has been reported that the percentage of titanium mesh exposure after skull repair is 17%, and the rate of removing titanium mesh due to wound no-healing is as high as 30%.[15] Once the titanium mesh is removed, it will lead to repair failure, and operations will be needed, which will bring difficulties to treatment and increase the patient's economic burden and physical suffering.[16] In this group, through wound preparation before the operation, usage of autogenous dermis combined with local flap transplantation after the expansion during operation, timely dressing change after operation, antiinfection, and other treatment, the wound with exposed titanium mesh was effectively repaired, while titanium mesh was preserved. The treatment strategy is safe, effective, and simple. At the same time, it greatly reduces patient suffering and costs, saves medical resources, and is worth popularizing when the condition permits. Shortcomings: The follow-up time of this case was only 6 months, and long-term follow-up observation is still needed to clarify the long-term effect of this treatment program. At the same time, the sample size of this study is small, and multi-center and large-sample studies are still needed to clarify its safety, effectiveness and scientific.

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