British Journal of Plastic Surgery (1980), **33**, 311–317
0007-1226/80/0075-0311 $02.00

THE RECONSTRUCTION OF CRANIAL DEFECTS INVOLVING SCALP, BONE AND DURA FOLLOWING ELECTRICAL INJURY: REPORT OF TWO CASES TREATED BY HOMOGRAFT, FREE GROIN FLAP AND CRANIOPLASTY

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Deep electrical burns over the cranium produce serious problems of reconstruction when the damage involves not only the bone, but also the dura and occasionally the brain itself.

In this paper, we describe a plan of surgical treatment which was successful in two patients in whom the bony injury had destroyed the scalp, the full thickness of the skull and the dura over an area of approximately 300 to 350 square centimetres.

CASE REPORT

Case 1. A 37-year-old electrician came into contact with a high voltage electric cable A.C. line (20,000 V) and fell from a height of some 10 metres. He was unconscious for 24 hours and sustained a compression fracture of the 4th lumbar vertebra and a deep burn, 12 cm in diameter, in the left temporo-parietal region (Fig. 1).

FIG. 1. Deep electric burn of the scalp and skull in the left temporo-parietal area (Case 1).

He was observed for six days in the Neurosurgical Department and then transferred to the Plastic Surgery Department. Two days later he developed neurological complications and fits, followed by a right hemiparesis.

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The surgical treatment of the skull burn was carried out in four stages:

Stage 1. Under general anaesthesia the necrotic scalp and periosteum was excised. Drill holes made through the outer table at several points, showed foul-smelling, greenish, necrotic diploe. The drill holes were then continued down to the level of the dura (Fig. 2). The clinical observations at operation confirmed the preoperative thermography findings.

FIG. 2. Several burr holes in the skull show the diploe: alive (A) or necrotic (B). The inner table can be drilled (C), so that the dura can be examined and any necrotic material evacuated.

Stage 2. Eight days later, there was no sign of any new granulation tissue in the burr holes. The full thickness of the skull was excised over an area measuring 10 cm in diameter. The periphery of the wound was healthy and well vascularised. There was a visibly necrotic area of dura in the centre of the wound approximately 4 cm in diameter (Fig. 3). The non-viable segment of dura was left intact and simply covered with a sheet of cadaveric homograft skin, which had been preserved in liquid nitrogen.

Stage 3. The homograft fulfilled its purpose admirably. The underlying brain was protected from infection. There was no leakage of cerebrospinal fluid and as the homograft was gradually rejected, it left behind a healthy granulating area with several epidermal "islands" (Fig. 4). The defect was then covered with a free flap transferred from the groin and joined by microvascular anastomosis to the superficial temporal artery and veins.

The immediate post-operative course was uneventful, but on the 8th day, there were signs of acute arterial insufficiency. Exploration of the vascular anastomosis showed spasm of the artery and an "empty" venous drainage system.

Excision of the adventitia and the local application of 2 per cent Xylocaine relieved the arterial spasm and restored dramatically the arterial and venous circulation in the flap. Following this operation the wound became infected, but this was controlled by antibiotics and evacuation of the pus. Despite this unfortunate complication the free flap survived.

Stage 4. Six months later the flap was consolidated and an acrylic prosthesis was inserted using the technique described by Woringer (1951) (Fig. 5). The post-operative course was uneventful. The only residual neurological complications of this man's injury were mild hemiparesis and minor troubles with balance.

FIG. 3. After excision of the dead bone, a necrotic patch of dura is shown in the centre of the wound. It is left in place and covered with a temporary homograft.

FIG. 4. After removal of the homograft, metaplasia of the dura produces islands of "neo-epidermis".

FIG. 5. Cranioplasty with an acrylic plate is relatively straightforward. The free groin flap has been elevated on its narrow pedicle to provide adequate exposure.

Case Report

Case 2. A 28-year-old electrician was electrocuted by contact with a cable carrying 20,000 Volts A.C. The entry wound was situated close to the bregma at the fronto-parietal junction where there was a charred area 10 cms in diameter. The patient also sustained a fracture of the upper third of the tibia.

The immediate neurological complications included paralysis of the right facial nerve and difficulty with speech and balance. The surgical treatment was carried out in four stages, as in the first patient.

Stage 1. The necrotic scalp was excised and burr holes drilled in the outer table of the skull.

Stage 2. After excision of the two layers of the skull a devitalised area of dura was exposed over the superior longitudinal sinus. The dura was left in place and covered by a sheet of homograft skin, stored in liquid nitrogen.

Stage 3. Two months later the epidermal remnants of the homograft were excised and a free flap from the groin was applied with microvascular anastomosis to the parietal branch of the left superficial temporal vessels. The post-operative course was completely uneventful.

Stage 4. Three months later the free flap was raised and an acrylic prosthesis inserted. Healing was completely uneventful (Figs. 6 and 7).

FIG. 6. Result after cranioplasty: A. X-rays (Case 1) show the size of the bone defect: the acrylic material is not visible. B. Xerogram (Case 2) shows the acrylic prosthesis on the vault of the skull.

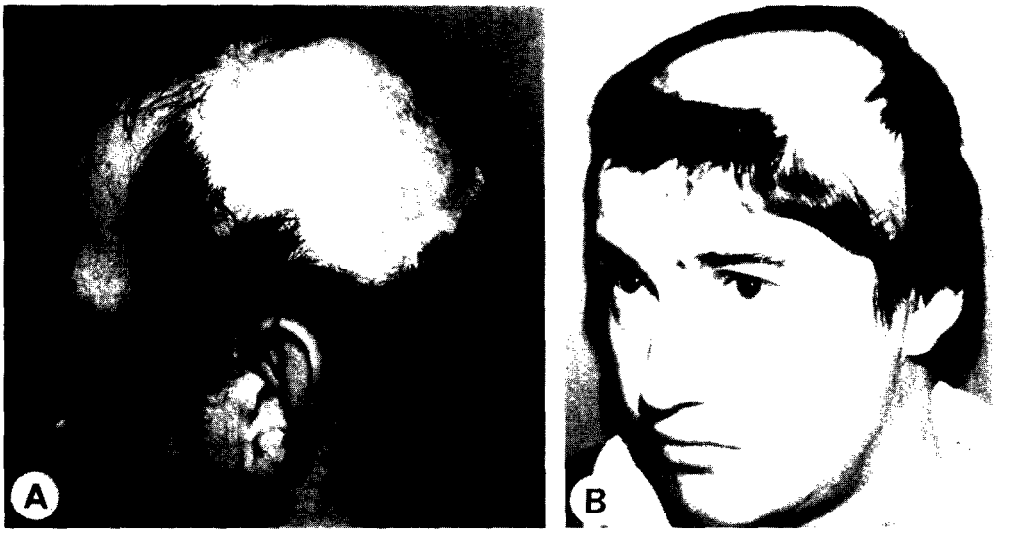

FIG. 7. Cosmetic result of the free groin flaps: (A) Case 1; (B) Case 2.

DISCUSSION

Very deep burns of the head involving both layers of the cranium, the underlying dura and brain are rare. The neurological complications at the time of the accident may be obvious, or appear later. Although the neurological complications may improve with the passage of time, this is not always the case and there is good reason to believe that the surgical management of the burn may be important in the quality of the end result. Contrary to the views put forward by Laurençon and Lepetit (1973), these complications seem to be the result of brain damage caused by a direct wound.

SURGICAL MANAGEMENT: SHOULD THIS BE CONSERVATIVE OR AGGRESSIVE?

"Conservative" approach. The policy of early or immediate skin cover of the burnt skull with a well vascularised flap is based on the premise that good thick skin cover will allow the devascularised bone to become reabsorbed and replaced by new bone in a healthy uninfected environment. This may well be valid for a small defect provided that cover is provided quickly and that there is sufficient tissue immediately available. But it would appear dangerous in cases of large tissue loss for two reasons. The local vascular damage may be greater than at first suspected (Skoog, 1970), and so impair the viability of local flaps and secondly the risk of osteitis and sequestrum formation when bone which is damaged to an unknown degree is covered by a flap in spite of Worthen's (1971) or Razemon's (1960) remarkable cases.

"Aggressive" approach. We agree with Sturim (1969) that it seems more prudent to investigate the bone damage by drilling large holes in the bone for two reasons:

1. *Diagnostic*: the absence of any blood supply to the diploe justifies the excision of the avascular inner and outer tables of bone, which can be done immediately or as a delayed procedure.

2. *Therapeutic*: damage to the underlying dura and brain can be investigated, necrotic material removed and pus drained.

The provision of cover. If one accepts that the immediate repair of cranial vault defects following large electrical burns involving the dura is necessary, then some form of temporary cover must be provided.

Temporary cover. If the dural layer is devitalised, it should not be excised unless there is good evidence of serious underlying damage which needs investigation and drainage.

It is better to apply a temporary biological dressing using a free split skin graft either as an autograft (Brown and Fryer, 1957) or a homograft (Di Vicenti *et al.*, 1969). We prefer the skin homograft as it is easy to apply and the gradual rejection process seems to assist in the gradual removal of the damaged dura and its replacement by a protective layer of granulation tissue.

Furthermore the dura seems to be able to create by itself a "neoepidermis" by a genuine metaplasia. We have been unable to trace any reference to this function of skin. Brown and Fryer (1957) have reported *bone* regeneration from dura and we ourselves have noted epithelial metaplasia on several occasions.

Permanent cover. In the choice of permanent cover, the long term requirement of a definitive cranioplasty must be taken into consideration. Several options are available:

1. *Local Flaps*: Local rotation, or transposition flaps are widely recommended and are particularly useful in bringing hair-bearing skin into sites that require hair for aesthetic reasons (Brown and Fryer, 1957; Sinha *et al.*, 1978; Kragh and Erich, 1961; Razemon, 1960). The multiple flap technique described by Orticochea (1967) may reduce the inconvenience of skin grafts on secondary defects but adds considerably to the number of scars over the scalp and this may make any form of cranioplasty difficult if not impossible.

2. *Distant Flaps*: Flaps from a distance, whether tubed (Bagozzi, 1955) or flat (Curtin *et al.*, 1963), add to the number of operations, but provide abundant albeit hairless cover which simplifies the problem of cranioplasty.

3. *Microsurgical Techniques*: A free flap transfer of omentum covered in turn by split skin grafts is invaluable in resurfacing very large scalp defects (McLean and Buncke, 1972), but it does not solve the ultimate problem of the cranioplasty.

A free cutaneous flap which can be taken from the axilla (Baudet, *et al.*, 1976) or groin, offers the great advantage of a one-stage repair with excellent vascularisation and provides abundant skin and subcutaneous cover for any subsequent cranioplasty.

Summary

The authors present two cases of extensive and very deep electrical burns of the skull, involving the dura and producing neurological complications.

In both cases the surgical excision and repair was carried out in four stages. This paper sets out the clinical justification for this approach.

The authors wish to thank the Editor and publishers of Annales de Chirurgie Plastique for permission to reproduce some of those illustrations which appeared in the paper by Micheau, Ph., Costagliola, M., Chavoin, J. P. and Chiotasso, P. (1979). *Annales de Chirurgie Plastique*, **24,** 83 entitled "Lambeau libre ou chirurgie 'classique' dans la réparation des brûlures graves du cuir chevelu et de la voûte cranienne".

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