

The Versatility Of Forehead Flaps As A Reconstructive Tool

*Dissertation submitted in partial fulfillment of the requirements for
the degree of*

M.Ch. (Plastic Surgery) - Branch III



**THE TAMILNADU DR.M.G.R.MEDICAL UNIVERSITY
CHENNAI**

AUGUST 2008

CERTIFICATE

This is to certify that, this dissertation titled “ **The Versatility Of Forehead Flaps As A Reconstructive Tool** ”, submitted by Dr. Dinesh Kumar .S appearing for M.Ch. (Plastic Surgery) degree examination in August 2008 is a bonafide record of work done by him under my guidance and supervision.

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Title of the work "Versatility of Forehead Flaps as a
Reconstructive Tool"

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The request for an approval from the Institutional Ethical Committee (IEC) was considered on the IEC meeting held on 15/2/2008 at the Conference Hall of the Dean, Lower Block I, Government General Hospital, Chennai.3.

The members of the Committee, the Secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the principal investigator.

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I solemnly declare that this dissertation “*The Versatility of the Forehead Flaps as a Reconstructive Tool*” was prepared by me in the Department of Plastic, Reconstructive and Maxillofacial Surgery, Madras Medical College and Government General Hospital, Chennai under the guidance and supervision of Professor & HOD Department of Plastic, Reconstructive and Maxillofacial Surgery, Madras Medical College and Government General Hospital, Chennai between 2005 and 2008.

This dissertation is submitted to the TamilNadu Dr. MGR Medical University, Chennai in partial fulfillment of the University requirements for the award of degree of MCh Plastic Surgery.

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INTRODUCTION

Forehead Flaps have been in use since ancient times as has been depicted in the classical paintings of the great Susrutha at work repairing the nose of those unfortunate to have their noses cut off as a punishment. The forehead flaps hold a closer relation to us Indians as we seem not only to be pioneers in utilizing this area for reconstruction but also contribute to the further development of their uses. The bipolar Narayanan flap is a point in case.

The forehead flaps have waxed and waned in their popularity at various periods in the long history of plastic surgery. Although it has proved its reliability time and again there seems to be a continued reluctance among the younger generations of plastic surgeons in using this virtual treasure trove of tissue for reconstructive options in the head and neck region due to concerns about the donor area scarring.

Probably the easy accessibility to technology and the ever increasing popularity of free flaps with their promise of a single-stage procedure – where the tissue can be sculpted to exactly fit the defect and thereby allowing the patient to return to near-normal life as early as possible – as compared to the multiple stages generally required when the forehead flap is used, distracts surgeons from these age-old and time-tested options.

It is also widely accepted that local tissues give the best colour and texture match to any reconstructed area. This is especially applicable to the face. Thus, currently the central forehead flaps are favoured in the nasal reconstruction.

The forehead flaps have lent themselves to such a wide variety of uses that a

revisit to their different clinical applications is well justified, if only to serve to bring the spotlight back to the most versatile donor area in the face.

AIM OF THE STUDY

This study on the versatility of the forehead flaps as a reconstructive tool was done with following aims.

- 1) To review the various flaps used from the forehead region in Department of Plastic and Reconstructive Surgery, Government Medical College, Chennai.
- 2) To study the effectiveness of these flaps in various clinical situations.
- 3) To report our experiences along with the other uses of forehead flaps reported in the literature.

REVIEW OF LITERATURE

The earliest accounts of forehead flaps appear in the *Susrutha Samhitha* where skin from the centre of the forehead was utilised to reconstruct noses as far back as 600 – 700 B.C.³ This knowledge was transferred to a family of potters (the Koomas) who continued to use it even during the time of British rule in India.⁶

Antonio Branca, of Italy, is credited with the first reported use of the mid-forehead flap outside of India.⁴ Based on an arabic translation of the *Susrutha Samhitha*, Branca performed the operation in the 15th century. He was persecuted for “interfering in God's work” and so the technique was still remained unknown to the Western World until J. C. Carpue read an editorial description of the technique that was published in the Gentlemen’s Gazette in 1794.⁵ Carpue practised the technique on cadavers for 20 years, until he found the right patients. He then described 2 cases in a monograph entitled “An Account of Two Successful Operations for Restoring a Lost Nose.”⁶

Further modifications of the forehead flaps for nasal reconstruction continued by Millard,^{9,11,12,13} Burget,^{14,15,16} Menick^{14,15,17} and others. The preference kept shifting from midline to paramedian to oblique and back to midline flaps in the attempt to increase the reach while preserving the blood supply. Elucidation of the vascular anatomy of these flaps was done by Kazanjian (1946)¹⁰ and Shumrick KA, Smith TL (1993).⁵ allowing for further refinements of these flaps. Converse described the scalping technique for using the forehead skin for reconstruction of near-total loss of nose (1942).^{74,75,76,77}

In 1893 Dunham described a laterally based forehead flap which 'was so cut as to contain, traversing its pedicle and ramifying in it, the anterior temporal artery. It had a rather long pedicle, about an inch wide, attached in front of the ear, and the mass of the flap was from the upper forehead where it slightly crossed the median line'.⁵⁸ He then dissected out the vessels and returned it to the forehead along with the pedicle at the time of division leaving the skin for reconstruction of the defect in the face.

The ability of a narrow pedicle to support a forehead flap was further demonstrated clinically by Monks (lower eyelid reconstruction 1989),⁶⁸ Horsley (cheek reconstruction 1916),⁶⁹ Esser (1917,1931), Gillies (1949) and many others. Wilson advocated a 2-centimetre pedicle for the forehead flap (1967).⁷⁰ A thorough understanding of the vascular anatomy underlying the forehead flaps was provided by the cadaver injection studies of Conway et al,⁵⁹ Corso⁶⁰ and Behan & Wilson.⁶¹ They showed the 4 major vascular territories supplied by the 6 named vessels with extensive anastomoses between each other.

Use of the flap for intra-oral lining was described by Blair in 1941.⁶² Four methods for its use have been described for passing the flap inside the mouth – McGregor passed the flap through an incision in the cheek about 1.5cm below the zygomatic arch,⁷¹ Millard used a lower route (a submandibular incision),⁶⁵ Hoopes & Edgerton described a subcutaneous tunnelling procedure⁶⁶ and subsequently Davis & Hoopes suggested passing the flap deep to the zygomatic arch.⁶⁷

The folded forehead flap was used for reconstruction of full-thickness defects of the cheek by Champion in 1960⁶⁴ and Naozer M. Kavarana from Tata Memorial

Hospital described its use for large full-thickness cheek defects in 1975.⁵⁵ They found that it decreased the morbidity for the patient and decreased the need for separate flap for lining/cover.

Narayanan described the bilobar forehead and scalp flap for reconstruction of very wide full-thickness cheek defects.²⁴

Smalley and Cunningham reported using the forehead flap to cover the defect over the carotid artery over the upper neck region in 1972.⁵⁶

Galeo-frontalis flaps were devised for repair of dural leaks, reconstruction of anterior cranial fossa defects and other craniodacial defects.^{80,81,82,83,84,85}

Worthen described the forehead rotation flap for reconstruction of forehead defects (1976).⁷³ He used various rotation flaps to cover the defects in the forehead. But most significantly, he used the remnant forehead skin as a single unit to reconstruct losses upto 40% of the forehead skin.

Mustarde described the glabellar V-Y skin flap for medial canthal reconstruction (1980).⁷⁸

SURGICAL ANATOMY OF THE FOREHEAD ^{1,2}

The forehead is defined as the area between the hairline superiorly, an arbitrary line connecting the eyebrows inferiorly and the temporal hairlines on the lateral aspects.

It consists of a smooth and slightly convex surface where the skin is draped over the frontal bone above the orbits with the superior margin shorter than the inferior margin due to the temporal hairline. In some individuals, a prominent supraorbital ridge makes the forehead appear concave just above the eyebrows.

The skin over the forehead is hairless, slightly paler than the rest of the face and depending on the age of the patient may either be smooth or bear variably deep wrinkles – the “worry lines”.

The forehead skin is the only single contiguous region that is supplied by six named vascular pedicles making for quite a richly supplied area with extensive vascular anastomoses between the various vascular pedicles.

The vascular pedicles are:

1. Left and Right Supratrochlear vessels
2. Left and Right Supraorbital vessels

They are 2 of the terminal branches of the ophthalmic artery which is a branch of the internal carotid artery as it emerges from the roof of the cavernous sinus, which then passes through the optic canal and gives multiple branches including the supraorbital and supratrochlear.

It is commonly believed that the supraorbital artery is the bigger of the two and that it is the dominant vessel. But recent studies show that it is not always so, and that in many cases, the supratrochlear arteries are the dominant vessels.

3. Left and Right Superficial Temporal vessels

The superficial temporal artery is one of the terminal branch of the external carotid artery. Running up behind the temporomandibular joint and in front of the ear and the auriculotemporal nerve, it crosses the zygomatic arch, where its pulsations can be felt, and branches out widely into the skin that overlies the temporal fascia. One branch, the middle temporal artery, pierces the fascia, supplies temporalis and anastomoses with the deep temporal branches of the maxillary artery.

The anastomoses between the supraorbital and the superficial temporal arteries provide a link between the internal and external carotid arterial circulations.

The vessels supplying the forehead are further bolstered by anastomoses with the terminal branches of the facial artery – the angular artery – and the vessels supplying the scalp – mainly the occipital and the posterior auricular arteries.

Fig.1 depicts the vascular anatomy of the forehead and scalp and the pattern of anastomoses between the various vessels.

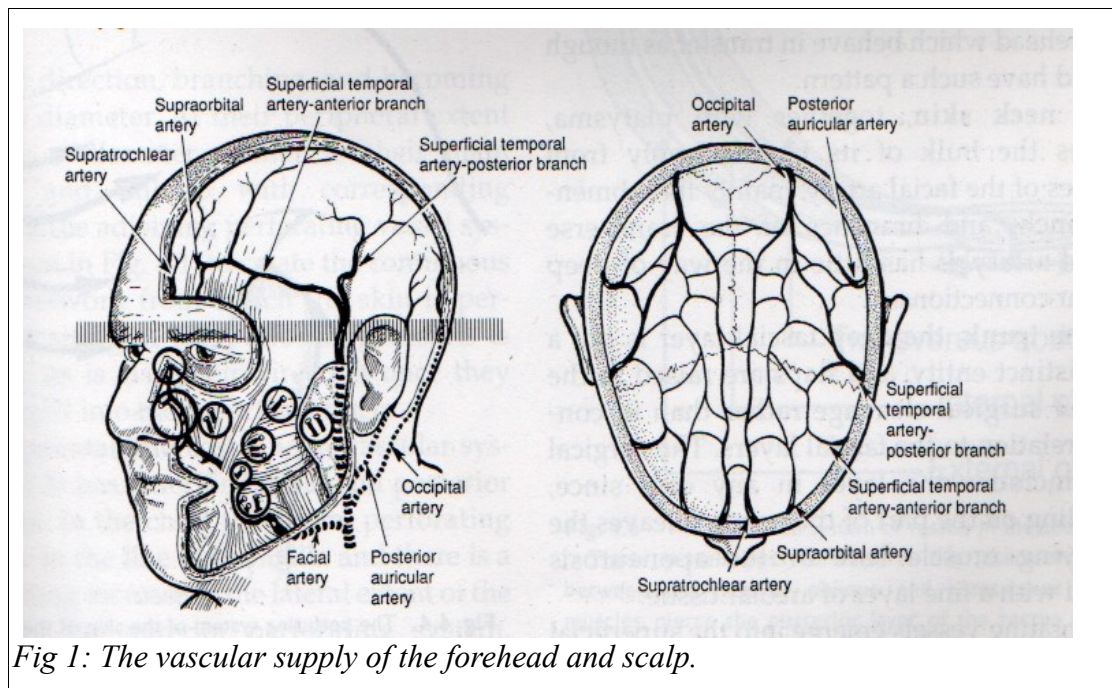


Fig 1: The vascular supply of the forehead and scalp.

The supraorbital and supraorbital arteries exit the orbit at the medial end of the orbit and the supraorbital foramen/notch respectively. At this level they are closely applied to the periosteum of the orbital rim. They then proceed deep to and rapidly pierce the frontalis muscle to enter the subcutaneous layer as they ascend into the forehead. In the upper half of the forehead, many fine branches of the arteries lie in the subcutaneous fat close to the dermis. So the entire frontalis muscle and some of the subcutaneous fat may be removed from the distal end of a paramedian forehead flap without injuring its axial arteries.

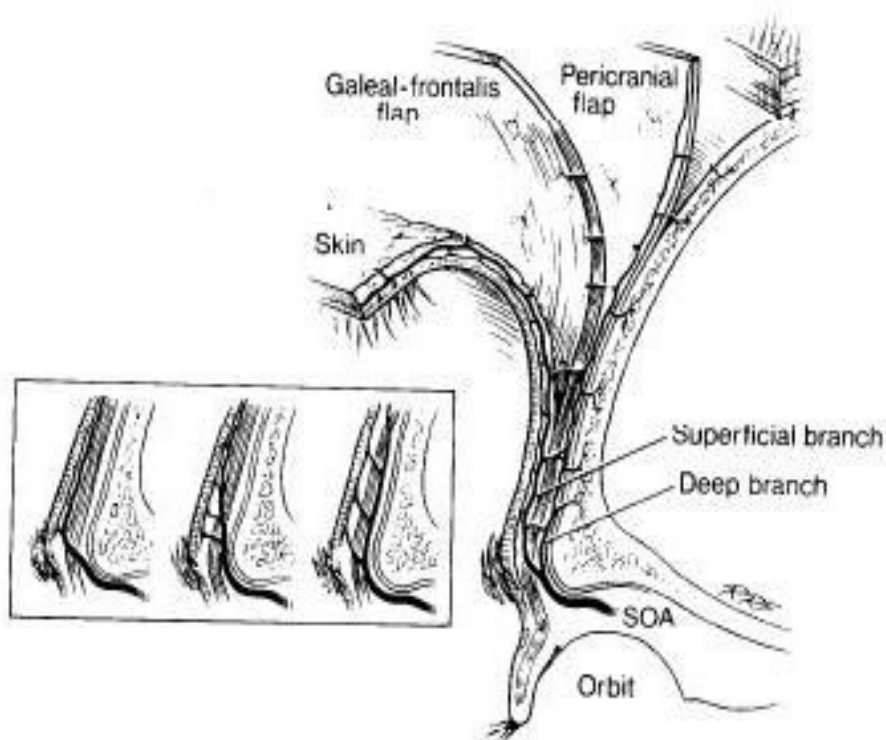


Fig 2: Pattern of branching of vessels allowing laminar flap harvest

The superficial temporal artery comes to lie in the superficial plane just anterior to the tragus of the ear. Proximal to this, it lies deep in the parotid gland which prevents its further mobilization. The superficial temporal artery ascends superficial to the zygomatic arch and soon divides into an anterior branch and posterior branch. A zygomatic branch arises from the trunk of the superficial temporal artery in about 80% of cadaveric studies and in the remaining 20% was seen arising from the anterior branch of the superficial temporal artery. Failure to include this dominant branch in the flap is thought to be the reason for the reported cases of failure of the transverse forehead flaps.

The surface markings for the main vessels are as follows:

1. Supratrochlear vessels :

The vessels are found between 3mm medial or lateral to the medial canthal region on the supraorbital margin.

2. Supraorbital vessels :

These vessels are usually found at the point where the mid-pupillary line at straight gaze meets the supraorbital margin.

3. Ant. branch of the superficial temporal vessels :

The superficial temporal artery divides into an anterior and posterior branches at the superior border of the ear just in front of the external ear.

The anterior branch then follows a curvilinear course more or less parallel to the hairline giving perpendicular branches to the scalp and corresponding branches to the forehead skin.

The supratrochlear and supraorbital vessels are accompanied by the supratrochlear and supraorbital nerves respectively. These nerves carry the sensations from the forehead as well as the frontal scalp as far as the vertex.

As part of the face and the scalp, the forehead skin also maintains the special layered structure that is present elsewhere on the face, namely, skin, subcutaneous fat, superficial muscles and its fascia, a thin layer of fibrofatty tissue, the galeo-frontalis, a layer of loose areolar tissue and periosteum (from superficial to deep). Special pattern of blood supply in the face also allows the same area to contribute two layers of flap based on a single common vascular pedicle, especially in the forehead region.

Due to this rich vascular supply of the forehead region, it allows mobilization of tissue in a variety of ways giving us paramedian, median, oblique, transverse forehead flaps as axial pattern flaps with skin pedicles or as islanded flaps, rotation flaps, V-Y advancement flaps and the scalping flap.

SURGICAL TECHNIQUES ²

1. Forehead Rotation Flap :

The entire forehead is available as an arterialized flap based on the superficial temporal artery to reconstruct forehead defects involving up to 40% of the surface area. The superior border of a forehead rotation flap is developed in the hair-bearing scalp and traverses the frontal scalp to the pre-auricular crease.

Elevation of the flap down to the supraorbital rim, results in a “free-swinging” extensible segment of tissue. After mobilisation is complete, back-cutting of the base is permissible but rarely necessary. Once the flap has been rotated to the desired position, the hairline on the distal margin of the flap is aligned with and sutured to the temporal hairline on the lateral margin of the defect without tension. The suture line is oriented transversely to minimise the only portion of scar that will be visible on the exposed forehead.

The secondary frontal scalp defect extends across the entire width of the frontal scalp but it is relatively narrow and amenable to primary closure.

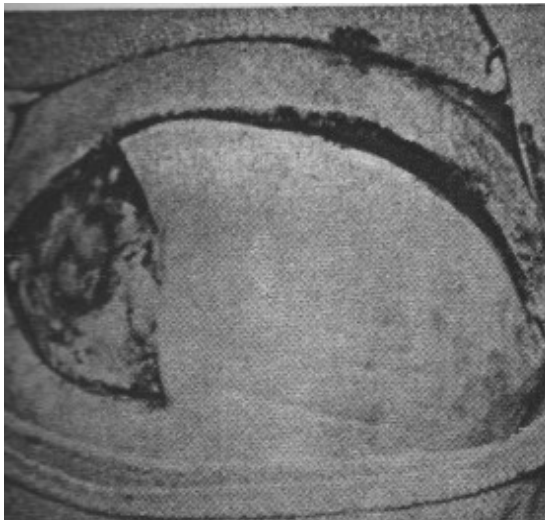


Fig 3: Forehead Defect and Flap Raised

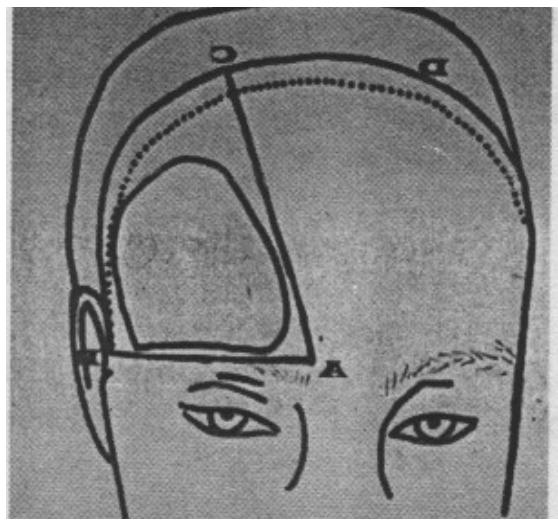


Fig 4: Diagrammatic representation

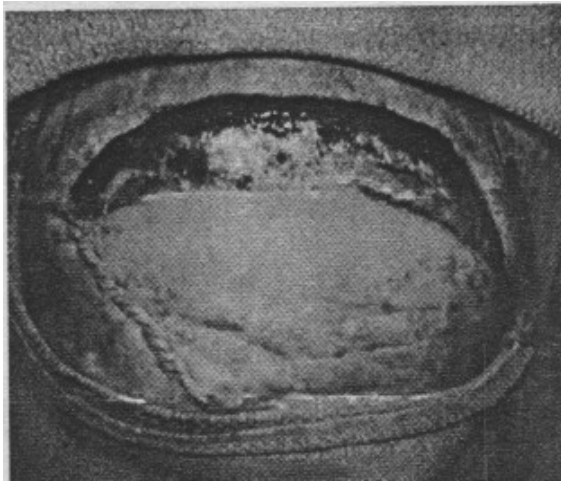


Fig 6: Forehead Flap Inset



Fig 5: Secondary Defect Closed Primarily

2. Paramedian Forehead Flap :

This flap has been classically used for reconstruction of nasal defects. It can be used to reconstruct the entire nose if needed. There are many variations of this flap made to increase its length using non-vertical extensions such as New's sickle flap and Gillie's up-and-down flap.

Principles of flap design and dimensions:

1. The flap is designed vertically and axially along the supratrochlear vessels. This makes its vascularity robust, so that it may be radically thinned and depilated.
2. The base of the flap is made no wider than 1.5 cm for easy mobility without strangulation.
3. The base of the flap is positioned to include a branch of the angular-supratrochlear arteries, which may be located with a Doppler flowmeter though usually not required.
4. Additional length is obtained by extending the flap's proximal end across the orbital rim or its distal end into the hair-bearing scalp.
5. The flap is not designed to fit the defect exactly – it is made slightly larger to allow for the edema at the recipient area and for the tissue shrinkage of the flap.
6. An exact three-dimensional pattern of the defect is used as a template for the flap's design.
7. The skin incision is made on the inner aspect of the flap markings to minimise the centripetal flap contraction, which obliterates surface

contour.

8. Distal portion of the flap is thinned to the required thickness to cover the defect and depilated where required.
9. The base of the flap is excised and discarded, not replaced on the forehead.
10. If primary closure is not possible, the upper half of the donor defect is allowed to close by biologic wound contraction and forehead skin auto-expansion. There is no necessity for skin grafts, local flaps, or mechanical tissue expansion to close this secondary defect.

It requires the talent of a tailor to fashion the forehead flap. A flap cut too small will collapse and distort the features at the site of inset. A flap cut too large allows centripetal contraction to pull the excess skin into a blob, obscuring the surface contour.

The incisions are made at the inside margins of the flap markings so as to not waste even half a millimetre of forehead skin. In the distal end of the flap (upper half of the forehead) the flap is raised superficial to the frontalis muscle. Proximally, the frontalis muscle is included with the pedicle to protect the axial vessels. If extra length is needed, corrugator muscle fibres are divided using magnifying loupes so that the vascular branches are preserved while restricting bands of muscle are released. If the flap still proves short, the the pedicle is extended across the orbital rim, including a bit of the eyebrow if necessary dividing corrugator muscle fibres while preserving the vascular branches.

After the flap is raised, the distal end and the flap borders are thinned as required using curved Joseph's scissors. Hair follicles remaining in the distal part of the flap are clipped off with fine scissors under 2.5X magnification. During the thinning, axial branches of the supratrochlear-angular arteries visible in the subcutaneous tissue very close to the dermis are preserved.

A right-sided flap usually rotates clockwise and a left-sided flap usually rotates anticlockwise. When required the flaps may be rotated in the opposite direction too. Key sutures are used to hold the flap in place and fine sutures are used to adjust its edges to the defect.

The secondary defect is usually closed primarily. But when the defect is too large for primary closure grafts and local flaps have all been tried to close the defect primarily. This usually compounds the deformity and increases the patient morbidity. The forehead is usually very forgiving and heals by wound contraction and secondary intention healing (described as auto-expansion of forehead skin). This process usually is not apparent until 3 weeks of healing when only granulation tissue is seen. Later it rapidly contracts and epithelialises within 1-2 weeks. So, only a layer on non-adherent dressing (e.g. Vaseline gauze) is placed over the defect and absorbent dressing done.

The raw posterior surface of the pedicle may be left open. However, a thin split-thickness skin graft applied to the back of the flap minimizes the problems of an open wound and the need for frequent post-operative visits.

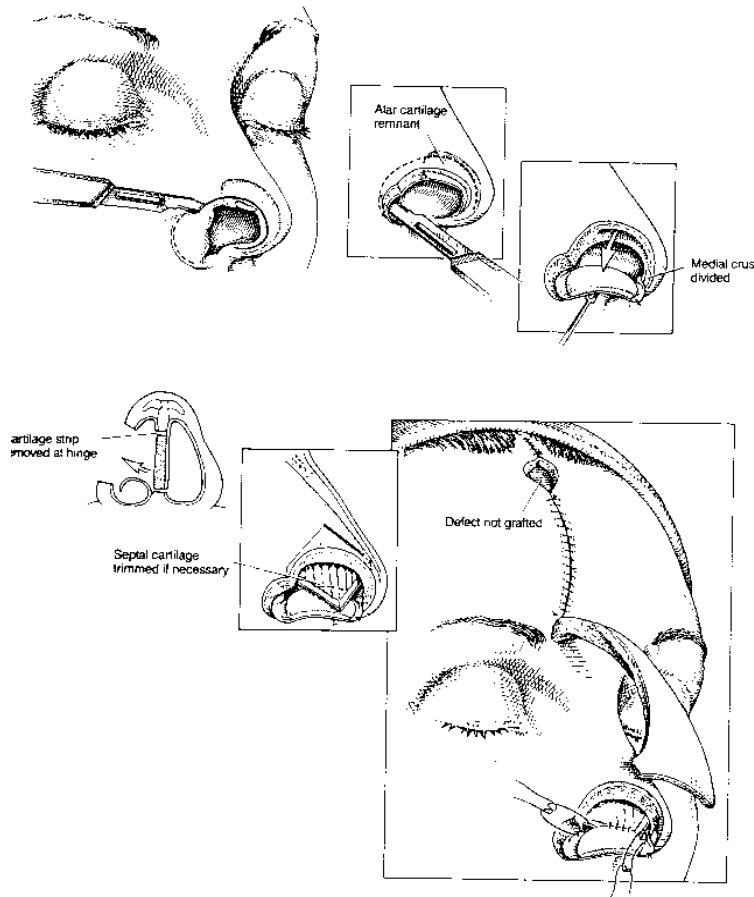


Fig 7: Paramedian Flap

Nearly all-sutures are removed by 4 - 5 days and the skin edges supported by skin tapes to avoid suture marks. The dressing on the donor defect is removed by the 7th post-operative day and then followed up with light bandaging/dressings until wound healing occurs.

Twenty one days later, the skin pedicle is excised and discarded as it will remain as a visible bump if replaced on the forehead. Because of the narrow design of the pedicle the eyebrows are not pulled closer.

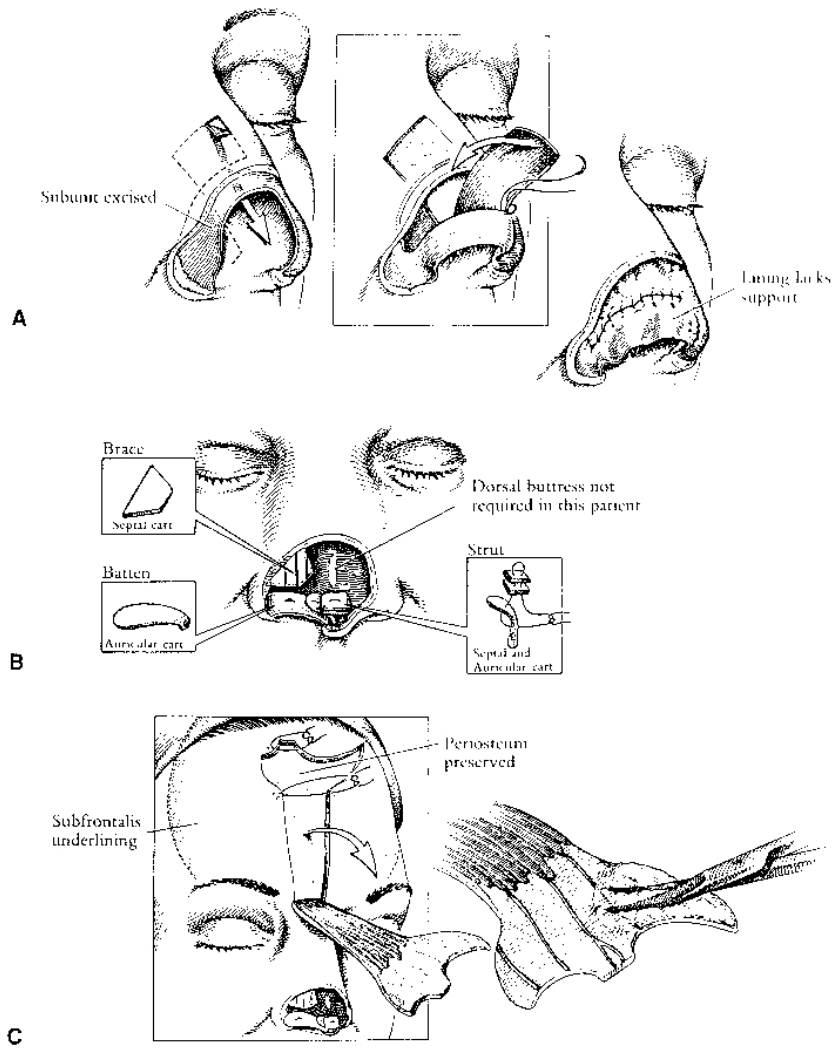


Fig 8: Alternate method for Paramedian Flap

Paramedian Forehead Flap



3. Midline Forehead Flap :

The midline forehead skin flap (and its variations) can serve for any nasal reconstruction from a severe tip and alae loss to a total nasal defect. Its main vascular supply is the supratrochlear bundle based on the medial aspect of one brow. The circulation to the distal portions of the flap is primarily random pattern.

The flap is best suited in a forehead of ample height (3 inches from brow to hairline). The pedicle is based on the supratrochlear vessels and the distal end of the flap is designed as per the nasal or eyelid defect and is made the broadest part and then tapering towards the neck of the flap. The sea-gull design of Millard allows harvesting both vertical and horizontal tissue and closure in an inconspicuous midline T scar.

The distal incisions are made first upto the galeal layer, which here includes the frontalis muscle too, to reach the loose areolar tissue plane. The rest of the flap is raised in this plane until the supraorbital margin is reached where the plane of dissection becomes deep to the periosteum. The neck of the flap then deviates to one side approaching the medial end of one eyebrow. The supratrochlear vessel is seen and preserved. The flap is now ready to be rotated into the defect.

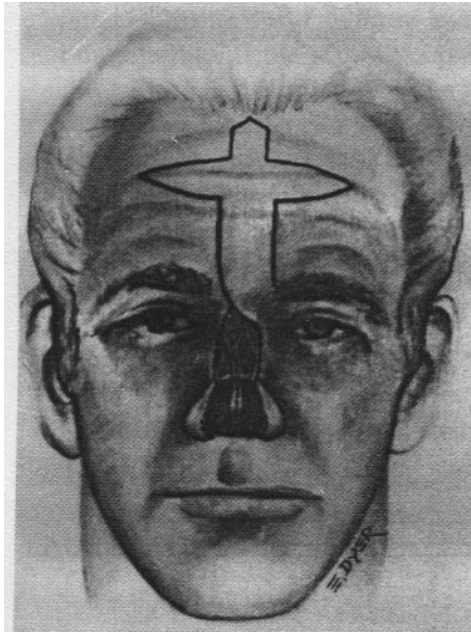


Fig 9: Midline Forehead Flap - Defect and Plan

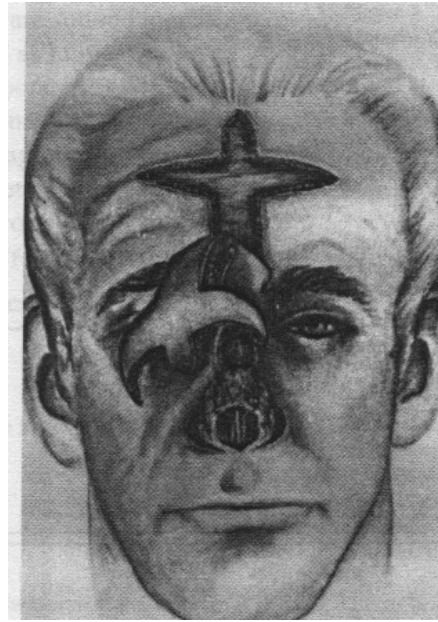


Fig 10: Midline Forehead Flap Raised

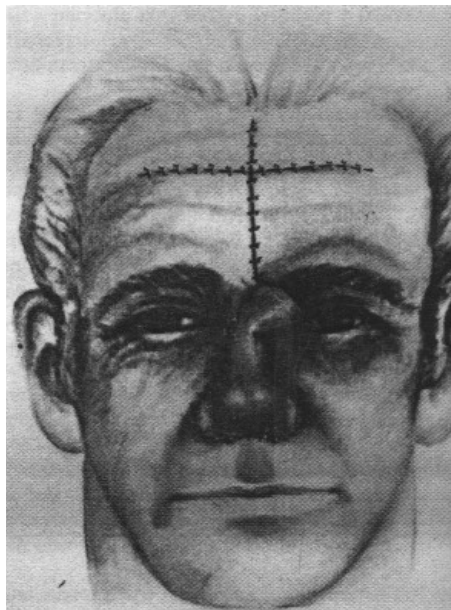


Fig 11: Midline Forehead Flap - Inset

Argamaso described an islanded forehead flap based on the supratrochlear vessels excluding the galea at the donor area. The inferior incisions were only down to the dermis and a subcutaneous pedicle approximately 2 cm wide was developed by sharp dissection and elevated from the underlying galea. The pedicle base is extended as closely as possible to the origin of the supratrochlear vessel as it emerges from the

rim of the orbit. He advised closure of the donor defect with an advancement flap from one side of the secondary defect and a rotation flap from the other side of the defect.

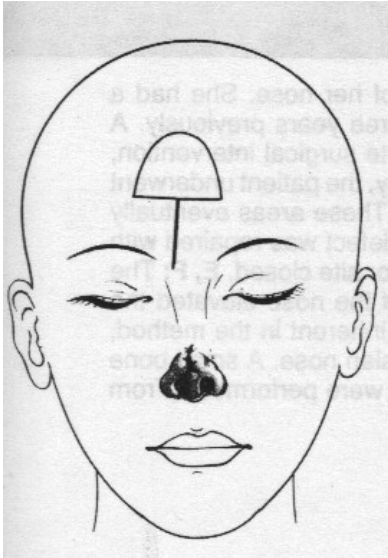


Fig 13: Islanded Forehead Flap - Defect and Plan

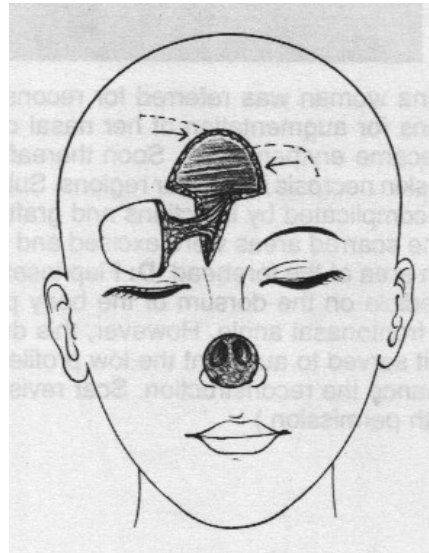


Fig 12: Islanded Forehead Flap - Flap Raised

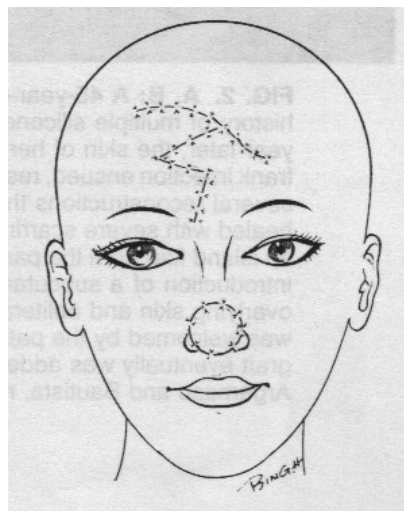


Fig 14: Islanded Forehead Flap Inset

4. Oblique Forehead Flap :

This flap is very useful when the forehead width is not adequate for a median or a paramedian flap to be used. The flap is located to one side of the midline and extends to the hairline recess. It is based on the supratrochlear vessels and its anastomoses with the supraorbital vessel branches.

The flap is based at the medial end of the eyebrow with a pedicle width (of the carrier segment) of about 0.5 to 1.0 cm. The length of the flap depends on the height of the browline and the depth of the hairline recess. The paddle is designed to fit the defect to be covered and can be “flagged” to one side of the carrier segment.

The supratrochlear artery is marked pre-operatively either by palpation or by use of a Doppler flowmeter. The flap is raised above the periosteum in the loose areolar plane down to the orbital rim, taking care to protect the vessels at the base. The defect left by the carrier segment is undermined and closed in 2 layers and that left by the paddle, if large, is closed by a post-auricular full-thickness skin graft.

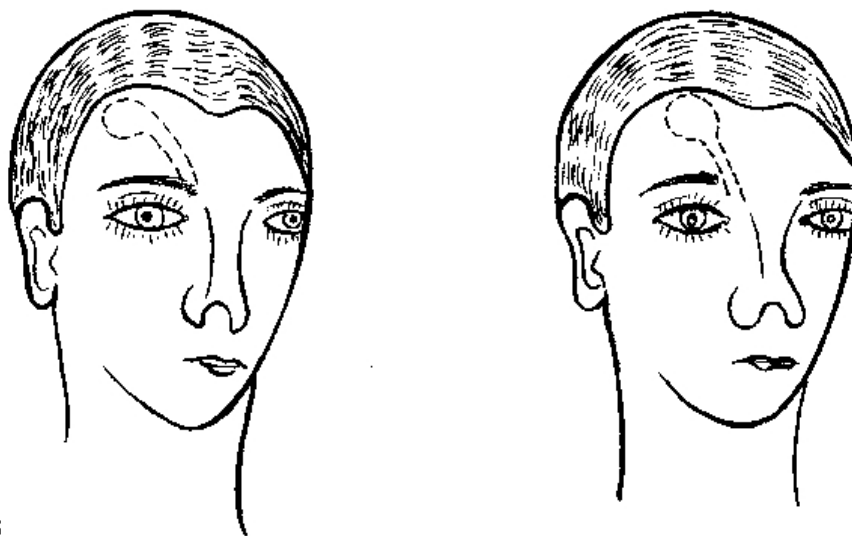


Fig 15: Oblique Forehead Flap A,B - showing different type of paddles

The pedicle cannot be tubed as it is too narrow and maybe be either split skin grafted or left open. The pedicle is divided by 18 - 21 days reinserting only the proximal part of the pedicle as a triangle to restore the eyebrow alignment.

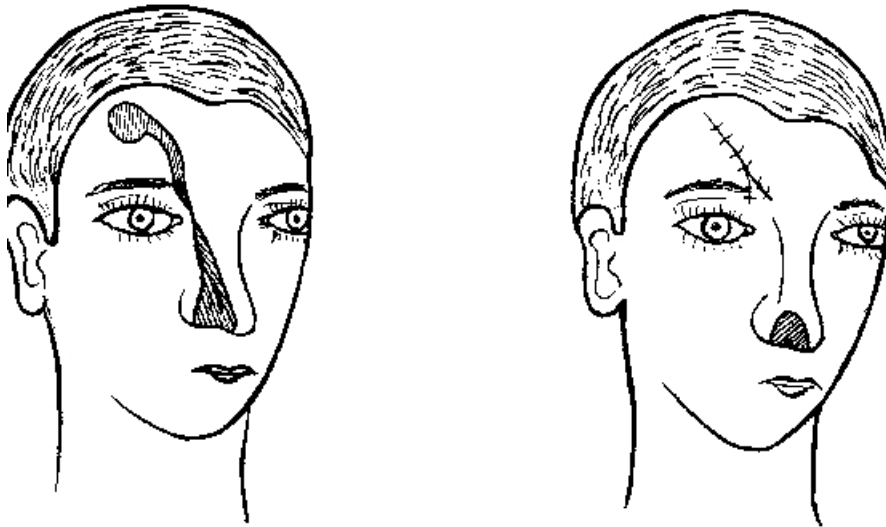


Fig 16: Oblique Forehead Flap C,D - showing transfer and division

5. Transverse Forehead Flap : (Total/Half)

This is one of the historic flaps and one of the first few axial pattern flaps described. It achieved enormous importance in head and neck reconstructions. But later lost its place to other options due the major drawback of the secondary defect and unappealing esthetics. Nevertheless, because of the reliability of its vascular supply, the excellent colour match (esp. for the cheek and upper lips) and its proximity to the face, it is always given a consideration and sometimes kept as the backup plan.

A forehead flap is long enough to cover any part of the ipsilateral face and can even cover the carotid artery in the upper neck on the same side. If the flap is tunnelled under the malar prominence, it can be used to line the entire cheek mucosa or even used to reconstruct the oropharynx. This flap also has the advantages of not causing any restriction of movement of the neck or limbs especially in the elderly patients in whom the majority of these flaps are required.

This flap is unique in the entire body in the fact that it is able to recruit 6 vascular territories – those of the supraorbital, supratrochlear and the anterior branch of the superficial temporal arteries – on a single pedicle (the ipsilateral superficial temporal artery) without delay procedures.

The flap vascular dynamics allows the harvest of the forehead skin from one malar bone to the contralateral malar bone. An average flap measures 25cm and can be safely carried on a pedicle no wider than 2 cm at its base. This pedicle is based just anterior to the tragus of the ear and contains the superficial temporal artery. It is also imperative that the superficial temporal vein that accompanies the artery is kept intact

along with its small accompanying veins.

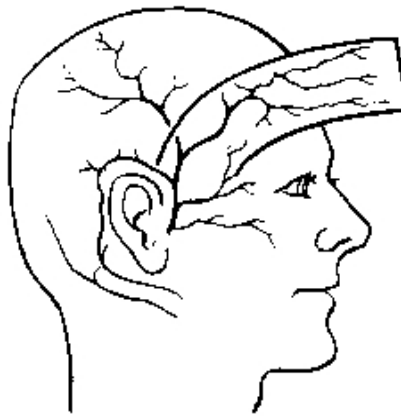
The superior incision is kept just below the hairline and the lower incision just above the eyebrows. In the midline, it is carried down into the glabellar region of the nose. The temporal hairline is preserved if possible. The most satisfying cosmetic result is obtained by elevating the entire forehead as a cosmetic unit with edges bevelled at 45 degrees to avoid the marginal “step” deformity.

The plane of dissection is kept at the loose areolar tissue plane, ensuring that the periosteum over the frontal bone is not lifted off along with the flap. Use of diathermy for hemostasis is also to be minimized. This allows for uniform 'take' of the sheet skin graft placed on the secondary defect. A single sheet graft applied onto the entire forehead gives the best cosmetic result. This may either be applied immediately and immobilised with a tie-over dressing or applied as an exposed graft after 48 hrs.

When used as a skin pedicled flap, the pedicle can be divided at 21 days and the proximal portion the flap that bears the temporal hairline can be replaced. Otherwise, the excess flap is either used for another part of the reconstruction or discarded, esp. when the forehead skin grafted area has healed well.

When used for intraoral reconstructions, immediate reconstruction can be performed by de-epithelialising the pedicle to allow for a single-stage inset of the flap. The pedicle can then be buried in the tunnel under the skin. This technique avoids the risk of second operation in the elderly, poor-risk patient but may result in some additional bulk or eventually the occasional development of epithelial cysts.. Introduction of the flap deep to the zygomatic arch increases the versatility of the

flap. This may require the division of the coronoid process of the mandible to allow for an adequate sized tunnel for the flap to pass through without compression of its pedicle.



(1)
McGregor 1963

Fig 17: Classical Transverse Forehead Flap

A true island flap may be used for a single-stage reconstruction. The course of the superficial temporal artery is carefully defined, and an incision is made 1 cm medial to this. The skin then is elevated to expose the vessel. A 1cm pedicle of vessels and subcutaneous tissue of sufficient length to carry the flap to the defect without tension is then carefully elevated. A subcutaneous tunnel between the base of the pedicle and the edge of the defect is created by blunt dissection, and the island flap is passed through the tunnel and sutured to the defect.

If the flap blanches, it should be returned to the forehead to allow the relief of the vessel spasm that is often caused by excessive stretching of the vessels not supported by a skin pedicle. Strict hemostasis should be achieved as any hematoma in

the tunnel will cause compression of the pedicle and will rapidly lead to necrosis of the flap.

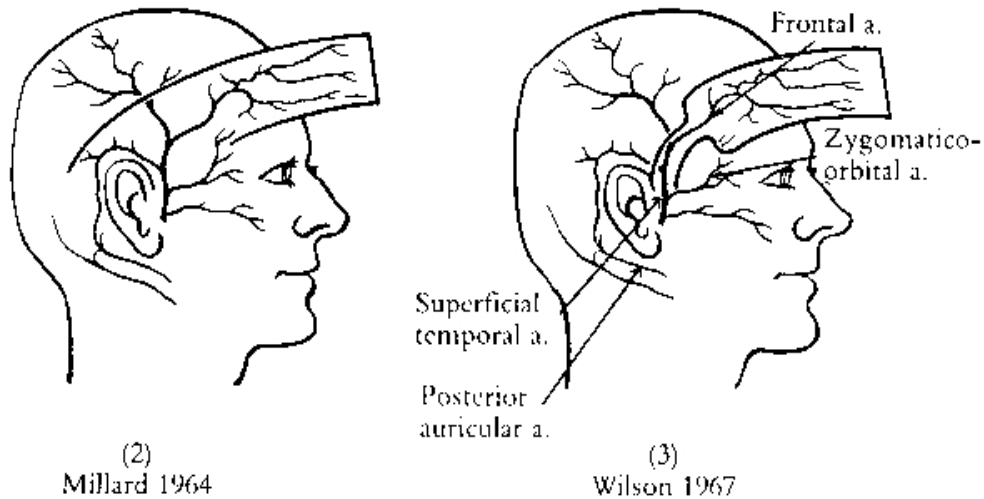


Fig 18: Variations of the pedicle

Modifications of the flap

Axial Fold

This is the safest method of folding, as the fold is along the axis of the vessels. It is most useful when the defect is along a free margin, such as in the full-thickness reconstruction of a lip.

Contraxial Fold

This flap provides for both the lining and cover, but folding the flap 180 degrees causes an acute angulation of the vessels. On occasion, it is possible to de-epithelialise the fold and obtain an immediate 90% inset; however, if the flap is first folded and delayed, the technique is usually free of complications. Alternatively, the

fold can be inset later, after laving a temporary fistula. The flap can then be safely inset after 14 days.

Lined Flap

Two weeks before the flap is required, it is lined by a split-thickness skin graft mounted on a stent mold that is inserted by means of an incision in the hairline into a pocket under the forehead flap. Thus, preliminary grafting of the forehead is achieved, and a lined flap is produced for the repair of full-thickness defects of the face.

Forked Flap or Split Flap

The forehead flap may be split to provide lining and cover to two separate cosmetic units. The position of the vessels is studied on the undersurface of the flap, and the flap is divided into two parts, each containing a branch of the superficial temporal artery. This is especially useful in the patient requiring reconstruction of both the upper and lower lips with the adjacent tissue in the nasolabial region. The two flaps are folded axially to provide lining and cover to the lip.

Extended Transverse Forehead Flap



6. Bilobar Forehead and Scalp Flap :

This flap can be used to reconstruct large full-thickness defects of the cheek and is especially used for reconstruction of post-excisional defects in patients with advanced malignancy. It is worthwhile to note that these patients need to undergo irradiation to ensure maximal disease free period and that this flap allows for that.

This flap uses both the terminal branches of the superficial temporal artery to harvest the forehead skin and a scalp flap on a single pedicle. The folding of the flap gives a well-matched thickness to the flap for reconstructing cheek defects.

The branches of the superficial temporal artery are identified either by palpation or by Doppler. The forehead part of the flap is raised as described above for the transverse forehead flap, but deviates when the superior incision reaches about 5cm near the point of branching of the superficial temporal artery. From there the incision is carried into the parietal scalp posteriorly and superiorly to harvest a flap measured to the exact skin defect of the cheek – which can be marked by planning-in-reverse. The parietal flap is raised again in the sub-galeal plane leaving the periosteum and the deep temporal fascia intact.

The pedicle of the bilobar flap is just 2.5cm wide above the zygomatic arch. The whole flap is everted and turned down. The forehead flap at this stage fits snugly into the oral mucosal defect, where it is sutured. The parietal scalp flap now is folded forward across the face to fit exactly into the skin defect of the cheek/chin/lips as necessary. The inset is given except for the posterior folded border. The secondary defect is covered by split skin grafts.

This obviously leaves a superiorly based fistula just in front of the ear which is

closed when the pedicle is divided at end of 21 days and the pedicle tissue is returned to the scalp.

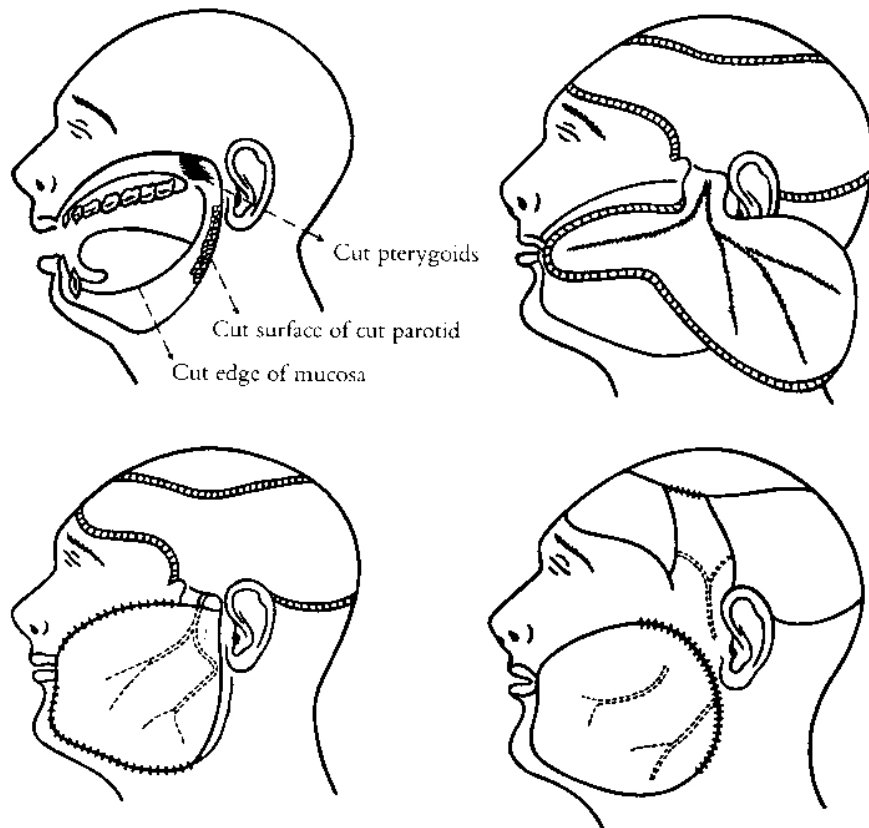


Fig 19: Bilobar Flap - Operative Steps

The island bilobar flap overcomes this problem. The superficial temporal artery is isolated by raising a rectangular scalp flap of skin only overlying the branching point of the artery and above. Once the vessel comes into view, it is preserved along with the surrounding dense fibrous tissue to form the vascular pedicle. The rectangular flap overlying the pedicle is then cut off and discarded. The pedicle is then retracted posteriorly and a vertical incision is made in the zygomatic skin bridge. The edges of this skin bridge are turned back and the incision is deepened and connected with the defect in the cheek preserving the facial nerve branches carefully the flap is then turned into the defect as detailed earlier and inset given completely.

The zygomatic skin bridge is returned to complete the inset.

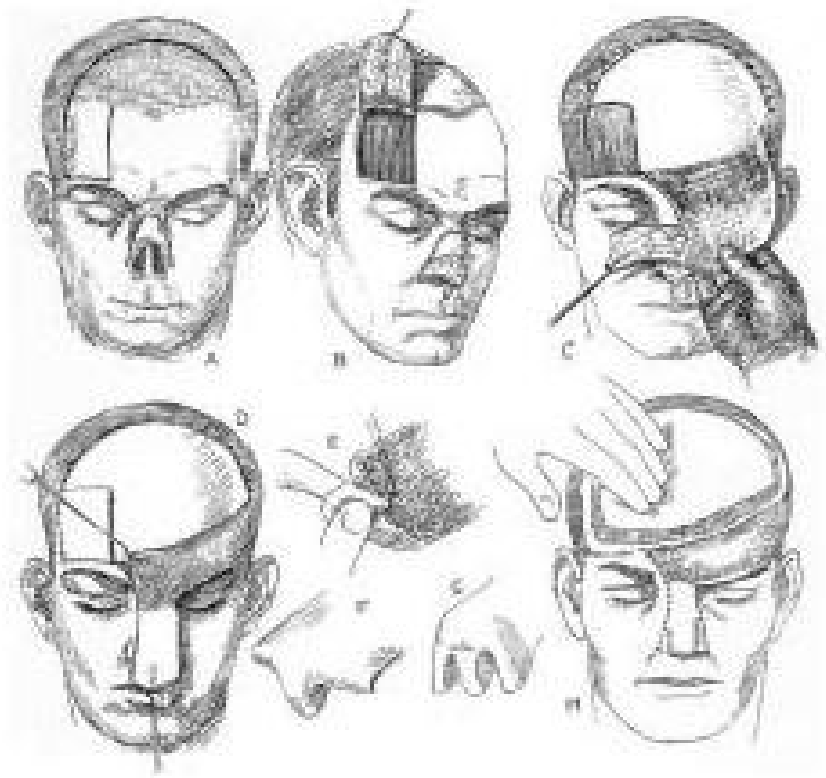
A trilobar flap has also been described with a third lobe being designed on the frontal part of the scalp. This allows for the third lobe to cover the neck or the region posterior to the ear. The third lobe may either be based on a specific branch of the superficial temporal artery or may be based on either the forehead flap or on the parietal scalp flap to suit the requirements.

7. Scalping Flap :

This flap described by Converse in 1942 was mainly designed primarily for nasal reconstruction. It is a reliable technique for reconstructing large nasal defects. The flap skin is supple enough to be folded to re-create the lobular portion of the nose. The flap design provides the desired length for reconstruction of the columella and the reconstructed nose thus has adequate size and projection.

The flap includes the forehead skin, the scalp and galea, and a major portion of the vasculature of the forehead and anterior portion of the scalp. The flap is based on the the rich vascular anastomoses between the supraorbital, supratrochlear and superficial temporal artery of the contralateral side with the supraorbital and supratrochlear vessels on the ipsilateral side.

Fig 20: Operative steps of a scalping flap (Converse 1942)

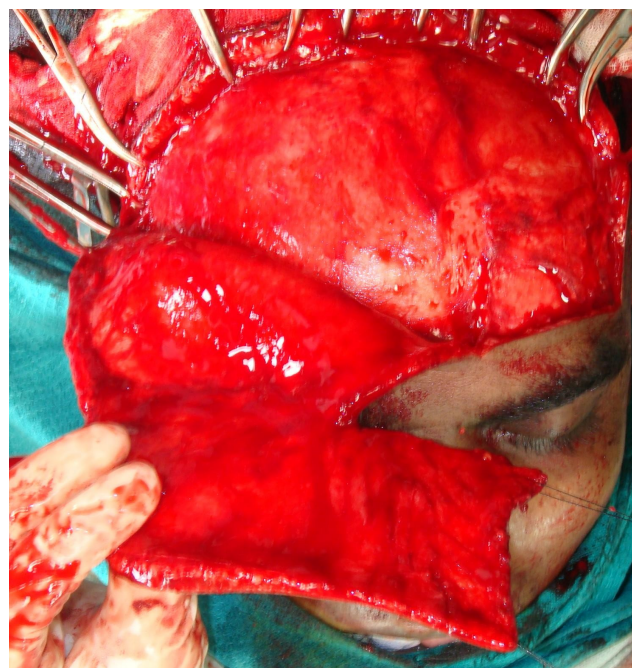


A rectangular flap is designed on the lateral part of the forehead based on the hairline. The carrier scalp flap will then be designed by a semicircular incision from the lateral edge of the flap running over the vertex and back down to the temporal region on the opposite side. When tissue for lining is also required, this flap may be combined with a central forehead flap (e.g. paramedian forehead flap).

After making an outline of the flap on the forehead and scalp, the flap is raised at the subcutaneous plane sparing the frontalis muscle. When the junction between the frontalis muscle and the galea is reached, the galea is incised and the remainder of the flap is raised in the subgaleal plane as for any other scalp flap. The flap incision continues posteriorly from the lateral margin of the flap to the level of a line extending across the scalp from the tip of one auricle to other – thereby preserving the superficial temporal vessels of the contralateral side (base of the flap). The flap is raised in this plane upto the supraorbital arches preserving the supraorbital and supratrochlear vessels as well as the respective nerves. The flap is now folded over itself (the scalp portion running over the everted and turned down forehead portion). The flap now is seen to easily reach the nasal defect and is inset as required. The donor area is resurfaced with a split thickness skin graft. The flap can be pre-fabricated with a cartilage graft which is inserted into the “business” area of the flap for reconstruction of the nasal support when used for columellar and alar reconstruction.

The flap is divided in a second stage between the fourteenth and eighteenth days. The division is done so as to leave enough skin for covering the superior portion of the nose if required. The scalp flap is returned after excising the skin graft.

Scalping Flap



8. Glabellar V-Y Advancement Flap :

This flap was primarily designed for reconstruction of medial canthal region defects involving the subcutaneous structures and/or bone when a skin graft will not be sufficient.

An inverted 'V' is designed over the glabellar skin which can then be advanced in V-Y fashion to cover the medial canthal defects.

The incision is carried down to the galeal layer and undermining of the flap is done in the loose areolar plane. The tissue is advanced into the defect and inset. The donor defect is closed as an inverted 'Y'. The flap is based on the angular vessels on the opposite side and its anastomoses with the vessels supplying the glabellar region.

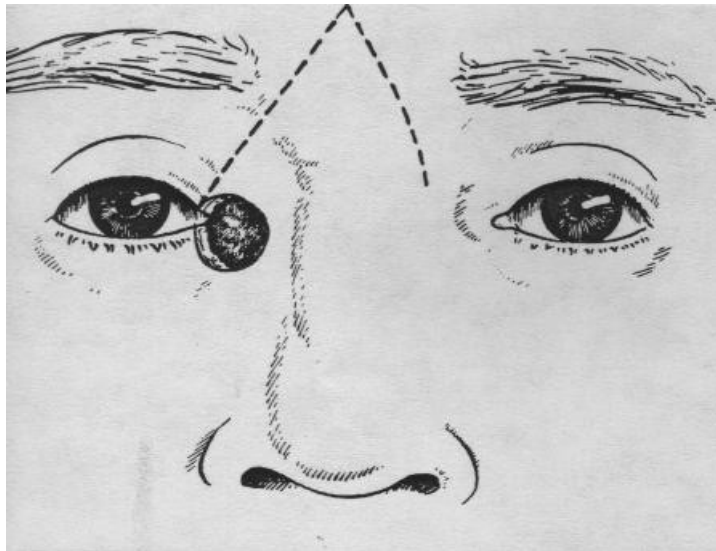


Fig 21: Medial Canthal Defect

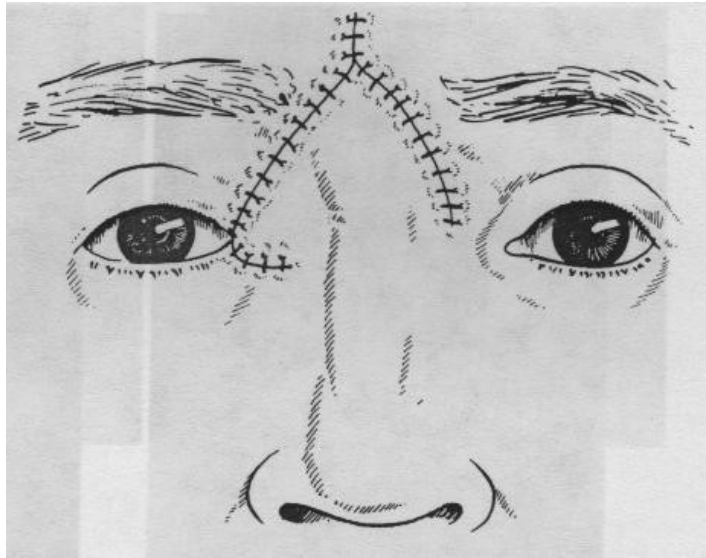


Fig 22: Glabellar V-Y Advancement Flap

If the defect extends into the eyelids, other flaps need to be used along with the glabellar flap for complete reconstruction.

9. Fricke Flap :

This is simply an interpolation flap based over the lateral canthal region utilising the supraorbital skin for reconstruction of the upper or lower eyelids.

MATERIALS AND METHODS

This study was conducted in the Department of Plastic Surgery, Government General Hospital and Madras Medical College over a period of 32 months September 2005 to April 2008.

All cases where a forehead flap was used in the reconstruction of a soft tissue defect in the face – either primarily or secondarily – were included in the study. The flaps were loosely classified as central forehead flaps (paramedian, median, oblique forehead flaps and the glabellar V-Y advancement flap) and laterally based forehead flaps (transverse forehead flap, bilobar Narayanan flap, scalping flap, forehead rotation flap, Fricke flap, etc.,).

Forehead flaps were done for a total of 29 patients for various indications. One patient died during post-operative period due to anesthetic complications and was not included in the study. So a total of 28 patients accounting for 28 flaps were enrolled for the study after getting their informed written consent.

The proforma for the collection of data was made. All the relevant details of the patient during preoperative, surgical, postoperative and follow up periods were collected and analysed.

Indications for forehead flap cover in our study included :

- 1) Post-excision defects in patients with malignancies.
- 2) Soft tissue defects in patients acute trauma.
- 3) Patients presenting with post traumatic soft tissue defects at a later date.
- 4) Patient presenting with a post-surgical defect.

The regions where defects were covered with forehead flaps included :

- 1) Nose
- 2) Cheek
- 3) Forehead
- 4) Eyelid/Periorbita

The age range of the patients was from 3 - 80 yr (average age – 45.21 yr). The study included 2 children (ages 3 and 4 yr) and 2 senior citizens (ages 73 and 80 yr). The study included 18 male patients and 10 female patients.

The defects around the medial canthus, eyelids and nose were favoured with one of the central forehead flaps whereas cheek, lateral canthus and lower face and neck defects were favoured with the transverse forehead flaps.

Among the central forehead flaps the paramedian forehead flap was the most favoured (5 out of 8). Similarly, among the superficial temporal artery based flaps, the folded transverse forehead flap was the most commonly used (12 out of 20).

All patients were kept in post-operative wards for a minimum of 5 days. Patients with good general condition were then discharged and reviewed twice a week – if the patients lived nearby to the hospital – or once weekly – if the patients were from a longer distance.

All patients with skin-pedicled forehead flaps underwent flap division at or around 21 days for laterally based flaps and at end of 14 days for central forehead flaps. All procedures were done after admitting the patient and with formal anesthetic assessment under adequate anesthesia. Patients were discharged on 4th / 5th post-operative day, after suture removal and advised to come for review to the OPD

regularly.

Follow-up visits were scheduled at weekly intervals for the first one month, then once a month for the next six months and then finally once a year. All patients who completed up to the 1 month review have been included in this study.

Any further flap adjustments, thinning and/or reshaping were undertaken only after a minimum of 3 months of complication-free healing period. Among the patients with central forehead flaps, only 2 patients had undergone a 3rd stage for flap thinning as compared to 8 out of 15 patients with a laterally based forehead flap.

Despite the gross inequalities between these essentially different flap types, they have been included in a single study as this study does not aim to assess the efficacy of any single flap. The study was only designed to highlight the versatility of the forehead region as a donor of good quality and highly color and texture matched tissue for reconstruction of defects in the head and region.

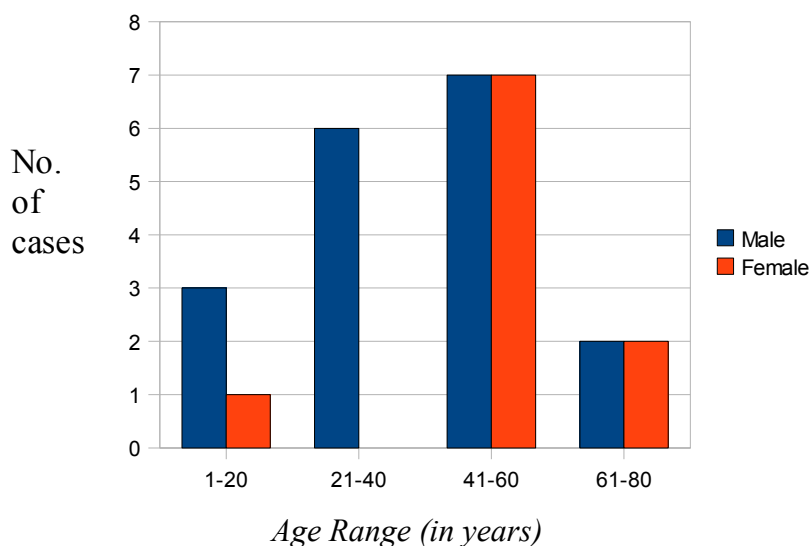
OBSERVATION AND RESULTS

A total number of 28 patients were included in the study over a period of 32 months between September 2005 to April 2008.

AGE AND SEX INCIDENCE

Age Group	Male	Female	Total
1 – 20 years	3	1	4
21 – 40 years	6	0	6
41 – 60 years	7	7	14
61 – 80 years	2	2	4
Total	18	10	28

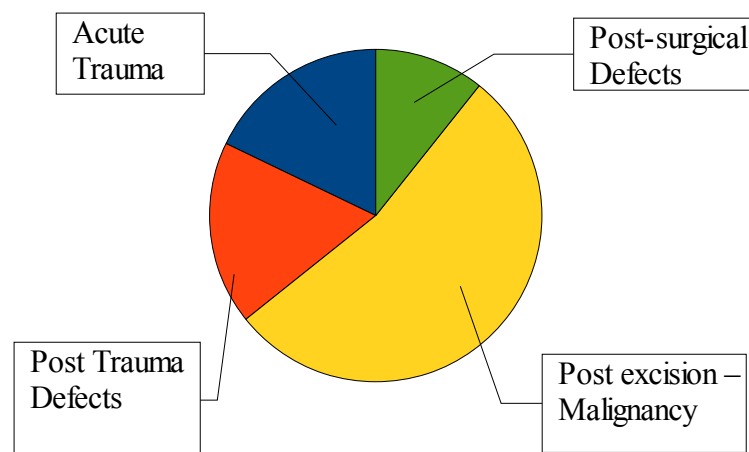
Chart 1: Age and Sex Distribution Chart



ETIOLOGICAL INCIDENCE

S.No.	Cause	Number
1.	Acute Trauma	5
2.	Post-Trauma Secondary Defects	6
3.	Malignancy – Excision	16
4.	Post-Surgical Defect	1

Chart 2: Etiology of Defects



Total no. of flaps = 28

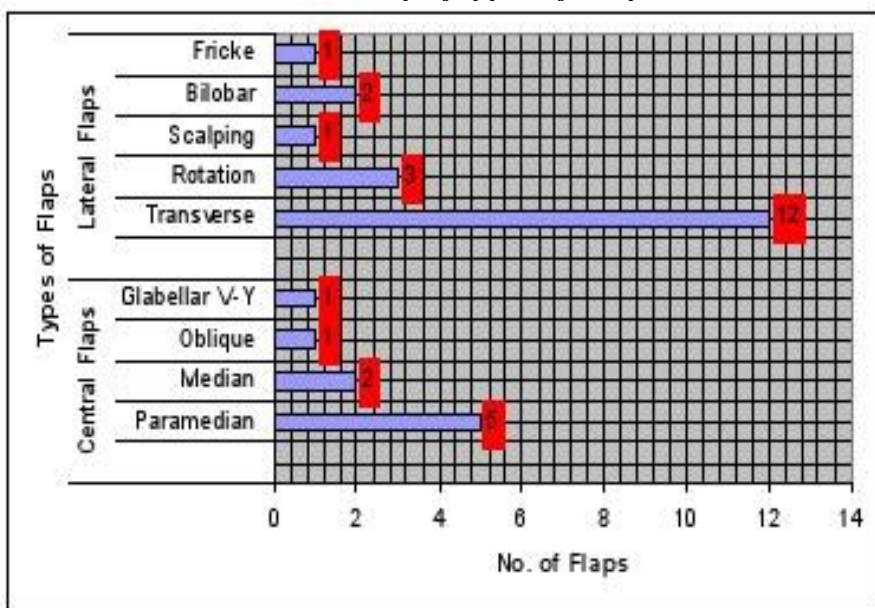
Total no. of central forehead flaps = 9

Total no. of laterally based forehead flaps = 19

TYPES OF FLAP USED

S.No.	Type of Flap	Number
1	Central Forehead Flaps	9
	Paramedian Forehead Flap	5
	Median Forehead Flap	2
	Oblique Forehead Flap	1
	Glabellar V-Y Advancement	1
2	Laterally-based Forehead Flaps	19
	Transverse Forehead Flap	12
	Forehead Rotation Flap	3
	Scalping Flap	1
	Bipolar Narayanan Flap	2
	Fricke Flap	1

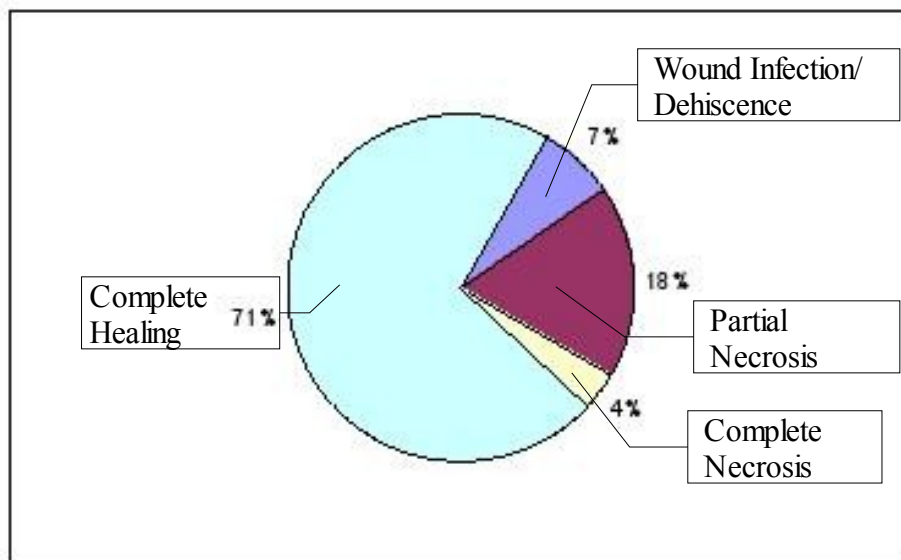
Chart 3: Break-up of types of Flaps used



OUTCOMES

No. of completely healed flaps	20
No. of flaps with wound dehiscence	2
No. of flaps with partial necrosis	5
No. of flaps with complete flap loss	1
Total	28

Chart 4: Pie-chart of various outcomes



No. of complications in central forehead flaps = 3

No. of complications in lateral forehead flaps = 5

Total no. of flap complications = 8

Age Distribution of Patients

No. of patients < 10 yr	2
No. of patients > 60 yr	2
Age Range of patients (in yr)	3-80
Average age of patients (in yr)	45.21

Stages of surgery required for end result

Average no. of stages required per patient	2.39
Average no. of stages required for central forehead flaps	2.25
Average no. of stages required per lateral forehead flaps	2.93
No. of patients with single-stage reconstruction	4
Maximum no. of stages in any patient	6

DISCUSSION

The forehead is a special area in the context of head and neck reconstructive surgery. It is unique in that it shares characteristics with both the face and the scalp. The forehead region has a rich vascular supply from 6 major vascular pedicles and is augmented by anastomoses with the arteries of the face and those of the scalp. Anatomic studies have proven the predictable vascularity of this region and reliable anastomoses between 4 vascular territories.⁷⁹ The forehead allows mobilization of tissue in a variety of ways with robust and reliable vascularity. Its proximity to the face and the qualities of the skin of the forehead makes it an indispensable tool in the reconstruction of soft tissue defects in the face and neck.

Various types of flaps have been described. The transverse forehead flap is one of the earliest axial flaps described. The paramedian/midline forehead flap has been practised from ancient times by early Indian practitioners. The major drawback as cited against the forehead flap is the cosmetic deformity associated with the donor defect.

Among the 28 patients who underwent various forehead flaps, 15 patients had primary or delayed primary cover for post-excisional defects. The majority of these were transverse forehead flaps with or without modifications. The majority of the flaps healed well although they invariably were staged procedures. Transverse forehead flaps seem to require a minimum of 3 stages – flap elevation and inset, flap division and flap thinning/commissuroplasty with or without reanimation of the oral sphincter. This is also the group that had maximum post-operative complications (partial/complete flap necrosis).

Although an objective assessment was not made regarding the patient satisfaction with the esthetic outcome, most of the patients were not happy with the end result in terms of appearance in the immediate post-op period. On further follow-up, however, most of the patients seem to be satisfied with the end result.

The patients who underwent nasal reconstruction with different types of central forehead skin flaps either for post traumatic defects or for post excision defects for malignancy were the most satisfied with the results. They also underwent lesser no. of procedures. Therefore, the central forehead flaps are the first choice reconstructive options for nasal reconstruction.

The forehead rotation flap for forehead skin defects was as a single-stage operation and achieved acceptable esthetic results. There was only one case of wound dehiscence which was noted in a patient with extensive injuries to the forehead and scalp for whom the flap cover was done in the emergency operation theatre after wound debridement.

The glabellar V-Y advancement procedure was done for a patient with a Tessier 0 cleft who had undergone multiple procedures for nasal reconstruction and presented with extrusion of rib graft. The flap cover was completed in a single-stage and healed well.

Usual Indications :

1. Nasal Reconstruction
 - i. Nasal ala
 - ii. Columella/Nasal tip defects

- iii. Sub-total/total nose defects
2. Eyelid and periorbital reconstruction
 - i. Upper Eyelid
 - ii. Lower Eyelid
 - iii. Medial Canthal region
 - iv. Lateral Canthal region
 3. Reconstruction of lip and cheek defects
 - i. Combined Upper Lip and Lower Lip defects
 - ii. Upper Lip and Nasal/nasolabial region defects
 - iii. Combined Lip and Cheek defects
 - iv. Full-thickness cheek defects
 4. Reconstruction of chin and upper neck defects

Advantages :

- 1) Colour match
- 2) Texture match
- 3) Proximity to the defects
- 4) Pliability of the flap

- 5) Reliability of blood supply
- 6) Versatility of the flap in terms of flap design

Disadvantages :

- 1) Donor area scar
- 2) Multiple stages

Specialised Indications (reported in literature):

1. The vertical median forehead flap has been used for repairing dural defects in the anterior cranial base.^{31,80,81}
2. It has been combined with other local or distant flaps for reconstruction of tongue,³⁷ oronasal fistulae,³⁹ recurrent oro-cutaneous fistulae, floor of mouth⁵⁷ etc.,.
3. Galeo-frontalis flaps have been similarly used to line anterior cranial fossa CSF leaks, and craniofacial defects^{80,81,82,83,84,85}. Large defects of the cribriform fossa have been closed with forehead flaps.³⁶
4. Vascularised calvarial bone has been used in conjunction with the galea-periosteal flaps for nasal, maxillary and orbit reconstructions.¹⁵
5. Bipedicled forehead flaps have been used for reconstruction of soft tissue defects in the face.³⁸
6. The paramedian forehead flap has also been used as a bilaminar flap – one layer consisting of skin and subcutaneous fat and the second layer

consisting of the galeo-frontalis.⁸⁶

Thus it seems that the versatility of the forehead region as a donor for various reconstructive purposes is only limited by the imagination and skill of the surgeon. The current body of literature also reaffirms the applicability of the forehead flaps in the current practice of “esthetic” reconstructive surgery.

Notwithstanding the objections raised to the use of forehead flaps, the reliability and robustness of the flaps and their versatility in terms of amount of tissue availability and freedom of fabricating the flaps should make them one of the main reconstructive options in head and neck reconstructions. The younger generation of plastic surgeons who seem fascinated with the latest advances like free flaps would do well to remember the forehead flaps as an important option and not just use it as a fall-back option.

CONCLUSION

The following conclusions can be made from this study

1. The forehead is a versatile donor area for head and neck reconstruction.
2. The forehead flaps have a robust vascularity and are reliable.
3. Properly planned forehead flaps are adequate and effective for most of the nasal defects and many of the post-excision defects in the face and neck.
4. The uses of the forehead flaps are only limited by the imagination and skill of the surgeon.

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APPENDIX

PROFORMA

THE VERSATILITY OF FOREHEAD FLAPS AS A RECONSTRUCTIVE TOOL

NAME : AGE: SEX: I.P.No. :
ADDRESS: OCCUPATION: P.S. No.:

DIAGNOSIS:

HISTORY:

PAST HISTORY:

1. H/o other illness
2. H/o treatment/ surgery

FAMILY HISTORY:

PHYSICAL EXAMINATION:

GENERAL EXAMINATION:

Built Stature Nourishment Anemic/ not anemic Vital signs

SYSTEMIC EXAMINATION:

INVESTIGATIONS:

Routine- Blood Hb%- TC DC ESR
Urine – alb sug dep
Blood sugar urea creatinine
Chest X- ray
ECG in all leads

DIAGNOSIS:

TREATMENT: operative/ non operative

SURGERY: Date of Surgery: Anesthesia: GA/LA

POST OPERATIVE PERIOD:

Graft/ Flap:
Complications:
Discharged on:

FOLLOW UP:

MASTER CHART

S.No.	Name	Age	Sex	I.P. No.	P.S. No.	DOA	DOD	Diagnosis	Surgery	Outcome	Total No. of Stages
1	Umashankar	40	M	761271 /06	210 /05	24/10/05	12/11/05	PT Defect Lt side Nose & Upper Lip	Transverse Folded Forehead Flap Cover	Complete healing	4
2	Valliammal	50	F	769703 /06	726 /06	05/12/05	10/12/06	Ca Lt Buccal Mucosa	WLE with SOND with Folded Transverse Forehead Flap	Complete healing	3
3	Amirtham	60	F	786760 /06	1153 /05	16/02/06	14/03/06	PS Defect Lt Buccal Mucosa & Lower Lip- Ca Cheek excision done	Transverse Forehead Flap Cover	Complete healing	2
4	Chinnaponnu	55	F	790302 /06	390 /06	09/03/06	25/03/06	Ca Lt Buccal Mucosa	WLE with SOND with Folded Transverse Forehead Flap	Complete healing	3
5	Swaminathan	54	M	794122 /06	590 /06	18/03/06	20/04/06	Ca Rt Cheek	WLE with SOND with Bipolar Narayanan Forehead Flap	Complete healing	2
6	Baskar	32	M	799203 /06	273 /06	08/04/06	20/04/06	PS Defect Rt Medial Canthal Region	Oblique Forehead Flap Cover	Complete healing	3
7	Rukkumani	55	F	835994 /06		06/09/06	26/10/06	Ca Rt Buccal mucosa	WLE with Rt RND with Folded Forehead flap	Complete healing	2
8	Balaraman	44	M	842351 /06		02/10/06	23/11/06	PT ST Defect Rt Cheek, Panfacial #	Transverse Folded Forehead Flap Cover	Complete healing	6
9	Kumaran	36	M	852368 /06	3037 /06	15/11/06	01/12/06	PT Skin Defect Rt Forehead and Frontal Scalp	Forehead Rotation Flap cover	Wound Dehiscence – Healing by Secondary Intention	1
10	Chandra	55	F	852860 /06	2866 /06	17/11/06	01/12/06	BCC Nose & Rt Cheek	WLE with Paramedian Forehead Flap Cover	Partial Flap Loss – Flap Adjustment	2
11	Nallan	55	M	860536 /06		19/12/06	26/12/06	PT Fistula Lt Medial Canthal Area	Paramedian Forehead Flap Cover	Partial Flap Loss – Flap Adjustment	2
12	Premkumar	4	M	006377 /07	297 /07	29/01/07	08/03/07	PT Skin Loss Lt Forehead, Scalp	Forehead Rotation Flap cover	Complete healing	1
13	Arunkumar	15	M	009886 /07	5355 /07	13/02/07	23/02/07	Tessier 0 Cleft with Augmentation Rhinoplasty with exposed cartilage – status	Glabellar V-Y Flap Cover	Complete healing	1
14	Rajam	63	F	023189 /07	3612 /07	10/04/07	24/04/07	BCC Rt Upper Lip & Ala	WLE with Transverse Forehead Flap Cover	Complete healing	3
15	Murugan	28	M	024088 /07	1194 /07	14/04/07	26/04/07	ST Injury Face – Lower Lid Defect	Islanded Transverse Forehead Flap Cover	Complete healing	2
16	Veeramma	49	F	035491 /07	1759 /07	29/05/07	14/06/07	PT Deformity Dorsum & Tip of Nose	Paramedian Forehead Flap Cover	Complete healing	3
17	Jeyakumar	25	M	036424 /07	1390 /07	02/06/07	08/06/07	PT Nose Deformity – Columella defect	Median Forehead Flap Cover	Complete healing	2
18	Rathinavel	62	M	053262 /07	2443 /07	07/08/07	24/08/07	Ca Lt Lower Alveolus	WLE with Lt Hemimandibulectomy with Transverse Folded Forehead Flap Cover	Partial Flap Loss – DP Flap Cover	3
19	Pandian	54	M	062800 /07	2679 /07	14/09/07	02/10/07	Recurrent Ca Rt Alveolus	WLE with Transverse Folded Forehead Flap Cover	Partial Flap Loss – Flap Adjustment & DP Flap Cover	3
20	Baby	60	F	066734 /07		29/09/07	23/10/07	Recurrent BCC Lt Lat wall of Nose	WLE with Paramedian Flap Cover	Complete healing	2
21	Chithra	3	F	066845 /07		30/09/07	02/10/07	RTA with ST Defect Rt Forehead	Forehead Rotation Flap cover	Complete healing	1
22	Jayavel	52	M	070966 /07	3237 /07	16/10/07	23/10/07	Meibomian gland Ca Lt Upper Eyelid	WLE with Excision of Lt Upper Eyelid with Fricke's Flap Cover	Near-Total Flap Loss – Lid Switch and Cheek Rotation Flap	3
23	Manikandan	19	M	088697 /07	3942 /07	29/12/07	03/01/08	Compound # Nasal bone with Skin Loss	Open Reduction and Paramedian Forehead Flap Cover	Wound Dehiscence – Healing by Secondary Intention	2
24	Sulthan Basheer	35	M	005128 /08	110 /08	22/01/08	31/01/08	Post-Human Bite Nasal Deformity	Scalping Flap for Nasal Reconstruction	Complete healing	2
25	Raji	50	M	018967 /08	664 /08	13/03/08	02/02/08	Ca Rt Upper Lip	WLE with Rt RND with Folded Forehead flap	Complete healing	3
26	Kuppammal	73	F	020147 /08		18/03/08	08/04/08	BCC Lt Nostril with DM	WLE with Median Forehead Flap Cover	Complete healing	2
27	Raji	80	M	023108 /08	725 /08	29/03/08	20/05/08	Ca Lt Lower Alveolus	WLE with Lt Hemimandibulectomy with Bipolar Narayanan Flap Cover	Complete healing	2
28	Muthu	58	M	025026 /08		05/04/08	18/05/08	Ca Rt Buccal mucosa	WLE with Rt RND with Forehead flap for lining & PMMC for cover	Partial Necrosis of forehead flap – SSG	2