Asian Biomedicine Vol. 5 No. 6 December 2011; 881-888 DOI: 10.5372/1905-7415.0506.098

Clinical report

Axial expanded forehead flaps for the repair of extensive facial defects: a report of 13 cases

Yangchun Xie, Xuefeng Han, Xu Zhou, Miaomiao Wang, Qingguo Zhang, Tun Liu
Plastic Surgery Hospital of Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China

Background: Repair of facial defects is a unique challenge because it is critical that donor tissues match the tissues in the affected region and provide good functional as well as aesthetic outcomes.
Objective: Summarize the outcomes of the use of expanded forehead flaps to repair extensive facial defects in 13 patients.
Methods: Axial expanded forehead flaps pedicled on the superficial temporal vessels and supraorbital and supratrochlear neurovascular bundles were used to repair defects of the nose, eyelids, and mouth. Seven cases involved damage to the nose and lip and six cases involved the forehead and nose. Among the latter six cases, three had skin surface tumors involving the forehead together with the upper eyelid and the nose, in which one was pigmented nevus, one was neurofibroma, and one was hemangioma.
Results: A total of 34 flaps, ranging in size from 2.5□4 cm to 12□9 cm, were used to repair facial defects in the 13 patients (five males, eight females; median age, 32 years). There were no surgical or postoperative complications, and all flaps survived. In all cases, cosmetic and functional outcomes were considered satisfactory.
Conclusion: The expanded forehead flap provides a large amount of tissue with color and texture similar to that of facial structures, and avoids significant donor sight scars. In addition, the extensive blood supply of the forehead helps to ensure flap survival. Expanded forehead flaps are useful for the repair of large facial defects.

Keywords: Axial flap, expanded forehead flap, facial defect, plastic surgery

Congenital or acquired facial skin defects often involve several parts of the face and their repair represents a significant challenge for plastic surgeons. A large amount of soft tissue is often required for reconstruction, and cosmetic outcome is of utmost importance, thus selecting donor tissues with color and texture close to the damaged tissue and minimizing the scar in the donor area at the same time is critical for satisfactory results. A vast number of techniques and flaps have been developed and used for the repair of facial defects [1-4].

Of the numerous flaps used for facial reconstruction, the forehead flap has found use in the repair of defects including those of the eyelids, nose, and mouth [2, 5-9]. Expanded forehead flaps not only provide a large amount of tissue for repair, but also results in minimal and inconspicuous scarring in the donor sites [5-7]. In addition, the blood supply of axial flaps helps to ensure flap survival.

The purpose of this report is to present our successful application of expanded axial forehead flaps based on the superficial temporal and supraorbital and supratrochlear neurovascular bundles for the reconstruction of extensive facial defects in 13 patients.

Patients and methods

The current report includes 13 patients, five males and eight females with a median age of 32 years. Seven cases involved damage to the nose and lip and six cases involved the forehead and nose. Among the latter six cases, three had skin surface tumors involving the forehead together with the upper eyelid and the nose, in which one was pigmented nevus, one was neurofibroma, and one was hemangioma. Patient

Correspondence to: Yangchun Xie, MD, Plastic Surgery Hospital of Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China. E-mail: xieyangchun 98987@126.com

demographic and clinical data are presented in **Tables 1** and **2**. This study was approved by the Institutional Review Board of our hospital. All patients signed informed consent, and patients whose cases and images are presented in this report gave permission for publication.

Forehead skin expansion

Expansion of the forehead skin was accomplished with various types of dilators based on the frontal hairline and the requirements of the flap transfer. When upper lip reconstruction was needed for male patients, scalp expansion was carried out. Rectangular dilators were used, their size ranged from 100 to 250 ml. Incisions parallel to the hairline were usually made 2 cm posterior to the hairline. Based on the direction of vessels supplying blood to the flap, dilators were placed under the vessel, and dissection was carried out at the deep layer of the frontal muscle. When supraorbital and supratrochlear vascular bundles were needed, subperiosteal dissection was carefully carried out 2 cm superior to the orbit. Sutures were removed eight to ten days after surgery, and saline injection was carried out twice a week from postoperative day (POD) number 14. The total amount of saline injected was based on the size of the defect to be repaired. Generally, the amount of injected saline was two to three times of the volume of the dilator. Flap transfer was performed two weeks after an adequate amount of saline had been injected.

Flap pedicled on the superficial temporal vascular bundle

The course of the superficial temporal vascular bundle was determined by the color Doppler ultrasonography before surgery. Based on the size of the facial defects, flaps pedicled on the bilateral superficial temporal vascular bundles were transferred to the upper lip or the lower lip. If the patient was a male, the expanded scalp was selected as the repair material, as it could reconstruct the beard, and the skin flaps were used to repair defects in the nose and other areas. Two parallel incisions were made along the bilateral crus of the helix at the upper pole of the ear. The width of the pedicle ranged from 3 to 5 cm, and the maximum area of the flaps used were 9x12 cm. The pedicle was cut three weeks after flap transfer, and the skin of the pedicle was transferred to other repair defects, such as nasal defects. Defects in the eyelid were repaired by the superficial temporal vascular pedicle, and the forehead defect was directly repaired by the remnant flap.

Flap pedicled on the supraorbital and supratrochlear neurovascular bundles

The course of the blood vessels was determined by the color Doppler ultrasonography before surgery. According to the size and morphology of the facial defects, two or more axial flaps were designed and transferred to repair the facial defects.

Management of the donor site

For the flaps pedicled on the superficial temporal vascular bundle, the incision in the forehead was sutured at the edge of the frontal hairline, which resulted in a minimal surgical scar. For the flaps pedicled on the supraorbital and supratrochlear neurovascular bundles, a linear scar in the vertical line of the forehead was inevitable; however, cosmetic suture was used to minimize postoperative scarring. The patients received appropriate and standard postoperative care, follow-up and rehabilitation.

Table 1. Patient demographic characteristics (n=13)

	Number (%)
Age (years)	32 (male: 25, female: 42)
Gender	
Male	5 (38.46%)
Female	8 (61.54%)
Reason for surgery	
Congenital	3 (23.08%)
Acquired	10 (76.92%)
Follow-up period (days)	148 (120,263)

Data are presented as median and interquartile range or number and percentage

Table 2. Patient demographic and clinical data

Case	Age (years)	Gender	Injury sites	Donor flap sites	Flap types and sizes (cm)	Flap survival (%)	Compli-cations	Follow-up (days)
1	32	male	Nasal ala, upper lip	Forehead and scalp	Bilateral superficial temporal vascular bundles (7.3x11.0, 9.5x6.9, 4.5x6.0)	100	None	1180
2	42	female	Whole face	Forehead and scalp	Supraorbital and supratrochlear neurovascular bundles (7.0x11.5, 5.0x3.4)	100	None	380
3	46	male	Upper eyelid and forehead	Forehead and scalp	Supraorbital neurovascular bundle and superficial temporal vascular bundle (7.0x11.5, 10x4.0)	100	None	18
4	37	female	Nose, upper lip	Forehead	Supraorbital and supratrochlear neurovascular bundles (8.1x12.0, 4.6x11.2)	100	None	338
5	35	female	Upper eyelid, nasal dorsum, right cheek	Forehead and buccal area	Supraorbital neurovascular bundle and superficial temporal vascular bundle (5.0x4.2, 8.0x6.0, 4.1x5.0, 0.3x6.5)	100	None	259
6	26	male	Scalp, left upper eyelid, left cheek, nose	Forehead and scalp	Supratrochlear neurovascular bundle and superficial temporal vascular bundle (5.1x3.6, 4.8x3.3, 5.6x4.8, 4.2x3.5)	100	None	120
7	17	male	Forehead, nasal dorsum	Forehead	Supratrochlear neurovascular bundle and superficial temporal vascular bundle (5.5x6.8, 5.8x6.9)	100	None	263
8	52	male	Left upper eyelid, forehead, lateral orbital rim, nasal dorsum	Forehead	Supraorbital, supratrochlear neurovascular bundles and superficial temporal vascular bundle (5.2x4.3, 7.6x3.6, 4.8x3.8, 4.2x3.5)	100	None	148
9	25	female	Forehead, nasal dorsum, upper lip	Forehead	Supraorbital and supratrochlear neurovascular bundles (3.2x4.1, 6.8x7.2, 2.0x3.1)	100	None	128
10	22	female	Nasal tip, ala and dorsum, upper lip	Forehead	Supraorbital and supratrochlear neurovascular bundles (4.9x6.0, 3.0x5.2)	100	None	226
11	19	female	Forehead, nasal dorsum	Forehead	Supraorbital and supratrochlear neurovascular bundles (5.3x4.8, 5.2x4.9)	100	None	127
12	33	female	Nose, lips	Forehead	bilateral superficial temporal vascular bundles (3.6x5.6, 2.0x4.0)	100	None	49
13	44	female	Nose, lips	Forehead	Supraorbital and supratrochlear neurovascular bundles (6.3x4.2, 3.2x4.5)	100	None	65

Statistical analysis

Continuous data were summarized as median and interquartile range (IQR: Q1, Q3). Categorical variables were expressed by number (percentage). Statistical analyses were performed using SPSS 15.0 statistics software (SPSS Inc, Chicago, IL, USA).

Results

A total of 34 flaps, ranging in size from 2.5x4 cm to 12x9 cm, were used to repair facial defects in the 13 patients. All flaps survived, and no complications occurred in any patient (**Table 2**). The flaps were trimmed repeatedly during the early stages, and the final cosmetic outcomes were satisfactory in all cases, and color and texture were judged to be excellent. There are three representative cases as follows.

Case 1

The patient was a 32-year-old male with defects in the upper lip and nasal ala as a result of a car collision. The upper lip defect was approximately 2.3x3.2 cm. He underwent debridement surgery at a local hospital and the avulsed tissues were sutured to the original locations without microvascular anastomosis techniques. Mummification necrosis occurred 18 days after treatment and the wound in the upper lip healed after local care. The patient was referred to our hospital and examination revealed a significant red scar in his upper lip, and the upper lip was tight and depressed (**Figure 1A**). The buccal gingival sulcus of the upper lip was shallow, and the upper lip was adhered to the upper jaw. The patient had difficulty opening his mouth. A 100 ml rectangular dilator was placed longitudinally in the forehead. Saline injections were begun 14 days after placement. Injections were performed twice a week and the amount of saline injected each time ranged from 5 to 16 ml. After 160 days, the total amount of saline injected was 280 ml. In order to prevent contraction of the expanded skin flap, reconstructive surgery was performed two weeks after the last saline injection to maintain the needed tension.

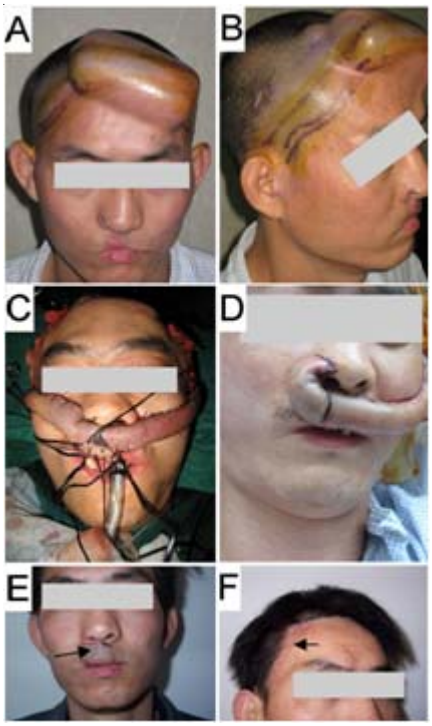

Figure 1. A 32-year-old male with defects in the upper lip and nasal ala as a result of car collisions. **A:** Before the surgery, a dilator was implanted in the forehead and water injected over a period of 160 days. **B:** The designed width of the flap with pedicle. Doppler ultrasound was used to determine the location of the superficial temporal artery. **C:** Bilateral frontal superficial temporal artery flap for transfer. **D:** One side pedicle was cut and the pedicle was transferred to repair the nose. A local flap was used as lining, and the expanded skin flap was used for coverage. **E:** Postoperative outcome. **F:** The donor site scar after healing.

The scar on the upper lip was removed, adhesions between the upper lip and the upper jaw were released, and the bilateral corners of the mouth were reset. Bilateral flaps pedicled on the superficial temporal vascular bundle, 3□4 cm, were created and used to repair the defects in the upper lip and the nasal ala (**Figure 1B**). After the formation of skin tubes, the flaps were transferred and sutured to the defect in the upper lip, and the donor site was closed primarily (**Figure 1C**). The wounds caused the incision of bilateral pedicles were protected by packing with iodoform gauze, and the pedicles were then replanted back after the pedicles were cut. An intermediate thickness skin graft measuring 4□6 cm was harvested from the abdomen, trimmed to a thin intermediate thickness, and sutured inside the oral cavity after the flap transfer as a lining of the flap. Press-packing with iodoform gauze was carried out for the graft inside the oral cavity. Postoperatively, dressing changes were performed daily, and sutures were removed 10 days after surgery. The skin graft survived, and the blood supply of the flaps was excellent.

One side pedicle was ligated 18 days after the operation to strengthen the blood supply to the flap. Six days later, the pedicle on the side without the nasal ala defect was cut and replantation was carried out. Three weeks later, the pedicle on the side with the nasal ala defect was cut and the flap near the pedicle was transferred to the nasal ala where the defect existed. The skin at the defect site was cut, the local skin was used for lining, and the transferred flap was used as coverage (**Figure 1D**). Pedicle division was performed 18 days later. At 1-year postoperatively, the outcome was excellent (**Figure 1E**). The depth of the gingival buccal sulcus was satisfactory and mouth opening was normal. The scars at the sites of the harvested flaps were removed, and flap trimming was not carried out (**Figure 1F**).

Case 2

The patient was a 42-year-old female with severe facial defects as a result of a flame burn three years prior. She had facial scaring, her nose was markedly reduced in size, and the nostril was closed. Additionally,

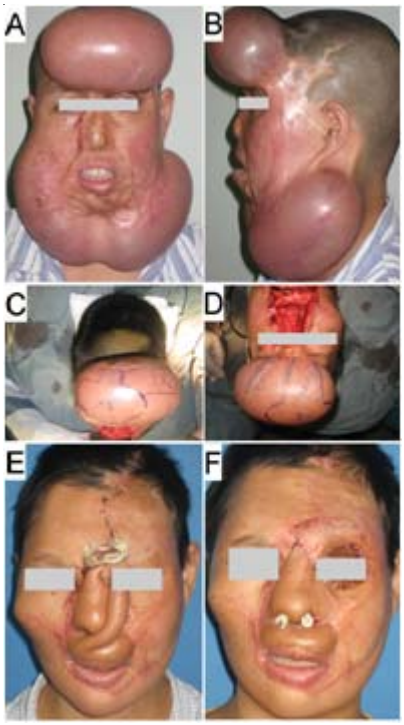

Figure 2. A 42-year-old female with burn scars on her nose with defects of her nose and nasal columelia (nasal atresia, upper lip defect, and valgus). **A, B:** Forehead skin was expanded before the surgery. **C:** The design of forehead pedicle flap with supraorbital neurovascular bundle and one large flap pedicled on the supraorbital and supratrochlear neurovascular bundles for the repair of the nasal defects. **D:** Local flap for lining. **E:** After pedicle implantation. **F:** Two weeks after pedicle ligation flaps are healing well and the cosmetic outcome is acceptable.

there was eversion in the upper and lower eyelids and a defect in the upper lip (**Figures 2A, B**). The nasolabial defects were repaired by flaps pedicled on the supraorbital and supratrochlear vascular bundles. The flaps were designed intraoperatively (**Figures 2C, D**). Images after flap transfer and two weeks after cutting the pedicle are presented in **Figures 2E, F**.

Case 3

The patient was a 46-year-old male with a large pigmented nevus, 11.5x9 cm, that involved the eyelids, nose, and forehead (**Figure 3A**). A random forehead flap pedicled on the supraorbital neurovascular bundle was used. The pigmented nevus on the nasal dorsum was repaired with an expanded flap pedicled on the supraorbital vascular bundle (**Figure 3B**). Others areas were repaired by flap transfer after surgical removal of the pigmented nevus. Eyebrow transplantation, flap trimming, and scar repair were performed six months after flap transfer (**Figure 3C**).

Discussion

The face is the most visible part of the body in which several organs can have different deformities and defects simultaneously. Because of the special characteristics of the face and the unique importance of good cosmetic outcomes, donor site tissues should be as similar as possible to that of the area to be repaired. A vast number of techniques and flaps have been developed and used for the repair of facial defects [1-4]. It has been suggested, however, that "the tint of forehead skin so exactly matches that of the face and nose that the forehead flap must be the first choice for reconstruction of a nasal defects" [10]. The forehead flap has been used for the repair of defects

Figure 3. A: A 43-year-old male with forehead, eyelid, nasal dorsum, and cheek defects due to congenital hairy pigmented nevus. **B:** Completion of forehead skin expansion. **C:** The supraorbital neurovascular bundle was used for repair of the nose and other skin flaps were used for the repair of the eyelid and forehead defects and the postoperative outcome was good.

of the eyelids, nose, and mouth [2, 5-9]. Expanded forehead flaps not only provide a large amount of tissue for repair [11], but also results in minimal and inconspicuous scarring at the donor sites [5-7].

Local flaps usually cannot provide sufficient tissue for repair of defects, especially when two different sites of the face are affected, and typically leave significant scars. Perioral flaps (cross-lip flap) have been used for lip reconstruction; however, they are associated with significant scarring around the mouth [12-14]. Local flaps (e.g., nasolabial flap, orbicularis muscle flap) and distant flaps (forearm skin tube, forearm free flap, dorsalis pedis flap) can be used to repair facial defects; however, these flaps each have their own shortcomings such as color differences, clumsiness, unsecured blood supply, and excessive thickness [15-17]. Significant scaring, pigmentation, and skin graft contracture are associated with skin grafting without expansion [18]. Expanded forehead flaps pedicled on the superficial temporal vessels utilize incisions at the hairlines, which avoids visible scars, and expanded forehead flaps pedicled on the supraorbital and supratrochlear neurovascular bundles leave less obvious incisional scars at the forehead [1, 4, 7, 8].

Li et al. [19] divided the midline forehead flap into two layers, a muscular part and skin part, to avoid the clumsiness of the flap and highlight the fine structures in the nose. We believe that the expanded forehead flap can be used similarly. The expanded forehead flaps we used were pedicled on the superficial temporal vessels on the supraorbital and supratrochlear neurovascular bundles, which ensured an adequate blood supply to the flap. For multiple defects in the face, axial flaps with several vascular pedicles can be formed for flap transfer and later reconstruction [20].

Facial defects often involve the nose, and the thin forehead flap pedicled on the supraorbital and supratrochlear vascular bundles is one of the best choices for repair [3, 21-23]. Weng et al [9] described the use of extended forehead skin expansion and single-stage nasal subunit plasty for nasal reconstruction in 43 patients. Only minor complications were reported, and 81% of the patients reported satisfactory aesthetic outcomes, 70% satisfactory functional outcomes, and 77% indicated satisfactory donor-site aesthetics. Brodland [2] described the use of the forehead flap for nasal defects and suggested that with careful attention, virtually any nasal defect can be restored with excellent functional and cosmetic results. It should be noted that trimming the flap two to three times after the repair of the nasal defect is usually required for good cosmetic outcomes [23].

Perioral reconstruction is uniquely challenging because the requirement of satisfactory functional as well as aesthetic results. Fan et al [6] reported full perioral reconstruction of burn scarring using bilateral-expanded forehead flaps in six patients. Reconstruction was successful in all patients, and all had good functional and cosmetic outcomes. Methods for repairing defects in the upper and lower lips should be selected based on whether the patient is a male or female. Expanded scalp flaps can be used for male patients to avoid secondary beard reconstruction, and expanded forehead flaps can be used for female patients.

Reconstruction of the eyelids also presents unique challenges. Lesavoy et al [8] recently reported total upper and lower eyelid reconstruction using an expanded forehead flap in a patient with radiation injury after left eye enucleation and radiotherapy for rhabdomyoscarcoma in infancy. The forehead flap provided a good aesthetic result and enough soft tissue for placement of an ocular prosthesis.

Conclusions

The expanded forehead flap provides a large amount of tissue with color and texture similar to that of facial structures, is particularly useful for highlighting nasal structures, and avoids significant donor sight scars. In addition, the extensive blood supply of the forehead helps to ensure flap survival. Expanded forehead flaps are useful for the repair of large facial defects.

The authors have no conflict of interest to report.

References

1. Tschoi M, Hoy EA, Granick MS. Skin flaps. Clin Plast Surg. 2005; 32:261-73.
2. Brodland DG. Paramedian forehead flap reconstruction for nasal defects. Dermatol Surg. 2005; 31:1046-52.
3. Chen EH, Johnson TM, Ratner D. Introduction to flap movement: reconstruction of five similar nasal defects using different flaps. Dermatol Surg. 2005; 31:982-5.
4. Tan O, Atik B, Ergen D. Temporal flap variations for craniofacial reconstruction. Plast Reconstr Surg. 2007; 119:152e-163e.

5. Fan J. A new technique of scarless expanded forehead flap for reconstructive surgery. Plast Reconstr Surg. 2000; 106:777-85.
6. Fan J, Liu L, Tian J, Gan C, Lei M. Aesthetic full- perioral reconstruction of burn scar by using a bilateral-pedicled expanded forehead flap. Ann Plast Surg. 2009; 63:640-4.
7. Huang YX, Zhan XH, Fan JC, Zheng JW, Wu ZH, Chen JC, et al. [Repair of scars in submaxillary region using expanded forehead axial flaps with fascia pedicles carrying bilateral frontal branches of superficial temporal artery and vein]. Zhonghua Shao Shang Za Zhi. 2010; 26:251-5. [Article in Chinese]
8. Lesavoy MA, Kohan E. Total upper and lower eyelid reconstruction using an expanded forehead flap. Ann Plast Surg. 2011; Mar 2. [Epub ahead of print]
9. Weng R, Li Q, Gu B, Liu K, Shen G, Xie F. Extended forehead skin expansion and single-stage nasal subunit plasty for nasal reconstruction. Plast Reconstr Surg. 2010; 125:1119-28.
10. Gillies H, Millard DR. The principles and art of plastic surgery. Boston, MA: Little Brown. 1957.
11. Hoffmann JF. Tissue expansion in the head and neck. Facial Plast Surg Clin North Am. 2005; 13:315-24, vii.
12. Fujinori R. Gate flap for the total reconstruction of the lower lip. Br J Plast Surg. 1980;33:340-5.
13. Aytekin A, Ay A, Aytekin O. Total upper lip reconstruction with bilateral Fujimori gate flaps. Plast Reconstr Surg. 2003; 111:797-800.
14. Rea JL, Davis WE, Rittenhouse LK. Reinnervation of an Abbe-Estlander and a Gillies fan flap of the lower lip: electromyographic comparison. Arch Otolaryngol. 1978; 104:294-5.
15. Sakai S, Sodeda S, Endo T, Ishii M, Uchiumi E. A compound radial artery forearm-flap for the reconstruction of lip and chin defect. Br J Plast Surg. 1989; 42:337-8.
16. Menick FJ. Defects of the nose, lip, and cheek: rebuilding the composite defect. Plast Reconstr Surg. 1979; 64:692-6.
17. McCarthy J, Lorenc ZP, Cutting C, Rachesky M. The median forehead flap revisited: the blood supply. Plast Reconstr Surg. 1985; 76:866-9.
18. Menick FJ. A 10-year experience in nasal reconstruction with the three-stage forehead flap. Plast Recongstr Surg. 2002; 109:1839-55.
19. Li QF, Xie F, Gu B, Zheng D, Lei H, Liu K, et al. Nasal reconstruction using a split forehead flap. Plast Reconstr Surg. 2006; 118:1543-50.
20. Taylor GL, Tempest M. Arteries of the skin. Churchill Livingstone. 1988; p72-84.
21. Burget G, Menick F. Aesthetic reconstruction of the nose. Mosby. 1993.
22. Millard DR Jr. Reconstructive rhinoplasty for the lower two-thirds of the nose. Plast Reconstr Surg. 1976; 58:283-91.
23. Menick FJ. Nasal reconstruction with a forehead flap. Clin Plast Surg. 2009; 36:443-59.