International Journal of Research in Medical Sciences
Mohanty U et al. Int J Res Med Sci. 2026 Dec;14(12):5800-5806
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20264486

Original Research Article

Clinical outcomes of reconstructive modalities for acquired scalp defects: a retrospective institutional study

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Received: 30 September 2026
Revised: 04 November 2026
Accepted: 07 November 2026

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ABSTRACT

Background: Acquired scalp defects present a complex reconstructive challenge due to variations in defect size, aetiology, tissue involvement, and the limited elasticity of scalp tissue. This study evaluated the clinical outcomes of different reconstructive modalities used for acquired scalp defects.
Methods: This retrospective observational study included 30 consecutive patients who underwent reconstruction of acquired scalp defects at our institution between August 2022 and July 2024. Patient demographics, aetiology, defect characteristics, reconstructive modalities, postoperative complications, secondary procedures, and follow-up outcomes were analysed.
Results: The study included 22 males (73.3%) and 8 females (26.7%), with a mean age of 31 years. Electrical injuries were the most common aetiology (40%), followed by road traffic accidents (23.3%). The vertex was the most frequently affected site (40%). Transposition flaps were the most commonly performed reconstructive procedure (50%), followed by free anterolateral thigh and latissimus dorsi flaps (10% each). Overall, primary reconstructive success, as defined by the study protocol, was achieved in 18 patients (60%). Postoperative complications included flap-tip necrosis, partial skin graft loss, wound infection, and complete flap failure. One failed free flap was successfully salvaged using a free latissimus dorsi flap.
Conclusions: Reconstruction of acquired scalp defects requires an individualized approach based on defect size, location, depth, and availability of surrounding tissue. Local flaps provide effective coverage for selected defects, whereas extensive defects with exposed calvaria may require free tissue transfer.

Keywords: Acquired scalp defects, Scalp reconstruction, Transposition flap, Free flap, Electrical burns, Reconstructive surgery

INTRODUCTION

Acquired scalp defects represent a significant reconstructive challenge owing to the unique anatomical, functional, and aesthetic characteristics of the scalp. These defects may result from burns, electrical injuries, trauma, tumour excision, infection, pressure injuries, or avulsion injuries and often involve varying degrees of soft tissue, pericardial, and calvarias loss. Reconstruction of scalp defects is particularly demanding because of limited tissue elasticity, the presence of hair-bearing skin, and the need

to achieve durable coverage while preserving cosmetic appearance.

The scalp consists of a thick, highly vascularized soft tissue envelope that generally permits reliable flap-based reconstruction. However, reconstruction becomes increasingly complex in cases associated with exposed calvaria, loss of periosteum, dural exposure, or full-thickness cranial involvement. Among these aetiologies, high-voltage electrical injuries pose additional challenges because the extent of tissue damage often exceeds visible wound margins and may progress over time secondary to vascular thrombosis and thermal injury.

The objectives of scalp reconstruction extend beyond simple wound closure and include protection of intracranial structures, restoration of stable soft tissue coverage, preservation of scalp contour and hair-bearing areas, minimization of alopecia, and achievement of satisfactory functional and aesthetic outcomes. Selection of the optimal reconstructive modality depends on multiple factors including defect size, location, depth of involvement, surrounding tissue availability, patient comorbidities, and surgeon expertise.[1-4]

A wide spectrum of reconstructive techniques has been described for management of acquired scalp defects, ranging from healing by secondary intention and skin grafting to local flaps, regional pedicled flaps, and microsurgical free tissue transfer. Small defects may be effectively managed with local tissue rearrangement, whereas extensive defects with exposed calvaria frequently require advanced reconstructive procedures.

Despite the availability of multiple reconstructive options, there remains limited institutional data comparing outcomes across different surgical modalities in acquired scalp defects.[1-4] Therefore, the present study was undertaken to evaluate the clinical outcomes of various reconstructive techniques employed for acquired scalp defects over a two-year period at our institution and to analyze reconstructive decision-making, postoperative complications, and functional and aesthetic outcomes associated with each modality.

METHODS

Study design and patient selection

This retrospective observational study included all consecutive patients presenting with acquired scalp defects who underwent reconstructive surgery at our institution between August 2022 and July 2024.

Inclusion criteria

All Patients of either gender presenting with acquired scalp defects secondary to electrical contact burns (high- and low-voltage injuries), traumatic scalp injuries, scalp avulsion injuries, vascular tumors, post-oncologic scalp defects, pressure sores and post-infective scalp wounds were included in the current study.

Exclusion criteria

Exclusion criteria included patients who succumbed to extensive electrical burns or associated injuries before undergoing scalp reconstruction and patients with congenital causes of scalp defects.

Initial assessment and wound management

All patients were initially managed in the emergency department according to standard trauma principles with assessment and stabilization of airway, breathing, and circulation. Associated injuries including craniofacial, thoracic, and skeletal trauma were evaluated and relevant investigations performed.

During the acute phase, scalp wound care consisted of regular dressing and serial debridement of necrotic tissue. In partial-thickness scalp injuries without calvarias exposure or pericardial involvement, conservative wound management was continued to promote granulation tissue formation.

For defects with exposed calvaria, definitive reconstruction was preferably performed within the first 1–2 weeks using flap coverage. In selected patients with extensive defects or significant comorbidities, outer table drilling was performed to induce granulation tissue formation followed by split-thickness skin grafting (SSG).

Preoperative evaluation and reconstructive planning

Preoperative assessment included evaluation of defect dimensions, location, depth of involvement, exposure of calvaria/dura, surrounding scalp tissue quality, recipient vessel availability for free tissue transfer, hairline preservation, and hair direction.

Investigations included complete hemogram, skull radiography, chest radiography, cardiological evaluation, computed tomography (ct) of the brain in cases with suspected calvarial or dural involvement and preoperative localization of scalp vessels using handheld doppler ultrasonography

Defect classification and reconstructive algorithm

Scalp defects were categorized according to maximum dimension namely small category (with defect size of <5 cm), medium category with a defect size of 5-10 cm and the large category with defect size of >10 cm.

The reconstructive modality was selected following the reconstructive ladder principle, namely small and medium defects characterized by local scalp flaps where adequate tissue laxity was available and large defects characterized

by free tissue transfer in cases of exposed calvaria, insufficient local tissue, or dural exposure.

Reconstructive options included outer table drilling followed by granulation and SSG; local flaps which included advancement, rotation, transposition, double transposition, bipedicle, and limberg flaps. Also, regional flap (trapezius myocutaneous pedicled flap for occipital defects) and free flaps (latissimus dorsi muscle flap and anterolateral thigh flap) were also included.

Operative technique

All procedures were performed under general anaesthesia. Patient positioning (supine, prone, or lateral) was individualized according to defect location.

A solution of adrenaline (1:200,000) was infiltrated along planned incision lines to reduce intraoperative blood loss and facilitate dissection. Incisions were oriented parallel to hair follicles to minimize follicular injury, with limited electrocautery use.

Local scalp flaps were elevated in the subaponeurotic plane while preserving vascular supply. Flap viability was assessed intraoperatively by confirming dermal bleeding at the flap margin. Galeal scoring was performed when additional advancement was required while avoiding excessive tension at closure.

For distant and free flap reconstruction, recipient vessels were dissected initially, and flap dimensions were tailored to match defect size and contour while ensuring adequate pedicle length.

Intraoperative blood loss and operative duration were recorded.

Outcome measures

Primary outcome

Reconstructive success was defined as complete defect coverage with stable wound healing without the need for an additional major reconstructive procedure. Minor secondary procedures, such as dog-ear correction or limited debridement of localized flap-tip necrosis, were not considered failure of the primary reconstruction. Major secondary reconstruction was defined as the requirement for a new flap or other major reconstructive procedure to achieve definitive wound coverage.

Overall, primary reconstructive success according to the predefined endpoint was achieved in 18 of 30 patients (60%). Secondary procedures were required in 12 patients (40%). These secondary procedures included both minor corrective procedures and procedures undertaken to manage reconstructive complications. Minor secondary procedures were not considered failure when stable wound coverage was maintained. One patient experienced complete failure of a free anterolateral thigh flap and subsequently underwent successful reconstruction with a free latissimus dorsi flap. Thus, flap salvage was achieved in this patient following secondary major reconstruction.

Secondary outcomes

Secondary procedures were categorized as minor or major. Minor secondary procedures included limited corrective procedures, such as dog-ear correction and localized debridement of flap-tip necrosis, whereas major secondary procedures were defined as procedures requiring a new major reconstructive modality to achieve definitive wound coverage. Final wound status was assessed during follow-up to determine stability and durability of the reconstruction.

At follow up

Patients were followed monthly during the first three months and subsequently every three months. The median duration of follow-up was 18 months (range, 6 -24 months). At each follow-up visit, patients were evaluated for stability and durability of the flap or graft, contour and colour matching, scarring, ulceration, alopecia, hair growth and hairline distortion, and donor-site morbidity.

RESULTS

The study included 30 patients, of whom 22 (73.3%) were males and 8 (26.7%) were females. Three patients (10%) belonged to the paediatric age group, while 27 (90%) were adults. The mean age was 31 years, with a range of 5–66 years (Table 1).

Table 1: Demographic characteristics.

	Number	Percentage
Age (years)		
Paediatrics (<18)	3	10%
Adult (≥18)	27	90%
Gender		
Male	22	73.3%
Female	8	26.7%

Electrical injuries were the most common cause of acquired scalp defects, accounting for 12 cases (40%), followed by road traffic accidents in 7 patients (23.3%). Other etiologies included bear mauling, monkey bites, and defects following tumour excision (Table 2).

The vertex was the most frequently involved anatomical site, accounting for 12 cases (40%), followed by the parietal region in 5 patients (16.7%) and the occipital region in 4 patients (13.3%) (Table 3).

Transposition flaps were the most commonly performed reconstructive procedure, accounting for 15 cases (50%). Other procedures included free anterolateral thigh flaps,

free latissimus dorsi flaps, split-thickness skin grafting, rotational flaps, and other local and regional reconstructive techniques (Table 4, Figure 1).

Table 2: Etiological distribution.

Causative factor	Total no of cases	Percentage
Electrocution	12	40
RTA	7	23.3
Bear mauling	5	16.7
Monkey bite	3	10
Post tumor excision	3	10

Table 3: Anatomical distribution of defects.

Variables	Total	Percentage
Vertex	12	40%
Occipital	4	13.3%
Parietal	5	16.7%
Frontal	2	6.7%
Temperoparietal	2	6.7%
Temporal	2	6.7%

Table 4: Reconstructive procedures.

Operations done	No of cases	Percentage (%)
Transposition flap	15	50
SSG only	2	6.7
Rotational flap	2	6.7
Limberg flap	1	3.3
Bipedicle advancement flap	1	3.3
Pedicled trapezius flap	1	3.3
Multiple drill holes with SSG	2	6.7
Free ALT flap	3	10
Free LD with SSG	3	10
Tissue expander	1	3.3

Postoperative complications included flap-tip necrosis, partial skin graft loss, wound infection, complete flap failure, flap inset dehiscence, and unstable scarring with ulceration (Table 5).

Table 5: Postoperative complications.

Variables	Total	Percentage
Flap tip necrosis	2	6.7%
Wound infection	1	3.3%
Partial skin graft loss	2	6.7%
Hematoma below SSG	1	3.3%
Complete flap failure	1	3.3%
Dehiscence of flap in setting with exposure of bone	2	6.7%

Flap tip necrosis, partial graft loss, dehiscence of flap inset site & unstable scarring were the most common complications

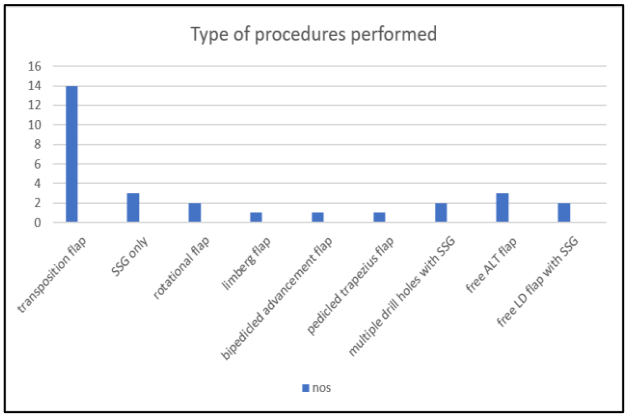


Figure 1: Type of procedures performed.

Dog-ear correction was the most frequently performed secondary procedure, followed by debridement of necrotic flap tips. Other secondary interventions were undertaken to manage reconstructive complications and achieve stable wound coverage (Figure 2).

Out of all the surgeries done, transposition flap was the most commonly done procedure in 50% of the cases followed by SSG & free ALT flap. Free LD flap was done following complete failure of free ALT flap in one case.

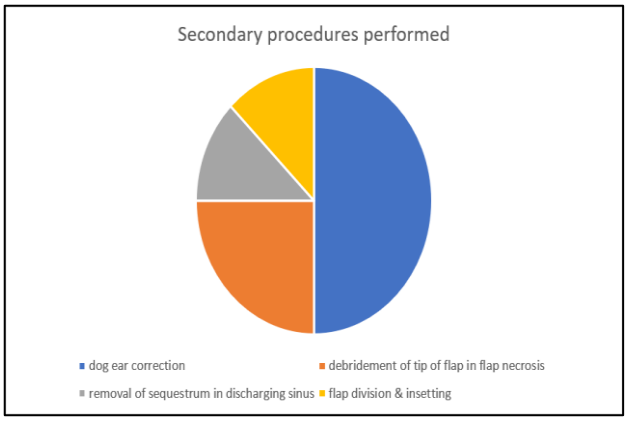


Figure 2: Secondary procedures.

Dog ear correction was the most commonly performed secondary procedure followed by debridement of necrosed flap tip. Reconstructive options included outer table drilling followed by granulation and split-thickness skin grafting; local scalp flaps including advancement, rotation, transposition, double transposition, bipedicle, and Limberg flaps; regional pedicled flaps; free tissue transfer using latissimus dorsi and anterolateral thigh flaps; and tissue expansion in selected patients where adequate surrounding scalp tissue and staged reconstruction were considered feasible.

DISCUSSION

The management of acquired scalp defects continues to represent a significant reconstructive challenge for surgeons worldwide due to the wide variability in defect size, etiology, tissue involvement, and patient-related factors. Each scalp defect is unique and requires careful preoperative assessment, individualized surgical planning, and selection of an appropriate reconstructive modality to achieve optimal functional and aesthetic outcomes.

In our study, males constituted the majority of patients (22/30, 73.3%). However, the present study was not designed to determine the factors underlying this sex distribution (Table 1 and 2).

A staged surgical approach was adopted for all patients. The initial stage involved thorough wound debridement to remove devitalized tissue and establish a healthy wound bed. Multiple sessions of wound dressing and local wound care were performed as necessary before proceeding to definitive reconstruction. This staged strategy facilitated infection control, optimization of local tissue conditions, and improved the likelihood of successful reconstructive outcomes (Table 3).

Our findings were compared with the study conducted by Hossain et al, who evaluated scalp reconstruction following high-voltage electrical burns.[5] Their study included 30 patients with post-electrical burn scalp defects, which is comparable to our cohort of 30 patients. Comparative analysis was performed with respect to patient demographics, particularly age distribution, reconstructive modalities employed, and postoperative complications. Such comparison provides an opportunity to assess the applicability and outcomes of different reconstructive strategies across similar patient populations.

The study also compared the findings with those reported by Dalay et al who described reconstructive outcomes in 15 patients with various scalp defects.[6,7] Their reconstruction techniques included four free flaps, one pedicled flap, and ten local flaps. The authors concluded that early definitive reconstruction using well-vascularized tissue resulted in superior wound healing, enhanced osteogenesis, reduced duration of hospital stay, lower infection rates, and minimized the need for subsequent surgical debridement of exposed bone. These observations are consistent with the principle that timely vascularized tissue coverage plays a critical role in optimizing outcomes in scalp reconstruction.

Transposition flaps were the most commonly performed reconstructive procedure in our series (15 cases) and were designed based on the major scalp vascular territories. The study's preference for transposition flap reconstruction is comparable with the findings of Zayakova et al, who reported the use of transposition scalp flaps in 11 of 13 patients with scalp defects of mixed etiology.[8-10] Similar to their technique, flaps in our study were elevated in the subgaleal plane with preservation of the periosteum whenever feasible (Table 4, Figure 1).

For extensive scalp defects, particularly over the vertex, multiple local flaps including bipedicle and double transposition flaps were used to achieve adequate coverage. Rotation flaps were employed for selected circular defects with primary closure of the donor site, while Limberg flaps were utilized for smaller circular defects.

Among 30 patients with exposed calvaria, full-thickness calvarial involvement was present in three cases. Two patients had small calvarial defects that did not require bony reconstruction, whereas one patient underwent reconstruction with titanium mesh performed by the neurosurgical team followed by local transposition flap coverage. One patient with a large scalp defect and small calvarial defect underwent reconstruction using a free latissimus dorsi flap (Table 4, Figure 1).

Postoperative complications included chronic discharging sinus (1 case), bone exposure (2 cases), partial flap necrosis (2 cases), partial graft loss (2 cases), complete free flap failure (1 case), and wound infection (1 case). The discharging sinus was secondary to sequestrum formation beneath the flap; following sequestrum removal and flap reinsert, complete healing was achieved. (Table-5) Similar delayed calvarial sequestration after scalp reconstruction has been reported by Gumus et al.[11,12]

Microvascular free flap reconstruction was performed in patients with extensive scalp defects and exposed calvaria. In some cases, full-thickness calvarial involvement required neurosurgical debridement, resulting in dural exposure. Reconstruction was achieved using either latissimus dorsi muscle flaps with split-thickness skin grafting or free anterolateral thigh (ALT) flaps. Superficial temporal vessels were selected as recipient vessels, reducing pedicle length requirements and avoiding vein grafts. Despite concerns regarding the adequacy of the superficial temporal vein for microvascular anastomosis, Lipa et al reported these vessels to be consistently reliable and of adequate caliber when palpable preoperatively.[13-16]

In this series, superficial temporal vessels were used as recipient vessels for all free flap reconstructions. In one patient, the right superficial temporal vein was of inadequate caliber despite proximal dissection, and microvascular anastomosis resulted in venous thrombosis and flap failure. Owing to the large defect size (22×18 cm^2), secondary reconstruction was performed using a free latissimus dorsi muscle flap utilizing the contralateral superficial temporal vessels, which resulted in successful flap survival. In the remaining cases, the superficial temporal vessels demonstrated satisfactory caliber and reliability (Figure 2).

This study showed that scalp defects were more common in males, predominantly in the 31–40-year age group, with the vertex being the most frequently involved site. Local transposition flaps remained the principal reconstructive modality. Small defects were effectively managed with rotation or Limberg flaps, medium-sized defects with transposition flaps, and extensive defects with exposed calvaria required free tissue transfer using anterolateral thigh (ALT) or latissimus dorsi (LD) flaps.[17,18] Although vascularized flap coverage provided durable reconstruction, postoperative alopecia remained a limitation following transposition and free flap procedures. The best aesthetic outcomes were achieved in defects reconstructed with local rotation and Limberg flaps. Subjectively, local rotation and Limberg flaps appeared to provide satisfactory aesthetic results in selected smaller defects; however, no standardized aesthetic assessment tool was used, and therefore no objective comparison of aesthetic outcomes between reconstructive modalities could be made

Novelty

Although several studies have reported individual reconstructive techniques for scalp defects, literature from eastern India remains limited. The present study provides a comprehensive institutional experience encompassing traumatic, electrical, oncological, infective, and pressure-related scalp defects managed using a broad spectrum of reconstructive modalities. The study highlights practical decision-making in selecting reconstruction based on defect characteristics and resource availability.

Limitations

This study has several limitations. First, it was a single-center retrospective study with a relatively small sample size. Second, the heterogeneity of defect etiologies and reconstructive techniques limited meaningful statistical comparison between groups. Third, objective assessment tools for aesthetic outcomes and quality of life were not used. Future prospective multicentre studies with larger cohorts are required to validate these findings

CONCLUSION

Reconstruction of acquired scalp defects requires an individualized approach based on defect size, anatomical location, depth of tissue involvement, and availability of surrounding healthy tissue. Our institutional experience demonstrates that local scalp flaps, particularly transposition flaps, remain effective reconstructive options for appropriately selected small and medium-sized defects, while extensive defects with exposed calvaria or inadequate local tissue may require regional or microvascular free tissue transfer. Although satisfactory wound coverage and durable reconstruction were achieved in most patients, complications such as flap necrosis, partial graft loss, wound dehiscence, and alopecia remain important considerations. The successful salvage of a failed anterolateral thigh flap using a free latissimus dorsi flap further highlights the importance of maintaining alternative reconstructive options. This study contributes to the understanding of practical reconstructive decision-making by presenting institutional experience across a diverse range of acquired scalp defect etiologic and reconstructive modalities, emphasizing the importance of defect-oriented surgical planning to achieve stable coverage and satisfactory functional and aesthetic outcomes.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Mahmood M, Eisen D. An algorithmic approach to scalp reconstructive surgery: maximization of cosmetic and functional outcomes. Arch Dermatol Res. 2024;316:137.
2. Mohan VC, Leonovicz OG, Schmidt JL, Gillipelli S, Parham MJ, Layon SA, et al. Scalp and forehead reconstruction following Mohs micrographic surgery. Semin Plast Surg. 2024;38(4):268-78.
3. Krishna D, Khan MM, Dubepuria R, Chaturvedi G, Cheruvu VPR. Reconstruction of scalp and forehead defects: options and strategies. Cureus. 2023;15(7):e41479.
4. Lane C, Lin A, Goyal N. Scalp and calvarium reconstruction. Otolaryngol Clin North Am. 2023;56(4):741-55.
5. Hossain MZ, Sarker B, Lenin LK, Hanna A, Dhar LK. Scalp reconstruction following high voltage electric burn. Bangladesh J Plast Surg. 2012;3(2):49-52.
6. Dalay C, Kesiktas E, Yavuz M, Ozerdem G, Acarturk S. Coverage of scalp defects following contact electrical burns to the head: a clinical series. Burns. 2006;32(2):201-7.
7. Srivastava JL, Biswas G, Narayan RP, Goel A. Chronically exposed calvarium following electrical burns. Burns. 1993;19(2):138-41.
8. Zayakova Y, Stanev A, Mihailov H, Pashaliev N. Application of local axial flaps to scalp reconstruction. Arch Plast Surg. 2013;40(5):564-9.
9. Shonka DC Jr, Potash AE, Jameson MJ, Funk GF. Successful reconstruction of scalp and skull defects: lessons learned from a large series. Laryngoscope. 2011;121(11):2305-12.
10. Sharma RK, Tuli P. Occipital artery island V-Y advancement flap for reconstruction of posterior scalp defects. J Plast Reconstr Aesthet Surg. 2010;63(3):410-5.
11. Gumus N. Negative pressure dressing combined with a traditional approach for the treatment of skull burn. Niger J Clin Pract. 2012;15(4):494-7.
12. Memon AR, Kumar M, Shaikh BF, Qazi A. Surgical reconstruction of scalp. Medical Channel. 2010 Oct–Dec;16(4):578–81.

13. Lipa JE, Butler CE. Enhancing the outcome of free latissimus dorsi muscle flap reconstruction of scalp defects. Head Neck. 2004;26:46-53.
14. Newman MI, Hanasono MM, Disa JJ, Cordeiro PG, Mehrara BJ. Scalp reconstruction: a 15-year experience. Ann Plast Surg. 2004;52(5):501-6.
15. Alvi S, Jenzer AC. Scalp reconstruction. In: StatPearls Treasure Island (FL): StatPearls Publishing; 2023.
16. Mehrotra S, Nanda V, Shar RK. The islanded scalp flap: a better regional alternative to traditional flaps. Plast Reconstr Surg. 2005;116(7):2039-40.
17. Redondo P. Simplifying forehead and temple reconstruction: a narrative review. J Clin Med. 2023;12(16):5399.
18. Abdallah A, Ahmed M, Omran. Reconstruction of scalp defects: a meta-analysis study. Int J Med Arts. 2023;5(5):3277-85.

Cite this article as: Mohanty U, Behera SS, Mallik S, Sarangi A, Sarangi AK, Nayak BB. Clinical outcomes of reconstructive modalities for acquired scalp defects: a retrospective institutional study. Int J Res Med Sci 2026;14:5800-6.