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Original Research Article

Reconstruction of scalp with local axial flaps

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ABSTRACT

Background: The scalp is a unique part of the human body and various etiological factors, such as tumour extirpation, infection, burns, or trauma, can lead to scalp defects. Primary closure, skin grafting, local flaps, tissue expansion or free tissue transfer are modalities available for scalp reconstruction. In this article, the authors share their institutional experience using various local flaps concerning the size, location, depth of defect and the quality of surrounding tissue.
Methods: From September 2017 to January 2020, 54 patients underwent scalp reconstruction with local flaps for a defect size of 5 to 150 cm^2 in the department of plastic surgery, SMS medical college, Jaipur. Patients were identified by age, sex, cause of the scalp defect; the location, size, and depth of the defect; condition of surrounding tissue and the type of reconstruction done.
Results: The most common cause of scalp defect was excision of malignant tumour (50%). Thirty patients had a large sized defect (40-90 cm^2) and 28 patients had 90-150 cm^2 defects. Surgical reconstruction was done using local flaps, transposition flap was the most used in 36 patients (66.7%) followed by rotation advancement flap in 11 patients (20.4%). The recovery was relatively quick. Minor complications happened in 5 patients (9.3%) that were managed conservatively.
Conclusions: In the present era of microsurgical reconstruction, local options as axial flaps provide a simpler and safer method of scalp reconstruction. A carefully planned scalp flap gives healthy, robust, hair-bearing tissue coverage and requires a shorter healing time for the patients.

Keywords: Scalp, Fasciocutaneous flaps, Electric burn, Reconstructive surgery, Cutaneous malignancy

INTRODUCTION

The scalp is the thickest skin in the human body which covers the pericranium and protects the intracranial structures.[1] Scalp defects may be caused by various etiological factors such as tumour extirpation, infection, burns, trauma, or congenital lesions leading to significant surgical and aesthetic concern.[2] Due to the inelastic galea, the paucity of the adjacent tissue, its limited expandability, and the convexity of its shape, reconstruction of scalp defects is often challenging.[3] Small defects (less than 5 cm^2) can be closed primarily; skin grafting is an appropriate option in cases when the pericranium is present. However, in cases of large scalp defects, denuded calvarium, exposed dura-mater or CSF leaks; neither primary closure nor skin grafting is applicable. Such injuries require local, distant vascularized flaps or free tissue transfer. Although microvascular tissue transfer has recently been reported to be successful for extensively large scalp defects, local flaps should be considered as the first line of treatment cases for small to medium-size defects. Local flaps from the adjacent regions provide the best method for functional and aesthetic reconstruction as they provide the best colour and tissue quality match, and permit not

only the restoration of continuous hair covering but also effective protection for the skull and its contents.[4]

The objective of the study was to share the institutional experience using various local flaps concerning the size, location, depth of defect and the quality of surrounding tissue.

METHODS

From September 2017 to January 2020, 132 patients underwent reconstruction of scalp defects in the department of plastic surgery, SMS medical college, Jaipur. Out of these, 54 patients having a defect size of 5 to 150cm^2 were included in this study. Patients were identified by the cause of the scalp defect; the location, size, and depth of the defect; condition of surrounding skin and the type of reconstruction done (Figure 1).

Etiological factors included tumour excision, trauma, and electric contact burns. After thorough debridement, defects were classified based on size as small (<5 cm^2), medium (5-40 cm^2); large (40-90 cm^2) and extra-large (90-150 cm^2). Patients having small scalp defects of size <5 cm^2 were closed primarily and those having defect >150 cm^2 were managed by free flaps, and were excluded from this study. Six patients had already previous surgery, but none of the patients had history of prior radiotherapy. Depending upon the anatomical location of the defect, they were divided into frontal, temporal, parietal, occipital and combined (large defects involving two contiguous anatomical areas of scalp). The surrounding tissues were categorized as good (pliable), satisfactory (when part of it was had cicatrices or superficial burns) and poor (adherent to pericranium). Accompanying comorbidities were taken into account, but were not regarded as contraindications. The depth of the wound was determined to be skin and galea loss, missing pericranium, bone defect or dural defect. Surgical reconstruction was done using local flaps depending upon the location of the defect and surrounding tissue availability. Surgical methods included fasciocutaneous flaps such as transposition flaps, rotation flaps, double hatchet flaps and bi-pedicle flaps. All of the flaps were planned to be two to three times larger than the measurements of the defect to achieve wound coverage without tension. The flaps were elevated by extensive undermining in the areolar tissues between the galea and the pericranium. During the dissection, care was taken to avoid injury to the periosteum of the calvaria. Whenever there was a need for additional tissue gain and mobility of the flap, galeal scoring was done at 1cm intervals in the direction of the flap movement. In 11 patients of malignancy, bony involvement was seen in whom outer cortex was chiselled out. While in 3 patients dural involvement was also present, which was widely excised and repaired with autologous fascia lata patch. Primary cranioplasty was not done in any patient because of malignancy. The donor site was covered with a split-thickness skin graft in 41 of the cases, and in 13 patients the donor was closed primarily. Vacuum drains and compressive bandages were applied in all patients for 48 hours.

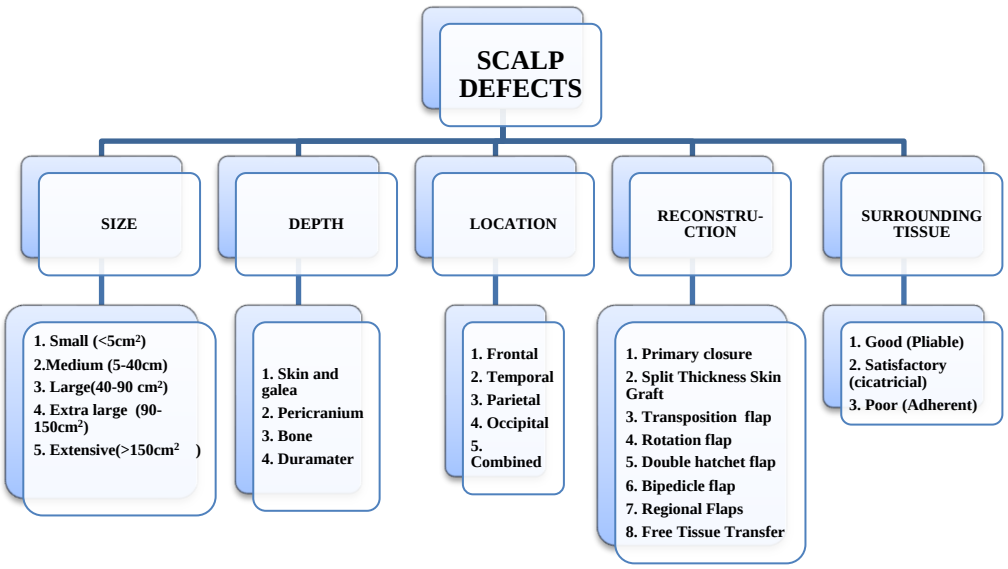

Figure 1: Classification of scalp defects on the basis of size, depth, location and reconstructive options.

RESULTS

The study group consisted of 54 patients, 36 male and 18 female, with a mean follow-up time of 6 months (range: 3 to 12 months). The mean age of the patient was 33 years (youngest patient was of 5 years and eldest of 63 years). 27 patients (50%) had a malignant tumour of the scalp, while 16 patients (29.6%) had a history of electric contact burn to the scalp and remaining 11 patients were cases of traumatic scalp defect (Table 1). After wide local excision or thorough debridement, 8 patients had medium-size defects (5-40 cm^2); 30 patients had large

defects (40-90 cm^2) and 16 patients had extra-large (90-150 cm^2). Depending upon the anatomical location of the defect, they were divided into as frontal (3 patients), temporal (9 patients), parietal (12 patients), occipital (2 patients) and combined (28 patients, who had large defects involving two contiguous areas of scalp). Skin and galea involvement were seen in 11 patients, while 29 patients (53.6%) had pericranium deep defects. Out of 27 patients of scalp malignancy, 11 patients (20.4%) had bony involvement, while in 3 patients dura-mater was also involved.

Table 1: Patient's characteristics.

Variable	Value (%)
No. of patients	54
Sex	
Male	36 (66.7)
Female	18 (23.3)
Age (years)	
Mean	39
Range	5-63
Causes	
Scalp Malignancy	27 (50.0)
Burn	16 (29.6)
Trauma	11 (20.4)

Table 2: Surgical data.

Variable	Value (%)
Defect size (cm^2)	
Medium 5-40	8 (14.8)
Large 40-90	30 (55.6)
Extra-large 90-150	16 (29.6)
Depth	
Skin And Galea	11 (20.4)
Pericranium involved	29 (53.6)
Bony defect	11 (20.4)
Dural defect	3 (5.6)
Location	
Frontal	3 (5.6)
Temporal	9 (16.7)
Parietal	12 (22.2)
Occipital	2 (3.7)
Combined (>2 areas)	28 (51.9)
Flap utilized	
Transposition flap	36 (66.7)
Rotation advancement flap	11 (20.4)
Double Hatchet Flap	2 (3.7)
Bipedicle flap	2 (3.7)
Double transposition	3 (5.6)
Complications	
Wound dehiscence	2 (3.7)
Distal flap necrosis	1 (1.9)
Graft loss	2 (3.7)

Surgical reconstruction was done using local flaps depending upon the pliability of surrounding tissue; transposition flap was used in 36 patients (66.7%), Rotation advancement flap in 11 patients (20.4%), and double transposition flap in 3 patients (5.6%) while double hatchet and bi-pedicle flap were utilized in 2 patients each to cover the defect (Table 2). In the early and late postoperative period, the qualities of coverage and recipient and donor morbidities were followed up. The recovery was relatively quick, without hematoma or seroma formation. None of the patients had complete flap loss or underwent secondary reconstruction, minor complications happened in 5 patients (9.3%): 2 patients had wound dehiscence which was managed by excision of the wound edges and secondary suturing. Two patients had partial graft loss and one 1 the patient had distal flap necrosis of 1 cm which was managed conservatively with regular dressing.

DISCUSSION

Reconstruction of the scalp following tumour extirpation, deep burns, traumatic injuries or postoperative complications can be quite challenging. The simplest possible method of reconstruction should be considered in all patients while using tissues with the same thickness and hair growth, which allows for adequate coverage, mobility, and stability.[5,6] For defects that are less than 5 cm^2 in diameter, primary closure is usually achieved with undermining of the remaining forehead or scalp where necessary.[7,8]

Over the century, different surgical techniques were applied for reconstructive work such as the perforation of the outer table of the skull, Sneve reported in 1893, skin grafting, Netolitzky reported in 1871, scalp flaps Messner in 1894, Cushing in 1918, Kazanjian and Holmes in 1944, Orticochea in 1967 and 1971, distant pedicle flaps and the microvascular free-tissue transfer McLean and Buckne, 1972.[9,10] Split thickness skin grafting is a suitable technique when the wound bed is well-vascularized but unsatisfactory functional and aesthetic results limit the application of this method.[11] However, in the case of medium to large size defect (5-30 cm^2), with a denuded calvarium, exposed dura, or cerebrospinal fluid leaks, the correct reconstructive technique is the application of local, regional, or free flaps.[12]

In the past, several algorithms for scalp reconstruction have been proposed based either on location, size, and etiology of the defect, quality of tissue and/or wound environment, structures exposed, and hairline distortion. Based on location and distortion of the hairline, Leedy et al described 4 separate algorithms for anterior, parietal, occipital, or vertex defect.[13] However, they do not account for the history of radiation or quality of the tissue or wound environment, which is a major factor to consider for the healing of large reconstructions. Newman et al described a simpler method of reconstruction first based on size: small (<10 cm^2),

medium (10-50 cm^2), or large (>50 cm^2). The second factor to consider is the quality of local tissue described as "good" or "poor". However, they did not consider defect location or hairline distortion, which are both significant functional and aesthetic concerns. Iblher et al. described an algorithm specific to oncologic reconstruction for scalp reconstruction with the primary considerations being clear surgical margins, followed by defect size; however, they did not account for location or quality of tissue.[14] Beasley et al created a bimodal algorithm based on location in the forehead or scalp, followed by size (>50 cm^2), and they accounted for tissue quality.[15] However, this algorithm is rather broad and does not consider hairline or a specific location in the scalp. Desai et al. proposed a comprehensive algorithm on reconstruction scalp defects including several key factors such as defect size, defect location, radiation history, and hairline distortion.[16] However, being a review of literature no real patients were involved in their study. The purpose of our algorithm is to provide a comprehensive view on how to approach scalp defects while taking into account all the important factors that have been previously repeatedly described in the literature by many experienced reconstructive surgeons (Figure 2). From our study, we have also tried to include the type of flap that can be raised based on the size and location of the defect as well as pliability of surrounding tissue. Finally, this algorithm refers to the surgical option that could achieve an optimal functional and aesthetic outcome; however, that reconstructive option may not always be feasible.

The scalp is a highly vascular tissue and a multitude of anastomosis allows for flexibility in the formation of the pedicle.[17] The blood supply of all scalp flaps is based on the interconnected network of the aponeurotic plexus. Each one of the five large arteries of the head i.e. supratrochlear, supraorbital, superficial temporal, post-auricular and occipital can be the pedicle vessel. Local flaps belong to the fascio-cutaneous type and provide the same tissue as the scalp (like with like tissue substitution). They and can be planned in various shapes depending on the size, localization, and depth of the wound.

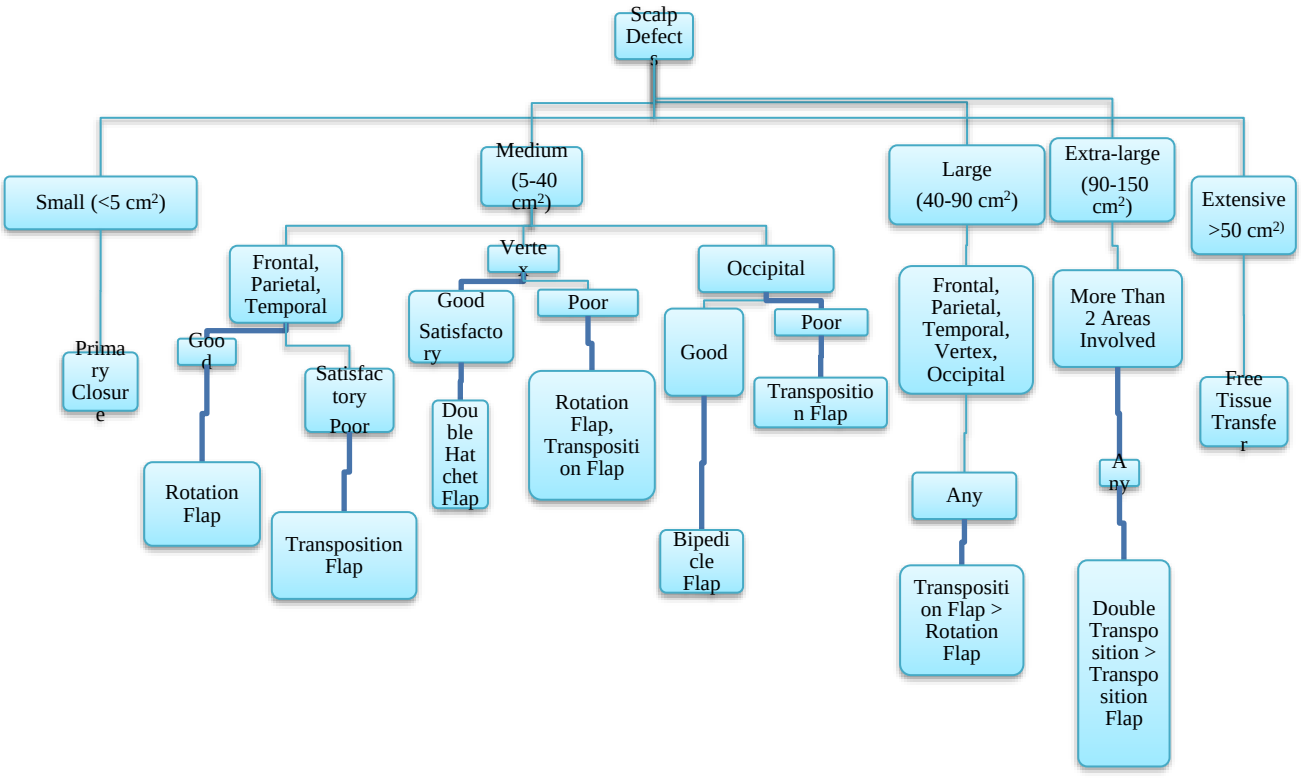

Figure 2: Re-constructive options for scalp defects on the basis of size, location and surrounding skin.

Meticulous surgical planning of local flaps for medium-sized defects allow primary closure of the donor site. This technique provides healthy, durable, and hair-bearing tissue, but the application of the method requires good quality of the surrounding tissue. In certain situations, galeal scoring may be performed in the direction of flap movement to gain flap length and reduce tension. Care should be taken to perform scoring parallel to the blood vessels and avoid scoring too deeply.[18] In large and extra-large defects, local flaps raised should be large enough to cover the recipient area without tension, but for the donor site, a skin graft must be placed. However, in these cases, special attention should be paid to prevent distortion of hairline and sideburns, which have to be preserved as much as possible. The donor site should be selected in the least aesthetically sensitive area depending on the defect.[19]

While planning the flap, not only the size of the defect but its anatomical location, and pliability of surrounding tissue are of prime importance. A medium-sized defect located in the frontal or vertex area can be closed with a rotation advancement flap, without the need for a split-thickness skin graft (Figure 1 and Figure 2).[20] Advancement flaps or multiple flaps (double hatchet or O→Z flap) with primary closure may be applied in patients with elastic scalp tissue, a moderately sized defect, and a location in the central or parietal area of the scalp (Figure 3).[21] In our study, we performed 11 (20.4%) rotation advancement flaps and in 2 patients double hatchet flap was done for medium-size defects in located in frontal, parietal and vertex regions. When the defect is located in the periphery or involves more than one zone (large and extra-large defects), transposition flaps or double transposition flaps were used (Figure 4 and Figure 5).[22, 23] However, the donor area was covered with a split-thickness skin graft. Taking into account the limited elasticity of the scalp, flaps must be planned to be 2 to 3 times larger in size than the measurements of the wound. They should be elevated by dissection at the subgaleal plane and care must be taken to avoid injuries to the pericranium. The rich vascularisation of the temporoparietal fascia is what permits the use of a larger and wider scalp flap. In this study, the transposition flap was the most commonly done and was done in 36 patients (66.7%) while the double transposition flap was raised in 3 patients. Apart from the size and position of the defect, another important factor when considering options for scalp reconstruction is wound depth. Malignant lesions of the scalp might involve not the bone and dura-mater which wide local excision, a water-tight closure to prevent CSF leak and requires cranioplasty in the same setting or as a secondary procedure post adjuvant radiotherapy. In our study out of 27 patients with malignancy, 11 patients (20.4%) had calvaria involvement in which outer cortex was chiselled. Out of these 3 patients had a dural extension, which was repaired with free fascia lata dural patch and was covered with a large transposition flap (Figure 4). In cases of medium size defect involving the occipital region a bi-pedicle flap based on bilateral occipital arteries can be raised (Figure 6). However, in extensively large defects (>150 cm^2), skin damaged by radiation treatment, a substantial bone loss, or when the defect covers more than 50 per cent of the scalp, local tissues may not be the appropriate approach, and the alternatives are tissue expansion, distal pedicled or free flaps. Tissue expansion is an effective method for enlarging tissues and achieving adequate coverage with local flaps, and in most cases, the procedure has satisfactory functional and aesthetic outcomes.[24] However, unfortunately, this method was not suitable for immediate coverage in our patients. We consider tissue expanders to be a secondary treatment for achieving aesthetic improvement and they are applied only at a patient's request. Planning and elevation of distal pedicled flaps require extensive dissection and they have restricted range of mobilization, which limits their extension to the lateral or occipital areas of the scalp. We did perform 15 free flaps during the same time duration, but only in cases where the defect was extensively large (>150 cm^2) or surrounding tissue was adherent to the bone. Free flap transfer is a safe and reliable technique for covering large and deep calvarial defects.[25-26] These flaps are not hair-bearing but provide a good quantity of tissue with quality elasticity. The method is preferred in case of malignancy, osteomyelitis, and deficiency of local tissue.[27] In our study, none of the patients had major complications, hematoma or seroma formation. Minor complications like wound dehiscence were seen in 2 patients and minimal graft loss occurred in 2 patients which was managed conservatively with regular dressings. Distal flap necrosis of 1cm was seen in only 1 patient in whom very large transposition flap was done, which was managed by excision and secondary suturing.

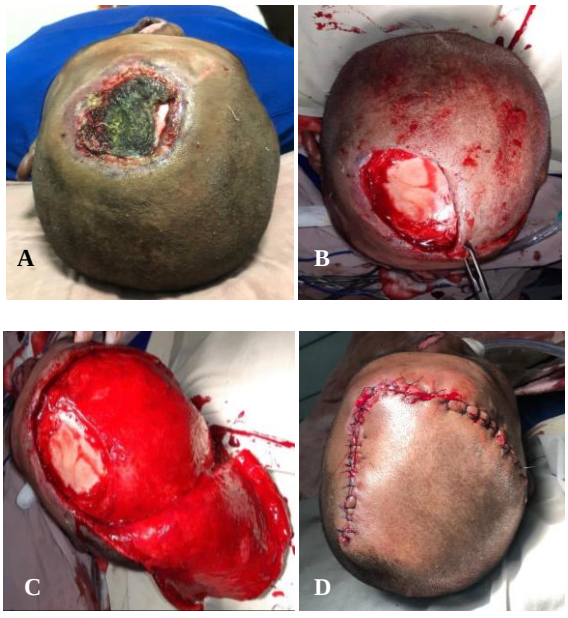

Figure 3: (A) Post trauma full thickness defect in frontal region, (B) post debridement defect size of 20cm^2, (C) a large rotation flap(490 cm^2) was raised to cover the defect preserving the anterior hairline, (D) post op photograph with well-maintained hairline.

Figure 4: (A) Post electrical burn full thickness defect(40 cm^2) in the frontal region, (B) post debridement two large rotation flaps(265 cm2 each) were raised, (C) immediate post op photograph, (D) late post op photograph after 3 months with well settled flaps.

Figure 5: (A) Squamous cell carcinoma in parieto-occipital region, (B) Wide local excision was done, with residual defect of 25cm^2, (C) Double Hatchet flap (O→Z flap) was marked and raised with extensive undermining, (D) Immediate post op photograph.

Figure 6: A) Squamous cell carcinoma temporo-parietal region with involvement of calvaria and duramater, (B) wide local excision was done (80cm^2 defect size), dural defect was covered with autologous fascia lata patch and a large transposition flap(225 cm^2) was raised to cove the defect, STSG was done at donor site, (C) post op photo after 5 days with well settled flap.

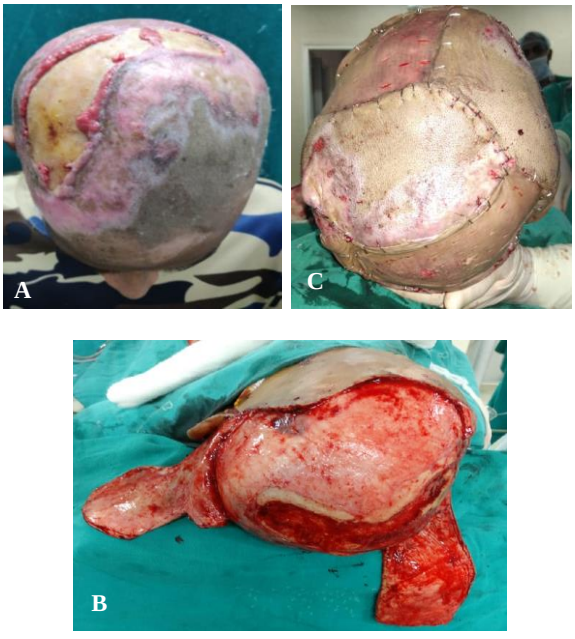

Figure 7: (A) Post electrical burn large full thickness scalp defect (60 cm^2) involving Tempo-parietal and vertex, with cicatrization or surrounding scalp, (B) two large transposition flaps were elevated to cover the defect, STSG was done at donor site, (C) post operative photograph.

Figure 8: (A) A case of electrical burn with occipital defect(20cm^2) in a child, (B) a bipedicle flap based on occipital arteries was raised and donor area was covered with STSG, (C) post operative photograph.

Limitations

The limitations of this study include a relatively small number of patients and the experience results from a single medical centre. A further prospective, multicentric study including the more precise acquisition of intraoperative details as well as pooling of data may offer more powerful evidence and experience of the reconstruction of the complex scalp defects.

CONCLUSION

Reconstruction of scalp defects with local flaps is a safe, relatively short and simple procedure unlikely to cause any major complications or demand special postoperative care. Even for a large and complex scalp defect, whether or not it includes a cranial or dural defect, a local scalp flap is the reconstructive method of choice. Our results from the application of 54 local axial flaps indicate that complications were quite rare and did not affect the survival of the flaps.

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Ethical approval: The study was conducted conforming to the Declaration of Helsinki.

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