51. Plastic and Reconstructive Surgery

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Historical Foundation

Plastic and reconstructive surgery is that field of medicine concerned with the restoration of the body's form and function. It is the study of wounds and their management, whether these wounds be inflicted by trauma, infection, genetic abnormality, or advancing age. Converse has characterized the qualities essential to a plastic surgeon as "a sense of form, an aesthetic judgment, and an ability to visualize the end results".

Many operative techniques in plastic surgery have a long history. In India, nasal reconstruction was first described over 2500 years ago. Romans of the first and second centuries AD practiced wound closure by skin flaps.

Gasparo Tagliacozzi (1545-1599) of Bologna has been credited with founding modern plastic surgery. His description of nasal reconstruction using an arm flap is both objective and scientific. After the death of Tagliacozzi, plastic surgery suffered a period of relative stagnation. Interest was renewed in the early part of the nineteenth century. This was the era when von Graefe first used the term "plastic" to describe his technique of nasal reconstruction. In 1869, Reverdin reported the use of a skin graft to hasten wound healing. Although not the first person to describe a skin graft, Reverdin's work did stimulate interest in the procedure.

The battle casualties of World War I provided impetus for the development of plastic surgery as a surgical specialty. John Staige Davis and Vilray Papin Blair of the United States and Harold Delf Gillies of Great Britain used their experience with war wounds to shape the principles of modern plastic surgery.

Basic Principles

Skin Incisions

Incisions should be planned such that the resultant scar lies parallel to the existing skin lines. Most skin lines represent lines of minimal tension which generally lie at right angles to the long axis of the underlying muscles. Additional lines of facial expression may result from the dependency of tissues. Scars placed parallel to these lines are narrower and less apparent to the observer.

The elliptical excision of a lesion is a common, useful technique. An ellipse may be closed in a straight line provided its long axis is roughly four times the length of the short axis. If the long axis is too short, the wound will form mounds of excess skin, known as "dog ears", at each end. Removal of a dog ear is a basic technique. This excision requires either lengthening the wound slightly, creating an oblique limb at the end of the incision, or closing with a Y-shaped scar.

Wound Closure

The product of a satisfactory wound closure is prompt healing and an inconspicuous scar. Elements contributing to this desired result are adequate wound preparation, selection of suitable materials, and good surgical technique. Gentle handling of the tissues with noncrushing instruments is crucial. The properly prepared wound is free of devitalized tissue. Wound edges are trimmed to allow smooth coaptation of skin.

Excess tension across a wound produces a wider scar. It also causes the skin sutures to leave more obvious marks. Judicious undermining of the surrounding tissues reduces tension. Buried sutures placed in the subcutaneous tissues and dermis likewise decrease tension on the skin edges.

Wound closure is accomplished using sutures, skin staples, or skin tapes. Absorbable sutures of either catgut or polymerized glycolic acid (Dexon, Vicryl) may be placed in the deep tissues to reduce tension on the skin wound. The skin may be approximated with a variety of monofilament or multifilament nonabsorbable sutures. A fine suture on a small needle causes less trauma passing through the tissues than larger materials. Skin staples and skin tapes may be applied rapidly but do not allow as accurate apposition of skin edges.

Several operative techniques are available for the placement of skin sutures. A simple interrupted suture placed under minimum tension is the mainstay of the plastic surgical wound closure. A second useful technique is the subcutaneous continuous suture, which requires no needle passage through the skin surface, and thus the closure heals free of suture marks.

Early removal of skin sutures minimizes the scar produced by the suture itself. Faciual skin sutures may be removed in 3 to 5 days, while those in less conspicuous areas may be left for up to 7 days. Skin tapes are placed to reinforce the wound after suture removal.

Skin Grafting

Skin grafting is a technique whereby a portion of the epidermis and dermis is removed from its own blood supply and transplanted to a distant site. This procedure is one of the most versatile in all of surgery.

A skin graft is either split thickness or full thickness. The *split-thickness graft* includes the epidermis and a variable amount of dermis. Split-thickness grafts are referred to as *thick, medium, or thin,* depending upon the amount of dermis raised. The most commonly used skin grafts measure 12/1000 to 18/1000 of an inch (0.3 mm to 0.5 mm) thick. A skin graft which includes the entire epidermis and dermis is termed *full thickness.*

The skin graft is employed in a variety of clinical situations. A wound which is too large to allow direct closure may be covered with a skin graft. Healing is accelerated, and the resultant wound is often more acceptable aesthetically than one left to contract and epithelialize. In the burned patient, skin grafts may be life-saving. Mucosal defects of the mouth and vagina may be managed with a skin graft.

Many skin donor sites are available, each with some unique advantage. Skin from the postauricular and supraclavicular regions provides a satisfactory color match for grafting of facial wounds. The abdominal wall and thigh are useful areas when large sheets of skin are needed. Skin grafts may be taken from the chest wall after irregularities overlying the ribs have been leveled by subcutaneous infiltration with saline. A donor site on the buttock is easily concealed by underclothing. Skin of the gluteal and inguinal folds may be raised as a full-thickness graft and the donor site closed primarily. When considering a donor site, it is wise to avoid areas which will be irritated when the patient sits or lies supine.

A skin graft survives by receiving nutrients from the recipient bed. During the first 48 hours after being applied the graft passively imbibes plasma from the bed, a process termed *plasmatic circulation.* Within the next 24 hours, blood is seen circulating in the graft vessels. This circulation is probably restored through several related processes. Direct attachment of vessels in the bed to those of the graft contributes to revascularization. In addition, new vessels from the bed both invade the graft directly and grow along pre-existing vascular channels.

A skin graft will "take" if certain prerequisites are met. The recipient bed must be adequately vascularized. A graft will not take over large (greater than 1 cm^2) areas of tendon without its paratenon or bone without its periosteum. Infection at the recipient site must be controlled. An infected wound (greater than 10^5 bacteria per gram of tissue) will not support a skin graft.

Three basic techniques are used to harvest skin grafts. The freehand method depends on a minimum of mechanical devices. Typically, a Humby knife with a guarded disposable blade is pressed against the donor site and advanced with firm back-and-forth strokes. The skin may be lubricated beforehand with saline, mineral oil, or blood. The drum dermatome, exemplified by the Reese instrument, provides a wide smooth sheet of skin. The power-driven Brown dermatome allows rapid harvesting of large areas of skin.

Meshing of a skin graft allows for expansion of graft and coverage of a larger wound. It is accomplished by placing the graft through an instrument which makes adjacent rows of small incisions in the tissue. A meshed graft cannot be expected to allow large volumes of fluid to escape through its interstices. The underlying bed should be as free of bleeding as that over which a sheet graft might be placed.

A skin graft may be disrupted by motion and by fluid collection beneath the graft. These problems are avoided in part by securely attaching the skin graft to the recipient bed. Sutures, skin staples, or skin tapes are used. The dressing is designed to provide immobilization and mild compression. A proper dressing is composed of a single layer of nonadherent gauze, several thicknesses of bulky absorbent pads, and an elastic wrap.

The *tie-over bolus dressing* is useful in areas which do not lend themselves to circumferential wrapping (face, oral cavity, etc.). A tie-over dressing provides continuous compression to skin grafts placed in concave wounds. Construction is begun by affixing the skin graft to the recipient site with sutures whose ends are left long. The graft is covered with Xeroform-impregnated fine-mesh gauze. A bolus of cotton wadding or synthetic fiber is

applied. The fine-mesh gauze is wrapped about the wadding, and sutures on opposite sides of the wound are tied together to hold the packing in place.

After steps have been taken to avoid motion and fluid collection under the graft, the prevention of postoperative infection is the final goal. A streptococcal infection is particularly threatening. Penicillin is given for 24 hours postoperatively as prophylaxis against this organism.

After a split-thickness skin graft has been raised, donor site care consists of allowing the area to epithelialize. Epithelium grows from epithelial cells left in sweat glands and hair follicles of the dermis. The donor site is covered with fine-mesh gauze impregnated with Xeroform. Absorbent pads are placed to reinforce the dressing. On the first postoperative day the pads are removed from the donor site without disturbing the fine-mesh gauze. Drying may be hastened by treating intermittently with a heat lamp or hair dryer. The gauze separates spontaneously in 10 to 14 days.

The skin graft dressing is left in place for 5 days unless symptoms or signs of infection appear. These signs include severe local pain, swelling, cellulitis of surrounding skin, odor, purulent drainage, and unexplained fever. After the initial dressing is removed, a light dressing may be placed to prevent injury to the graft.

Grafted wounds of the lower extremity are not allowed to hang dependent until after the first postoperative week. Following that interval the extremity is wrapped with an elastic bandage before ambulation is resumed. Wrapping should be done through at least the third postoperative week or until the graft has healed.

Maturation of a skin graft takes place in several stages over a long period of time. Primary contraction occurs just after elevation and is caused by shortening of elastic fibers in the skin. A split-thickness graft immediately shrinks 9 percent in surface area while a full-thickness graft is reduced by 41 percent. Secondary contraction commences after about 1 week and continues for as long as 6 months. Full-thickness grafts show little secondary contraction. Split-thickness grafts tend to contract more, thinner grafts exhibiting the most contraction. Skin grafts darken on sun exposure and hold the pigmentation. Excessive pigmentation may be minimized by avoiding sunlight and applying sun screens. Sensation begins to return to the graft in 10 weeks and is maximal after 2 years.

A *composite graft* comprises several tissue layers transplanted as a unit. An example is the use of a wedge-shaped segment of ear skin and cartilage grafted into a defect of the nasal alar rim. Such a graft will take if no portion of it is over 1 cm from the vascular supply.

Grafts may be raised and stored for up to 21 days if wrapped in a gauze sponge soaked in sterile saline, placed in a sterile container, and refrigerated at 4 °C. A graft may also be "stored" by replacing it immediately on its donor site. It may then be removed for use as long as 5 days later, although delaying over 24 hours increases the pain and bleeding following removal.

The next great advance in skin grafting may well be the use of a living skin substitute. Such a tissue has been developed in experimental animals. The skin equivalent consists of

dermal and epidermal elements made with cells taken from the graft recipient. It holds the promise of providing skin coverage in patients with limited donor sites.

Flaps

Use of a tissue flap is an important alternative in managing the difficult wound. A flap is usually a composite of skin and subcutaneous tissue attached by a pedicle through which it receives nourishment and drains venous effluent. A flap may promote, and in some cases may provide the only means for, healing. Moreover, a well-chosen flap has the potential of improving the functional and aesthetic result.

A skin flap is classified as either random or axial pattern, depending upon the nature of its blood supply. The *random pattern skin flap* receives blood through its dermal-subdermal plexus. This plexus is supplied by musculocutaneous vessels and nourishes the flap through its pedicle. In conctrast to the random flap, the *axial pattern skin flap* is vascularized by a direct cutaneous artery.

Random Flaps. The *Z-plasty* is a particularly useful random flap. It may be employed to lengthen a straight scar, break the line of a linear scar, and align a scar within the lines of minimal tension. The classic Z-plasty consists of two triangular flaps of skin and subcutaneous tissue. The sides of both triangles are equal in length and the angles are 60°. Specific cases may dictate variations in these dimensions and in orientation of the flaps.

The *advancement flap* is random in nature. It is moved into a defect without rotation about a pivot point. The simple advancement flap is constructed by incising three sides of a flap and undermining in the subdermal fat, leaving a vascularized pedicle. The flap is stretched (advanced) into the defect. The V-Y advancement flap allows lengthening of a scar. Application of this flap is limited as it lacks sufficient mobility. The V-Y advancement has been used successfully for lengthening of the nasal columella.

The *rotation, transposition,* and *interpolation flaps* are random and have in common an arc of rotation and a pivot point about which they move. Rotation and transposition flaps share the characteristic of closing defects adjacent to the flap. The interpolation flap, however, satisfies a defect which is nearby but *not* adjacent.

The rotation flap is usually semicircular in shape. After raising the flap and rotating to close the defect, the donor site may be sutured primarily or covered with a skin graft.

The transposition flap is often rectangular. Its donor site may be closed by direct suture or sking grafting. Anoither option for closing the donor site left by a transposition flap is the use of a secondary flap whose long axis is at right angles to the primary one (bilobed flap). The Limberg transposition flap depends on loose adjacent tissues for closure of the donor site.

The bipedicle *tube flap* is one whose edges are rolled under and sutured to form a cylinder. The flap is transferred directly or moved on a carrier, usually the upper extremity.

The development of axial pattern, musculocutaneous, and free flaps has reduced the indications for a tube flap.

Axial Flap. Axial pattern flaps are better vascularized and more reliable than random flaps. The *forehead flap* based on the superficial temporal artery has been useful in resurfacing intraoral defects. The *deltopectoral flap* receives its blood supply from the second, third, and fourth anterior perforation branches of the internal mammary artery. This flap is particularly helpful in reconstructing head and neck wounds. The *groin flap* is nourished by the superficial circumflex iliac artery and allows coverage of hand and forearm wounds.

The omentum is dissected from the greater curvature of the stomach and sustained as an axial pattern flap on the right or left gastroepiploic vessels. It may be transferred to satisfy a defect of the abdominal or chest wall. After the defect is filled, the omentum may be covered with a meshed split-thickness skin graft.

The *island flap* is of the axial pattern type whose pedicle consists of the nutrient vessels without a bridge of skin or subcutaneous tissue. A sensory nerve may be included in the pedicle. These flaps have been used for hand, head, and neck reconstruction.

Muscle and Musculocutaneous Flaps. Recently, the enormous potential of muscle and musculocutaneous flaps has been appreciated. Muscle has an excellent blood supply and, when transferred into a poorly vascularized wound, can promote healing. Although the blood supply to skin was described by Manchot in a doctoral thesis in 1897, it has only recently been recognized and appreciated that the skin receives much of its blood supply from the underlying muscle. Certain muscle transfers may include an overlying skin island. This musculocutaneous unit has many reconstructive and aesthetic uses.

Free Flaps. The free flap is one in which tissue is moved to a distant site by locating and detaching its blood supply and transferring the flap to a new anatomic area. The vessels are then sewn to a local artery and vein by use of microvascular techniques. The tissues transferred may be a composite of muscle, skin, and/or bone.

Tissue Transplantation

Tissue may be transplanted to restore contour or lend structural support to a specific area. A transplant is performed by separating the tissue completely from its blood supply, moving it to a new location, and allowing ingrowth of blood vessels at the new site. To ensure healing, a transplant must be stabilized securely during the postoperative period. Infection, hematoma, and seroma must likewise be prevented.

Many autogenous tissues have been used as transplants. Dermis may be harvested from the infragluteal fold and used to augment a depressed area. Fat has been used for a similar purpose. However, both dermis and fat tend to be absorbed over time. Bone from a rib, iliac crest, or proximal ulna is useful in providing support but also undergoes gradual incomplete resorption. Cartilage from the nasal septum and ear has found wide application. Unfortunately, the quantity of autogenous cartilage is limited. The composite graft of skin and cartilage from the ear can be used to reconstruct a nasal defect. Tendon and fascia both serve as successful autografts.

Synthetic Materials

Synthetic materials are used in plastic surgery if autogenous tissues are unsuitable or in short supply. Various plastics and metals are available. The most commonly used tissue substitutes are fabricated from silicone elastomers. These compounds are long chains of dimethylsiloxane units which are provided in the forms of silicone fluids and silicone rubber. The mammary implant is a silicone elastomer shell filled with a silicone gel.

Microsurgery

Plastic surgical procedures requiring an operating microscope and specialized techniques fall in the category of microsurgery. Improvements in microsurgical equipment have allowed reliable anastomosis of vessels as small as 0.8 mm in external diameter. Microsurgery has made possible the transfer of free flaps and replantation of traumatic amputations. In selected cases, microsurgical neurorrhaphy yields a superior result.

Reconstructive Surgery

Breast

Macromastia. *Macromastia* is an abnormal enlargement of the breasts caused by hormonal factors or obesity. On examination, the nipple and areola are displaced inferiorly. The skin of the breast is present in excess. Volume of the breast fat or parenchyma is increased. The patient experiences a feeling of heaviness or pain in the breasts, particularly before a menstrual period. Pain is often present in the shoulders, neck, and back. Skin irritation occurs in the submammary fold.

Evaluation of a patient with macromastia requires a careful breast examination, including mammography for patients over thirty-five years of age or with a family history of breast cancer. Obesity is a common finding, and the patient is advised to lose weight before considering surgery.

Reduction mammaplasty relieves macromastia. Before unergoing operation, the patient is informed of the intended postoperative result and potential complications. These complications include the possibility of hematoma, nipple necrosis, and hypertrophic scars. The patient must have an understanding of the location of the scars. She is told that lactation and breast feeding may not be possible after reduction mammoplasty. Some women experience a decrease in nipple sensibility postoperatively and must be aware of this possibility.

The various reduction mammaplasty operations are designed to achieve similar goals. Repositioning of the nipple and areola, usually with reduction of areolar diameter, is important. Blood supply to the nipple and areola is preserved through a dermal-fat pedicle which is nourished by perforating vessels from the internal mammary artery, pectoralis major muscle, intercostal arteries, and lateral thoracic artery. Excess skin is removed, forming a new skin brassiere. A subtotal resection of the breast fat and parenchyma is done in such a way as to provide a natural breast mound about which the skin is draped. Meticulous skin closure completes the procedure.

Outlining the proposed incisions is done preoperatively with the patient awake and in an erect sitting position. The new site for the nipple and areola is selected. The nipple is centered at the level of the inframammary fold, usually 18-24 cm from the sternal notch and 11 to 13 cm from the midsternum. The inframammary fold is marked and remains in a constant position throughout the procedure. The remaining lines are drawn on the skin of the breast with methylene blue.

Selection of an operative technique from among the many available is made on the basis of breast size and the surgeon's experience. A patient with extreme hypertrophy is best treated by a free nipple graft and removal of excess skin and breast tissue. Less severe enlargement is managed by either the McKissock, Strombeck, or Pitanguy techniques.

The reduction mammaplasty described by McKissock is in common use. It employs a keyhole pattern of skin excision and an appropriate parenchymal reduction. The original procedure consisted of a bipedicle vertical dermal and parenchymal flap for support of the nipple-areolar complex. The nipple and areola will survive consistently, however, on the lower pedicle alone. Division of the upper pedicle simplifies positioning of the nipple and areola.

The Strombeck mammaplasty uses a horizontal dermal and parenchymal pedicle to transport the nipple-areolar complex. This procedure is good for moderately hypertrophic breasts, but nipple transposition is difficult in large breasts. Postoperatively, the breast appears flattened inferiorly using the Strombeck technique.

Pitanguy's mammaplasty is successful in reducing the slightly to markedly hypertrophic breast. The technique's advantages include flexibility in nipple positioning and an aesthetic postoperative results. Lactation is preserved in some patients. It takes an experienced surgeon to perform the necessary freehand measurements and reduction.

The nipple transposition operations described above run the risk of nipple loss in extremely large breasts. Free nipple-areolar transplantation is used in patients with extremely large breasts. This operation involves raising the nipple-areolar complex as a full-thickness graft, performing a reduction of breast skin and parenchyma, and placing the deflated nipple-areolar graft in an appropriate position. A large volume of parenchyma can be removed and operating time minimized. A good breast contour is achieved. Disadvantages of this procedure include a loss both of lactating function and nipple sensibility. The nipple often loses pigment and projection.

Ptosis. *Ptosis of the breast* exists when the nipple has descended below the level of the inframammary crease. It is usually present in patients with macromastia but may occur alone. Ptosis is caused by weight loss, aging, and atrophy in the postpartum or postmenopausal period.

The magnitude of ptosis determines the appropriate operative procedure for its relief. Mild ptosis is treated by the Aries-Pitanguy technique and more severe ptosis by Goulian's dermal mastopexy. If in planning an Aries-Pitanguy procedure it becomes apparent that the distance from the inferior margin of the areola to the inframammary fold will exceed 6 cm the Goulian operation should be chosen.

Whatever method is selected, the major points of the mastopexy are the same. A new nipple site is selected. The vertical and horizontal skin redundancy is determined and a new skin brassiere designed. In small breasts as much breast tissue is preserved as possible. The breasts are reshaped, augmenting volume with submuscular silicone breast implants when necessary.

Some patients whose nipples are at or above the inframammary fold have apparent ptosis. In these cases there is hypoplasia of the upper breast quadrants, descent of the remaining breast tissue, and skin redundance. The preferred treatment for these patients is *augmentation mammaplasty.*

Hypomastia. *Hypomastia* is present when there is insufficient volume of one or both breasts. Patients with hypomastia request augmentation mammaplasty to increase their self-image by improving the appearance of their breasts.

The prosthesis we prefer has a double lumen. The inner one is a shell of silastic filled with dimethylsiloxane polymer. The outer lumen is inflated with a variable amount of saline at the time of implantation. Steroids are added to the contents of the outer lumen in an effort to decrease capsular contracture.

The breast prosthesis is inserted under local or general anaesthesia. Either an axillary, periareolar, or inframammary incision is made. A pocket is created in the submuscular plane deep to the pectoralis major and serratus anterior muscles. Some surgeons place the prosthesis superficial to the pectoralis major muscles, although this appears to result more often in capsular contracture. Whatever position is selected, the pocket is made large enough to accomodate the implant without its margins being visible through the skin. The pocket is irrigated with an antibiotic solution prior to insertion of the implant.

Postoperative care includes continuation for 24 hours of the same antibiotic given just before the skin incision was made. The patient is instructed to wear a brassiere continuously for 2 weeks after the surgery. Breast massage is begun after 1 week and continued for 6 weeks.

Around any implanted alloplastic device, the body will form a capsule. That reaction is a normal physiologic one. If the capsule remains thin and filmy, the breast augmented by a silicone gel prosthesis will stay soft and natural. Should myofibroblastic proliferation ensue due to inflammation provoked by hematoma, subclinical infection, trauma, the silicone itself, or other unknown causes, the result is fibrous contracture and a firm breast. In severe cases, the result is adherence to the pectoral fascia and distortion of the breast. The incidence of capsular contracture has been reported as high as 40 percent when the implant is placed in the submammary position. The incidence appears to be considerably lower in those patients whose implants are placed in submuscular pockets. In capsular contracture the breast is hard and often painful. Treatment includes both closed and open capsulotomy techniques. If the implant is in the submammary position, conversion to a submuscular position is often curative. Some patients with severely symptomatic capsules require the removal of the implants and abandonment of attempts at augmentation.

Complications of augmentation mammaplasty include hematoma, infection, and pain in the immediate postoperative period. An occasional patient will complain of decreased nipple sensibility.

Breast Reconstruction after Mastectomy. Subcutaneous mastectomy is indicated in patients who have have high risk or great fear of developing cancer of the breast. Prior to undergoing this procedure, the patient must understand that the removal of the glandular tissue is never complete, and thus the risk of developing breast cancer is not totally relieved. Following subcutaneous mastectomy, the breast is reconstructed by augmentation with a prosthesis. Reconstruction is either performed simultaneously with the mastectomy or delayed until pathology reports are available and healing is complete. The results of reconstruction after subcutaneous mastectomy are usually satisfactory, but a restored breast is rarely confused with a normal one, as some distortion of the contour or nipple-areolar complex often occurs.

Reconstruction of the breast after radical or modified radical mastectomy offers the patient a sense of "wholeness". The best candidate is a patient whose tumor was small and who has a minimal risk of local recurrence.

Reconstruction is usually delayed until after the mastectomy wound has healed. If chemotherapy or radiation therapy is required, surgery is postponed for approximately 1 year. In the absence of proven metastatic disease, an uncertain prognosis does not preclude breast reconstruction.

Several reconstructive techniques are available. The use of local skin flaps has been largely abandoned. If the patient has had a modified radical mastectomy and has sufficient skin, a breast prosthesis is placed beneath the pectoralis major and serratus anterior muscles through an incision in the healed mastectomy scar. The patient whose remaining chest wall skin is tight or who has undergone a radical mastectomy requires the addition of skin and soft tissue provided by a latissimus dorsi musculocutaneous flap. The bulk of the latissimus dorsi flap is usually augmented simultaneously, using a breast prosthesis. After radical mastectomy with the removal of the pectoralis major muscle the patient frequently complains of loss of the anterior axillary fold. This fold is restored at the time of breast reconstruction by detaching the latissimus dorsi muscle from its insertion and suturing it to the original site of the pectoralis major muscle insertion on the humerus.

The procedures described create a breast mound. It is usually necessary to tailor the opposite breast at the same time, either by reduction mammaplasty, mastopexy, or augmentation, to achieve symmetry. If the patient falls into the high-risk category for carcinoma, either simple or subcutaneous mastectomy of the opposite breast, with immediate reconstruction, is indicated. After 3 months, the patient undergoes nipple-areolar reconstruction if she so desires.

The breast can be reconstructed using a rectus abdominis musculocutaneous flap. A skin island is designed horizontally or vertically in the upper or lower abdomen; blood supply is provided by the underlying rectus abdominis muscle. This tissue is shifted superiorly to stimulate a breast. Sufficient bulk is provided by the muscle and subcutaneous fat, and a breast prosthesis is usually not required.

Gynecomastia. *Gynecomastia* is an enlargement of the male breast resulting from an increase in glandular tissue. Idiopathic gynecomastia sometimes occurs in adolescence. A testicular tumor may cause gynecomastia in the prepubertal patient. Male breast enlargement is seen in association with endocrine disorders including hyperthyroidism, hypothyroidism, pituitary chromophobe adenoma, acromegaly, and adrenal tumors. Liver disorders, especially cirrhosis, cause gynecomastia. Drugs such as digitalis, estrogens, and cimetidine stimulate breast enlargement. In addition, cannabis drug abuse will cause gynecomastia. Males with Klinefelter's syndrome usually have gynecomastia.

The treatment of gynecomastia in adolescents is expectant, as the process often resolves within 2 years. If the enlargement is excessive or lasts over 2 years, a full evaluation is followed by surgical reconstruction. The procedure for gynecomastia is performed through an inferior periareolar incision. Excess breast tissue is excised, and care is taken to bevel the tissues at the periphery. A thick nipple flap is preserved to reduce the chance of nipple necrosis.

Chest and Abdominal Wall

Defects of the chest and abdominal walls result from trauma, extirpation of tumors, radiation necrosis, congenital abnormalities, and infection. Reason for closure of these defects include the protection of vital organs, enhancement of respiratory function, eradication of infection, and improvement in appearance. The goal of therapy is to provide a stable, healed wound without herniation of abdominal or thoracic organs. Ideally, coverage is provided by flaps of uninvolved tissue, with structural integrity restored when necessary using fascia, synthetic material, or bone. A single-stage procedure is preferred.

Numerous alternatives for treating chest and abdominal defects have been described. Prior to closure, all necrotic debris is removed. Direct suturing of the wound edges is commonly used. If excess tension prevents direct closure, a skin graft or local skin flap can sometimes cover the wound.

Larger defects require a more extensive procedure for closure. The greater omentum is useful in managing such wounds. Based on the right or left gastroepiploic artery, the greater omentum is freed from the colon and stomach and transferred into the wound. Once in place, the omentum is covered with a split-thickness skin graft.

Muscle and musculocutaneous flaps have successfully healed chest and abdominal wounds. The pectoralis major muscle and musculocutaneous flaps are effective in treating chest wounds, in particular the infected median sternotomy wound. Blood reaches the pectoralis major muscle from a branch of the thoracoacromial artery and branches of the internal mammary artery. The muscle will survive after division of one or the other blood supply. The latissimus dorsi muscle flap, with or without an overlying skin island, is useful in managing chest wounds. This flap will survive as an island based on the thoracodorsal vessels.

The rectus abdominis musculocutaneous flap will survive on a vascular pedicle consisting of the superior or inferior deep epigastric vessels. This flap will reach the lower chest and entire abdomen.

Large abdominal wall defects and hernias are often best managed by reinforcing the wall with a synthetic mesh and covering the repair with local skin flaps, muscle, or musculocutaneous flaps. The tensor fascia lata musculocutaneous flap is particularly useful in the lower abdomen, as the fascia lata provides additional strength for the repair. Wounds of the inguinal and perineal region have healed after closure with a gracilis muscle flap.

The giant hairy nevus presents a unique problem when located on the chest or abdomen. This nevus is present at birth and has the potential of developing into a malignant melanoma before puberty. If the nevus is small, it is excised and closed in a single stage. Larger nevi are excised and the defect covered with a local flap or a skin graft in one stage or serially. Subtotal excision and closure may be done repeatedly for large lesions until the nevus has been completely removed.

Pressure Sores

Sustained pressure applied to any part of the body can result in ulceration. Tissue necrosis and ulceration are caused by ischemia induced by the pressure. A pressure of 40 to 80 mmHg applied to the tissue continuously for 4 hours causes microvascular changes and edema. This pressure, persisting over 8 hours, induces permanent microvascular changes. A patient may experience sustained pressure to a region due to unconsciousness, spinal cord injury with paralysis, rigid casting, or physical restraint.

Cursory examination of a pressure sore reveals a skin ulcer usually located over a bony prominence. This benign-appearing ulcer belies a more extensive wound involving the underlying subcutaneous tissues, fascia, muscle, and often bone itself. Long-standing pressure sores contain a partially epithelialized cavity, or bursa, which retards spontaneouos healing.

Basic care of the patient who has, or is at risk of developing, a pressure sore is directed at the avoidance of pressure. In attempting to heal the pressure sore, the body expends considerable energy. Therefore, the patient's nutrition must be vigorously maintained.

Flexor spasticity is a common problem in the patient with a spinal cord injury. The intermittent muscular spasms apply shearing forces to the sites of potential ulceration, contributing to the development of pressure sores. Spasticity is treated initially by removal of noxious stimuli and administration of antispasmotic medications. In severe cases, spasms are relieved by denervation through intermittent longitudinal myelotomy.

Once a pressure sore has become established, surgical treatment is necessary. A superficial sore will often heal spontaneously after debridement with subsequent avoidance of pressure. Deeper sores require more extensive surgery. The wound is completely excised, including the epithelialized bursa. Any underlying bony prominence is removed, along with all granulation tissue covering the exposed bone. The wound is either closed directly or filled with vascularized tissue. Local skin flaps commonly break down with time. The application of muscle and musculocutaneous skin flaps has resulted in more secure and prolonged healing.

Selection of the appropriate flap depends upon location of the ulcer. A sacral sore is best treated using a gluteus maximus musculocutaneous flap. The pressure sore over the

greater trochanter responds to coverage with the tensor fasica lata musculocutaneous flap. An ischial sore is closed with a gluteus maximus or hamstring musculocutaneous flap.

Lymphedema

Lymphedema is an abnormal accumulation of lymph in the intercellular spaces of a part of the body, usually the upper or lower extremity. It may result from removal or destruction of the regional lymph nodes or from a congenital defect in the lymphatics. A patient with persistent lymphedema suffers permanent changes in the extremity. Fibrosis develops in the connective and subcutaneous tissues, the skin thickens, the region swells, and nonpitting edema persists. Lymphangiosarcoma may arise in areas of chronic lymphedema.

The management of lymphedema includes compression and elevation of the extremity. Care is taken to avoid infection, particularly by beta-hemolytic streptococcus, as each episode worsens the edema. Diuretics are useful adjuncts.

Operation is reserved for patients in whom medical therapy has failed. Excision of the involved skin and subcutaneous tissues, with split-thickness or full-thickness skin graft coverage, often results in chronic ulceration. The use of a pedicled omental flap inset into the extremity to drain lymph has not been effective. Microvascular lymphaticovenous anastomoses offer some promise. The most satisfactory therapeutic compromise is staged, subtotal excision of the involved tissues beneath local skin flaps. All operations must be followed by sustained elastic compression of the extremity.

Lower Extremity Defects

Defects of the lower extremity are caused by trauma, venous stasis, arterial insufficiency, diabetes, and the extirpation of cancer. Infections of the soft tissue and bone of the leg, particularly chronic osteomyelitis, present difficult management problems.

Small soft tissue defects less than 1 cm^2 in area can be expected to heal spontaneously. Skin grafts promote healing in larger defects which are adequately vascularized and do not involve exposed tendon or devitalized bone. Ulcers which occur in association with arterial insufficiency heal after restoration of blood flow to the extremity.

Venous stasis ulcers appear in the patient with chronic venous insufficiency of the lower extremity. Venous insufficiency is treated first. The ulcers are then allowed to heal by epithelialization or are managed by excision and skin grafting. Free microvascular tissue transplantation has been unsuccessful in treating venous stasis ulcers. After the ulcers are controlled the patient must persist in wearing compression bone.

Patients whose wounds include either a large segment of exposed bone, a compound fracture of the femur or tibia with extensive soft tissue injury, or chronic osteomyelitis are best treated with muscle or musclocutaneous flaps. Local transposition muscle flaps are preferred in these wounds *except* in the distal third of the tibia. Serious wounds and osteomyelitis of the distal third of the tibia are better managed by free microvascular muscle or musculocutaneous tissue transfer.

Ulcers on the plantar surface of the foot often heal after a skin graft is applied. Local skin and muscle flaps employing intrinsic muscles of the foot are also useful in treating these wounds. The muscle flap must be covered by a skin graft. Ulcers on the feet of patients with diabetes are difficult to treat, responding best to local wound care or simple closure methods.

Genitourinary System

Hypospadias occurs when the urethral metatus opens on the ventral surface of the penis, on the scrotum, or in the perineum. Most patients with hypospadias have chordee, a ventral curvature of the penis which becomes more obvious during erection. Chordee is caused by fibrous tissue which extends between the urethral meatus and glans penis. An IVP has been suggested in all patients with hypospadias, because of an increased incidence of renal abnormalities.

The goals of hypospadias management are the relief of chordee, assurance of a sexually adequate penis, placement of the urethral meatus at the tip of the glans penis, and restoration of normal urination. Treatment begins soon after birth with the avoidance of circumcision. An intact foreskin is useful in subsequent reconstruction.

Two-stage techniques of hypospadias repair start with the operative relief of chordee as early as age one and a half years. A urethroplasty is done as a second stage at age four to nine years.

Numerous single-stage techniques for hypospadias have been described. The procedure by Horton and Devine is useful for hypospadias with any meatal position. The chordee is released and a "flip-flop" of skin and soft tissue of the glans penis is fashioned to form the distal urethral meatus. A full-thickness skin graft is tubed and used to reconstruct the urethra if the meatus is located far proximally.

The overall success rate for hypospadias repair is approximately 85 percent. Complications include initial failure to make the proper gender assignment, hematoma, infection, flap necrosis, stricture, and fistula formation. If a urinary fistula occurs postoperatively, it is repaired after a 6-month interval.

Epispadias is present if the urethral meatus appears on the dorsum of the penis. It is often associated with exstrophy of the bladder, in which case the bladder opens anteriorly on the abdominal wall, the pubic symphysis fails to fuse, and there is a midline diastasis of the abdominal wall muscles. The primary treatment objective in patients with epispadias and exstrophy of the bladder is the establishment of unobstructed renal function. If the bladder can be closed, it should be. Otherwise, the bladder should be excised and a urinary diversion procedure carried out for ureteral drainage. Repairs of the epispadias resemble those of hypospadias. Intrinsic to the repairs is reconstruction of the bladder neck, including urinary sphincters.

The patient suffering loss of the scrotum or penis often seeks reconstruction. The penis and scrotum have both been restored using local abdominal flaps and gracilis musculocutaneous flaps. A simple method of scrotal reconstruction can be achieved if the testes are covered with split-thickness skin grafts. Burial in the subcutaneous tissue of the

medial thighs has been advocated. Testes so buried will retain hormonal function, but because of the higher temperature in this heterotopic site, aspermia may result.

Vaginal agenesis occurs in congenital absence of the vagina, testicular feminization syndrome, adrenogenital syndrome, and gonadal dysgenesis. Treatment as outlined by McIndoe involves the dissection of a perineal pocket and insertion of a split-thickness skin graft to create a vagina. The graft is tailored and held in place by a stent until healing is complete. Broadbent, however, has demonstrated that an adequately capacious vagina can result from simple progressive dilatation by vaginal bougies.

Removal of the vagina and vulva for cancer creates a large defect. Successful perineal and vaginal reconstruction has been achieved using gracilis musculocutaneous flaps.

Aesthetic Surgery

Facial Aging

Changes in facial appearance are a sign of advancing age. These changes are related to an absorption of subcutaneous fat, a decrease in the thickness and elasticity of the skin, and a failure in adherence of the skin to deeper tissues. The result is sagging of the facial skin and the formation of wrinkles in areas of skin adherence and muscle insertion.

A desire to look younger or simply to improve facial appearance can cause a patient to seek aesthetic surgery. Before undergoing an operation, the patient needs to understand the proposed procedure. The patient must have realistic goals in order to be satisfied with the postoperative result.

The *rhytidectomy* (facelift) is performed under local or general anaesthesia. After the proposed sites of incision are marked with methylene blue, the areas to be incised are infiltrated with 0.5% lidocaine with 1:200,000 epinephrine. The incision begins in the hairline above and anterior to the ear, continues in front of the ear, and curves posteriorly around the lobe to terminate approximately 6 cm posterior to the mastoid process. Appropriate undermining is performed medially to free the skin from the underlying structures. A fibrous tissue layer of varying thickness known as the *superficial musculoaponeurotic system* (SMAS) lies between the skin and facial muscles. This tissues extends from the frontalis muscle in the upper face to the platysma below. The SMAS transmits the pull of the facial muscles to the overlying skin. Tightening the SMAS by plicating it to itself and by suturing the SMAS to fascia overlying the mastoid bone gives additional support to the facelift operation.

After the SMAS is secured, an appropriate amount of skin is excised from the anterior skin flap, and the wound is closed. Drains are usually not necessary. A firm head dressing helps prevent hematoma formation.

The submental region and neck often require special attention. A submental lipectomy through a separate incision is sometimes required to remove fat deposits beneath the chin. Suturing and repositioning of the platysma muscle have been advocated to improve the contour of the neck.

Serious complications following rhytidectomy are unusual. Significant hematomas beneath the skin flaps occur in approximately 4 percent of patients. These areas are allowed to heal secondarily and the scars revised later if needed. Less than 1 percent of patients experience injury to a major branch of the facial nerve.

Dermabrasion helps to remove fine wrinkles, particularly about the mouth. Superficial acne scars and other minor surface irregularities are smoothed using dermabrasion. A power-driven rotary device is preferred. The wound following dermabrasion is cleansed daily and dressed with antibiotic ointment. Protection against direct sulight while the wound is red to pink in color reduces the chance of developing local hyperpigmentation. This requires use of a cosmetic sunscreen or wearing of a hat for 2 to 3 months.

Chemical face peel is used to flatten fine wrinkles and tighten the skin. This technique involves creation of a superficial chemical burn which, when healed, relieves wrinkling. It is sometimes difficult to control the burn depth, and unsatisfactory scarring has resulted. Hyperpigmentation, particularly in dark-skinned individuals, occasionally complicates this procedure.

Eyelid

The appearance of baggy eyelids is due to drooping of the eyebrows, redundance of eyelid muscle and skin, and herniation of intraorbital fat. The patient desires relief from a perpetual "tired look" about the eyes. Caution is exercised when considering surgery for a patient with a history of thyroid disease or chronic "dry eyes", as symptoms may worsen postoperatively.

Blepharoplasty involves removing a variable amount of skin and orbicularis oculi muscle from the upper and lower eyelids. If herniation of infraorbital fat is present, a subtotal excision of the fat decreases bulging of the lids. Eyebrow ptosis is relieved by a browlift using either a supraciliary or coronal incision and skin resection.

Nose

A perceived nasal deformity and the desire for improved appearance stimulate the patient to request reconstruction. Complaints include a nasal hump, nasal tip deformity, unsatisfactory nasolabial angle, broad alar rims, broad nasal bridge, deviation of the nose from the midline, and difficulty in breathing.

A well-planned and executed *rhinoplasty* and a satisfied patient mark the mature plastic surgeon. This procedure is done under local or general anesthesia. Bleeding is reduced by using topical or locally injected vasoconstrictors in the nasal septum and skin. The tip is approached first, with the resection of portions of the lower lateral alar cartilages, if refinement of this area is required. The skin of the nose is undermined through intranasal incisions, and the bony and cartilaginous hump is removed. The nasal bones are separated from the maxilla with an osteotome and subsequently placed in the desired position. If nasal obstruction is present, resection of the nasal septum deep to the mucous membrane and perichondrium of the septal cartilage completes the procedure. The nasal cavities are packed lightly, and the external nose is supported with adhesive paper strips and a rigid split.

Severeal weeks are required for swelling of the soft tissue to disappear and the nose to assume its final shape.

Abdomen

A patient disturbed by lax skin, striae, and a moderate excess of abdominal fat often seeks surgical assistance. These abdominal complaints follow weight loss, pregnancy, or aging.

Surgery for the massive abdominal fat apron involves simple excision and closure. *Abdominoplasty* is used to treat the more moderate excess of fat and skin. A shield-shaped segment of skin and fat is removed from the lower abdomen, and the upper skin flap is undermined. Any diastasis of the rectus abdominis muscle is repaired. The umbilicus is relocated and the wound closed. Underclothing conceals the scar.

Thighs, Buttocks, and Upper Arms

A patient often notes skin redundancy of the thighs, buttocks, and upper arms following massive weight loss. This is particularly common in the individual who has undergone an intestinal or gastric bypass for morbid obesity. Removal of the redundant skin can be done to improve contour in the affected area. However, the resultant scar are often prominent and difficult to conceal.

Head and Neck Surgery

Congenital Defects

Cleft Lip

Cleft lip is a common genetic abnormality. A cleft lip with or without a cleft of the palate occurs in approximately *one out of every 1000 live births.* Genetic factors which influence the development of cleft lip include race and sex. A cleft lip deformity is seen more commonly among Orientals than among Caucasians or blacks, and occurs more often in males. Environmental factors contributing to the development of cleft lip are *maternal disease during pregnancy, teratogenic drugs, and advanced parental age.* If a parent or older sibling has a cleft lip the chance of a subsequent child being born with the same defect is higher.

A cleft lip may occur *unilaterally* or *bilaterally.* It is said to be *incomplete* if a bridge of skin connects the cleft and noncleft sides. If no skin bridge exists, the cleft is termed *complete.* Deformity of the nose usually accompanies the cleft lip. The nasal defect is represented by a distortion and displacement of the lower lateral nasal cartilage.

The patient with a cleft lip should be evaluated by a team of specialists including a plastic surgeon, orthodontist, speech therapist, and otologist. After a treatment plan has been outlined and when the child is old enough to tolerate an elective procedure safely, surgical repair is done. In general, surgery is scheduled by the "rule of tens". That is, the child should

be at least 10 weeks of age, weigh 10 pounds, and have 10 grams of hemoglobin. By that time, the tissues are large enough to allow accurate repair.

The goal of every cleft lip operation is to approximate the normal state. Existing lip elements are rearranged to achieve the desired result. The operation is done under general anesthesia. Lines of incision are marked with methylene blue, the lip is infiltrated with dilute epinephrine solution to provide vasoconstriction and attendant relative hemostasis, and the procedure is performed. The technique designed by Millard and in common use today closes the lip defect and assists in proper positioning of the involved nasal cartilage. After cleft lip repair, pressure of the lip on the alveolar ridge narrows an associated cleft palate. Further correction of the nasal deformity, often with simultaneous revision of minor lip irregularities, is done when the child is older.

Bilateral clefts of the lip are repaired in one or two stages. Before surgery, the central portion of the lip and maxilla (prolabium and premaxilla) often protrude excessively. This protrusion has been corrected using external pressure applied through adhesive tape or a specially designed bonnet which molds the central segment into an anatomic position.

Cleft Palate

An isolated cleft of the palate occurs in approximately 4 out of every 10000 live births. An appreciation of normal anatomy is necessary to understand the palatal cleft. The incisive foramen divides the normal palate into the primary palate anteriorly and the secondary palate posteriorly. A *unilateral cleft of the primary palate* extends from the incisive foramen obliquely to the right or left to terminate in a fissure between a canine and its adjacent incisor. Primary palatal clefts are occasionally *bilateral.* A *cleft of the secondary palate* occurs in the midline and extends posteriorly from the incisive foramen to involve the posterior aspect of the bony palate, the soft palate, and the uvula. Clefts of the primary and secondary palates may occur together or independently. If a bridge of tissue is present across the defect, the cleft is termed *incomplete.*

In clefts of the secondary palate, the palate is often short. The palatal muscles are abnormally inserted into the posterior margin of the hard palate. In a normal individual the palate moves superiorly and posteriorly during speech and swallowing. This action temporally blocks the nasopharynx and is termed *velopharyngeal closure.* Due to malpositioning of the palatal muscles and palatal shortening, the cleft palate patient often suffers from insufficient velopharyngeal closure, with resultant hypernasal speech. Mild feeding difficulties are common in the infant with a cleft palate. Middle ear infections occur frequently and can result in hearing loss.

Repair of the cleft palate is undertaken at age 18 to 24 months. Closure of the palate relieves velopharyngeal insufficiency at this early time and allows speech to develop more normally. Restoration of maxillary contour promotes better dental occlusion. Some authors believe that early closure of the hard palate contributes to the midface hypoplasia often seen in the older patient with a repaired cleft palate.

The surgical procedure is done under endotracheal anesthesia. The hard palate cleft on the nasal side is repaired using two mucosal flaps raised from the vomer. The remainder

of the cleft is closed with mucoperiosteal flaps from the hard palate which serve to fill the defect and lengthen the palate. The alveolar ridge cleft is repaired using a buccal sulcus mucosal flap.

Velopharyngeal insufficiency which persists after palate repair or occurs as an isolated defect is treated with a flap raised from the posterior pharyngeal wall and sutured into the posterior free margin of the soft palate. This pharyngeal flap reduces the cross-sectional area of the nasopharynx and thus promotes palatal closure during phonation, with improvement of hypernasal speech. Speech therapy and orthodontia are requisite to the proper habilitation of these patients.

Craniofacial Anomalies

Craniofacial anomalies are relatively rare disorders resulting in abnormal facial contours and often a grotesque appearance. Paul Tessier pioneered the accurate description and reconstruction of these deformities. Craniofacial anomalies may be divided into rare facial clefts and craniosynostosis.

Unusual facial clefts are described anatomically, with the orbit as a center of reference. *Craniofacial microsomia* is the most common of these clefts. The deformity is usually unilateral, but may be bilateral. A groove is present in the cheek from the oral commissure to the ear, producing macrostomia. The ear is deformed and preauricular tags are usually present. The trigeminal and facial nerves on the affected side and the muscles supplied by them are often involved, producing occlusal abnormalities and weakness in facial expression. The zygomatic bone and vertical elements of the mandible on the involved side are hypoplastic.

Craniosynostosis is a pathologic process caused by premature closure of one or more cranial sutures. *Crouzon's syndrome* is characterized by early closure of the coronal suture with a hypoplastic, retruded midface. The orbits are shallow and the globe protuberant. The eyelids are often unable to close over the cornea, and ulceration results. Some degree of ocular hypertelorism is common. The children with this defect are generally of normal intelligence.

Appert's syndrome is a more severe form of craniosynostosis and also involves the coronal suture. The forehead is tall and depressed. Orbital hypertelorism is common, along with midface hypoplasia and clefting of the palate. Syndactyly is frequently seen, usually involving the central three digits. Most children with Appert's syndrome have some mental retardation.

Surgical repair of these anomalies is achieved using extracranial and intracranial approaches to the cranium and facial bones. The involved bones are separated, repositioned, and supported with bone grafts and interosseous wiring.

Maxillomandibular Disproportion

An abnormality in the shape, size, or position of the mandible or maxilla can cause a patient to seek surgical correction. The plastic surgeon must consider the relative position

of the mandible to the maxilla and relationship of the facial bones to the cranial base. Evaluation of such a patient includes dental casting to assess occlusion and the preparation of a standard cephalogram for cephalometric analysis. Frequently, the less severe case of maxillomandibular disproportion can be treated successfully by orthodontia. The more severe deformity requires operative relief.

In retrognathia, the mandible is of normal size but is located posterior to its normal position. *Micrognathia* is manifest by a small mandible. The mandible appears recessed in the patient with retrognathia or micrognathia. In both cases, the operative technique for treating the deformity involves splitting the mandibular rami bilaterally in the sagittal plane. The mandible is then repositioned anteriorly and held in position with intermaxillary fixation for 10 to 12 weeks. There is some risk of damage to the inferior alveolar nerve during the procedure, and the patient must be aware of this preoperatively.

The patient with mandibular *prognathism* suffers from a prominent, overdeveloped mandible. This is corrected operatively by a sagittal split of the mandibular rami, removal of a segment of bone on the external surface of the mandible along the margin of the osteotomy, and repositioning of the jaw posteriorly. An alternative approach is through a vertical osteotomy beginning at the sigmoid notch and carried to a point just posterior to the mandibular angle. The mandible is then set back, allowing the bones to overlap at the osteotomy site. With either the sagittal split or vertical osteotomy, the patient is placed in intermaxillary fixation for 10 to 12 weeks.

A patient may have a mandible of normal dimensions, but suffer from a chin which is either too large or too small. A small chin can be augmented wioth a silicone prosthesis. The more severe case of a large or small chin is treated by a horizontal osteotomy and repositioning of the mentum.

The most common deformity of the maxilla is *hypoplasia*, often seen in the patient with a cleft palate. *Hyperplasia of the maxilla* is manifest by a long face and excessive exposure of the gingiva when smiling. The operative treatment of hypoplasia of the mandible involves a Le Fort I osteotomy. A mucosal incision is made in the upper gingivobuccal sulcus exposing the maxilla above the tooth roots. By means of an air-driven reciprocating saw, an osteotomy is cut along the outer wall of the maxilla from the pyriform aperture to the pterygopalatine suture bilaterally. This isolated lower segment of the maxilla is then repositioned and stabilized. Maxillary hyperplasia is also treated with a Le Fort I osteotomy, although in this instance a vertical segment of maxilla is removed, allowing the lower portion to shif upward into a more normal position.

Ear Deformities

Microtia is characterized by a small, malformed ear. Usually all that remains is a malpositioned ear remnant. A hearing deficit is almost always present. Repair of microtia begins at age five to six years and is performed in stages. The first stage is implantation of a framework fashioned from a rib cartilage. Carving this cartilage requires considerable artistic ability. Subsequent stages include lobule rotation, elevation of the ear, deepening of the concha, and a formation of a tragus.

Prominent ears are usually caused by a lack of definition of the antihelical fold. This deficiency results in a cupped ear which projects from the skull at an increased angle. The goal of operation is to recreate an antihelical fold. To achieve this, the surgeon takes advantage of cartilage's tendency to bend away from the side where it is scratched or scored. The operative procedure is carried out by elevating the skin from a portion of the exterior surface of the ear cartilage, scoring the cartilage, including the anterior perichondrium, and removing a skin ellipse from the posterior aspect of the ear. A more natural contour is assumed immediately.

Haemangioma and Lymphangioma

The *capillary hemangioma* is a common disorder in the pediatric age group. It represents an abnormal accumulation of small vessels in the subepidermal and deep dermal layers. A *port wine stain* is a form of capillary hemangioma which is flat and uniformly dark red in color. Port wine stains do not resolve spontaneously and are present at birth. Treatment is by excision, laser cauterization, tattooing, and application of cosmetics.

The *strawberry hemangioma* is also a form of capillary hemangioma. This lesion is raised and bright red. It is not present at birth but becomes apparent within 1 to 3 weeks after birth. A strawberry hemangioma usually grows rapidly for the first 6 months of life, at which time growth slows. Therapy initially consists of observation, as the majority of strawberry hemangiomas resolve spontaneously over a protracted period of up to 6 years. Surgical excision is done in selected cases. Prednisone and radiation therapy have been used with varying success.

In the *cavernous hemangioma,* cell organization is more mature and deeply situated in the tissues. Location in the head and neck is common. This lesion is blue, swollen, and present from birth. Gigantism of the affected part can occur. The cavernous hemangioma with numerous venovenous communications seldom involutes, and complete cure is rare. Management is by palliative, and often subtotal, excision. If excision is indicated, intraoperative bleeding can be minimized by preoperative embolization of vessels supplying the hemangioma.

The *arteriovenous malformation* is an accumulation of communicating arteries and veins. This lesion can result from trauma initially involving a single artery and vein, or can be congenital, with a massive syncytium of abnormal arteriovenous connections. The traumatic arteriovenous fistula is controlled by closing the hole between the artery and vein. Like the venovenous congenital malformation, cure of the congenital arteriovenous fistula is rare. Operation is hazardous and usually palliative. Arteriography is necessary for diagnosis. Selective arterial embolization shows promise as an adjunctive and perhaps curative procedure.

A *lymphangioma* consists of a mass of immature lymphatic channels. The *cystic hygroma* is a form of lymphangioma with cellular and cystic components. This lesion is distributed through a particular region without regard to tissue planes. Most often seen in the head and neck, the cystic hygroma swells when the patient has an upper respiratory infection. This swelling can cause difficulty in breathing. Some cystic hygromas will involute unless

there is a hemangiomatous component. If operation is required, subtotal excision is the best the surgeon can offer. The lesion so permeates the normal structures that complete extirpation is impossible and dangerous.

Thyroglossal Duct and Branchial Cleft Anomalies

The embryonic thyroglossal duct gives rise to the thyroglossal duct cyst and fistula. A thyroglossal duct cyst presents as a midline mass in the anterior neck. If the duct is open to the skin, it is termed a fistula. Both the cyst and fistula can become infected. If infection is present, incision and drainage are performed. Once infection is controlled, the lesion is treated by complete excision, usually with removal of the central portion of the hyoid bone. The entire thyroid gland may be aberrantly positioned anywhere along the thyroglossal fistula. Therefore, a preoperative thyroid scan is essential.

The branchial cleft cyst, sinus, and fistula are remnants of the first or second branchial cleft or pouch. Both first and second branchial cleft fistulas are located adjacent to cranial nerves, the first close to the facial nerve and the second associated with the hypoglossal nerve. A branchial cleft fistula has both an internal and an external opening. A fistula which lies between the external auditory canal and the submandibular area originates from the first branchial cleft. The internal opening of the second branchial cleft fistula is usually in the posterior tonsillar pillar, while the external one is found along the anterior border of the sternocleidomastoid muscle. The branchial cleft sinus has either an external or internal opening but not both. The branchial cleft cyst is closed at both ends. These structures sometimes become infected and require drainage. When the infection has cleared, complete excision is indicated. In the case of a second branchial cleft fistula this may require several incisions in a "stepladder" fashion, progressing upward from the external opening to expose the entire length of the fistula or sinus.

Acquired Defects

Skull and Scalp Deformities

Injuries which involve large areas of scalp loss are treated in several ways. Application of a split-thickness graft allows the wound to heal. Later, the skin graft is excised serially to reduce the size of the defect. Orticochea has described a technique for management of larger wounds of the scalp. This procedure involves the use of three or four scalp flaps which are transposed into the defect. The underside of each flap is scored with multiple parallel incisions through the galea to allow expansion of the flap and coverage of the area of loss. Requisite to success is extensive mobilization of the entire scalp. Avulsion of the scalp has been successfully treated by replantation using microvascular techniques.

Should the defect involve the loss of both scalp and underlying calvarium, wound coverage for protection of the brain and prevention of infection is paramount. An electrical injury often results in such a full-thickness loss. If the bone is charred, debridement is carried down to the meninges. The dura is left intact and a split-thickness graft applied if the defect is large. A smaller defect is covered by a transposition flap. Dura damaged by the injury but free of underlying infection is treated with a topical antibiotic such as silver sulfadiazine until granulation tissue forms, and then skin is grafted. However, this wound is unstable and does

not provide rigid protection to the brain. The calvarium can only be reconstructed after full-thickness scalp or skin cover is provided. The multiple flap technique, a free falp of muscle, or omentum covered by skin grafts can be used to provide coverage. The previously applied skin graft is excised at the time of flap transfer. The calvarium is reconstructed at the same time or at a third stage using split rib grafts. Alloplastic materials can be used but are susceptible to injury, infection, and subsequent extrusion.

Eyelid and Eyebrow Reconstruction

A full-thickness defect of the eyelid results from trauma, infection, and tumour excision. The upper eyelid is the more important of the two lids. It is the principal protector of the cornea and functions best when it is mobile. A loss of one-fourth or less of either eyelid is closed directly. Larger defects of the upper eyelid are reconstructed using composite tissue from the lower eyelid. Local flaps of tissue from the adjacent cheek are used to recreate the lower lid. When conjunctiva is lost, it can be provided by a mucosal graft from the nasal septum, with or without cartilage.

Laceration through the eyebrow requires careful approximation. Loss of the eyebrow is treated using hair-bearing tissue from the scalp. This tissue is transferred as a free graft or an island flap.

Eyelid Ptosis

Elevation of the upper eyelid is accomplished through contraction of the levator muscle (innervated by the IIIrd cranial nerve) and Muller's muscle (sympathetically innervated). Ptosis, or drooping, of the upper lid can have many causes. Injury to the oculomotor nerve results in ptosis. A feature of Horner's syndrome is ptosis. Upper eyelid ptosis can also occur as an idiopathic congenital defect. The treatment of ptosis involves resection of a sufficient amount of the levator complex and resuture to raise the upper eyelid. Milder forms may be treated by transconjunctival removal of a portion of the tarsal plate and resuture. More severe forms, where there is no levator function, are treated by fascial suspension to the frontalis muscle.

Nasal Reconstruction

Loss of a part or all of the nose results in a striking defect and presents a difficult reconstructive problem. A small skin deficit superficial to the cartilage is repaired by a split-thickness skin graft, full-thickness skin graft, or local flap. A defect of the alar rim is reconstructed with a composite graft of skin and cartilage from the ear.

A more serious nasal deficiency involves the loss of skin, cartilage, bone, and mucous membrane. In this case the requirements are a stable framework for support of the nose, tissue for internal lining, and skin for external coverage. The framework is supplied by a bone graft. A split-thickness skin graft or turnover flaps of adjacent tissue provide lining. Skin coverage is obtained using nasolabial flaps, a forehead flap, or scalp flap.

Lip Reconstruction

A full-thickness lip defect requires skin, vermilion, and muscle for reconstruction. Various local flaps of the lip are available. The Abbé flap is useful, often combined with the transposition of cheek flaps to satisfy large defects.

Facial Palsy

Facial palsy results from paralysis of the facial nerve. This paralysis is occasionally congenital. A stroke victim often suffers unilateral facial nerve palsy. An acoustic neuroma or the excision of such a tumor can result in facial nerve injury and paralysis. Swelling due to inflammation in the bony canal (Bell's palsy) produces nerve injury. The facial nerve can also be damaged by a fracture of the temporal bone. Laceration of the nerve itself can occur anywhere along its course after it exits from the stylomastoid foramen. Facial nerve function may also be impaired through direct invasion by a parotid cancer.

With paralysis of the facial muscles, the patient is unable to wrinkle his forehead, elevate his eyebrow, or close his eye. Upper eyelid paralysis may result in exposure keratitis. The cheek muscles are paralyzed, and the corner of the mouth sags. All facial expression in response to emotion is lost on the affected side. In addition, eating and talking are compromised by the flail buccinator muscle within the cheek.

The lacerated or resected facial nerve should be repaired or grafted promptly. The traditional treatment for long-established facial nerve paralysis is static suspension of the eyelids, cheek, and oral commissure using fascia lata strips. Newer techniques include muscle transfer employing the muscles of mastication which are not innervated by the facial nerve. Nerve grafts from the ipsilateral descending branch of the hypoglossal nerve or from the contralateral unaffected facial nerve have been done. Transplantation of a muscle with its motor nerve by microsurgical technique has been reported with success.

Parotid Duct Laceration

The parotid duct is sometimes divided in deep facial lacerations. A knowledge of the duct's location is essential to proper diagnosis. The divided duct is repaired with fine sutures over a small plastic catheter.

Facial Fractures

Facial fractures are common in this violent, mobile age. The patient with facial trauma may have injuries of the chest, abdomen, upper airway, cervical spine, and brain that are life-threatening. These injuries must be managed first.

Examination of the facial skeleton proceeds from the upper to lower face. The forehead is palpated for signs of depressed fracture or frontal sinus injury. The orbital margins are checked for any irregularity. Ophthalmologic examination may disclose enophthalmos, inferior displacement of the globe, and intrinsic damage to the eye. The nose is observed for asymmetry and depression; the presence or absence of septal hematoma within the nose should be defined. The zygomatic arches and malar eminences are palpated to reveal any

deformity. Dental occlusion is noted. The maxillary bones are examined intraorally and extraorally. Midface stability is checked by grasping the upper incisors and alveolar ridge and gently attempting to displace the structures anteriorly or posteriorly. Intraoral and extraoral palpation of the mandible completes the bony examination. Numbness of the nasolabial region or chin implies injury to the infraorbital or inferior alveolar nerve.

A thorough radiologic examination is necessary for the proper diagnosis of a facial fracture. This radiologic examination includes a posterior-anterior, lateral and Water's view of the facial bones. A nasal fracture can be confirmed by lateral film of the nose. Oblique, lateral, and Towne's views of the mandible are useful if a mandibular fracture is suspected. A Panorex roentgenogram exposes most of the mandible except the mentum and is helpful in localizing fractures of this bone. Submental fractures within the bony orbit are diagnosed by tomography or CT scanning. Radiologic examination requires manipulation of the patient. Therefore, the status of the cervical spine must be determined first, either by physical examination or a lateral x-ray film.

Treatment of a mandibular fracture is dictated by its location and extent of displacement. The pull of the muscles of mastication contribute to displacement of the fracture. The mandibular condyle is the single area most often fractured, although it is not uncommon for the mandible to break in more than one place.

The principles of management of a mandibular fracture are early reduction with the restoration of normal dental occlusion, firm immobilization, and control of infection with antibiotics. Intermaxillary fixation (IMF) is a basic technique of immobilization. Metal bars are ligated to the upper and lower rows of teeth using stainless steel wire. The upper and lower bars are joined by rubber bands to achieve occlusion, with the mandible held tightly against the maxilla.

Fractures of the various anatomic regions of the mandible are managed by area. A fracture in the parasymphyseal region is treated by open reduction and internal fixation of the fragments, followed by IMF. When a fracture occurs in the body of the mandible and a full complement of teeth is present, IMF alone is used. A body fracture of the edentulous mandible is treated by performing open reduction and internal fixation, combined with IMF using dentures or dental splints. An alternative in the case of an edentulous body fracture is application of an external fixation device. Fractures of the ramus, coronoid process, and condylar process are splinted with IMF. An alveolar ridge fracture is stabilized by ligating the involved and adjacent uninvolved teeth to themselves or to an arch bar.

A zygomatic bone fracture is often displaced, resulting in depression of the malar eminence. The lateral canthus of the eye is likewise displaced laterally and inferiorly. If significant deformity has occurred, open reduction and internal fixation are mandatory.

Certain fractures inside the bony orbit are sustained as a result of a blow to the eye. The sudden increase in intraorbital pressure causes collapse of the floor or medial wall of the orbit. These "blowout" fractures are accompanied by a herniation of orbital fat into the maxillary, or ethmoid, sinus. The patient often complains of double vision. Acute enophthalmos is sometimes noted. An orbital floor fracture can trap the tissues adjacent to the inferior rectus muscle and prevent upward gaze on the injured side. However, blunt

trauma to the muscle itself is sufficient to impede its function. True mechanical limitation of the extraocular muscles is best assessed by the forced duction test. A local anesthetic is instilled into the conjunctiva, and the insertion of the inferior rectus muscle is grasped with forceps. Traction on the muscle at this point and observation of the globe's mobility confirm the presence or absence of entrapment.

The indications for operation in blowout fracture are entrapment on forced duction, significant enophthalmos, and the presence of a large fracture on x-ray examination. The surgical procedure involves dissection of the orbital contents deep to the periosteum and return of the herniated tissue to the orbit. Often the bony fragments of the orbital floor are stable after anatomic reduction. If not, a silastic sheet is used to reinforce the floor of the orbit. Alternatively, a thin bone graft or cartilage segment may be used.

A nasal fracture is frequently accompanied by depression of the nasal bones, asymmetry, and nasal obstruction. Nasal roentgenograms are of limited value. An obvious deformity is corrected immediately under local or general anesthesia. If the nose is swollen, reduction of the nasal fracture is delayed several days until the swelling subsides and accurate reduction of the fracture is possible. If a displaced fracture is allowed to completely heal without reduction, the resultant deformity can be corrected only by operation rather than by simple manipulation. A hematoma of the nasal septum occasionally complicates a fracture of the nose. This hematoma must be drained immediately and the nose packed. An untreated hematoma is prone to infection, which can lead to septal perforation or collapse.

Complex nasoorbital fractures involve the frontal sinus, root of the nose, and ethmoid sinuses. These fractures are best managed by repair under direct vision after turning down a coronal flap of scalp and forehead skin to provide good exposure.

A maxillary fracture follows a powerful blow to the midface. The *transverse, or Le Fort I, fracture* separates the lower maxilla, hard palate, and pterygoid processes as a single or comminuted unit from the rest of the maxilla. The *pyramidal, or Le Fort II, fracture* involves separation along the nasofrontal suture, floor of the orbit, zygomaticomaxillary sutures, and pterygoid processes. The *craniofacial disjunction, or Le Fort III fracture,* separates the midface from the cranium by fracturing through the zygomaticofrontal sutures, nasofrontal suture, and floor of the orbit. Treatment of these fractures requires IMF, with fixation of the mandible and maxilla to the first stable bony structure immediately above the fracture.

Reconstruction after Tumor Excision

The diagnosis and treatment of intraoral and upper respiratory tract tymors is covered in Chap. 16. After extirpation of head and neck tumors, the problem of reconstruction remains. The goals of therapy are restoration of appearance, speech, chewing and swallowing abilities, and oral continence. Patients often require pain relief, closure of a fistula, and alleviation of drooling.

Intraoral defects have been managed by split-thickness skin grafting. Tongue flaps are occasionally used, but they limit the mobility of the remaining tongue, adversely affect speech

and swallowing, and are sometimes painful. Larger intraoral wounds have been closed using forehead, deltopectoral, platysma, sternocleidomastoid and pectoralis major flaps.

The adequate resection of cancer demands the extensive removal of soft tissue and sometimes large segments of the maxilla or mandible. A deficiency of skin, bone, and oral cavity lining results. Such a defect can be treated with regional flaps and a bone graft. Recently, composite flaps of soft tissue and bone have been used to achieve healing in this difficult wound. The pectoralis major musculocutaneous flap with an overlying rib is an example of such a flap. Bone from the iliac crest with overlying skin and muscle can be transferred as a free flap based on the deep circumflex iliac artery.

Some patients require resection of a portion of the cervical esophagus, particularly after removal of laryngeal carcinoma. The esophagus is usually closed directly, but formation of a postoperative stricture is a common problem. Local axial and musculocutaneous flaps have been used to reconstruct the esophagus. Advanced lesions of the hypopharynx require combined resection of the larynx, pharynx, and cervical esophagus. Frequently, simultaneous bilateral neck dissections are required. The hypopharynx and cervical esophagus have been successfully reconstructed with a free intestinal graft, usually from the jejunum or ileum, transferred by microvascular techniques. This procedure has the advantages of being done in a single stage and of providing early return of function. Success rate now exceeds that of conventional flap techniques that have the disadvantages of multiple operative stages and a skin-mucosa suture line that is very liable to stricture formation.