

# Plastic and Reconstructive Surgery of the Face

## Flaps of the Head and Neck

Frank W. Pirruccello

Cheated of feature by dissembling nature,  
Deform'd, unfinish'd, sent before my time  
Into this breathing world, scarce half made up,  
And that so lamely and unfashionable  
That dogs bark at me as I halt by them;  
Why, I, in this weak piping time of peace,  
Have no delight to pass away the time,  
Unless to spy my shadow in the sun  
And descant on mine own deformity:  
And therefore, since I cannot prove a lover,  
To entertain these fair well-spoken days,  
I am determin'd to prove a villian  
And hate the idle pleasure of these days.

The Tragedy of  
King Richard The Third  
William Shakespeare  
Act I, Scene 1

### Foreword

As a reported for the Chicago Tribune, I've known Dr. Pirruccello for 10 years. He is known in the newspaper world as an important medical source. The reason: He not only knows his field, he *cares*. The person who wrote this book - because he cares - is a Renaissance man, and there aren't too many of them these days.

He is a great surgeon. He is a writer. An artist. A musician. He writes medical texts and detective novels. He paints, draws, and used to sculpt. He had his own band in college and still likes to sing. He is a horseman, owns horses, rides them, and often wheels around in a four-wheel antique doctor's carriage. With dignity.

He is a loving man, married, with eight children. Dr. Pirruccello is a skillful teacher, too, as this book illustrates. And here, as elsewhere, not only is he an expert in facts and techniques - he *cares*.

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## **Chapter 1. A Brief History of Plastic and Reconstructive Surgery of the Face: Flaps of the Head and Neck**

... That by beauty beautiful things become beautiful  
... and that by greatness only great things  
become great and greater greater  
... and by smallness the less become less.

Plato

Although the Edwin Smith Papyrus presents evidence of surgical problem solving, circa 3000 BC, Sushruta Samhita, circa 600 BC, was probably the first to describe a facial flap for the reconstruction of a nose. Let us first turn our attention to a translation from the original Sanskrit:

"Now I shall deal with the process of affixing an artificial nose. First the leaf of a creeper, long and broad enough to fully cover the whole of the severed or clipped off part, should be gathered and a patch of living flesh, equal in dimension to the preceding leaf should be sliced off (from down upward), from the region of the cheek, and after scarifying it with a knife, swiftly adhered to the severed nose. Then the cool-headed physician should steadily tie it up with a bandage decent to look at and perfectly suited to the end for which it has been employed.

The physician should make sure that the adhesion of the severed parts has been fully effected and then inserted two small pipes into the nostrils to facilitate respiration and to prevent the adherent flesh from hanging down. After that, the adherent part should be dusted with the powders of Pattangs, Yashitimadhukam, and Rasanjana pulverized together; and as soon as the piece has grown fast, the attachment to the cheek is severed..."

Born in the 16th century, Gaspar Tagliocozzi, anatomist at the University of Bologna in Italy, experimented with the fabrication of noses from the tissues of the upper arm. Consistent with superstitions of the times, he was accused of being in league with the devil, and even at the time of his death and burial there was argument as to whether he should be buried in consecrated ground. To his credit, he wrote the first tomes in plastic surgery.

It was in these textbooks that Tagliocozzi drew an analogy between the grafting of trees and the grafting of tissues, declaring that the kind of tissue replacing missing tissue should resemble the recipient area in texture and quality.

A shrinking of grafted tissue after transplantation was also observed and Tagliocozzi noted that it was better to take too much tissue than too little.

His second book emphasized that these operations must be carefully planned and required detailed stages which he described in this way: first, the donor area was chosen to match the recipient area, and for this reason he chose the upper inner aspect of the arm. Parallel incisions marking the flap were made, and after this they were dissected and a piece of linen was placed between the flap and the underlying structures. Several days later, one of the ends of the flap was incised. At this point, the patient was dressed with a prefabricated

mantle-like coat that allowed the arm to be secured to the garment so that the patient could not move the arm and detach the flap.

Making a pattern of the nose with paper was routine after which the template was traced to the arm and the nose was formed in this manner. The flap was then secured with ligatures of some description to the missing area of the nose. And, after 12 days, the flap was cut and the arm released from the face.

Tagliocozzi was accused of consorting with devil and interfering with the work of the Divine One which contributed to the extinction of his operation for a long period of medical history.

Interest in the forehead flap for reconstruction of the nose was revived in the 18th Century by an article written by Thomas Cruso and James Findlay which appeared in the English Gentlemen's Magazine. The authors wrote about a person called Cowasjee, a Mahratta of the caste of husbandman who had been a bullock driver with the English army. In the year 1792, he was imprisoned by Tipoo Sultan, the ruler of Mysore, who cut off his nose and one of his hands.

At Kumar, a Mahratta surgeon created a new nose for him by means of a forehead flap. This kind of operation was not uncommon in India. Apparently, the medical information had not reached the west.

It was known that the Sultan offered a bounty of a pagoda to anyone who brought in a nose. Cornwallis, who was defeated in America, was the commandant of the British Forces. The description related how a thin plate of wax was moulded to the stump of the nose forming a template. It was then flattened and laid on the forehead. A line was drawn around the wax, and the operator dissected off as much skin as it covered, leaving undivided a small slip between the eyes. This slip preserved the circulation until union had taken place between the new and old parts. The cicatrix of the stump of the nose was next pared off and an incision was made through the skin immediately adjacent to the raw parts which passed around both alae and went along the upper lip. The skin was then brought down from the forehead and twisted half round; its edge was inserted into the incision so that a nose was formed with a double hold above, and with its alae and septum below fixed in the incision. The incisional line was secured with Terra Japonica. This cement was the only dressing used for 4 days when it was removed and the wound dressed with ghee, a kind of butter or oil. The flap was separated from the forehead on the 25th day.

Having read the account of the Indian rhinoplasty, J. D. Carpue, an English surgeon, studied the material closely and decided that the operation might prove worthwhile. Like today, some of the new procedures had to be undertaken surreptitiously and this case was no exception. One of his patients who had lost his nose by disease was selected by Carpue for a rhinoplasty. After a preliminary incision was made (probably to test his ability to heal), the operation was carried out. And, because of its success, it was performed in a second case 2 years later and reported in a book.

There is no question that their report must have been received with jeers as well as cheers; nonetheless, we should be pleased that Carpue had the intestinal fortitude to perform

the operation. And thus, another chapter was written in the annals of medicine in which a western surgeon plucked the baton offered by surgeons of the east.

In his book on plastic surgery, J. S. Davis made several suggestions on the formation and handling of skin flaps that are as relevant today as they were in 1915. He suggested that the tissues should be treated with the greatest consideration, and that the keenest cutting instruments must be used in order to avoid unnecessary injury to the tissues. He also recommended that the flaps should be handled with special forceps or small sharp hooks, and emphasized that hemorrhage should be checked. Finally, he suggested that accurate apposition of the sutured edges was desirable.

Further, Davis admonished that sutures should be placed to avoid tension which always jeopardized the success of a flap, and that flaps should include the skin and as much of the subcutaneous tissue as needed. He added that the shape of the flap should correspond accurately to the defect which it was to cover, and that long pointed flaps should be avoided because of almost certain necrosis at the tip.

Emphasizing the fact that the donor flap should match the recipient area, he noted that flaps should be chosen with regard to the character of the skin surrounding the area into which it was to be put. Hair is fine in hair transplants, but Davis emphasized that a flap of hirsute skin should never be turned into the mouth or any other mucous lined cavity. This surgeon emphasized basic principles of plastic surgery that are of paramount importance today and should be emblazoned on the frontal hemispheres of any person performing reconstructive surgery.

Also at Johns Hopkins Hospital, in 1898, Halstead reported a method of moving a pedunculated flap from its original site by waltzing it in a series of staggered movements. In the treatment of an extensive burn of the cheek, neck, and arms, he moved a flap by twisting it twice on itself, first upon a small pedicle of skin, and second on a little broader pedicle of cultivated cicatricial tissue. In this manner he wrote, "The flap makes a complete revolution".

Boston was the home of George Monks, a surgeon who, in 1898, reported the use of a flap based on the superficial temporal artery and which was carried subcutaneously to the region of the eyebrow and sutured into the defect. This was undoubtedly the first report of an island flap to be reported in the Boston Medical and Surgical Journal, or anywhere else as far as that is concerned.

Of importance is that the artery *and* the vein must be dissected free or the flap will not survive. This, of course, is the beginning of the arterialized flap and undoubtedly has given momentum to attempts at the free transplantation of the anastomosed microvascular arterial flap. George Monks, a sculptor, was an interesting man who should be sought out and studied by the aspiring plastic surgeon looking for inspiration.

In this century, Horsley et al used an island artery flap to a full thickness loss of the lip and chin. They outlined and dissected the superficial temporal artery, and also made an incision across the face in the direction of the lip to bury the arterial pedicle.

All of these discoveries were major advances by pioneers seeking to improve man's lot. And for this, we owe them our respect as we turn our attention to more modern microvascular and other techniques.

## Chapter 2. Flaps

"... bodies are beautiful in proportion as they are useful,  
or as the sight of them gives pleasure to the spectators  
... sounds and music are beautiful for the same reason..."

Plato

If a quantity of tissue is outlined incorporating its own blood vessels, and if the mass is then moved in stages to a recipient area, surviving on its own vascularity, the tissue entity is dubbed flap. It differs from a free graft in that it is self-nourishing, and it is moved in steps leaving one end attached. An obvious exception is the free flap which is moved immediately to a recipient area by the direct anastomosis of existing vessels, according to the concepts of microvascular anastomosis.

Since a flap carries its own sustenance and since it also provides bulk that cannot be furnished by a thinner split thickness graft, it follows that a flap is necessary where a void exists or where bone, tendon, blood vessels, or nerve is exposed. When contouring is necessary or thicker tissue is mandatory for bearing weight, a flap is indispensable.

When the palmar aspect of the hand needs padding for grasping, or where a split graft would be inadequate for protection, a flap is indicated. In aesthetic operations where a feature is to be reconstructed, oftentimes a flap is unavoidable. If an area is heavily scarred restricting growth and development as well as movement, releasing scars and replacement with a flap or "z" flap is imminent. Irradiation injuries with eventual ulceration may require new blood vessels.

What the devil is this phenomenal piece of tissue that is left loose and hanging with one end attached to the body and the other end flying free in the breeze? It is a flap, and flaps are best described in relation to the derivation and location of their blood supply, for this is not simple anatomy but functional anatomy that bears a direct relationship to the manner in which the flap is dissected and migrated. With this in mind, we find that flaps are basically of three kinds:

1. Axial cutaneous, where all the blood vessels are found to penetrate the flap *above* the muscular plane.
2. Myocutaneous, in which the vessels come through or are incorporated *in the underlying muscle*. This includes all myocutaneous flaps.
3. Local flaps include transposition, rotation, interpolation, advancement, bipediced, or any other nomenclature that might inspire the surgeon.

In order to work successfully with flaps, one must remember that:

1. Flaps retain the color and texture characteristics of the donor area.
2. The closer the site of flap origin is to the recipient area, the greater is the likelihood of a good match. Obviously, local flaps are superior in this regard.
3. Distant flaps retain the qualities of the area they come from; hence, they do not serve the purposes of the recipient areas as closely as local flaps.

Similar to a skin graft, a non-hairy area is best served with a relatively hairless graft, and a fine grained area is served by a fine grained graft. By the same token, tissues from the abdomen have a different color when they are exposed to the air say, for example, than the face, and also they tend to acquire fat like the abdomen if the patient begins to gain weight.

A graft taken from a child's pudendal area, though relatively hairless when it is taken, may still become quite hirsute when the child approaches puberty.

At this point, it is advantageous to list the merits of the flap over a split thickness skin graft:

1. The flap carries its own blood supply, and in cases where the recipient area vascularity has been compromised as in an irradiation insult, this can make the difference between success or failure.
2. A graft depends on the recipient site for sustenance, making its survival totally contingent on the ability of the area to provide everything necessary.
3. The site must remain bacteria clean as evidenced by negative cultures, so that infection does not occur and insures that anastomosis of vessels can occur in a healthy environment.
4. A flap is more apt to survive with careful strategy, but it must be emphasized that a flap can fail.
5. Sufficient tissue can be moved to the recipient area by planning for it, thus allowing for full coverage and anticipating shrinkage.
6. A flap can be used to cover nerves, tendons, and blood vessels. Coverage with a split thickness skin graft is inadequate.
7. With care, a flap can be constructed to bear weight, or to endure pressure in the hand.
8. With a microvascular technique, many stages in migration of a flap may be eliminated.

### **Disadvantages of the flap are as follows:**

1. A series of operations are usually required by a flap.
2. Scarring at the donor site is usually greater with a flap than with a split graft.
3. If the arm is used as an intermediate carrier, painful joints and muscles can ensue, thus limiting this procedure to younger patients.
4. Facial expression is limited under a flap because of its thickness.
5. Microvascular techniques speed up the transfer of tissue but the flap can be lost, and these donor sites again are more scarred up than the split graft site.
6. Myocutaneous flaps are a marvelous adjunct to the movement of tissue, though close attention to detail and fastidious techniques are required.

Many clinicians believe that it is low oxygen tension in flaps that creates failure, and hyperbaric oxygen chambers can reverse this problem if used early enough.

When looking at a flap of tissue at its moment of inception, that is, after you have cut off part of its blood supply, many color changes are observed. Hues of white, blue, and pink are seen that are undoubtedly due to sympathetic nerve denervation.

If you examine the dermal and subdermal bleeding and find it profuse and red, you have indications of a good flap. Unfortunately, at times, the only indication of life is a cyanotic oozing of blood or at times nothing at all emanating from the dermal area. This is bad.

Touching a blue or white flap with the finger will give a gross determination of how quickly the superficial circulation will return the flow of blood into the skin. Ordinarily after momentarily obliterating the superficial circulation with finger pressure, the fingerprint will quickly return to pink. In a cyanotic flap, there is no such phenomenon or very little of it. White color indicates an absence of observable circulation, while blue indicates congestion. Pink is a good and desirable shade.

Gradual changes over hours and days consist of blistering, desquamation, and finally demarcation of good tissue from necrotic tissue. These things can be complicated by hematoma and infection. All twisting of tubes and flaps must be avoided since they contribute to these problems. Bulky pressure dressings can be harmful.

If a flap is rolled up along its greater dimensions, without tension, of course, the simple flap becomes a tubed flap. Pliable, soft, and loose are the characteristics of a good tube. And there should be no indication of tightness or discoloration along the suture line.

When the tube is completed, an attempt is made to approximate the skin edges under the flap, and if this fails because of tension in the skin, as evidenced by blanching, then the donor site should be split thickness skin grafted.

Moving a tube to the desired recipient area can be a series of well-orchestrated moves or a total disaster. "Every movement has a meaning all its own" was never more true than in the moving of a tube.

Depending on the location of a tube, its vascularity, its dimensions tells one when it can be moved. Instinctively one knows that the closer to the face, the more abundant the blood supply, and perhaps the quicker the movement. The skin on the feet of an old diabetic is not going to cooperate like the skin on the face of a healthy young adult.

It is a pleasure to see a segment of tissue borrowed from the abdomen, transferred to a wrist, and migrated to the bed of a dissected out neck contracture; hence, saving the long walk to the recipient area.

Forming a flap or tube along the long axis of somatic growth is the same concept used by myocutaneous flap experts.

in raising a tube, the same concept is in operation that is used in the formation of a flap excepting that the usual 3-1 is an estimate of length and width ratio. If the incisional lines incorporate a blood vessel, and remain parallel to the embryonic lines of migration of the skin somites, chance for survival is excellent.

### **Chapter 3. Scalp Flaps**

"... I have seen many beautiful things  
... they are not the same as absolute beauty,  
but they have beauty present with each of them."

Plato

Thick and hairy, the heavy cardboard-like scalp presents a formidable obstacle to routine reconstruction. A wide flap which includes a known artery in its base can be moved without dissection of the vessels as long as one knows the distribution of its blood supply, and only if tissues are handled carefully. This is common knowledge among neurosurgeons who routinely move large osteoplastic flaps; however, neurosurgical flaps are returned to their original position *without torsion* of their bases. A long narrow flap requires that a major blood vessel be included in its construction, with care taken that an artery and its concomitant veins are dissected carefully within the confines of the flap. The superficial temporal artery and vein are commonly used in this way. Thus, even considering the fact that architectural vicissitudes of the scalp tissues are contrary to the formation of a good flap, it can be raised and moved if done carefully, and if the basic precepts of tissue handling are obeyed.

Adherent to the superficial fascia of the scalp and the thick skin of the head, as well as the aponeurosis connecting the occipital and frontalis muscles, is the superficial fascia of the scalp. Arising from the occipital protuberance, the curved portion of the occipital bone and the mastoid bone, the fascia converges to a tendonous aponeurosis over the top of the skull, and converges with the muscles of the nose and circumorbital area. This muscle can create monkey-like expressions by drawing the tissues of the face up into an expression of alarm and creating lines across the forehead as if in a primeval reaction to surprise or fright.



Functionally, the thick scalp prevents many serious injuries to the underlying bone of the skull, thus preventing many serious intrusions into the area of the brain of man.

### **Baldness**

If you want to get rich fast, start a new religion or invent a cure for baldness. It has been reported that there are over 300,000 different things one can buy for the treatment of alopecia. These nostrums are available as over-the-counter items that do not require a physician's prescription or can be purchased at beauty or barber shops. Thousands of items are sold through the mails, as well. All of these so-called cures are being investigated by the Food and Drug Administration.

Most of the drugs being used on the labels do not promote the growth of hair, and are not necessarily harmful if taken externally, as the label usually advises.

Vitamins, oils, cleansers, and hormones are found in many of these prescriptions, all of which make us the country with the healthiest head of skin and possibly the cleanest and shiniest scalp, although not necessarily the most hirsute.

Alopecia from illness, drug therapy, hormonal imbalances, or nutritional problems are usually reversed when the underlying disorder is corrected.

It is fair to conclude that restoration of hair growth is dependent on the restoration of health, and scalps that have grown bald in a legitimate pattern will remain the way in spite of physical therapy or the addition of multi-colored solutions to the head.

### **Flap Discussion**

Let us begin with a basic example. One finds that the simple flap is indeed a well-known structure, but its identity has been obscured by complicated names. A *contiguous, sliding, rotating, adjoining, approximating, bordering, abutting* flap on a *single pedicle* is, in truth, a piece of tissue that has been left attached at one end, while the other end has been moved a few centimeters to cover a defect next to it. A simple flap simply moves one end a few centimeters to cover its neighboring defect. The area from which the flap moves may be repaired by moving loose tissue over it, but if this puts the flap under tension, despite undermining, a split thickness graft is used to cover the flap.

After reviewing the gross anatomy of the scalp, one is able to draw or perform most of the flaps described by simply basing the flap on known blood vessels such as the supraorbital artery and vein or the supratrochlear artery and vein.

A flap outlined up and down on the forehead over either eyebrow becomes a supraorbital flap. By the same token, a flap outlined over the eyebrow and shaped like a loop to the area over the other eye is also a supraorbital flap, though a bit more exotic. Another New and Erich creation is a loop-shaped flap that is also based on the supraorbital vessels but higher up near the hairline.

These ingenious clinicians also devised a sickle-shaped temporal flap whose blood supply comes from the superficial temporal artery and its parietal branch. This, too, is found almost completely in the scalp except for its tip which is located in a hair-free area at the side of the head.

Numerous articles have appeared in journals concerning the restoration of hair by implanting punch grafts and using flaps of various kinds. According to Nataf, punch grafts can transplant about 70 hairs per square centimeter, which is about one-half normal density, but by fusiform grafts, it is possible to transplant about 100 to 120 hairs. By using flaps, 200 to 250 per square centimeter can be transferred, which is about normal density.

Fusiform grafts are cut in a manner that ensures the oblique direction of hair growth. The lengthwise manner in which the fusiform grafts are cut allow for fewer pilo-erector muscles to be severed, which is a problem when punch grafts are taken.

Unlike the disordered look that frequently results from transplanted hairs, the oblique excision and preservation of pilo-erector muscles creates a more natural appearance to the transplanted hairs.

In Nataf's article, several flap illustrations reveal a strategy whereby the end of the flap is split in an arborescent fashion; hence, when hair grows, length and dispersion will hide more of baldness than if the arborescence had not been used.

It has been proposed that a number of procedures, such as free grafting and flap creation, can be used to correct baldness. Scalp reduction by operative excision combined with flaps and grafts can be synergistic. In Stough's opinion, despite adjunctive therapy, the punch graft remains the back bone of all modalities.

In presenting his case, the author demonstrates a condition in which a portion of the scalp over the vertex of the skull is excised in two steps. By using multiple punch autografts, he demonstrates growth of hair over the tope of the head.

In another case, he illustrates a superiorly based temporal flap while in another, he demonstrates an inferiorly based temporal flap. No long term pictures are available at this time. A final case is shown after the implantation of 500 autografts and grooming. He recommends a "blender" graft of occipital hair after three or four sessions.

Although infections are mentioned, he states that they have been minimal. He also uses an electric hand dryer which in his words enriches the texture of the skin and he suggests the use of a fogging technique, as well, by which the scalp is color sprayed.

To treat occipital baldness associated with fronto-parietal baldness, Juri et al have rotated 25 scalp flaps. For the correction of isolated occipital baldness, 35 flaps have been rotated without any necrosis. Patient acceptance has been good.

By using the Doppler ultrasonic flowmeter to trace the temporal artery and its anastomosis with the occipital artery, flaps approximately 3 cm in width have been outlined over these vessels and moved anteriorly to create a new hairline. This eliminates guesswork

as to the location of the vessels and the important anastomotic points.

By moving hair bearing flaps of tissue from adjacent areas into small bald defects of the scalp, the ideal remedy for alopecia is found. If the surrounding tissues have been injured by radiation, aberration in the blood supply makes it impossible to use them and flaps from other parts of the body must be enrolled into service. These flaps may be moved directly to the area by carefully planned steps, or delivered by an intermediate carrier such as the arm.

After delaying parietal-occipital flaps twice, they can be moved to balding areas of the scalp. Thus, permanent hair can be moved to genetically determined deficient areas, giving the greatest density of transferred hair to a recipient area in the shortest period of time.

It is important that the flap blends with the contours of the hairline so that the tissue looks natural. Kubaker suggests that a 4 cm width to the flap is appropriate since it allows the maximum width while still allowing the operator to *close the donor area*.

In evaluating Kubaker's cases, complications have been modest. In outlining the flap, the first delay is accomplished by incising along the proximal portion of the flap. The second delay is performed a week later by incising along the distal edge of the flap. In order to close the donor area, a wide undermining of the adjacent scalp tissue is necessary.

Juri et al use two flaps in the treatment of fronto-parietal baldness, and a third is sometimes migrated using the old scar from the first flap. They also discuss flaps used in the treatment of occipital baldness.

When working on the scalp, it is important to inform the patient that *infection* and bone *necrosis* can occur. Purulent infection which occurred in one of Marchac's cases was cleared up, though Z-plasty was employed after ward to move or transpose hair bearing tissue more inferiorly to cover the alopecia. It is important to obey the road signs, and the rules of plastic surgery are no exception. They must be obeyed to the letter. Incision through the galea allowed the flaps to be moved more easily.

### **Ordinary Injuries**

Ordinary injuries to the scalp may produce significant hemorrhage through the full thickness of the skin, especially if there is a massive contusion or if a large artery is torn. A small punctate area can bleed profusely, whereas a large laceration can expose a Niagara Falls of fatal haemorrhage.

Stopping or staunching the flow of blood may require hand and finger pressure and clamping of vessels in the aponeurotica level. In an emergency, even a towel clip can be used to bring the skin edges together as a quick method of stemming the blood flow.

When suturing the scalp, the use of 2- to 4-0 nylon is recommended as it can be handled with ease and is usually available. The placement of a series of well-placed simple interrupted sutures is sufficient after the bleeding is controlled. At times, simple clamping and cauterizing the vessel will do the trick.

If a segment of scalp is missing and the patient's condition is unstable, a wet dressing should be used until reconstruction can be carried out safely.

At times, one may consider sliding a segment of flap adjacent to the defect over the bone, especially when the periosteum is missing. At the same time or later, if the patient's condition dictates, a split graft may be placed on the donor site.

An interesting and useful method of closing scalp defects was described recently in which multiple flaps were used in a pinwheel design. Two cases are discussed in which the authors describe this technique in closing defects of 4.0 x 3.5 cm and 4.5 x 3.5 cm. The range in the patients' ages was great, one was 5 years of age while the other was 76 years of age. The flaps were elevated in a pinwheel design to just beyond the bases of the flaps, permitting rotation of each flap so that the apices met in the center of the defect. A single central buried suture of 4-0 dexon was used to approximate the central points. The remaining limbs were sutured with interrupted 4-0 nylon.

### **Electric Burns**

In electrical injuries, large segments of the skull and scalp are lost without terminal injuries to the brain. These burns demonstrate massive injuries to the *blood vessels* and present many interesting problems in reconstruction. Over the centuries, the challenge of treating electrical burns has stimulated surgeons to devise methods of conveying tissues to the scalp.

When the scalp has been lost, the skull exposed and the periosteum is missing, devascularization of the bone will be followed quickly by necrosis and infection. A local flap must be turned over the exposed bone to cover it and to bring in a fresh blood supply.

By drilling many holes in the outer table of the bone and putting wet dressing on the area, granulation tissues containing blood vessels will appear soon in the healthy skull. And after 7 to 14 days, sufficient granulations will appear to support the growth of thin split thickness graft. This can be done when a flap cannot be swung into the area immediately or when one is planning a flap in a long range program and cannot afford to allow the bone to be exposed.

In unhealthy or elderly persons or those with irradiated skulls, granulations may not appear and a flap should be planned immediately. The old saw of converting an open wound to a closed wound was never more dramatically indicated. To repeat: It is of utmost importance to adequately cover exposed arteries, veins, nerves, tendons, or bone if one expects them to carry on their vital functions.

### **Avulsion**

Traumatic avulsion of the scalp has occurred with enough frequency to make safety engineers nervous. This injury occurs most often in industrial settings where employees work near gears, belts, and moving parts without adequate protective head gear.

Perhaps one of the most striking examples of this kind of injury occurred in 1889 at a grist mill in Michigan. The hair of a 9-year-old girl operating a machine there became entangled in the whirling horizontal shaft. Her brother tacked her as she spun around, pulling her off the machinery although her hair, scalp and right ear remained fixed to the revolving horizontal bar.

According to Straith and Beers, this youngster's 4.5-year stay in the hospital traces the history of homografting and zoografting in the early formative years of reconstructive surgery. The doctor, several nurses, and orderlies each donated pinch grafts to be transferred to her denuded scalp. Assuredly, these emotional displays of camaraderie were morale building, and despite the fact that the homografts lasted only a short time, the young patient's spirits remained high.

Following the homografting episodes, the patient's sister was strapped in bed with her and a *flap* of skin from the sister's side was brought across and sutured into the scalp defect. This failed; but undaunted, the surgeon attempted to transfer a flap from a dog to the patient. The two were also tied together in bed, but this too failed.

Finally, the area healed with the use of WONDERFUL DREAM SALVE. But alas, the wound eventually reopened, and the patient died as the result of a stroke in 1949, her head wound still granulating.

In reviewing this case which had its beginning in 1889 when plastic surgery as we know it now was in its infancy, one cannot help but think how this person's entire life changed on that one gruesome day at the grist mill. She spent the rest of her life dressing and treating her miserable scalp.

Today, the treatment of choice would be microvascular reimplantation of the avulsed scalp, thus eliminating her 50 years of wound care.

Another case reported by the authors involved a farm hopper accident in which a youngster was scalped. The scalp was recovered and delivered to the hospital in an ice bucket where it was split down to the base of the hair follicles. The outer layers of the scalp were sutured into place over the defect and a stent dressing was applied. Only half of the scalp survived.

At the time of the second procedure, the occipital scalp was shifted forward as a visor flap so that the hair line anteriorly would be intact and the hair could be combed posteriorly over the grafted hairless area. The result was admirable.

### **Massive Reconstruction**

Many scalp injuries with tissue loss can be repaired by using the Gillies rotation flap and a split thickness graft with which to repair the defect left by the simple flap.

Beers and Pirruccello present the cases of two young girls who injured their scalps in automobile accidents.

Having sustained a scalp loss of 8.5 x 7.5 cm involving the left temple and forehead area and a partial avulsion of the left ear and lower portion of the concha and lobule, the first patient was taken to the operating room after her condition had stabilized. The hair was shaved from the scalp and debris scrubbed from her head and neck under general anaesthesia. After a Gillier rotation flap was advanced from the left parietal region into the defect, a Z-plasty was carried out in the lower left temple area to relieve tension in the flap. Following this, a split thickness graft was sutured into the donor defect left by the flap. The pericranium was intact in this area enabling a split graft to survive. The exposed ragged ear cartilage was removed next and the avulsed helix was covered with advanced preauricular skin. Later, a portion of the skin graft was removed to permit more normal hair coverage.

The second patient was 16 years of age and had extensive scalp lacerations and tissue loss. She was taken to the operating room where her hair was clipped and the wound irrigated. The damaged area was scrubbed vigorously with a soap preparation. After foreign material was removed, the contused margins were debrided and the area was again irrigated with saline solution. Contrary to many popular concepts, scalp areas can become infected and they must be scrubbed and irrigated.

It is important at this point to emphasize that wounds be closed with minimal tension. If bone is exposed without pericranium, a flap must be used to cover the bone cells to prevent necrosis, infection, and osteomyelitis. It is important that the scalp be advanced whenever it will cover denuded bone. Relaxing incisions, rotation flaps, and the use of skin grafts are all useful. Multiple incisions through the galea on the under surface of the flap make allowances for advancement and stretching of the scalp.

When scalp wounds are associated with an underlying cranial defect, the sliding rotation flap is exceedingly helpful. By incising in a wide curve so as to produce a hemispheric-shaped flap, the flap is projected so that the width of the defect is at least two times beyond its margin. The area where the flap originates is covered with a split thickness graft with a tie-on dressing.

All of these methods are useful in covering bare bone. If bone is not covered, you are inviting serious complications including necrosis. Bare bone cannot be covered successfully with split thickness skin; however, when the outer table of cranial bone is thinned and perforated in multiple areas by the use of a chisel or a neurosurgical burr, granulation tissue will grow out from the medullary cavity and will support growth of a split thickness skin graft in about 2 weeks' time.

The pericranium must be covered rapidly as well, or it will disappear. The failure of scalp flaps can usually be attributed to outlining without sufficient anatomical knowledge of the direction of a nutrient artery. Infection, thrombosis, and excessively tight dressings also take their toll.

Use of microvascular techniques are reported to successfully replace avulsed scalp tissue.

## Chaper 4. Restoration of Eyebrows

"... a thing is beautiful in itself;  
as related to something else is is either more or less beautiful  
... the more beautiful can have no existence without the beautiful."

Plotinus

For many years, medical literature has described the replacement of a missing eyebrow by taking a flap of tissue from its fellow on the opposite side. Nonetheless, free grafting of hair-bearing tissue is superior in that it leaves no obvious donor defect. In cases where the eyebrow is bushy and a 5 to 8 mm segment or strip of tissue would not be missed, a full thickness graft from this area is justified.

The Monks or arterial peninsular hair-bearing flap is an excellent method of replacement.

Caterpillar or creeping flaps from the occipital area were described by Lexer. A flap is raised less than an inch in width from the occipital area, and it is folded on itself, raw surface to raw surface. The tip is brought back and sutured into position near the base or pedicle. After a few weeks, the original base is incised and the flap is extended into the adjacent area. This procedure is repeated until the flap is sutured into the missing eyebrow.

In modern rhetoric, several approaches can be used to restore a lost feature such as an eyebrow.

1. A full thickness hair-bearing graft is transferred immediately following the injury. The donor site is usually the ear opposite to the injury.

2. A full thickness hair-bearing graft can be migrated as a secondary procedure. This can be done after the original area of injury has been closed with a split thickness graft as a temporary measure, thus making it an elective procedure; ie, the patient may be pregnant at the time of the accident and a cover-all split graft may be used to cover the flaw on a temporary basis.

3. A hair-bearing arterial peninsular scalp flap based on the superficial temporal artery when a larger quantity of tissue to complement aesthetic restoration is necessary.

The full thickness hair-bearing graft is usually dissected from the hairline behind the ear. The skin in this area gradually blends into the thicker typical scalp tissue and the hair follicles tend to be more superficial. This hair can be handled more easily without going to the depth required elsewhere on the scalp. The graft is dissected deeply enough to include the base of the hair follicle and some of the surrounding underlying fat. By cutting on the curve of a pair of small strabismus scissors, the fine particles of fat can be removed carefully around the base of the hair follicles. The follicular base is easily recognizable as a bulbous black protuberance extending through the fat. The hairline behind the opposite ear is used as the hair tends to grow upward and can be trimmed nicely as it falls inferiorly into the eyebrow line. The donor site can be closed easily by direct approximation. Many of the

original hairs will fall out within 6 weeks. This followed by a secondary growth of hair which restores the hair-bearing appearance to the grafted area. The eyebrow restoring procedure can be done immediately following the accident or as a secondary procedure after primary coverage has been obtained.

When the deformity is more marked and form and substance of the brow is lost down to the underlying periosteum or bone, replacement can be carried out with a long peninsular hair-bearing flap from the temporal area. This flap can be marked out with the Doppler apparatus, incorporating the superficial temporal artery and vein. This approach allows the operator to violate the basic concepts of flap formation by making a flap that is easily 10 times as long as it is wide. The superficial temporal artery usually emerges from the fascia in the preauricular area roughly at the level of the tragus. At this point, it emerges from its deeper relationships and makes an ideal place to base the flap. It is impractical to base the flap any lower than this point. The flap is quite long and narrow yet survives nicely to provide adequate blood supply to its tip. Outlining the flap is followed in 2 weeks with lining of the flap. Then, several days later, the distal end is delayed. The long peninsular flap is turned into the defect in the supraorbital area. A week later, the previously placed skin graft over the eyebrow is dissected as a flat with the base downward to make room for the hair-bearing flap. This increases the quantity of tissue available to the upper eyelid giving the projecting brow effect which is so important. The flap is left attached for 3 to 4 weeks and is then detached. The unused portion is returned to the side of the head. Later, the eyebrow can be trimmed to a thinner and more suitable match with excellent results.

An interesting case is described where a man lost approximately one-third of his forehead, right eyebrow, and adjacent tissue. He required a Gillies rotation flap, an Italian forearm flap, and a hair-bearing peninsular flap, inspired by the work of Monks. In this case, the superficial temporal artery was used twice, once for the scalp flap and then again for the peninsular arterial eyebrow flap.

Popularized at the Mayo Clinic is the sickle-shaped temporal flap which incorporates the superficial temporal artery. The flap is outlined and completely undermined leaving its temporal and frontal areas attached. Two weeks later, the distal portion of the flap is raised and lined with a split thickness graft. The graft will provide lining for tissues inside the nose where the lining membranes are missing. About 2 weeks later, the distal or frontal portion of the flap is cut across so that the entire blood supply comes from the temporal (superficial temporal artery). Approximately 2 weeks later, the distal two-thirds of the flap is elevated and sutured back into place. After 14 days, the flap is lifted, brought down, and the distal portion sutured into the defect. At this point, the denuded area on the scalp is covered with a split thickness graft.

After 3 weeks, the flap is cut free from the recipient area leaving enough tissue to reconstruct the defect, while the remaining graft is brought back to the side of the head. This minimizes the defect simply because most of the tissue is returned to its point of origin.

All of these interval figures are variable according to the color of flap and the intensity of the dermal bleeding.



In reconstructing as much as one-fifth or one-quarter of the total scalp surface, Orticochea has devised a method which does not require extensive grafting. He uses a tourniquet and advises gentle treatment of tissues. He also recommends a transverse section of the epicranial fascia of all flaps to allow for stretching, while preserving the integrity of the blood vessels.

To cover an area in the occipital or occipito-parietal region, initially two flaps are outlined which are located just above and in front of the raw surface to be reconstructed. The pedicles should originate in the supra-auricular, auriculomastoid or the pre-auricular region, immediately in front of the raw surfaces' latter aspect. Further specific information is available in an account which appears in the *British Journal of Plastic Surgery*, 20:159, 1967.

Four years later, in 1971, Orticochea developed a different technique. For large tissue loss in the frontal and occipital regions, he devised a three flap technique that contained the entire remaining scalp. He believed that it was easier than his four flap technique because the operative procedure was easier and the width of the pedicles wider, thus insuring a better blood supply.

Flaps one and two are outlined along the superior border of the raw area so that when they are mobilized they will automatically cover the raw surface.

Each of the flaps has its own vascular pedicle. Thus, when reconstructing the scalp or forehead, the superficial temporal artery and vein are in the pedicle, and when the reconstruction is carried out on the occipital region, their pedicles will carry the occipital and posterior auricular vessels of the external carotid.

Pedicles in the temporal region contain the posterior auricular and occipital vessels if the region to be reconstructed is located on the forehead. When the occipital region is to be reconstructed, the pedicle includes the superficial temporal vessels.

## **Chapter 5. The Forehead**

"... Is not this a way which you have with the fair:  
one has a snub nose and you praise his charming face;  
the hook nose of another has, you say, a royal hook;  
while he who is neither snub nor hooked has the grace of regularity..."

Dialogues of Plato - The Republic V

Acting as a double agent, the forehead serves both as recipient and donor of tissue. Whether smooth or wrinkled, the tissues of the forehead heal nicely in the face of a number of unlikely procedures that seem to be their lot. Scalp flaps galore have been used to resurface this area. Flaps have been migrated from the abdomen or other parts of the body using the arm as a carrier, and local tissues have been moved quickly to replace a large midline segment.

On the other hand, beginning with Susruta, 600 BC, and continuing on through Tagliacozzi, tissues from the forehead and face have been borrowed for the reconstruction of

the nose. In the 19th Century, it seemed that every European medical center was busy devising a modification of the Indian method of rhinoplasty.

Because of the excellent color match, and since the arm was not used as a donor which meant fewer surgical acrobatics, the Indian method of rhinoplasty (using forehead tissue) was advocated by many experts.

In the 19th Century, Lisfranc and Labat wrote extensively on the rhinoplasty. In Germany, Blasius was busy writing about the same subject as were Von Langenbeck, Dieffenbach, and Linhart.

These surgeons were extending incisions down one side or the other to allow for easier movement through the original 180°. Nostrils were formed and the flap was folded at its distal end in many ways to form columella and nostrils.

The Italian method, as promulgated by Tagliacozzi, advocated creating a nose from the tissues over the biceps on the upper arm. The flap was based inferiorly in relationship to the nose and it was turned into the defect with the upper portion of the flap secured to the defect. The arm was secured to the head by means of a jacket and headpiece which were probably stitched together.

Gillies implanted three pieces of cartilage in the areas above and to the side of the nose. The lateral areas coincide with the nasolabial flap area.

Next, the flaps were outlined and the cartilage was put in place. Three weeks later, the scarred edges were raised with the cartilage.

The upper flap covered the dorsum of the nose, while the nasolabial flap with imbedded cartilage was rotated to form the greater alar areas. The large flap was brought down from the forehead and several minor flaps were formed over the tip. These flaps tend to interdigitate with the smaller flaps that are lining the nose. This simulates a nose, but it is certain that many smaller detailed procedures were required at a later date.

It is apparent that the Gillies method is quite similar in that the flap is large and sits to one side of the forehead, picking up the supraorbital blood supply from the medial side of the eyebrows.

In 1898, Bardenheuer performed a method of Indian rhinoplasty that was quite advanced and similar in a sense to a forehead sickle flap that was done at the Mayo Clinic for so many years. The flap was based over the right supraorbital vessels, extended superiorly beyond the hairline on the forehead, and dipped down onto the other side of the forehead forming an arc that included almost all of the forehead (1898).

The sickle-shaped temporal flap of New and Erich was an excellent means of covering defects, especially of the nose, over a wide range of area.

In passing, it is wise to mention Joseph again since he also performed the Italian rhinoplasty using the upper portion of the arm to replace tissue missing from the nose. Again,

the deformity of the forehead was absent since the donor site came from the arm; the color match was bad, however, and the arm had to be held in an awkward position sometimes for three weeks which is certainly a drawback by producing postoperative debility.

## Chapter 6. Myocutaneous Flaps

"... the beautiful is that which, apart from a concept, is cognized as object of a necessary delight..."

Kant

"... the delight is not delight in the beautiful but in the good (in perfection)..."

Kant

According to McCraw et al, compound muscle-skin flaps should, by derivation, be termed "musculocutaneous" flaps.

Most muscles are supplied segmentally by several vascular pedicles, some of which are capable of supporting a large segment of muscle when the adjacent vascular pedicles are ligated. Such a stalk is the "dominant" vascular pedicle of the muscle. When a given area of muscle and skin is completely detached from the body except for the connection of this dominant vascular pedicle, the resultant flap is called an "island" myocutaneous flap. The point of entry of this dominant vascular pedicle into the muscle determines the mobility of the island flap. We call this the "axis" of rotation or rotation point of the flap. The extent or reach of the cutaneous tip of the flap is called the "arc" of the flap.

The muscle acts as the carrier of the skin or cutaneous segment of the myocutaneous flap. Because the cutaneous segment of the compound flap is variably vascularized, its dimensions must be discussed separately from the whole flap. When all of the skin of a myocutaneous flap is centralized over the muscle, it is directly vascularized by the perforating vessels, and the compound flap can be elevated without any detectable change in the normal blood supply of the cutaneous segment. When the cutaneous segment of a myocutaneous flap extends out beyond the muscle, this peripheral part is not as well vascularized, and may be supplied by perifascial vessels or the subdermal vessels. This peripheral skin is comparable to a random flap attached to an axial flap, and it may require a delay procedure.

In order to select intelligently a myocutaneous flap, one must know the viable muscle length supplied by its dominant vascular pedicle. This muscle length will determine the size of the viable cutaneous segment of the flap. Once this is known, the flap can be determined by locating the dominant vascular pedicle which is the rotation point axis of the flap. These are the primary surgical considerations.

Secondary surgical considerations include the functional expendability of the muscle, the inherent cutaneous sensibility, and the relative desirability of muscle bulk. When muscles are detached from their insertion, they lose about 50% of their volume. Denervation of a muscle can also cause shrinkage. Cutaneous sensibility is quite variable (eg, ranging from

absent to fair to normal in the rectus abdominis, gracilis, and biceps femoris flaps, respectively).

In their discussions on observed myocutaneous vascular territories, McCraw et al consider all of the known flaps but of immediate significance is the sternomastoid flap which has an arc to the midline lip, malar area, and temporal fossa, and the trapezius which extends to the anterior floor of the mouth, tonsil, nasolabial fold, temporal fossa, opposite shoulder and mastoid. These statements are taken almost verbatim from McCraw et al.

It is interesting to note at the outset that all muscles are flaps. This is inherent in the manner in which muscles are developed embryologically. They tend to drag their blood and nerve supply along with them so that they all tend to have a proximal blood supply. This unique method of vascularization allows a large segment of tissue to be moved on a pedicle which literally swings around a main blood vessel. There are exceptions to this rule since the blood supply may arise from two or more sources, but in general, it is true. One should always think in terms of veins traveling with the arteries since this is a major factor behind the ability to move a muscle directly.

In determining the distance that a muscle may be moved, one must bear in mind that the tissue must not be stretched because this compromises the blood supply, and, in fact, is contrary to all rules of reconstructive surgery. And, it is important beforehand to be certain that the muscle is large enough to cover the defect without pushing, pulling, or twisting. In other words, in estimating the ability of a muscle to do a job, one must ascertain that the arc of coverage is an easily produced arc created without pulling, and that the muscle covers the defect gently, without effort.

Anatomically speaking, an operator without firsthand experience and extensive knowledge of anatomy should not be moving muscle flaps until he has reviewed the body in the anatomy laboratory as well as in the textbook. A surgeon who operates without this intimate knowledge is like a computer operator without training.

Motor nerves are sacrificed if necessary since the new function of the muscle is unrelated to its old activity. And apparently even if sensory innervation is sacrificed, which is not the preferred method, it will not interfere with the viability of the muscle.

It is important to graft a muscle belly as soon as it is turned with a split thickness graft because there is less danger of necrosis, infection, and a greater chance of success.

In developing the concept of myocutaneous flaps, Dibbell gives Monks of Boston credit for publishing the first tissue transfer by the island technique - the year was 1898. And Littler should be acknowledged for being the first to provide protective sensation to the hand by using the island technique. Meanwhile, Dibbell chose the T-10, T-11 intercostal bundles to provide a pressure sensor from an area with sensibility to an anesthetic site on a paraplegic's back.

One case study traces the history of a 2.5-year-old Caucasian female with motor loss below the L-4 to L-5 (also with a sensory loss) due to a meningomyelocele. She was taken to the operating room where the first of four procedures was performed. The intercostal

bundle below the 10th rib was carefully dissected free and a half of a 50-cent piece of skin island was dissected on one side. The second stage completed the deep cutting around the bundle and the skin island. At this stage, the entire island flap was elevated and replaced into its bed. At the final or fourth stage, the decubitus ulcer was excised, the neurovascular flap raised, and a subcutaneous tunnel to the sacrum formed. The island and its blood supply was passed through the tunnel and sutured into its new place over the sacrum. Follow-up on the child who is now 4 years old reveals adequate sensation and the area has healed completely.

A compound neck pedicle designed for the repair of massive facial defects was described by Owens in the *Plastic Journal* in 1955 in which he studied its formation, development, and application.

In 1967, Littlewood described a sternomastoid flap for repair in extensive carcinoma of the head and neck.

McCraw et al applied the myocutaneous flap principle to the lateral neck flap by including the upper part of the trapezius muscle with the flap. This flap was developed in an effort to improve the vascularity of the old Mutter flap.

The Mutter flap is an example of muscle-giving vascular augmentation to a known skin flap. Only the upper portion of the trapezius muscle is included in the flap. This flap contains muscle and skin in its proximal half, but only skin and fascia in its distal portion. The normal blood flow of the proximal half is unchanged when the flap is raised. Retaining this much skin integrity does the following:

1. ensures the viability of the flap;
2. permits a longer and narrower flap; and
3. gives a better rotation point to allow great upward and anterior mobility of the flap.

Extensive carcinoma resections of the head and neck are repaired by compound skin and sternomastoid flaps. These are reported by Littlewood in the *British Journal of Plastic Surgery*. Since the superior location of the blood supply to the sternomastoid flap comes from above through the branches of the external carotid artery, a large flap including the sternomastoid muscle can be raised with the addition of a 5 x 5 cm area of pectoral skin. The cheek, palate, and most areas below the level of the orbit can be repaired by this method.

The group from Eastern Virginia Medical School presents uses of the trapezius and sternomastoid myocutaneous flaps in head and neck reconstruction. McCraw et al describe the uses of the myocutaneous flap principle to the lateral neck flap by including the upper part of the trapezius muscle with the flap. This flap was developed in an effort to improve the vascularity of the old Mutter flap.

McCraw et al go on to say that an undelayed upper trapezius myocutaneous flap can be used to resurface an area 8 cm wide in the upper posterior part of the pharynx, the ipsilateral tonsil, the buccal mucosa, and the cheek or neck anteriorly. Superiorly, the flap will reach the temporal fossa; posteriorly, it can reach the opposite midneck or mastoid fossa, and

the opposite midshoulder.

Three cases are presented, including melanoma as well as squamous cell carcinoma, with impressive results. A theoretic criticism that sacrifice of the occipital vessels during neck dissection might compromise viability of the flap has not been confirmed in these cases, probably because it is unusual to injure these vessels.

The sternomastoid myocutaneous flap is a combined skin and muscle flap which is used to carry neck and pectoral skin. The upper two-thirds of the muscle is raised with the flap. The flap has a superior base, and the average flap is 6 x 24 cm and extends 4 to 5 cm below the clavicle.

This flap can be used for the external repair of narrow defects inferior to a line extending from the top of the ear to the lateral part of the nose, and the midline of the upper and lower lips.

McCraw et al state that both of these myocutaneous flaps can supplant forehead and deltopectoral flaps in certain instances. They are useful in many repairs of the head and neck regions.

Using the pectoralis major myocutaneous flap as an axial flap, based on the thoracoacromial and lateral thoracic arteries, Ariyan has demonstrated that the flap is useful as the source of a large composite free flap because of its neurovascular pedicle.

Since the sternocleidomastoid muscle is supplied by three arterial sources, occipital, superior thyroid, and the thyrocervical trunk, a paddle of skin can be moved based on the inferior or middle blood supply. Following tumor resection, Ariyan moved the flap under the mandible and secured it in its new location.

Myocutaneous flaps based on the platysmal muscle were used to replace tissue excised from 14 male patients with T-2 and T-3 intraoral epidermal carcinoma by Futrell et al. The cervical skin was reflected superiorly after completion of the neck dissection, and the platysma myocutaneous flap was rotated superiorly 180° into the oral cavity.

## **Chapter 7. Composite Grafts**

"... beauty is that which irradiates symmetry  
rather than symmetry itself  
and is that which truly calls out our love..."

Plotinus - Sixth Enneads

Between the years 1887 and 1914, while working in his clinic in Germany, Koenig wrote extensively on many matters in surgery, one of which concerned a composite graft for restoring the lost alae of the nose. The edges of the defect were trimmed and a suitable pre-shaped area was excised from the helix of the ear to repair or restore the contour.

During World War II, Brown and other plastic surgeons at Valley Forge Hospital in Pennsylvania revived this practice with excellent results and popularized it all over the world. They advocated that the size of the graft which contained cartilage and two layers of skin should be 1 cm or less in width. And it was promulgated at that time that there was a high mortality of this kind of graft. This figure has since proved to be high (over 50%), and was probably quoted to prevent this operation from falling into disrepute. It is an excellent operation and no one has devised anything better to resemble the ala of the nostril.

Although Joseph did not report that he performed composite grafts, his use of auricular skin in conjunction with cartilage was innovative for its time. In Lexer's book, published in 1908, many of these things were also discussed.

Use of the composite graft which contains two layers of skin containing a cartilaginous sandwich coming from the helix of the ear, is commonplace today. It is an excellent source of tissue for replacing the columella and, among other things, relieves the bound down nasal tip in the cleft lip patient. The mortality of the composite graft should be below 5%. This is a ballpark figure but seems logical.

Although the composite graft is not moved as a flap but moved as a graft, it functions like a flap in that it provides lining with cartilage and an external skin surface. It is an excellent method of restoring the ala or the columella of the nose because of its rounded and contoured edges. In addition, it provides lining and thickness and it fills a void - something that a simple graft cannot do.

The composite graft is limited in that it can provide only about a square centimeter of tissue. Although this is not a hard and fast rule, it is best to stay within the confines of a centimeter if one wants consistently good results.

In taking a composite graft, one must exercise patients and softness of touch. Beforehand, trim the edges of the defect to be repaired. If it is in the area of a resected basal cell carcinoma, or another tumor, make certain by frozen section control that the lesion is clean and that there is no residual tumor left behind. Be sure that the recipient area is absolutely dry as far as hemostasis is concerned. Use of the low voltage cautery is recommended so that even the smaller vessels are coagulated and the field remains dry.

With the recipient area prepared, carefully grasp the helix of the ear between the thumb and forefinger, avoiding the use of instruments of any description, and with the Bard Parker No 11 blade cut straight through the full thickness of the helix. Having predetermined by eye or by actual measurement what a centimeter is, cut again through the full thickness of the helix at an angle that resembles a pie cut and emerges at the curl of the helix at approximately a centimeter.

Without putting the composite graft down, and gently holding it between the index and forefinger, move directly to the recipient area, secure the apex of the composite to the apex of the wound using a 5-0 silk suture. After placing a few more sutures around the graft, some on the interior surface of the ala and others on the external surface of the graft, carefully secure the graft into position in the defect. Do this rapidly, neatly, and without trauma so that the period of handling of the composite is minimal. In fact, it should not take more than a

few minutes. Pack the nose lightly with petrolatum gauze and use a petrolatum gauze dressing over the outside with a voluminous amount of cotton. The face is splinted with bandages and the patient should be placed on a liquid diet for four days and advised to keep the face splinted or quiet. The donor site is sutured with 5-0 nylon and quickly reconstructed. The wound if followed carefully and sutures are removed on the 7th and 10th day.

Sincere credit and thanks must be given to those plastic surgeons working at Valley Forge Hospital for this and their many other contributions.

Dupertuis, while serving as a commander in the US Navy during World War II, performed 15 free earlobe grafts of skin and fat with a loss of 4 grafts. In his paper, he states that Joseph reported a composite graft to correct a defect on the other ear. Konig reported 47 operations with a success of 25 - the year was 1914. Limberg reported 47 composite grafts with 6 failures in 1935.

Using the area between the lobe and the tail of the helix, Dupertuis' pictures show grafts of over a centimeter in size, shaped to fit the recipient areas.

To repeat, it is the shape, color, and texture match that makes these free grafts desirable. It is useful in restoring the nasal tip, alar border, columella, and floor of the nostril.

## **Chapter 8. Nasolabial Flaps**

"... the lack of beauty is a thing  
we cannot tolerate in our civilization ..."

Freud

During the 1800s, papers began to appear with pictures of nasolabial flaps. There were many surgeons using this flap and among them was Joseph in Berlin.

Combining the best features of the Indian rhinoplasty with the finest advantages of the bilateral nasolabial flap, Joseph performed a significantly advanced rhinoplasty. He outlined a forehead flap based on one side of the eyebrow that picked up its blood supply from the supratrochlear and supraorbital vessels. However, he first turned bilateral nasolabial flaps so that the skin side was turned into the nasal cavity. And, after they were turned in and sutured together, the donor sites were closed along the nasolabial groove, and the scar tissue was turned in from either side of the upper portion of the wound. This provided complete lining for the opening in the face and the Indian flap was brought down to cover the entire area. Joseph left a tab on the end of the flap to provide for the columella, while he turned a tab from the center of the lip to meet this tab and to provide lining to the tip of the flap. The thinking was sound and the reconstruction should have been more than adequate. I have not seen pictures of this reconstruction.

As early as 1864, Von Langenbeck used nasolabial flaps in reconstructing the nose as did Von Hacker in 1897. And today, the nasolabial flap is one of the work horses of the face in repairing many nasal defects. As can be seen in these drawings, practically any portion of the nose can be reached by varying the distance up and down. And, 90% of the time the flaps



can be moved, eliminating many steps. All of the rules of flap watchers must be observed: namely, the dermal bleeding must be brisk and red and the color of the flap must be good with excellent pressure return before it is moved. The same rules apply to the nasolabial flap but ordinarily it can be moved quickly.

If a lesion such as a basal cell carcinoma is found at the tip of the nose, the lesion must be removed by serial excisions with frozen section control; that is, if the patient wants to go the surgical route. A biopsy is done and if it proves to be positive the specimen is usually placed, or stapled, on a sterile glove package labeled for orientation like the face of a clock with 12:00 o'clock being the uppermost. It is sent to the laboratory for frozen section. The report from the pathologist will indicate whether or not the margins are free of tumour. Most important, though, is the fact that, if the lesion is positive, the orientation on the drawing around the specimen will enable you to scientifically remove the lesion. He may say it is positive at 1, 3, 6, and you are able to trim another section away, very much like Mohs and Szujewski do. Now you are certain that, for practical purposes, the local lesion is removed.

Closing lesions on the nose is like porcupines making love - it must be done very carefully since most closures produce deformities. If the lining is left behind and the wound can be closed with minimal deformity, then so be it. On the other hand, any lesion approaching a centimeter in size is probably going to need a split thickness graft, a full thickness graft, or a nasolabial flap.

Illustrations reveal that the nasolabial flap can be based superiorly or inferiorly depending on where you are going and what you want to accomplish. First, take a small segment of gauze and fold it to the width and length of the flap you desire to use to see if it will reach the defect. Although it is primitive, it is effective and will show you whether you have good reach, strained reach, or questionable reach, and the length of the flap can be varied accordingly.

Now let us look at the anatomy of the area of the nasolabial flap. Running along a line lateral to the reflection of the nostril and extending inferiorly approximately a centimeter from the corner of the mouth is the nasolabial crease. The corner of the mouth has its own fold which is created by the muscle bundles converging on that area to form the corner of the muscular mouth. Above the nasolabial crease is the cheek and medial to it is the upper lip.

This area is richly supplied in blood vessels considering that the external maxillary artery or facial artery and vein pass from approximately the midpoint of the mandible along a line that is almost parallel to the nasolabial fold. Although the infraorbital vessels appear on the face at the infraorbital foramen almost at right angles to the fold, branches are quickly dispersed to the area which, in their abundance, make up for their unusual angular relationship.

Sensory supply comes primarily from the infraorbital filaments which are mostly sensory, while the muscles beneath this impressive array of anatomy are moved by branches of the VIIth nerve, chiefly the buccal and zygomatic terminal filaments.

Paralleling the nasolabial flap is the large up and down flap that is based primarily on the infraorbital vessels. (It should be noted that anatomical purists might take exception to covering this flap here. However, this author believes it should be included with this section.)

This flap is a throwback to Susruta and the early Hindu anatomists. Examples of these flaps are shown, and both were used to resect well-spread basal cell carcinomas of the side of the nose including the alae. These are broad flaps and can usually be moved in one stage. Used primarily in those areas where a much greater amount of tissue is necessary, these flaps need lining from either the mucosa of the mouth or other skin that will not create deformity.

When these flaps are moved, they are based most often superiorly; and when they are moved into the more medial defects, the tissue of the infraorbital area is drawn with it, hence preventing an ectropion from tissue loss. The fact is that the infraorbital area is supported by this swath of tissue being moved medially.

Important in the planning of the nasolabial flap is that a borrowed tissue deformity is not created. If the flap moves tissue inferiorly, it is important to look for ectropion of the lower lip; and if tissue must be moved superiorly, one must watch for a pulling up or over of the upper lip. It is possible to distort the soft tissues of the nose also if one does not keep his eyes open.

A nasolabial flap may be made bilaterally with both sides out or with both sides in, as Gillies and Joseph did. With both raw sides out, however, another flap, usually a forehead flap, will be necessary for outside cover.

Let us recapitulate and determine how many ways there are to repair defects of the nasal region:

1. Small defects may be covered with a *split* thickness graft. If the graft is taken from a relatively hairless area, say, for example, the inner aspect of the arm, the color match will be satisfactory.

2. The same defect can be covered with a *full* thickness graft taken from behind the ear. If the defect is much larger and you still elect to take a full thickness graft, you should go to the supraclavicular area or to any other relatively hairless area like the inner aspect of the upper arm.

3. If the full thickness is lost, and especially if the roll of the ala is missing, you should consider a composite graft from the ear.

4. If the quantity of tissue is greater than a centimeter and you do not want to use a composite graft, the treatment of choice then is the nasolabial flap from the immediate area.

5. If the amount of tissue is significantly more than the local tissues can afford, then you must use a forehead flap, whether you choose the typical Indian method or variations, such as the sickle flap as popularized at the Mayo Clinic. This decision depends on your needs and your experience.

6. Sometimes you have to rely on the Italian flap with the arm serving as donor as well as carrier. On the other hand, the arm may serve as a carrier for a tube which has been formed on the abdomen that is looking for transposition.

7. A tubed cervical flap, or a flap from anywhere, for that matter, is fine as long as you have a plan and the tissues will move. The color match, of course, will not be as good but, depending on the urgency of the problem, the amount of tissue needed is the only indication. Younger people tolerate arm movements better than those over 35 years of age.

8. The sickle-shaped temporal flap, as advocated by New and Erich, is a good flap in experienced hands.

## Chapter 9. Lip Switch Flaps

"... That which lies between the greater and the less, namely, the equal  
... beauty, and the like to which the perfect number is most akin..."

Nicomachus

Sophus August Vilhelm Stein was born a couple of years before George Washington died (1797), and he lived well into the 19th Century (1868). It was 1848, or about halfway through the century, that he wrote a paper entitled "Lip Repair (Cheiloplasty) Performed by a New Method". And it was in this paper that he described the lip switch operation. His original operation was carried out on a 48-year-old sailor who had a carcinoma of the lower lip which made it necessary to sacrifice most of the lip.

By making a double flap in the upper lip in the midline with the arterial supply based laterally, Stein was able to swing both flaps simultaneously into the lower lip. He first minimized the deformity by using three twisted sutures which brought most of the lower end of the wound to the midline. He was careful to preserve the arteria coronaria (the superior labial artery) as he made his two flaps turning them into the lower wound and twisting sutures to keep them in position.

After 20 days, the flaps were cut and the operation completed, in his words, "... by uniting the mid-clefts in both the upper and lower lips several twisted sutures, after making the edges bleed".

Commenting on this paper, Doctor Niels C. Petersen of Denmark stated that Stein's Cheiloplasty with two flaps from the unaffected upper lip was performed in 1847 - 10 years after Sabattini had used a similar method, but before the cross-lip flaps reported by Estlander (1872) and Abbe (1898).

Further, Petersen states that Stein's cheiloplasty was performed without anesthesia. He had used ether anesthesia more than a year prior to that time, but apparently he thought this case was not suitable. Stein's two flap operation suffered a strange fate. Apparently it was not repeated by him or by any other Danish surgeon until 62 years later when, in 1908, two cases were reported from Sundby Hospital in Copenhagen.

His 1872 paper was entitled "Eine Methode Aus Der Einen Lippe Substanzverluste Der Anderen zu Ersetzen". (A Method of Reconstructing Loss of Substance in One Lip from the Other Lip), Dr. J. A. Estlander, Helsinke, Finland.

While working in his clinic in Helsinke, Finland, Jakob August Estlander came to the conclusion that many or most of his contemporaries were vying for distance in the reconstruction of the lip, in that some surgeons extended their incisions as far away as the thyroid gland and ignored the local possibilities of tissue transplantation. His point was that the best possible replacement for lost tissue of the lip was lip tissue itself since nothing would come as close to its appearance or function. So why not use the lip?

In the year 1871, a 63-year-old farmer presented with a carcinoma of the lower lip. One of his assistants performed the usual operation, but it was complicated with a recurrence. Estlander removed the lesion and rotated tissue from the corner of the right upper lip into the defect. The triangle of tissue was quite long, extending along the side of the nose, with the base of the flap bordering along the upper lip.

Rotating the flap easily around the corner of the mouth and in effect creating another corner of the mouth, Estlander discovered that, in spite of the apparently large size of the defect, it was corrected easily by the flap. The patient was gratified with the result as he was not able to hold a piece of bread in his lip which had been impossible after the first operation.

Another case described a face which had been ravaged by the effects of Typhus, probably an early example of Noma. Following the removal of scar tissue, a flap was created from the lower lip extending quite a bit below the lower edge of the lower jaw, and was kept alive in the intact coronal vessels (inferior labial).

Further, a third case documented another gangrene of the face (Noma) complicated by a systemic disease (Typhus). In this instance, the face was reconstructed from a flap taken from the upper lip and cheek.

Estlander was concerned about the thickness of the pedicle since the thinner it was, the easier it was to turn it into the defect, but he also understood that the thinner the pedicle the less likely it was that the flap would survive.

The professor was a thinking man who died when he was only 50 years of age. He was fighting infection actively before the word became popular and prophesized things that later proved to be true.

In 1898, an article appeared in the Medical Record by Robert Abbe, of New York City, New York, in which a flap was reported to have been turned into the upper lip from the lower lip to fill a void left by the repair of a bilateral cleft lip. To quote the author, "... a flap taken from the central portion of the lower lip, a little wider than the upper gap, was then made in such a way as to make a hinge upon one side containing the lower branch of the coronary artery on the left, which flap was turned upward so that its lower edge on the chin was placed beneath the columna nasi. The vermilion border was exactly stitched on one side, and numerous very fine stitches were applied...".

Commentary by Richard Stark concerning this article reveals that Abbe alluded neither to Sabattini, Stein, or Estlander. It is unlikely, he adds, that he was aware of their work.

Another modification of the Monks island flap technique involving a viable segment of tissue on the end of a known artery and vein, is reported in germinal literature. Roscic et al describe the excision of a lesion in the nasal glabella and its reconstruction by an island flap from above the right eyebrow based on the supratrochlear artery. There is good photograph evidence of the success of the procedure.

## Chapter 10. Microvascular Techniques

Salibian and his co-workers from Irvine, California, discuss free microvascular flaps for defects of limbs, head, and neck, and relate how Harii et al performed the first successful microvascular skin flap transfer in 1972. Their first case involved a free scalp flap based on the superficial temporal vessels to treat alopecia. Also, in 1972, McLean and Buncke performed a microvascular anastomoses to cover an exposed skull with the omentum. Harii et al reported, in 1978, that he had done 184 free flap transfers with only 12 failures - approximately a 7% failure rate.

Also in 1979, Salibian et al reported in the *American Journal of Surgery* that they had transferred a total of 23 microvascular flaps including 15 groin flaps, one dorsalis pedis neurovascular flap, four osteocutaneous groin flaps (with iliac crest), one osteocutaneous skin, rib flap, one omental flap, and one jejunal segment.

Six of the 23 flaps failed, five of the 16 skin flaps failed, and one of the five osteocutaneous flaps failed. Six flaps of the 11 transferred to the lower extremity failed.

In 1977, Buncke's group stated that with the microvascular technique one is able to transfer full thickness skin to the scalp areas where the tissues have been destroyed by electric burns. Obviously this is done in one step. Destroyed tissues of the scalp were replaced in two boys aged 15 and 16 years by microsurgical technique. Electric burns had been sustained 2 months and 18 months before admission.

The first patient had a 4 x 6 cm area of exposed bone over the right anterior portion of the skull. Using the superficial temporal and other superficial circumflex iliac vessels, tissue was transferred directly from the right groin to the scalp. After marking the recipient and donor areas with ultrasound techniques, and after the outer table of the exposed bone was removed, the tissues were sutured into position.

Thomas Dent Mutter, an 1831 graduate of the University of Pennsylvania, a friend of Joseph Pancoast, dissected a severe burn contracture of the neck on a 28-year-old girl, and did an immediate repair with a deltoid or neck flap. In his words, "The dissection was painful but not bloody ... and carefully attached by several twisted sutures ... the edges of the wound on the shoulder from which the flap had been removed were brought together by straps and sutures ... with the exception of its upper third was completely covered in".

Recently, the deltopectoral flap, also known as the Bakamjian flap, has become more popular because of its versatility. It differs from Mutter's flap in that, instead of being used

at the base of the neck, it is rooted parasternally and is usually migrated directly superiorly so that there is little twist in the base. The blood supply is extensive including the cutaneous branch of the thoracoacromial artery and the perforating branches of the internal mammary artery. The flap reaches the ipsilateral side of the face or the inferior portion of the opposite side.

## **Chapter 11. Complications**

"... We may regard it as a favor that nature has extended to us that besides giving us what is useful it has dispensed beauty and charms in such abundance..."

Kant

Flaps of the random type or axial pattern are essentially methods of moving skin, subcutaneous tissue, muscle, bone, and cartilage. By definition, flaps are always attached to one end from which the entire mass is anchored. The point of attachment is the most important aspect in the success or failure of the flap mass.

The attachment of the flap must contain the arterial and venous blood supplies and lymphatic drainage. Without these, the pedicle amounts to a piece of detached tissue which is too thick to survive.

The ultimate complication in flap construction is necrosis of the pedicle due to a failure of the blood supply.

In considering these possibilities of pedicle loss, we must think of the initial preparation.

(A) Preparation: The flap must be designed and elevated with a base that provides sufficient blood supply. The proper vasculature must be present and the base must be of sufficient bulk to provide for it.

(B) Positioning and Immobilization: When the flap is elevated and rotated, it must be placed in intimate contact with its base and its margins without tension. Stretching the tissues to compensate for an end that is too small can lead to severe ischemia and subsequent loss of tissue. If the rotation is too great, kinking of the base with compromise of the blood supply can be catastrophic. Bridging in open spaces permits gravity to pull on the insertion site and this constant steady pull without adequate support will readily cause separation and cutting of the sutures with a gradual detachment.

It must be remembered that immobilization is very important and bridging between chest and face or extremity and body must be accompanied by more than satisfactory immobilization. In the typical cross-leg pedicle, both legs are immobilized quite securely to permit attachment or slow separation from the tension.

(C) Protection: When the pedicle is inserted, attention must be paid to protecting the suture lines, both donor and recipient sites, from the possibility of external infectious agents.

Trauma may be induced from the tape attached to the pedicle, any of the devices used in immobilization, abrasions, or pressure injuries which can be caused as a result of the anesthesia or hypesthesia which is present in the pedicle and the patient may not realize that he or she is causing injury because there is lack of sensation. Therefore, adequate protection must be employed in the early postoperative condition. The wound must also be protected from factitial irritation.

(D) Other factors: Other situations which can cause difficulties in the flap are back cutting to increase rotation. The back cutting occurs at the base of the flap and this can sever vital vascularity which is important to survival of the pedicle. The elimination of "dog ear" or redundant tissue at the base of rotation of the pedicle should not be performed at the initial surgery in that this again may compromise severely the vascular exchange so necessary for survival. The possibility of thrombosis within the pedicle or base is always present and this can be due to severe kinking, to the trauma of raising, migrating, or inserting the pedicle, edema within the pedicle beneath a subcutaneous tunnel, or of any number of situations relative to the general systemic condition of the patient.

In short, pedicles either of the random or the axial pattern type must be treated according to good atraumatic surgical principles after having been well-planned and executed. They should be cared for with constant vigilance keeping all the possibilities of complications in mind. Salvaging a pedicle with hyperbaric oxygen, low molecular weight dextran, cooling, and vasal dilators have all been utilized with minimal eventual gain.

## **Chapter 12. Head and Neck Reconstruction Using Microvascular Techniques**

Reconstructive microsurgery frequently provides solutions to clinical problems which exceed the capacity of standard plastic surgery techniques.

The most dramatic indication for head and neck reconstruction using microvascular technique is the replantation of amputated tissue. Total scalp amputations, partial face amputations, and amputation of the ear have been replanted successfully. Replantation restores specialized tissue such as the mucosa of the lip and the delicate architecture of the nose and ear far better than traditional techniques.

Microvascular surgery is commonly performed on an elective basis to reconstruct defects of skin, bone, mucosa or, in certain instances, the upper esophagus.

Standard reconstructive procedures are excellent for most defects in the region of the head and neck. However, trauma, irradiation, and the ablation of malignant tumors can result in defects of skin, bone, mucosa or a combination of these tissue which exceed the capacity of pedicle flap techniques. Advantages of microvascular reconstruction in these situations are that the procedure is carried out in one-stage, there is often a minimal donor site defect, and the blood supply in the region of injury can actually be enhanced.

Large scalp defects in areas of intense irradiation or multiple previous operative procedures make local tissue transfer techniques unsatisfactory. These problems can be solved by microvascular composite tissue transplantation from other regions of the body.

Small defects involving less than one-half of the surface of the hair-bearing scalp can be resurfaced by a groin flap. As much as one-half of the scalp can be replaced by transplantation of the latissimus dorsi muscle to which skin grafts are applied. The latissimus dorsi muscle with its overlying skin and subcutaneous tissue can be transferred as a free myocutaneous flap. In defects which involve more than one-half of the scalp, the omentum is used because of its large surface area. Introduction of free split rib bone grafts with soft tissue is not routinely performed.

Reconstruction of the mandible can be performed in a one-stage microvascular procedure. Both skin and bone can be provided by means of microvascular transplantation of osteocutaneous flaps consisting of a rib and its overlying skin and subcutaneous tissue or the anterior iliac crest with its overlying skin and subcutaneous tissue. In addition, smaller anterior mandibular defects can be reconstructed using a dorsalis pedis osteocutaneous flap which is transplanted along with an underlying metatarsal to provide both soft tissue and bone.

Ablation of malignant tumors may result in defects in the floor of the mouth or the cheek which require reconstruction using a groin flap, iliac flap, or dorsalis pedis flap. Muscle or omentum can be used for very large defects.

Esophageal reconstruction utilizing free transfer of a segment of jejunum allows larger resections with tension free, well-vascularized enteric anastomoses.

A combination of microneural and microvascular techniques can restore animation to patients who have lost the function of their facial muscles secondary to central nerve injury or to old facial nerve injuries.

Two-staged reconstruction is required. Initially, sural nerve grafts are placed subcutaneously. Later, free muscle from the leg, chest, or back can be placed subcutaneously to suitable recipient vessels, and reinnervated by means of the nerve graft.

### **Case History**

A 1-year-old boy was severely burned in a house fire. As a result of his injuries, he lost the scalp, subcutaneous tissue, and cranium over most of his brain.

Split thickness skin grafts were applied to the dura which provided unstable skin coverage.

At the age of 7, this young man had unstable skin and the pulsations of his brain were easily seen beneath the skin graft envelope. The patient had multiple areas of chronic ulceration and infection which made it impossible for him to wear a wig. His baldness had a significant psychological impact as a result of ridicule by his peers. In addition, the patient was required to wear a helmet to protect his brain from even the most minor trauma.

The patient was considered a suitable candidate for microvascular reconstruction using the latissimus dorsi muscle to which split thickness skin grafts were applied. The muscle was used to provide the proper vascular bed for multiple split rib bone grafts which provided



protection for the brain.

Examination by means of a Doppler indicated that the occipital vessels and the left superficial temporal vessel had been lost as a result of the initial injury. However, the superficial temporal vessels were present on the right side and these served as recipient vessels which were anastomosed to the thoracodorsal artery and vein within the latissimus muscle. The microvascular anastomoses were successful and, in a one-stage procedure, the patient's scalp and cranium were reconstructed.

The patient is now free of infection and can wear a wig. He has stable skin coverage, and, in addition, his brain is better protected as a result of the successful bone grafts.

The latissimus dorsi muscle and its overlying split thickness skin grafts have provided excellent contour.