

COMPLETE AVULSION OF SCALP

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Avulsion of the scalp involves loss of specific irreplaceable tissue, danger of serious complications, and a marked cosmetic deficiency, particularly important in young women. The constant care and attention given to the hair is a major factor in the psychological upset that may accompany its loss. The term 'complete avulsion' implies that the avulsed scalp is entirely detached from its surrounding and underlying tissues, as distinct from 'partial avulsion', where some attachment persists. Extensive complete avulsion of the scalp is a comparatively rare injury. Few surgeons have experience of more than one case, and the following report may therefore be of general interest.

CASE HISTORY

The patient, a 41-year-old European woman, was admitted to Addington Hospital on 5 December 1961, after an accident that same afternoon at a local textile mill, where her work involved the use of a sewing machine. She bent down to retrieve a bobbin and her hair was caught by the shaft driving the sewing machines, and as a result she was completely scalped. This shaft was situated in a well, below floor level. She was not wearing the regulation cap to cover her hair.

On admission she was given plasma and antitetanus serum, followed by blood transfusion. The avulsed scalp had been brought to hospital by the ambulance driver. I first saw the patient the same evening in the theatre, where she was receiving a blood transfusion. Her remaining hair had already been shaved. The patient had a complete avulsion of the scalp extending from the upper eyelids to just above the occiput. The size of the defect was about 10 inches by 8 inches. On the left side a partially avulsed flap including the eyebrows and part of the upper eyelids was still attached to its base, which was situated posteriorly. This had been torn away from a line extending from the right upper eyelid across the root of the nose to the left upper eyelid. A large posterior scalp flap was completely undermined to the base of the neck.

All devitalized tissue was debrided. The partially avulsed flaps on examination were thought at the time to be viable, for some of the edges were bleeding, and so these were sutured into their correct anatomical position with interrupted 3/0 'mersilk'. The large defect of the scalp remained completely covered by pericranium (periosteum) except for two small areas over the posterior aspect of the scalp. During the operation the patient developed profuse bleeding from the left



Fig. 1: Taken in theatre, showing the large defect following avulsion and the posterior flap undermined to base of neck. Two small areas of exposed cortex are visible.

occipital artery, and this was controlled by ligation. Medium-thickness Thiersch grafts (split skin grafts) were cut from the left thigh and sewn into position in the edges of the scalp and to each other. The best available pieces of skin were used to cover the frontal region. All the grafts were placed transversely. The grafts were dressed with tulle gras, fluffed-out gauze fixed with a tie-over dressing, and crepe bandage. The skin that had not been used was stored, which is a routine procedure in our department. Blood transfusion was continued until the patient had recovered from her shocked condition. Daily injections of penicillin and streptomycin were instituted. The following day the patient's general condition was satisfactory.

The first dressing was done on the 5th postoperative day. All grafts had completely taken. Two days later it was noted that the left frontal flap was developing a demarcation line at

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its distal end. This portion included all of the right eyebrow, half of the left eyebrow, and some skin of the eyelid. It was obvious that this portion would necrose. Part of the large

since none of the available methods for reconstructing eyebrows would have been suitable in her case. Temporal flap was not available, the mastoid hair had gone grey, and further she did not want any more operations.

DISCUSSION

Salient Anatomical Points

The scalp consists of 5 layers, viz. skin, subcutaneous tissue, occipito-frontalis muscle and its aponeurosis, subaponeurotic layer, and periosteum (pericranium). The superficial fascia in the scalp is a firm fibro-fatty layer adherent to the skin and to the underlying occipito-frontalis and its aponeurosis. The galea aponeurotica is a

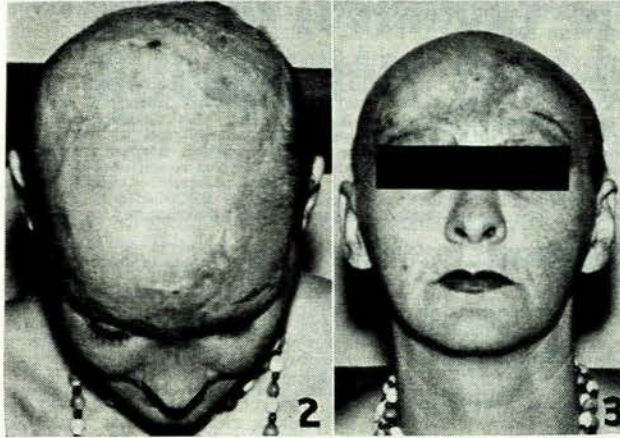


Fig. 2: Showing skull covered with Thiersch grafts. Note loss of right eyebrow and part of left eyebrow.
Fig. 3: Showing loss of eyebrow before final Thiersch and Wolfe grafts were applied to forehead.

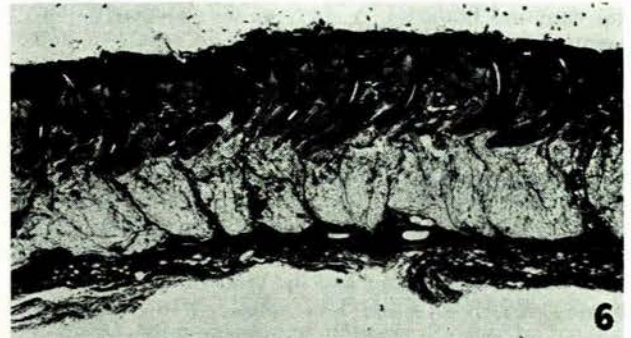


Fig. 6. Section of scalp, showing skin, subcutaneous tissue, and galea. Note hair follicles penetrating into subcutaneous fat.

posterior flap on the left side was also showing a demarcation line at its distal end. The grafts remained in excellent condition and the necrotic flaps were kept dry until the demarcation line was clearly defined, when they were removed. This left a raw area in the frontal region covered by granulation tissue.

On 14 January this granulating area was prepared for grafting, a sensitivity swab being taken from the wound and an appropriate antibiotic lotion applied 3 times a day for 3 days to sterilize the area. On 17 January the granulating area was successfully Thiersch-grafted, a few small residual raw areas of the scalp healing by epithelization.

By 8 February all raw areas were completely covered by grafts and epithelium. The case was reviewed at intervals, and it was noted that, owing to skin shortage over the region of the glabella, she had developed bilateral epicanthal folds. The graft that had been applied to the granulating area was wrinkled and lacked the uniformity and texture of the original graft; it was therefore excised and replaced by a thick Thiersch graft taken from the buttock. The graft was a complete take and gradually improved with time. The bilateral epicanthal folds were corrected by a Wolfe (full thickness) graft after division of the scar contracture.

The patient has now been fitted with a wig. Regarding the loss of eyebrows, I advised that she pencilled in the eyebrows,

dense fibrous tendinous structure between the frontal and occipital muscles. The occipito-frontalis muscle is loosely attached to the periosteum by a subaponeurotic areolar tissue and a layer composed of a network of loose areolar tissue containing fat. This has commonly been referred to as the 'cotton-wool' layer, and in this plane the scalp can be undermined easily and extensively. It is also the plane in which avulsion or scalping injuries take place.

The first three layers are intimately united and, whether they are raised as a flap or torn off in an accident, remain firmly connected to each other. The blood vessels and nerves run in the superficial fascial layer. This is the reason why large scalp flaps can be raised without interference with the blood supply. The skin of the scalp is thicker than elsewhere in the head and neck, and it is thicker in the occipital region. The tensile strength of the hair and its firm attachment result in rupture of the scalp from the cranium. The line of tearing usually begins in the frontal area, where the skin is thinner, and the prominent supraorbital edge acts as a knife edge and cuts through the skin of the upper lids where the scalp is torn. The line of cleavage is through the loose areolar tissue, and the periosteum usually remains intact, but may be avulsed. The skull rarely fractures in a scalping accident.

The many hair follicles of the scalp extend through the skin deeply into the fat of the superficial fascia. This differs from other parts of the body, where the follicles are situated in the dermis. This anatomical relationship accounts for loss of grafts when an attempt is made to replace an avulsed portion of scalp as a free graft, because the thick layer of fat, fascia and muscle prevents the growth of blood vessels into transplanted scalp. If one



Fig. 4: Showing lateral view of patient wearing wig.
Fig. 5: Showing patient wearing wig and eyebrows pencilled.

cuts a large Wolfe graft from the scalp, the deeply situated hair follicles are destroyed and the hair will not grow; so there is no object in spending time when a Thiersch graft will suffice. Yet, on the other hand, small hairy Wolfe grafts do survive and are used to reconstruct eyebrows. This is really a type of composite graft. In such a graft the hair follicles penetrating the fat are left intact.

The pericranium and periosteum is a thin fibrous membrane containing blood vessels, and is loosely attached to the cortex of the outer table of the skull, except at the suture lines, to which it is adherent. The blood supply of the scalp is profuse from the frontal, posterior auricular and occipital arteries and the superficial temporal, parietal, and temporal branches. A study of the vascular pattern is essential in selecting flaps to be used in repair of defects and deciding on the direction of scalp incision. Because of abundant blood supply, large flaps can be shifted on relatively small pedicles. The outer table of the skull is vascularized by vessels running in the pericranium and by the diploic vessels running between inner and outer tables. The large veins of the scalp are connected by emissary veins with the intercranial sinuses. The diploic veins communicate with the meningeal vessels and the sinuses of the dura mater and the veins of the pericranium. By this means, infection may spread to the intracranial vessels and produce meningitis, intracerebral abscesses, or thrombosis of the large venous sinuses. All these anatomical features account for the results of trauma, aetiology of loss of the scalp, and the treatment that should be carried out.

Aetiology of Large Losses of the Scalp

1. Traumatic avulsion of the scalp usually occurs in women working in factories, because their long hair can easily be caught in moving parts of machinery. It is compulsory for such workers to wear close-fitting caps as laid down by the Factory Regulations.

2. Burns. Large losses of scalp may be caused by various thermal agents (Fleming¹):

- (a) These usually occur as a result of prolonged contact with heat, e.g. when an epileptic falls into an open coal fire. Harrison² discussed 11 cases of scalp loss; 10 of them were due to burns, in 7 of which bone was involved.
- (b) Permanent waving apparatus (Christopher³).
- (c) Electricity. Bagozzi⁴ described 3 cases of loss of scalp and bone caused by serious electrical burns.
- (d) Radiation. Neuman⁵ described 4 cases of radiation necrosis of forehead and scalp, with exposure of bone, following on X-ray therapy for malignancy. I have seen similar cases at Wentworth Hospital.

3. Any type of trauma due to the impact of sharp and blunt objects (Rylander and Kisner⁶).

4. Infection. Severe sepsis resulting in thrombosis of blood vessels or intense accumulation of pus under the galea has occasionally produced extensive sloughing of the scalp (Cushing⁷). Syphilis and lupus vulgaris have also been responsible for large losses.

5. Malignancy of the scalp is treated by wide excision of the lesion and repair either by a free graft, local scalp flaps, or flaps from a distance (Fitzgibbon and Bodenham⁸).

6. Caustic paste as used by 'quacks' in cancer treatment (Dickie and Hughes⁹).

7. Scalping by paws of animals (Pirogoff¹⁰). Cohney¹¹ describes a case of avulsion of scalp from dog bites.

8. Scalping by humans. In the past Europeans, Asiatics, Africans and the American Indians have scalped their victims.

The custom is mentioned in II Maccabees, VII:7. Herodotus reported that Scythians scalped war victims in 1500 B.C. (Melpomene IV, 64, Laurent translation, quoted by Kazanjian and Webster¹²).

9. Congenital defects of the scalp have been reported (Peer and Van Duyn¹³).

Treatment in the Past

Kazanjian and Webster¹² (1946) quote some very interesting historical notes on the early treatment of scalp avulsion: 'Celsus recommended perforation of the dry, blackened sequestrum with an awl or terebra; and Fabrice d'Aquapendente, following Galen's practice, advised rasping the denuded calvarium. However, these writers deferred action until delineation between the sequestrum and normal bone had occurred. Augustin Belloste was the first to state that small perforations of the outer table should be made at the primary dressing of the wound, thus entirely avoiding exfoliation of the bone.'

'Replacement of the avulsed scalp was attempted in 40 of 173 cases reported by Wheeler. In none did the scalp survive. Malherbe, in 1898, replaced the entire scalp with complete healing in 98 days. However, the scalp died and was converted into a parchment-like covering, under which healing occurred with complications.'

'A new landmark in the treatment of these cases was . . . the discovery of skin grafting. Netolitsky* was the first man to utilize skin grafts to hasten healing in an extensive loss of the scalp; he used full-thickness grafts from the dorsum of the hand. In 1889 Socin first employed Ollier-Thiersch grafts for losses of the scalp, and Balas was probably the earliest to report the complete covering of the scalp with Ollier-Thiersch grafts at one operation. Recorded are many cases where the "small deep grafts" of Davis, skin from other individuals, cadavers, and animals (chickens, dogs, frogs, etc.), the lining of cysts and amniotic membrane, were used. The early authors were wont to believe that skin grafting should not be attempted until granulations had developed on the periosteum. Robinson was one of the leaders in the next forward step, for he stated that grafts would readily grow on the primary wound surface.'

The temptation to replace avulsed scalp in the original form is great. Most of the cases in which this has been done have failed.¹² The reason for this is dealt with in the discussion of the anatomy of the scalp. Delak¹⁴ reported a case of successful replacement of a completely avulsed scalp. He stated that it could be made successful by adequate operative technique, careful postoperative compression dressing, and the use of antibiotics. He prepared the scalp as a Wolfe graft by excising the galea and subcutaneous tissue, and the scalp survived. Three months later a thin growth of soft hair was noted on part of the scalp, but the photograph is not convincing. Meister¹⁵ tried some full-thickness grafts from the scalp, half postage-stamp size. Only a few of these grafts survived and grew hair. Geinetz¹⁶ cut Thiersch grafts from the scalp by a rather ingenious method. He tacked the scalp to the wooden head of a milliner's mannikin and cut Thiersch grafts from it with a razor type of grafting knife. This procedure, however, defeats the object of getting hair to grow from the grafts, for it is obvious that it will destroy all hair follicles.

The complications of inadequate treatment in the past include scar contracture of the upper lids, causing ectropion with subsequent exposure of the eyeball with damage to the cornea and resulting complications. Cases have been reported in which after extreme retraction and eversion of the lids, the patient has lost an eye. Scars of the scalp are particularly subject to trauma and result in recurrent ulceration, which heals slowly. As one would expect, carcinomatous degeneration has been reported.¹²

General Treatment

Scalp avulsion is an injury that has far-reaching effects on the patient. It involves long-term hospitalization, economic loss to the patient, and devastating disfigurement and psychological effects.

The blood loss must be adequately replaced. Antitetanus serum, or, if the patient has been previously immunized, tetanus toxoid must be given. Broad-spectrum antibiotic therapy or chemotherapy is instituted. If the avulsed scalp is brought to hospital, then the hair should be cut off and kept, for it may be used in the making of a wig. As soon as the patient has been resuscitated, operation should be started.

*Wien. med. Wschr. (1871), p. 819.

Local Treatment

The scalp must be shaved and the raw areas cleaned. Haemorrhage is controlled by ligature or diathermy. All devitalized tissue is debrided. All flaps that are still attached are sutured into correct anatomical position. If the periosteum is intact, medium-thickness Thiersch grafts (split skin grafts) should be applied to defects. The grafts are fixed in position by suturing them to the edges of the defect and to each other. The best possible piece of skin should be used for the frontal region and preferably applied transversely in order to place the junctional scars in the line of the natural skin creases. The fixation of the grafts and dressing can be attained by various methods. I prefer tulle gras dressings and fluffed gauze fixed with tie-over sutures. A quicker, and often useful, method, is to make a stent mould of the defect and apply the graft to the mould, which can then be retained either with tie-over sutures or a firm dressing. Skin not utilized is stored; it can be used for the covering of minor defects should there be loss of graft. A simple and effective method is to apply the skin, raw surface upwards, on tulle gras, folded, then wrapped in gauze wrung out in saline, and placed in a sterile container. The container can be kept in a domestic refrigerator, maintaining the temperature in the region of 4°C. It will be effective for 3-4 weeks.¹⁷ There are better and more elaborate methods of storing skin, but they require special apparatus.

According to the progress, the grafts are usually dressed after 5-7 days, excess trimmed, and sutures removed. Thereafter I dress them on alternate days if clean, otherwise with daily wet dressings of 5% milton or eusol. If there has been loss of graft, then stored skin is applied. First the granulations must be clinically clean, then a sensitivity swab is taken for culture and an appropriate antibiotic applied for 3 days;^{18, 19} then the stored skin is applied as a dressing. Subsequent treatment is as for a graft dressing. Flaps that will be lost will show a demarcation line, and as soon as this is well defined, the necrotic tissue is removed. Thereafter the procedure is to apply grafts to the granulating area in the manner mentioned above.

Cases with Loss of Periosteum

Free graft will not take on bare bone and this requires special treatment. Hemperl and Laughlin,²⁰ in a study of the osteological consequences of scalping, reported that in the area where the pericranium had been removed, the outer table of the skull necrosed, with the result that the necrotic portion became separated from living bone by granulation tissue and exfoliation. New bone was formed from the remaining diploe. In the area where skin had been lost this was ultimately replaced by scar tissue.

The best and quickest method of treating this is to chisel away the outer table of the skull until bleeding points are exposed and wait for granulation tissue to grow, which in turn is grafted. Some prefer to drill multiple holes in the outer table and wait for granulation tissue to grow. This is also effective, but slow.

It is possible in certain cases with loss of periosteum to cover the defect by well-planned scalp flaps, the design of which in turn depends on the size and position of the

defect and the availability of scalp tissue. Fracture of the skull is extremely rare in these cases, but if it should occur the appropriate treatment for head injuries would have to be instituted.

Complications are prevented by adequate primary treatment. Those that arise are mainly due to skin shortage and are best treated by application of free grafts after re-creating the original defects. Each case should be treated on its own merits. Eye complications require specialized treatment; ectropion must be corrected as soon as possible by free grafts. Carcinomatous degeneration requires adequate excision and flap replacement. Lost hair is replaced by a wig. The patient should be supplied with two so that one can be kept properly cleaned. Lost eyebrows can be replaced either by a full-thickness hair-bearing graft from the scalp, island flaps, or pedicle flaps from the temporal region. The last-mentioned are multi-stage procedures and require repeated hospitalization. Pencilling-in of the eyebrows is a very effective method of camouflage and an alternative to reconstruction of eyebrows.

SUMMARY

A case of complete avulsion of the scalp is described, and the methods of treatment of complete and partial avulsion of the scalp are discussed. The essential aspects of surgical anatomy of the scalp are discussed in relationship to scalp injuries. The reason why it is futile to replace the completely avulsed scalp is fully explained, and if a graft is taken from the scalp the hair follicles that penetrate the subcutaneous fat are destroyed. When pericranium is intact, the immediate covering of the defect with thick Thiersch grafts is the preferential method of treatment. When pericranium has been destroyed, the exposed cortical bone should be chiselled away until bleeding points have been found, in order to facilitate formation of granulation tissue. In some cases local flaps can be used to cover defects. Complications and their treatment are discussed. Rehabilitation with a wig and eyebrow reconstruction form an essential part of the final treatment.

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