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Reconstruction of skull and dural defects using anterolateral thigh flaps

A STROBE-compliant article

Wan-feng Zhang, BA[a], Qiu-fang Gao, MA[a], Zi-biao Li, MA[a], Ya-jun Ma, BA[a], Xue-tao Niu, BA[a], Bin Ma, BA[a], Ke-yi Ren, BA[a], Ren-chun Huang, BA[b,*]

Abstract

It is difficult to repair large skull and dural defects. We observed the therapeutic effects of anterolateral thigh flaps with vascular fascia lata for repairing large skull and dural defects.

From December 2008 to June 2019, we repaired large skull and dural defects for 28 cases including 12 cases with scalp malignant tumor and 16 cases requiring removal of titanium mesh which had been once placed due to craniocerebral trauma. The scalp malignant tumor invaded full-thickness skull in 12 cases; and invaded cervical lymph nodes, dura mater or brain tissue in 3 cases. In the 12 cases with scalp malignant tumor, the scalp defects of 12 cm × 9 cm to 22 cm × 18 cm and skull defects of 9 cm × 7 cm to 15 cm × 12 cm after radical tumor resection were repaired using anterolateral thigh flaps of 14 cm × 11 cm to 23 cm × 19 cm with fascia lata of 10 cm × 8 cm to 16 cm × 12 cm. Postoperative radiotherapy and chemotherapy were also performed in the 3 cases with tumor metastasis. In the 16 cases requiring removal of titanium mesh, the skull and dural defects of 8 cm × 7 cm to 15 cm × 11 cm after removal of titanium mesh were repaired using anterolateral thigh flaps of 10 cm × 8 cm to 16 cm × 12 cm.

In all cases, the transplanted anterolateral thigh flap with fascia lata survived after surgery and no vascular crisis occurred. During the followup of 8 months to 9 years, the flap appearance in the head-repaired area was fine, no external hernia of brain tissue occurred, the appearance of the femoral donor site was acceptable, and femoral muscle strength and movements were normal in all cases. The 12 cases with scalp malignant tumor had no local recurrence or distant metastasis.

Repairing the skull and dural defects caused by radical surgery for scalp malignant tumor or removal of titanium mesh using anterolateral thigh flaps with vascular fascia lata, is effective. The appearance in the head-repaired area is fine without external hernia of brain tissue.

Abbreviation:

Keywords: dura mater, fascia lata, microsurgery, skin flap, skull, titanium mesh

1. Introduction

The malignant tumors derived from the scalp are common clinically, and mainly include squamous-cell carcinoma, basal cell carcinoma, and dermatofibrosarcoma protuberans in pathology. The scalp malignant tumor fails to be diagnosed and treated effectively in the early stage, it will invade the skull, dura mater, brain tissue, and nearby sentinel nodes. Radical surgery is necessary for preventing tumor local recurrence and distant metastasis. Radical tumor resection is characterized by surgical negative edge,[1] which requires removal of tumor-invaded skull, dura mater, and brain tissue. Therefore, after radical tumor resection, a large defect remains to be repaired. For the titanium mesh placed in the second stage after decompression of craniocerebral trauma,[2] when the titanium mesh has to be removed due to body rejection to titanium mesh or infection occurring under the titanium mesh, a large surgical defect also remains to be repaired. The studies on repairing large skull and dura defects using anterolateral thigh flaps with vascular fascia lata by microsurgery has rarely been reported.

From December 2008 to June 2019, we repaired large skull and dural defects for 28 cases including 12 cases with scalp malignant tumor and 16 cases requiring removal of titanium mesh using anterolateral thigh flaps with vascular fascia lata, and obtained better therapeutic effects.

2. Subjects and methods

All study methods were approved by ethics committee of the Central Hospital of Hanzhong City. All patients enrolled into the study gave written informed consent.

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The authors have no conflicts of interests to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

[a] Department of Burn, [b] Department of Emergency medicine, Central Hospital of Hanzhong City, Hanzhong, China.

[*] Correspondence: Ren-chun Huang, Department of Emergency medicine, Central Hospital of Hanzhong City, No. 557, Middle Section, West Road of Laodong Road, Hantai District, Hanzhong 723000, Shanxi Province, China (e-mail: dqyyzwf@163.com).

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2.1. Clinical data

In this study, there were 12 cases with scalp malignant tumor and 16 cases requiring removal of titanium mesh. In the 12 cases with scalp malignant tumor, 7 were males and 5 were females, with a mean age of 46 years (range: 25 to 67). Of the 12 cases, 6 had squamous-cell carcinoma, 2 basal cell carcinoma, and 4 dermatofibrosarcoma protuberans. The scalp malignant tumor invaded skull Full-thickness in 12 cases; and invaded cervical lymph nodes, dura mater or brain tissue in 3 cases. In the 12 cases with scalp malignant tumor, the scalp malignancy area was of 4 cm × 4 cm to 17cm × 13 cm with a disease course of 1 to 5 years. In the 16 cases requiring removal of titanium mesh, 10 were males and 6 were females, with a mean age of 44 years (range: 22 to 56). Removal of titanium mesh was due to body rejection to titanium mesh in 5 cases, and due to infection under the titanium mesh in 11 cases. In the 16 cases, the titanium mesh placement time was between 6 months and 2 years and the skull and dural defect was 8 cm × 7 cm to 15 cm × 11 cm (Table 1).

2.2. Surgical treatment

For the cases with scalp malignant tumor, a small amount of tumor tissue was first taken for pathological biopsy to determine tumor pathological type; and then head CT scan, B-ultrasound examination for lymph nodes and other organs was performed to know whether there was tumor metastasis. For the cases requiring removal of titanium mesh, head CT scan was performed to distinguish between titanium mesh rejection reaction and infection under the titanium mesh and to know the sizes of skull and dural defects. Secretion culture was done if possible. The position of cutaneous branch of descending branch of lateral femoral circumflex artery was determined and marked by preoperative Doppler ultrasonic blood stream detector in the 28 cases.

After surgery-related examination was performed, patients received surgery under general anesthesia, and a head tourniquet is used to reduce intraoperative bleeding. In the cases with scalp malignant tumor, tumor tissue, and tumor-invaded cervical lymph nodes, dura mater or brain tissue were removed and the scope of tumor resection extended to 3 cm to 5 cm outside tumor edge. The resected tissue edge was sent for rapid frozen pathological examination, if the pathological result was positive, the tumor resection scope should be accordingly expanded until the pathological result was negative. After radical tumor resection, the scalp defects of 12 cm × 9 cm to 22 cm × 18 cm and skull defects of 9 cm × 7 cm to 15 cm × 12 cm were repaired using anterolateral thigh flaps of 14 cm × 11 cm to 23 cm × 19 cm with fascia lata of 10 cm × 8 cm to 16 cm × 12 cm followed by placing 1 or 2 drain tubes. In the 16 cases requiring removal of titanium mesh, the skull and dural defects of 8 cm × 7 cm to 15 cm × 11 cm after removal of titanium mesh were repaired using anterolateral thigh flaps of 10 cm × 8 cm to 16 cm × 12 cm followed by placing 1 or 2 drain tubes. When taking the anterolateral thigh flaps, we should pay attention to the nerve dominating the vastus lateralis muscle. The femoral donor wounds were directly sutured in 5 cases, were repaired using intermediate split thickness skin graft from ipsilateral thigh in 14 cases and were repaired using perforating branch flap of ipsilateral medial vastus muscle flap in 9 cases.

After resuscitation from general anesthesia, cases were in a semi-recumbent position. Conventional fluid replacement, anti-infection, anti-vascular spasm and antithrombosis were performed for postoperative 3 to 5 days. The flap was kept warm using lamp and its blood flow was observed. The drainage tube was removed 3 to 5 days after the operation, dressing changes for the operation wounds were regularly performed, and the stitches was removed 10 to 14 days after the operation. The 3 cases who had dura mater, brain tissue or cervical lymph node metastasis, received postoperative radiotherapy and chemotherapy.

3. Results

In this study, the transplanted flaps all survived and no vascular crisis occurred in the 28 cases. During the followup of 8 months to 9 years, the flap appearance in the head-repaired area was fine, no external hernia of brain tissue occurred, the appearance of the femoral donor site was acceptable, and femoral muscle strength and movements were normal in all cases. The 12 cases with scalp malignant tumor had no local recurrence or distant metastasis. Surgical data and follow up time are shown in Table 2.

Case 1: A 65-year-old man had a 1-year history of surgery for squamous cell carcinoma on his left parietal region and 9-month local recurrence. One year ago, the case received surgery for the head scalp squamous cell carcinoma, 3 months later a mass occurred in the previous lession. The physical examination on admission: There was an ulcerated wound with a size of 5 cm × 4 cm on his left parietal region, and the ulcerated wound contained suppuration and malodorous secretions. The lymph nodes around ears and on the neck were not palpable. His head CT revealed that the tumor invaded the skull on the left parietal region and the superficial layer of the left parietal lobe. B-ultrasound did not show metastasis to lymph nodes around ears and on the neck, and other related examination also did not found distant metastasis to liver, lung, and other organs. On the

Table 1

Patients demographics.

Items	Scalp malignant tumor (n = 12)		Removal of titanium mesh (n = 16)	
Sex				
Male	7		10	
Female	5		6	
Age (year)	25-67 (range 46)		22–56 (range 44)	
Course (year)	1–5		0.5–2	
Pathology	Squamous-cell carcinoma	6	Rejection to titanium mesh	5
	Basal cell carcinoma	2	Infection under the titanium mesh	11
	Dermatofibrosarcoma protuberans	4		
Defect area	4 cm × 4 cm-17 cm × 13 cm		8 cm × 7 cm-15 cm × 11 cm	

Table 2

Surgical data and follow up time.

Items	Scalp malignant tumor	Removal of titanium mesh
Area		–
Defect scalp	12 cm × 9 cm–22 cm × 18 cm	
Defect skull	9 cm × 7 cm–15 cm × 12 cm	8 cm × 7 cm–15 cm × 11 cm
Flap	14 cm × 11 cm–23 cm × 19 cm	10 cm × 8 cm–16 cm × 12 cm
Fascia lata	10 cm × 8 cm–16 cm × 12 cm	10 cm × 8 cm–16 cm × 12 cm
Donor wounds		
Direct suturation	5	
Intermediate split thickness skin graft from ipsilateral thigh	14	
Perforating branch flap of ipsilateral medial vastus muscle	9	
Duration of medication	3–5 days	
Removal of drainage tube	Postoperative 3–5 days	
Dermal sutures out	Postoperative 10–14 days	
Follow-up	0.67–9 years	

day of admission, a small amount of tumor tissue from the center of the lesion was taken for pathological biopsy, and the pathology suggested head scalp squamous cell carcinoma. Based this, the cases was diagnosed with postoperative recurrence of head scalp squamous cell carcinoma. The position of cutaneous branch of descending branch of the right lateral femoral circumflex artery was determined and marked by Doppler ultrasonic blood stream detector. On the fourth day after admission, radical surgery was carried out under general anesthesia. After a head tourniquet is worn on his head, the scalp including 5 cm outside tumor edge, full-thickness skull of 10 cm × 9 cm, dura mater of 10 cm × 9 cm and the tumor-invaded brain tissue were all removed. All the resected tissue edges were sent for rapid frozen pathological examination and pathological results were negative. After radical tumor resection, there was a wound with a size of 15 cm × 13 cm. At the same time, an anterolateral thigh flap of 15 cm × 14 cm with a fascia lata of 11 cm × 10 cm was taken from his right thigh to repair the above head wound. The fascia lata and dura mater were sutured together, and the anastomoses of the right lateral femoral circumflex artery and vein with the left superficial temporal artery and vein were performed followed by placing 1 drain tube. The donor site was repaired using the intermediate split thickness skin graft from the right interfemus. The drainage tube under the transplanted flap was removed on the third day after operation. The transplanted flap and the intermediate split thickness skin graft on the righ thigh were all survived with would healing on the tenth day after operation. The case received 30-day radiotherapy 3 weeks after operation to prevent recurrence or metastasis of head scalp squamous cell carcinoma. When the case was followed up 1 year after operation, there was no hair in the head-repaired area, no local recurrence or distant metastases of the malignant tumor and no external hernia of brain tissue; the appearances in the head-repaired area and in the right femoral donor site were acceptable; and the right femoral muscle strength and movements were normal (Fig. 1).

Case 2: A 60-year woman received a decompression by removal of the frontal bone due to craniocerebral trauma 1 year ago, and then underwent second stage skull defect repair using titanium mesh 3 months after operation. Six months later,

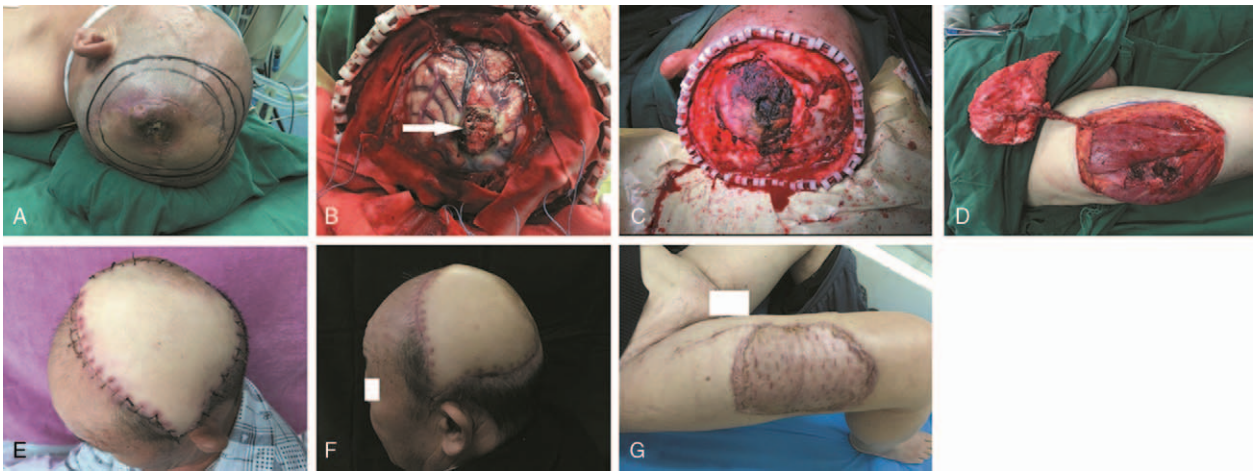

Figure 1. The wound after radical tumor resection is repaired using a anterolateral thigh flap with a fascia lata in the case with postoperative recurrence of scalp squamous cell carcinoma on his left parietal region. 1a: Resected scope; 1b: After removal of the scalp, skull and dura mater, the arrow indicates tumor invasion into the superficial layer of the left parietal lobe. 1c: The defects of scalp, skull and dura mater after removal of the tumor-invaded brain tissue. 1d: Taking the right anterolateral thigh flap with a fascia lata. 1e: The head appearance after post-operative 12 days. 1f: The head appearance after post-operative 5 months. 1g: The appearance of the donor site of the right thigh after post-operative 5 months.

Figure 2. The wound after removal of titanium mesh is repaired using an anterolateral thigh flap with a fascia lata in the case requiring removal of titanium mesh. 2a: Right frontotemporal wound and infection caused by titanium mesh rejection reaction. 2b: Infection under titanium mesh after removal of the titanium mesh. 2c: Taking the left anterolateral thigh flap with a fascia lata. 2d: The donor site is repaired using the perforating branch flap of medial vastus muscle. 2e: The appearance of the donor site after post-operative 1 month. 2f: The head appearance after post-operative 20 days. 2g and 2 hour: The head appearance after post-operative 1 year.

titanium mesh rejection reaction led to frontal skin ulceration. The case received out-patient conservative treatment for more than 3 months, but the therapeutic effects were bad and the skin ulceration was severe with suppuration, so she went to our hospital. The physical examination on admission: The case had 2 wounds including a frontal wound of 4 cm × 3 cm and a temporal wound of 3 cm × 1 cm. Her frontotemporal skin was red and swollen with ulceration and pus. Head CT showed local soft tissue thickening. The secretion culture from the wound suggested staphylococcus aureus resistance. The case was diagnosed with titanium mesh rejection reaction, infection and scalp defect. On the third day after admission, after the titanium mesh and granulation tissue on the brain tissue surface of frontal lobe and temporal lobe were removed, and the debridement for the right frontal wound and temporal wound was performed under general anesthesia, there was a surgical defect with a skull and dura mater defect of 12 cm × 10 cm and a frontotemporal skin defect of 13 cm × 8 cm. At the same time, an anterolateral thigh flap of 15 cm × 9 cm with a fascia lata of 13 cm × 11 cm was taken from her left thigh to repair the above surgical defect followed by placing one drain tube. After the donor site was directly sutured, there still was a wound of 10 cm × 7 cm which was repaired using the perforating branch flap of medial vastus muscle. The drainage tube under the transplanted flap was removed on the third day after operation. The transplanted flap and the perforating branch flap of medial vastus muscle on her left thigh were all survived with would healing on the twelfth day after operation. The case was discharged 14 days after operation. When the case was followed up 5 years after operation, there was no hair in the head-repaired area and no external hernia of brain tissue; the appearances in the head-repaired area and in the left femoral donor site were acceptable; and the left femoral muscle strength and movements were normal (Fig. 2).

4. Discussion

The scalp is located on the surface of human body, so it is easily hurt by exoteric various factors such as mechanical stimulation, ultraviolet sunlight irradiation, and burn.[3,4] If the scalp wound can not be cured for long term, it may develop scalp malignant tumor. Scalp malignant tumor is usually occurs in countryside because the scalp wound is often delayed due to poor economic conditions. The scalp malignant tumor has the characteristics of aggressive growth, destroying the skull, dural mater, and other tissues. In addition, when the tumor metastasizes to the distant lymph nodes and organs, although the patients receive local palliative surgery combined with radiotherapy and chemotherapy, their life quanlity are still be affected.

The scalp malignant tumors commonly include squamous-cell carcinoma, basal cell carcinoma, and dermatofibrosarcoma protuberans in pathology.[5] Squamous cell carcinoma often resembles a cauliflower, and is characterized by rapid progression as well as easy rupture, infection and metastasis to local lymph nodes, even invasion of liver, lung, and other important organs. Basal cell carcinoma is characterized by slow progression and rare metastases, but it may destroy the deep tissue of tumor site. Scalp dermatofibrosarcoma protuberans is often nodular. It usually invades deep tissues such as skull and has high local recurrence rate, but it has rare rupture and low distal metastasis rate. In this study, the scalp malignant tumor invaded full-thickness skull in 12 cases; and invaded cervical lymph nodes, dura mater or brain tissue in 3 cases.

If the scalp malignant tumor fails to be diagnosed and treated effectively in the early stage, it will invade the skull, dura mater, brain tissue, and other tissues. When the scalp malignant tumor invades the skull, dura mater and other tissues, radical tumor resection is necessary. Preventing postoperative recurrence requires radical removal of the tumor-invaded scope and depth, and surgical negative edge is the key to prevent local recurrence and distant metastasis after operation. Therefore, in the 12 cases of this study, the resected tissue edges were sent for rapid frozen pathological examination, if the pathological result was positive, the tumor resection scope should be accordingly expanded until the pathological result was negative in oreder to achieve local radical tumor resection.[6] For the scalp malignant tumor invading cervical lymph nodes, dura mater or brain tissue;

postoperative radiotherapy and chemotherapy were used to prevent local recurrence or distant metastasis. In this study, 3 cases who had scalp squamous-cell carcinoma which invaded cervical lymph nodes, dura mater or brain tissue, also received postoperative radiotherapy and chemotherapy. Local recurrence and distal metastasis of the scalp malignant tumor often occur within 6 months after operation, and are easily found. In this study, the 12 cases were followed up for 8 months to 9 years without local recurrence or distant metastasis, indicating that the therapeutic effects of radical surgery were better in the 12 cases.

The scalp malignant tumor fails to be early diagnosed and treated and when tumor area is more than 5 cm × 5 cm and invades the skull, dura mater or brain tissue; there will be a large surgical defect after radical removal of the tumor. It is difficult to repair the large surgical defect by direct suture combined with skin grafting or local head flap. In this case, the latissimus dorsi muscular flap was used to repair the large surgical defect. However, it is difficult to retain the thoracodorsal nerve in situ when taking the latissimus dorsi muscular flap, which affects postoperative upper limb muscle strength; and the flap appearance transplanted in the head-repaired area is bloated. The anterolateral thigh flap with a fascia lata has been widely used in clinical practice, such as bone exposure wound repair and the reconstruction of tendon or achilles tendon.[7,8] In the 12 case of this study, the scalp malignant tumor invaded full-thickness skull, even dura mater and brain tissue. After radical tumor resection, there were large surgical defects with scalp defects of 12 cm × 9 cm to 22 cm × 18 cm and skull defects of 9 cm × 7 cm to 15 cm × 12 cm, which were repaired using anterolateral thigh flaps with fascia lata.

In order to relieve intracranial hypertension after craniocerebral injury, decompression is necessary by removal of skull. Restoring the integrity of the skull cavity can not only make the brain safe, but also improve the cerebral blood flow.[9] Titanium mesh as skull defect repair materials is widely used in clinical practice. However, titanium mesh exposure is one of the serious complications after skull repair with an incidence of about 1.6%.[10] The titanium mesh exposure is mainly due to rejection reaction or infection. Rejection reaction usually occurs 6 to 12 months after skull repair. Local scalp, especially the frontotemporal skin, first becomes thin followed by skin ulceration. After debridement combined with suture or flap graft, skin ulceration may occur again with yellow thin liquid and has not response to antibiotics.[11] The titanium mesh exposure caused by infection may be related to the low resistance of patients. The scalp ulceration infection may diffuses under the titanium mesh. When the titanium mesh rejection reaction or the infection under the titanium mesh occurs, the titanium mesh has to be removed. After removal of the titanium mesh, there will be a defect which also requires repair. If the defect is large, local head flap graft is not feasible. In the 16 cases of this study, removal of titanium mesh produced skull and dural defects of 8 cm × 7 cm to 15 cm × 11 cm which were repaired using anterolateral thigh flaps of 10 cm × 8 cm to 16 cm × 12 cm.

Anterolateral thigh flaps with fascia lata is characterized by good tensile strength,[7,12] large flap available, abundant blood supply, strong anti-infection ability and no rejection reaction in autologous tissue. For the cases with scalp malignant tumor or the cases requiring removal of titanium mesh, if the defect area after removal of tumor or titanium mesh is less than 15 cm × 15 cm and is located in the forehead, temple or parietal region; the anterolateral thigh flap with vascular fascia lata may be taken in the simultaneous period and is used to repair the skull defect to prevent external hernia of brain tissue. This treatment method avoids second stage titanium mesh replacement and immune rejection reaction to titanium mesh. In the 28 cases of this study, after the skull defects were repaired using anterolateral thigh flaps with vascular fascia lata; the flap appearance in the head-repaired area was fine, no external hernia of brain tissue occurred, the shape of the femoral donor site was acceptable, and femoral muscle strength and movements were normal.

Precautions of this operation were the following several points:

1. Preoperative head CT is necessary because the scope and depth of radical tumor resection as well as the required flap areas are determined based on the tumor-invaded scope and depth as well as the skull defect areas covered by titanium meshes;
2. The resected tissue edge should be sent for rapid frozen pathological examination, if the pathological result is positive, the tumor resection scope should be accordingly expanded until the pathological result is negative. Although this may delay the operation time, it is important for preventing local recurrence and distant metastasis after operation;
3. Removal of the tumor or the titanium mesh as well as taking the anterolateral thigh flap with vascular fascia lata may be simultaneously carried out by 2 groups to shorten the operation time.
4. When taking the anterolateral thigh flaps, we should pay attention to the nerve dominating the vastus lateralis muscle, avoiding affecting postoperative thigh muscle strength after operation.
5. The suture fixation between the fascia lata and dura mater should be safe with moderate tension.
6. After resuscitation from general anesthesia, the case should be in a semi-recumbent position and the flap is kept warm using lamp, which was beneficial to the venous return of the transplanted flap.
7. Head surgery may induce temporary intracranial hypertension sometimes, so hormone or dehydrating agent should be used if necessary.
8. It is necessary to wear a brace on the skull defect repaired by the anterolateral thigh flap, preventing from external damages.
9. Whether the skull defects of more than 15 cm × 15 cm can be repaired using anterolateral thigh flaps remains to be further investigated.

In summary, for the skull defect area of less than 15 cm × 15 cm after removal of tumor or titanium mesh, microscopic repair using the anterolateral thigh flap with vascular fascia lata is an effective method because the appearance in the head-repaired area is fine without external hernia of brain tissue. The shortcoming of this treatment method is that there was no hair in the head-repaired area.

Author contributions

Conceptualization: Ren-chun Huang.
Data curation: Qiu-fang Gao, Xue-tao Niu, Ke-yi Ren.
Investigation: Zi-biao Li.
Methodology: Ya-jun Ma.
Validation: Bin Ma.
Writing – original draft: Wan-feng Zhang.
Writing – review & editing: Ren-chun Huang.

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