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Reconstructive

Crane Principle Revisited

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Background: Scalp and forehead defects represent one of the most complex defects for reconstruction. The nature of these sites being hair bearing, together with the complicated nature of the injuries, for example, electrical burns and motor vehicle accidents, and of course the aesthetic concern being in the face, all add to the complexity of reconstruction.
Methods: This is a case series representing the experience of the authors in using the "crane principle" in the reconstruction of various defects in the forehead and the scalp presented to emergency department, Cairo University Hospital, for the period between January 2018 and January 2019.
Results: Twenty patients, 15 men and 5 women, presented with various soft tissue defects of the forehead and the scalp. The injuries of eighteen patients were due to motor vehicle accidents, and 2 patients had postelectrical burns. Age range was from 20 to 65 years, with a mean follow-up of 8 months. The number of total complications was 5. Three patients had wound dehiscence, and 2 patients had ulceration in the grafts placed at the flap donor site.
Conclusion: Crane principle represents an adequate reconstruction tool for forehead and scalp defects especially when the access to free flap and more complex reconstruction techniques is not available. *(Plast Reconstr Surg Glob Open 2020;8:e2741; doi: 10.1097/GOX.0000000000002741; Published online 22 April 2020.)*

INTRODUCTION

Soft tissue defects of the forehead and the scalp are among the most difficult defects for reconstruction due to the complexity of these tissues. The hair-bearing nature, the high-energy forces involved in the trauma (e.g., exit of high voltage electrical current or motor vehicle accidents), being in the face, and of course the aesthetic concern, all add to the complexity of reconstruction.

Although various forms of reconstruction of the scalp and the forehead have been described in literature, ranging from healing by secondary intention to free composite reconstruction, the crane principle represents one of the classical and straightforward techniques for reconstruction. The crane principle was first described by Skoog[1] in 1963 for reconstruction of a scalp defect following an electrical burn injury.

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METHOD AND TECHNIQUE

Initially, patients had adequate debridement within 24 hours of the time of injury. A rotating diamond head with copious saline irrigation was used to remove thin layers of outer cortex. The end point of debridement was the presence of minute punctate bleeding. The viability of the underlying bone was assessed. All patients had intact outer cortex with no visible macroscopic injury. This was followed by a second look (after 48 hours) to ensure the viability of the tissues and the need for further debridement. If no further debridement is needed, the flap is rotated or transposed to the defect, usually within 72 hours.

The crane principle was used in all patients. A temporary scalp flap was transferred to the defect with the exposed bone. The donor site of the flap was covered with split thickness graft. The physiology of this phenomenon was explained by Millard[2] in 1969 with his animal experiments at that time and reinforced by Pribaz et al[3] in 1994.

Upon retrieval of the flap, to avoid exposure of the denuded bone, supragaleal dissection was done, leaving a layer of galea over the pericranium. Using the famous mnemonic for SCALP (S: Skin; C: dense Connective tissue; A: epicranial Aponeurosis; L: Loose areolar tissue; and P: Pericranium), the flap was elevated as SCAL and retrieved as SC, leaving the galea as a vascularized tissue for graft take. The graft (from the flap's donor site) was recycled and placed at the original site of injury (Fig. 2).

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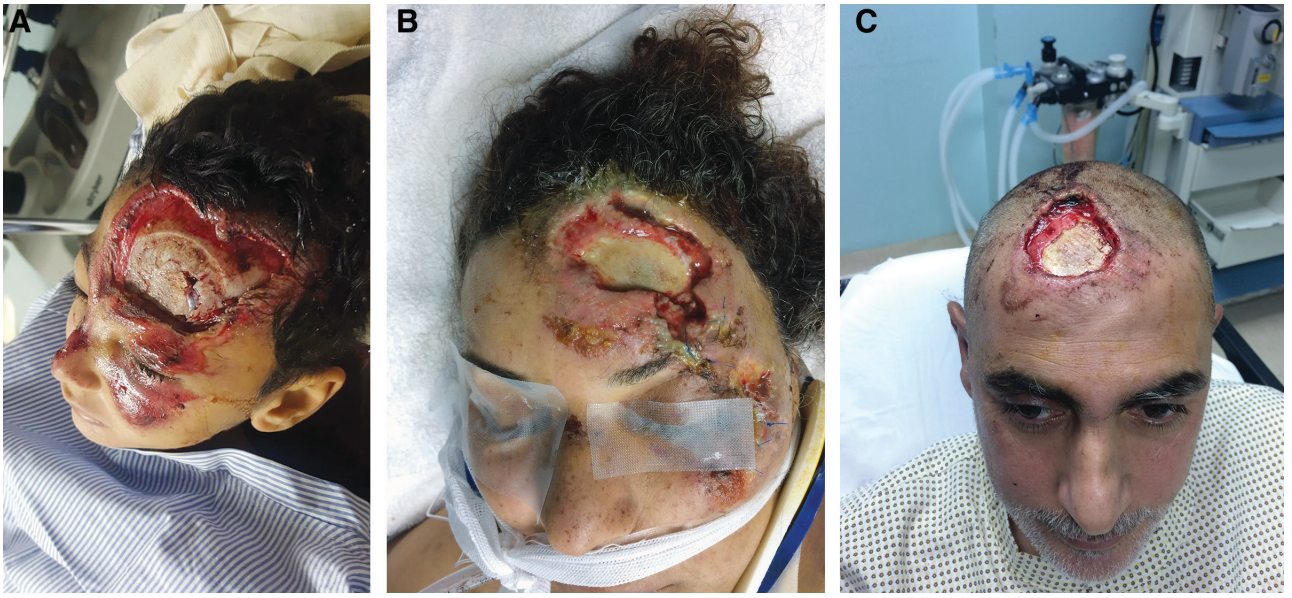

Fig. 1. Various forehead and scalp defects following motor vehicle accidents (A, B) and electrical burn (C).[3]

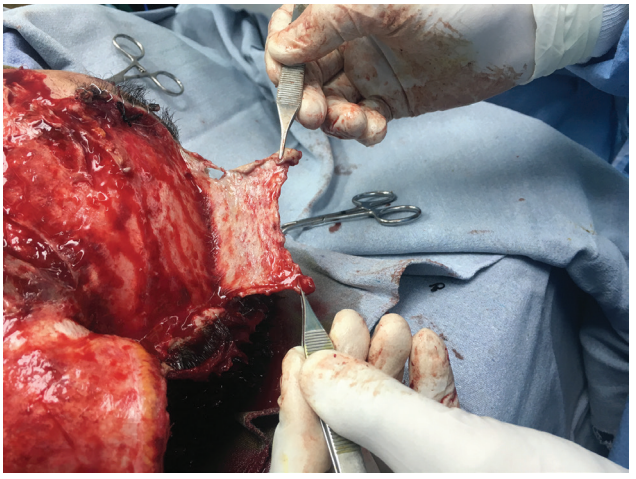

Fig 2. During the second stage of reconstruction, the flap was elevated from the site of injury, and the graft was recycled from the flap's donor site to be placed at the original site of injury.

The recycled graft should be of adequate thickness to be adequately harvested, but without jeopardizing its later take. The graft site was effectively sealed with the retrieved flap, that is, no theoretical risk of bony exposure, even if it happens during graft recycling, a flap was coming back in to close the defect. The average time for flap retrieval was 2 weeks. Patients were placed on high protein diet with multivitamins supplementation to help with wound healing process.

RESULTS

Twenty patients, 15 men and 5 women, presented with various defects of the forehead and the scalp. Age range was from 20 to 65 years, with a mean follow-up time of 8 months. Eighteen patients were due to motor vehicle accidents, and 2 patients were postelectrical burns. The electrical burn patients required at least 2 sessions of debridement before initiating flap reconstruction (Figs. 3, 4).

Five patients had complications in this case series. Three patients had wound dehiscence secondary to wound infection, and 2 had ulceration in the grafts (placed at the flap donor site). The latter complication was managed when the flap was returned to its original site. Other complications were managed conservatively.

DISCUSSION

Forehead and scalp defects represent a challenge for the plastic surgeon due to the complex nature of the tissues, the hair-bearing scalp, reconstruction of the hairline, the various etiopathological conditions affecting these sites, and the esthetic concern when performing reconstruction.

The crane principle has been described for reconstruction of various body sites, including the orbitocranial defects, frontal region,[4] hand,[5] and the lower limb.[6]

The transferred flap, with its unaltered blood supply, stimulates granulation tissue formation at the original site of injury, producing a healthy bed for graft application later, when the flap is returned to its original site. Rodríguez-Lorenzo et al,[7] in his seeding experiment, showed increased stem cell seeding and survival in all prefabricated flaps when compared with nonfabricated subcutaneous flap, donating increased viability of the flap and recipient bed.

Flap retrieval was done within 2 weeks. This time was usually enough regarding the safety of the flap vascularity and neovascularization process as attributed by many authors in previous experimental animal studies.[8,9]

There is a wide variety of options for reconstruction for the forehead and scalp, ranging from healing by secondary intention, grafting, and up to free flaps, and recently, face transplantation.[10] Although the free flaps might be bulky at first, some authors believe that free flaps are ideal for reconstruction of the scalp defects due to its ability to

Fig. 3. Female patient following motor vehicle accident (A). Debridement and a rotational flap done with split thickness of the donor site using the crane principle. The rotational flap is returned to its original site with grafting of the forehead (B). Defect size 11 × 10 cm.

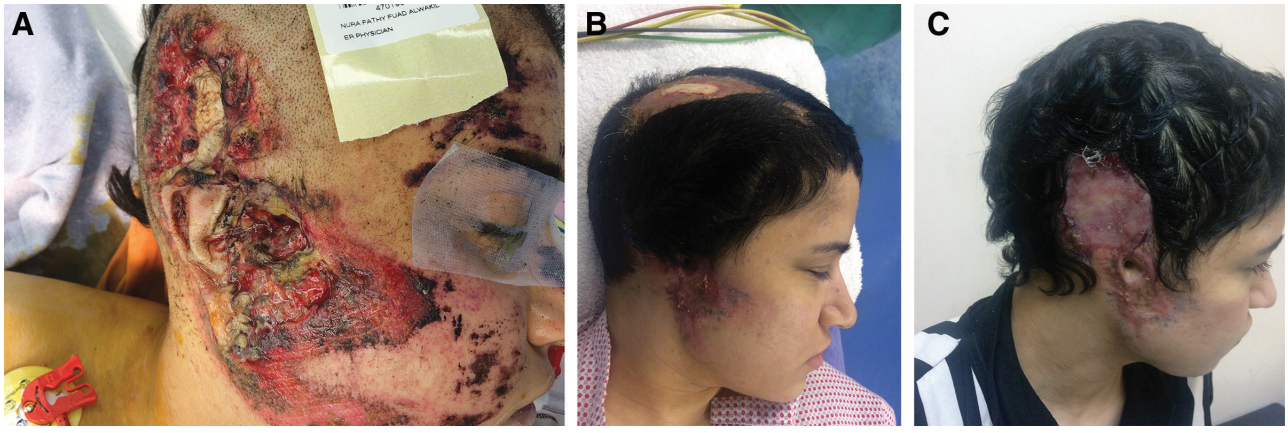

Fig. 4. Female patient following motor vehicle accident (A, B). Debridement and a rotational flap done with split thickness of the donor site using the crane principle (B). Notice the ulceration in the donor site. The rotational flap is returned to its original site with grafting of the temple region (C). Triangular defect measuring 11 × 10 × 4 cm.

mold to the skull shape, provide a good viable durable coverage, and of course, its necessity if an associated calvarial reconstruction is required.[11]

In situations where the resources are bounded (as in developing countries), where the availability for a trained microvascular surgeon as well as microsurgical facilities may be checked, other options for reconstructions should be considered; hence, the crane principle is revisited.

The crane principle is a relatively straightforward technique with minimal training required. Additionally, the surgery is much shorter than the lengthy free flap procedure, minimizing the costs and reallocating the resources for maximum efficiency. Furthermore, there is minimal donor site morbidity with no additional sites required other than the site of injury (in contrast with the free flap). Even following flap retrieval, the graft is recycled from the flap's original donor site with no additional donor sites.

Being a reproducible technique, crane principle is more suitable than free flap in mass causalities, being easily applied and requiring shorter time.

However, the crane principle can be challenging in difficult situations of osteomyelitis or when there is a calvarial bony defect. Additionally, oncological reconstruction with postoperative irradiation could represent a further restraint. The free flap is ideal option in these situations.[12]

Additional drawbacks include the multiple staging nature of the procedure and time needed for healing. The

latter is quite variable between the patients and might be lengthy; however, the forehead and the scalp are among the sites known for better healing and remodeling.[13]

CONCLUSION

Crane principle represents an adequate tool for reconstruction of forehead and scalp defects, especially when the access to free flap and more complex reconstruction techniques is not available.

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PATIENT CONSENT STATEMENT

All patients provided written consent for the use of their images.

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