Reconstructive Plastic Surgery

Converse

Preface to the Second Edition

The first edition of *Reconstructive Plastic Surgery*, widely distributed throughout the world, was considered by many to be the standard reference for plastic surgeons. A second edition is long overdue. There were a number of factors in the delay: an upsurge of activity at the Institute of Reconstructive Plastic Surgery; fulfillment of a promise made to V. H. Kazanjian to write a third edition of our book *The Surgical Treatment of Facial Injuries*, published in 1974; and the rapid advances in plastic surgical concepts and techniques since 1964. Constant revision has been required to keep the contents of the chapters up to date.

Not since World War II has plastic surgery gained so much prestige or have so many advances been made as in the last decade: evolution of new concepts in flap surgery based on expanding knowledge of skin circulation; increased understanding of the biology of wound healing and tissue transplantation; reduction in burn morbidity and mortality; reconstruction of the face by complex craniofacial osteotomies; introduction of the microscope into vascular and nerve repair, enabling the free transfer of composite tissue and the replantation of severed parts; new concepts in the treatment of acute injuries and deformities of the upper extremity; and refinements in surgery of the aging face. This edition incorporates these and other advances, which have been built on a foundation of surgical principles established in the past.

The titles of the one hundred chapters that make up this work constitute a listing of subjects that encompass and define the scope of plastic surgery. A perusal of the table of contents shows that *Reconstructive Plastic Surgery* covers many subjects that have been considered the appanage or special endowment of allied specialties. The word "allied" is particularly applicable to a philosophy that implies teamwork, a collaboration of specialists. An ecumenical approach benefits both patient and surgeon. The plastic surgeon can learn from his colleagues in the clinical fields and from research workers in basic sciences, thus enlarging the body of knowledge of the specialty.

Since my early training I have witnessed the fragmentation of general surgery and the rise of new surgical specialties and of subspecialties. Forecasting "Surgery in the twenty-first century," J. Englebert Dunphy wrote, "Surgical care will be delivered exclusively by specialists and at varying levels of primary to tertiary care. Specialization will be even greater than at present so that the old-fashioned general surgeon of the past will disappear. Very difficult or complication operations within the established specialties will be performed by superspecialists" (Surgery, 75:332, 1974).

But how to coordinate the activities of superspecialists? The answer is the orchestral concept. The virtuosi play their individual instruments, but the orchestra conductor ensures harmony and the success of the concert - a word that originally meant an understanding or harmony between a number of persons. No single plastic surgeon can be an expert in all areas of the specialty. The solution, therefore, is the team. The resident in training thus benefits from the teaching of each expert within the group of specialists.
It is difficult to unite all aspects of plastic surgery under one roof. A multiple hospital organization offers the resident exposure to the greatest variety of clinical problems and those of allied specialties. Such an arrangement exists at the New York University Medical Center, which includes the Institute of Reconstructive Plastic Surgery in the University Hospital, Bellevue Hospital Medical Center, the New York Veterans Hospital, and a teaching affiliation with the Department of Plastic Surgery at the Manhattan Eye, Ear and Throat Hospital.

In the Preface to the first edition I gave tribute to the many coauthors who contributed to its success. My gratitude and indebtedness is again expressed to those who revised their chapters and to the new authors who introduced new ideas and techniques. Together we were able to rejuvenate a text which, after being reprinted a number of times, is widely read 13 years after its publication.

Dr. J. William Littler, master of hand surgery, has edited the section on surgery of the upper extremity. He has left his imprint and injected his own philosophy of diagnosis and treatment throughout the section.

Dr. Joseph G. McCarthy, Associated Director of the Institute, has given talent, time and energy to make possible the completion of this extensive revision and has made many original suggestions which have enhanced its usefulness.

We can confidently predict the progressive growth of our specialty, a specialty with unlimited possibilities engendered by the fertile imagination of the plastic surgeon, whose ideal combines a vision of the desirable with an appreciation of the attainable.

John Marquis Converse, M. D.
Preface to the First Edition

This treatise is the result of the concerted efforts of my coauthors; to them I express my indebtedness and my gratitude.

The work attempts to assemble present-day knowledge concerning the rapidly growing field of reconstructive plastic surgery. Each author was asked to treat the subject assigned to him in the manner he felt most suitable. Because of limitations in the already lengthy text, many distinguished plastic surgeons who have made important contributions to the specialty could not be included as coauthors. They will find, however, that their work has been referred to repeatedly in the various chapters.

My friend Dr. J. William Littler, master of hand surgery, added immeasurably to the value of the work by editing, illustrating and contributing to the section devoted to surgery of the hand and upper extremity.

Special care has been taken to ensure uniformity of the terminology throughout the text, which is the terminology generally employed in the specialty journals of the English speaking world. An effort was made to clarify and simplify the language and apply simple terms in the place of the pedantic terms often favored by the medical profession. English has become the international language of medicine. May this simplification of the text make it more understandable throughout the world.

The text has been divided into seven parts: 1, General Principles; 2, The Head and Neck; 3, The Hand and Upper Extremity; 4, The Lower Extremity; 5, The Trunk; 6, The Genitourinary System and Anorectal Malformations; and 7, Tissue Transplantation and Burn Shock.

For the convenience of the reader, the text has been published in five volumes. Ernest Hemingway once stated that no book should be so large that it could not be read in bed, and it is hoped that the reader will find these volumes easier to handle than the originally projected two large volumes.

The opening chapters deal with the basic principles of plastic surgery. The philosophy of plastic surgery cannot be taught in a textbook, however, but only through the guidance of a master surgeon in the clinical management of the patient. There is never a day that I do not give silent tribute to my own teachers, Kazanjian and Gillies, and feel privileged to attempt to teach others as they have taught me.

Specialization in surgery was a consequence of the development of abdominal surgery. Prior to his entry into the abdominal cavity, the surgeon's activity was largely confined to what was often referred to as "external pathology," in contradistinction to "internal pathology" considered to be amenable to medical care only. Specialization was necessary when the surgeon's activities became too diversified as new fields of surgical endeavor were developed.

Recognition of plastic surgery by the medical profession, now an accomplished fact, was slow. Saving life and restoring function have been the mission of the physician; the concept of surgery for the improvement of facial appearance, of corrective or cosmetic
surgery, was more difficult to accept. Changing concepts have resulted from the reclamation of severely injured individuals by workers in the various aspects of rehabilitation; from the often dramatic results obtained through reconstructive surgery, particularly in victims of war; from the recognition of the importance of the teachings of psychiatry and of the need for corrective surgery for the mental well-being of the patient.

The sheer ever-increasing numbers of individuals who are the victims of accidents, who suffer disability and disfigurement from the resection of tissue for the eradication of tumors, or as a result of a destructive disease such as leprosy, or who are born with a congenital malformation have created a demand for highly skilled professional care.

Disfigurements of the body and, in particular, because of its special social significance, disfigurement of the face, have deep psychologic repercussions. Perhaps in no field of medicine is the careful psychologic evaluation and handling of the patient more necessary than in plastic surgery. The finality of the surgical result may not be accepted by the patient, who must be led progressively to the realization that his remaining physical handicap must not preclude his return to active social participation. If success in plastic surgery, as Gillies has stated, is a matter of balance between beauty and blood supply, success in the psychologic handling of the patient is a matter of balance between hope and truth - hope: the patient expects total correction of his deformity and the solution of all his associated problems; truth: an improvement, small or large, can be achieved but may not meet the patient's expectations of total recovery. These aspects are discussed in Chapters 15 and 16.

Volumes 2 and 3 of the text deal with the corrective and reconstructive surgery of deformities of the head and neck, including cleft lip and palate, a frequent congenital deformity.

Volume 4 covers the reconstructive surgery of the hand and extremities. The face and hands have many aspects in common from the viewpoint of the plastic surgeon. They are exposed areas of the body; their shape and movements characterize the individual; they participate in communication and social interaction. The face and hands are activated by a finely differentiated musculature; the fine movements of the digits are reminiscent of the delicate shades of expression produced by the facial musculature of expression. Surgery of the hand requires a thorough understanding of the anatomic, physiologic and functional aspects of hand disabilities.

Plastic surgery of various deformities of the trunk, including the breast, of the genitourinary system, of anorectal malformations, and recent advances in transplantation are described in Volume 5 of the text.

The plastic surgeon, that daily transplanter, must consider himself akin to the transplantation biologist. Transplantation biology is at the forefront of the phenomenal advances in surgery of recent years. Transplantation of tissues and replacement of structures and organs, physiologically worn out, resected for disease or amputated in accidents, will be one of the major tasks of the surgeon of the future. The plastic surgeon, because of his experience in transplantation in his clinical practice, his ability to perform delicate and intricate techniques, is admirably suited by temperament and training to play a leading role.
in the development of transplantation surgery. The teaching of transplantation biology should become an integral part of the teaching of the plastic surgery resident.

Preoccupied by the details of surgical technique, the plastic surgeon may find himself devoting the major portion of his vital energy to activities in the operating room. Progress is made through the application of a sum of knowledge to the resolution of a particular problem and time must be allowed for the necessary observations and conclusions. A rationing of activities, an efficient distribution of effort are best achieved if the surgeon has a well organized hospital service. This requires the attribution of a sufficient number of hospital beds, operating rooms and research facilities. Good quality patient care goes hand in hand with resident teaching and research activities.

Emphasis must be laid upon the need for the interdisciplinary approach to many of the complex clinical problems of plastic surgery. Collaboration with members of the allied surgical specialties, of medicine, dentistry, speech pathology, psychiatry and the social sciences is often required to achieve the physical and psychosocial rehabilitation of the patient.

Because of the diversity of plastic surgery in its various clinical applications, the future plastic surgeon should receive the broadest possible preliminary training in surgery and the surgical specialties. A trained surgeon prior to his residency in plastic surgery, he will soon begin to see the solution to the various clinical problems through the eyes of a plastic surgeon; he will learn to make the diagnosis of the deformity and to visualize repair in terms of fit and form; where to make his incisions; how to design a flap; when to graft to ensure maximum survival. He has become a plastic surgeon because he is thinking as a plastic surgeon and is now capable of applying the principles of plastic surgery to any area of the body.

John Marquis Converse, M. D.

Chapter 1

Introduction to Plastic Surgery

John Marquis Converse

What is Plastic Surgery? Plastic surgery is a specialized branch of surgery concerned with deformities and defects of the integument and the underlying musculoskeletal framework.

The origins of the art of plastic surgery, rooted in ancient history, are related to the relief of facial deformity, in particular to reconstruction of the amputated nose, and thus the restoration of the individual, the person. A person: the noun person is derived from the Latin "persona," which signified the mask that actors wore and then, by metonymy, the role played by the actor, the personage he represented in the play (persona dramatis). The word has gradually become synonymous, in general, with personality, with the idea of individuality, the individual.

We have taken for granted that each human face is different, that no human face has ever been reduplicated among the millions that surround us and the billions that have preceded us. Not even a facial feature has ever been reproduced. The uniqueness of the individual, which extends to the subcellular level, is the clue to the diversity of the facial features of man, his facial expression with its infinite variants, the timbre of his voice, his posture, his movements, and the entire mysterious psychosomatic complex that constitutes the personality of a human being.

It was only many centuries later, in the nineteenth century, that the principles and techniques of plastic surgery were applied to other areas of the body. Surgery of the hand was developed only in the present century.

Because of the special nature of plastic surgery, it is largely concerned with form, as is implied in the term "plastic." Functional aspects of plastic surgery are also important: for example, reestablishing the continuity of the mandible to permit mastication, restoring the function of the hand, or making possible the healing of a compound fracture of the tibia by providing adequate soft tissue coverage over the fractured bone.

A paramount quality required for plastic surgery is a sense of form, an esthetic judgment, and an ability to visualize the end result. Webster in his foreword to the textbook by Gillies and Millard, *The Principles and Art of Plastic Surgery* (1957), quotes from Aristotle's "On the Parts of Animals": "Art, indeed, consists in the conception of the result to be produced before its realization in the material." Perhaps this quality is the most essential requisite for a plastic surgeon; it is the quality that distinguishes the artist from the technician.

The term "plastique" was used by Desavit in 1798. "Plastic surgery" was part of the title of Zeis's book, *Handbuch der plastischen Chirurgie*, in 1838. Von Graefe was the first to employ the term "plastic" in his monograph entitled *Rhinoplastik* published in Berlin in 1818. In most countries, the term "plastic surgery" designates the specialty. Until the end of
the nineteenth century, plastic surgery was essentially reconstructive. With the perfection of techniques, the correction of minor defects that are congenital in nature or secondary to aging came to be practiced. Thus corrective or esthetic surgery in contradistinction to reconstructive surgery provided another challenge for the plastic surgeon. Although no clear distinction between the two types of plastic surgery is required, there being an esthetic aspect in reconstructive surgery and often a reconstructive aspect in esthetic surgery, the terms reconstructive and esthetic are convenient only to differentiate between the surgery of major and minor defects.

Gillies often mentioned a definition which I recall. He defined reconstructive surgery as an attempt to restore the individual to the normal; esthetic surgery, he stated, attempts to surpass the normal. The relief of facial disfigurement, the restoration of function, the closure of defects - these are easily understood goals and imperative surgical procedures. But what is the "normal"? Esthetic concepts have changed from century to century, from decade to decade, and from culture to culture.

A review of the progressive development of plastic surgery helps one to understand the present status of the specialty - thus the following brief account of the history of plastic surgery. Additional historical data are included in many chapters of this text.

The Ages of Plastic Surgery

In an address to the Royal College of Physicians Winston Churchill remarked, "The longer you look back, the further you can look forward." Similarly, the thoughts, struggles, and efforts of those who have preceded us form the foundations of the present-day practice of plastic surgery. Plastic surgery is one of the oldest forms of surgery. Its often told history will not be reviewed in detail in this textbook. The reader is referred to the works listed in the bibliography at the end of the chapter.

Although ancient man practiced trephination of the skull, specialized surgery appears to have been practiced by the Babylonians during the time of Hammurabi (circa 1950 B.C.) when the operation for cataract was performed as a legitimate surgical procedure.

In India, Sushruta, the Hippocrates of the sixth or seventh century before Christ (Rogers, 1967), described operations for the reconstruction of the nose and the earlobes in the Sushruta samita (translated by Bhishagratna, 1916). Amputation of the nose was a common practice to punish criminals and the inhabitants of conquered cities. The operation was performed by members of a caste of potters known as the Koomas (see Chapter 29, p 1209). Knowledge of these operations probably filtered through the Persians, the Greeks, the Arabs, the Nestorian Christian communities in India, Persia, and Iraq and through Jewish scholars to Rome (Gnudi and Webster, 1950).

Celsus (25 B to 50 AD) used advancement flaps. It is not clear whether the flaps were raised prior to advancement, as was done in the nineteenth century under the name of "flaps according to the French method" or "gliding flaps" ("lambeaux par glissement"). He was probably the originator of the island flap with a subcutaneous pedicle.
Galen (130 to 200 AD) did not concern himself with plastic surgery techniques. Progress in surgical techniques during the period of the Roman Empire was epitomized by Paulus Aegineta (625 to 690 AD), thought to have been a major link between the medical learning of the Hindu and Arab schools and the increasing number of Western scholars during his lifetime. He may be considered one of the originators of plastic surgery as we know it today (Rogers, 1974). He described procedures varying from the treatment of nasal and jaw fractures to operations for hypospadias. With the death of Paulus Aegineta, the enrichment of medical and surgical knowledge provided by the Greco-Roman period came to an end.

The rise of Islam enhanced the prestige of Arabic medicine. It has been suggested that contacts between the Arabs, the invaders of Sicily, and the local practitioners, such as members of the Branca family, led to the transmission of the art of reconstructive rhinoplasty as practiced in ancient India. Occidental medicine thus is indebted to Arabic medicine. Arabian scholars in the 8th century AD provided Arabic translations of the work of the famed Indian practitioner Sushruta, which were subsequently translated into Latin (Gnudi and Webster, 1950).

The Renaissance

The period of the Renaissance or rebirth of civilization which marked the transition from the Middle Ages emerged in Italy in the fourteenth century, reaching its height during the fifteenth and sixteenth centuries. The cultural enrichment spread throughout Europe, often intermingling with older interests and forces and flourishing in different lands.

During the first half of the fifteenth century, plastic surgery came to be practiced in Sicily by members of the Branca family. Sicily was a center of Arabic, Greek, and Occidental learning during the earlier centuries, and it is thought that the elder Branca used the method of repair described by Sushruta. Antonio Branca, the son, abandoned the ancient Indian method and was probably the first to use a flap from the arm to repair mutilated lips and ears.

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During the sixteenth century the Vianeo family practiced the art of plastic surgery in the region of Calabria in the southwestern part of the Italian peninsula. A number of other practitioners appeared to have repaired mutilated noses. Symonds’ observations (1935) on the increase of violence during the period from 1530 to 1600 are of particular interest: “Compared with the middle ages, compared with the Renaissance, this period is distinguishing by extraordinary ferocity of temper and by an almost unparalleled facility of blood shed.”

Remarks of Paré. The need for reconstructive operations during the sixteenth century due to the frequent duels and clashes of armed men appears to have coincided with an increased interest in this branch of surgery. The renowned surgeon Ambroise Paré warned, however, of the extreme difficulty and discomfort of the operation for the repair of a mutilated nose:
"We have testimony of this from a gentleman named the Cadet of St Thoan, who, having lost his nose and having long worn one of silver, became angry at the remark that there was never a lack of laughing matter when he was present. And having heard that there was in Italy a master re-maker of lost noses, he went to find him, and he made a new one for him in the way described above as an infinite number of people have since seen him, not without the great marvelling of those who had known him before with a silver nose. Such a thing is not impossible; nevertheless it seems to me very difficult and burdensome to the patient, both because of the trouble of keeping the head down with the arm for so long a time, and because of the pain of the incisions made in healthy parts, cutting and lifting away the part of the flesh of the arm to form the nose; in addition, this flesh is not of the same quality nor similar to that of the nose, and even when agglutinated and reformed it can never be of the same shape and color as that which was formed in the place of the lost nose, likewise the openings of the nostrils can never be as they were originally."

Paré apparently shared the common misunderstanding concerning the arm flap technique of nose repair, as he named the biceps muscle as the donor site and specified 40 days as the period requisite for union.

Paré's negative attitude was all the more surprising as he expressed the horror of his contemporaries for facial mutilations in his book published in 1575:

"Having arrived in the town, I entered a stable and there I found four soldiers who were dead and three who were leaning against the wall, their faces completely disfigured and they could not see nor could they hear or speak and their clothes were still smoking from the gun powder that had burnt them. As I was looking at them with pity, an old soldier approached me and asked me if there was any way by which I could cure them: I answered that there was no way. Suddenly he approached each one of them and cut his throat, gently and without anger. Seeing this cruel action I told him that he was a bad man to have done this. He answered that he prayed God that if he should be so afflicted there would be someone who would render him the same service rather than allow him to languish miserably."

**Work of Tagliacozzi.** It would appear that Paré never came to know the work of the man who was to lay the cornerstone of modern plastic surgery. Gaspare Tagliacozzi of Bologna. The work of Tagliacozzi, particularly in nose reconstruction, was renowned throughout Europe. His treatise "De Curtorum Chirurgia per Insitionem," published in 1597, summarizes his life's work. In describing the technique of preparing the arm flap for transplantation to reconstruct the nose, he specified the delayed flap and in Chapter 10, "The proper age of the flap when we make the implanting," he stated, "It is not well to implant the flap in its age of infancy because then it is not strong enough, it has suffered the violence of the first operation, and is subject to inflammation or hemorrhage. Nor is its youth the proper time as it is then still not firm enough and is subject to various evils. Nor yet should one await its old age, for by then it has become too wrinkled, blanched, pallid and juiceless." But "when it has reached the age of manhood and has entirely hardened, and now begins to be turned, strong enough and fortified to sustain the force of the operation, it is necessary to take the flap, and join it with the missing parts in the new union of grafting, for it cannot be done better or more safely. Thus it will satisfy the hopes of ourselves and of the patient abundantly."
Between the taking up of the flap and the insertion (about fourteen days) the patient is not limited as to diet and may go about freely" (Gnudi and Webster, 1950).

The Seventeenth and Eighteenth Centuries: The Decline

Tagliacozzi's technique was probably little practiced during the seventeenth and eighteenth centuries. The decline of plastic surgery after the death of Tagliacozzi parallels the decline of surgery, which was languishing throughout all of Europe, particularly in Italy. The errors which Tagliacozzi had combated so vigorously augmented the misconception and fears that stifled its acceptance. Finally the whole subject, including Tagliacozzi's name, became the object of ridicule from the pens of the wits of the polite society of the eighteenth century.

The greatest hindrance to the acceptance and use of plastic surgical operations came from a misconception that reparative tissue could be taken from a slave or person other than the patient and that under such circumstances, a kind of mystic sympathy existed between the new nose and the person from whom it had been taken, causing the nose to die when the original donor died.

The encyclopedists or "phylosophes," a group of scientific determinists (Diderot published the first volume of the "encyclopédie" in 1751), had great influence during the eighteenth century. One of the encyclopedists, Voltaire, wrote a satirical poem concerning the "sympathetic" slave, the donor tissue having been taken from a slave's buttocks. Ironically, the age of enlightenment was not an age of enlightenment for plastic surgery. Although it has been stated that the Faculty of Medicine of Paris interdicted face repairing during the eighteenth century, there appears to be not truth to the statement. What did happen was that a thesis, "Whether defective noses can be remade from the arm," was rejected by the Faculty. The jokes about "nose and face repairing" during this period, although more cruel, were not unlike the jokes made during the period of development of esthetic surgery in our era.

Second Rebirth

A Report from Indica. In October, 1794, a letter was written to Mr Urban, the editor of the Gentleman's Magazine published in London. The letter stated that a friend in India had communicated to the author the following report on a hitherto unknown operation which had long been practiced successfully in those parts. The letter concerned an incident that had occurred in the Third Mysore War waged by the British East Indian forces against Sultan Tippoo.

"Cowasjee, a bullock-driver with the English army in the war of 1792, was made a prisoner by Tippoo, who cut off his nose, and one of his hands. In this state, he joined the Bombay army near Seringapatam, and is now a pensioner of the Honorable East India Company. For about twelve months, he was wholly without a nose; when he had a new one put on, by a Mahratta surgeon... This operation is not uncommon in India, and has been practiced from time immemorial.

Two of the medical gentlemen, Mr Thomas Cruso, and Mr James Findlay, of Bombay, have seen it performed as follows: a thin plate of wax is fitted to the stump of the nose, so as to make a nose of good appearance; it is then flattened, and laid on the forehead. A line
is drawn round the wax, which is then of no further use; and the operator then dissects off as much skin as it covered, leaving undivided a small slip between the eyes. This slip preserves the circulation, till an union has taken place between the new and old parts.

The cicatrix of the stump of the nose is next pared off; and, immediately behind this raw part, an incision is made through the skin, which passes round both alae, and goes along the upper lip. The skin is now brought down from the forehead; and, being twisted half round, its edge is inserted into this incision; so that a nose is formed with a double hold, above, and with its alae and septum below, fixed in the incision.

A little Terra Japonica is softened with water, and, being spread on slips of cloth, five or six of these are placed over each other, to secure the joining. No other dressing than this cement is used for four days; it is then removed, and cloths, dipped in ghee (a kind of butter), are supplied. The connecting slip of skin is divided about the twenty-fifth day, when a little more dissecting is necessary to improve the appearance of the new nose.

For five or six days after the operation, the patient is made to lie on his back; and on the tenth day, bits of soft cloth are put into the nostrils to keep them sufficiently open. This operation is always successful. The artificial nose is secure, and looks nearly as well as the natural one; nor is the scar on the forehead very observable, after a length of time.

Chance plays a part, as it often does. Joseph Carpue, who at the time was 30 years old, read the story of Cowasjee and there rose before his eyes the images of all those hapless souls whose faces had been shattered. If such an operation were possible in India, he reasoned, it should also be possible in Europe. He began seeking more detailed reports of the operation. He questioned all the army men and civil servants who returned to London from India, in the hope that they might be able to give him some information. Altogether, he devoted nearly 20 years to investigating this matter. Carpue even located Lieutenant-Colonel Ward, who had been commander of the unit to which Cowasjee belonged and who had witnessed the operation. Cowasjee had fallen into Tippoo’s hands along with four other Indian soldiers. All five had had their noses and hands cut off and had been sent back to the English troops as terrifying examples. They were a ghastly sight. Leaves had been bound over the stumps of their wrists to stop the bleeding, but the horrible vestiges of their noses had not even been bandaged.

Another chance encounter occurred when Ward noticed a scar on the bridge of a peddler’s nose and inquired what it was from. The peddler admitted that his original nose had been cut off by the headman of his home village in punishment for adultery. He pointed out another scar on his forehead and described how an artist had shaped a new nose out of the skin of his forehead for him. This operation was often performed, he said, because the punishment of cutting off a nose was so common. Ward then sent for the practitioner who lived some 400 miles away. He performed the operation described in the Gentleman’s Magazine in 1794.

Carpue located physicians who had witnessed the operation. Barry, who had worked for the East India Company, informed him that the operation had taken 1.5 hours and that it had been performed with an old razor which had to be repeatedly honed in the course of the operation. Carpue obtained another report that indicated that the art of nose operations in
India was widely practiced by the Koomas, a caste of brickmakers (or potters) in Hindustan. At the beginning of the operation the patient was given betel and arrack. During the operation he had to lie flat on the floor with both hands at the side, and despite the intense pain, the man would unfailingly lie without stirring.

The practice of cutting off noses was common in India to punish thieves, adulterers, and prisoners of war. Only 24 years before the story published in the Gentleman's Magazine, Protwinarajan, the king of Ghorka, captured the city of Kirtipor in Ceylon in 1770. The King ordered a census taken by cutting off the noses and lips of all the inhabitants, even the smallest children. The population figure was then to be determined by a count of cut-off noses. Kirtipor was afterwards renamed Naskatapoor, meaning the city of severed noses.

**Carpue's Experience.** Carpue hesitated to perform the operation until September, 1814. A man came to call on him who wore a black patch over his face. He said, "I heard in Gibraltar that you can restore lost noses, and that you are the only man who knows the method. I have come here to beg your aid." The stranger removed the patch. In place of the nose was a gaping red hole. The patient told the following story:

"In 1801 I entered the Egyptian army as a fledgling officer. There I suffered an attack of jaundice, and the army doctors prescribed mercury. From this you will probably assume that in truth I suffered from a syphilitic disease. I know that syphilis also destroys noses. But I can prove by the testimony of my doctors that I never had any such disease. The mercury which was administered to me in Egypt, then in Malta, then in Ireland, and finally here in London, poisoned me and in the end resulted in the loss of my nose."

Carpue pointed out to the patient that the English climate differed in some essential features from the climate in India. The new nose might drop off from freezing or become purulent.

Early in October, 1814, Carpue decided to risk the operation. Carpue first made a test to determine whether healing would occur or whether the mercury poisoning had undermined the soundness of the apparently healthy parts of the face. Carpue took a scalpel and made several incisions close to the root of the nose; within a few days the incisions were already beginning to heal. On October 23, the operation took place. Carpue formed the model of the nose out of wax in accordance with the descriptions of the Indian procedure. He then flattened the model, laid it on the patient's forehead, and drew a line around it with red paint. Then he had the patient lie on his back on the operating table, his head supported by a pillow. The patient refused to be held, although Carpue warned him that the operation would be unusually painful.

Carpue drew lines with the red paint around the stub of the nose, where he would have to make incisions in order to insert the edges of the new nasal skin. The patient did not stir as the knife cut the outlines of the flap on the forehead and freed the skin from the frontal bone. By the end of 9 minutes, according to the friend who had accompanied the patient, Carpue was placing the lowest part of the new nose into the incision above the upper lip and suturing it ligature by ligature while the blood continued to run from the forehead across the patient's face. After having sutured the two sides of the nose, he cut out the nostril openings and inserted lint to keep them open. Carpue endeavored to bring the edges of the wound on
the forehead as much into contact as possible. The patient opened his mouth and said, "It was no child's play - extremely painful - but there was no use complaining." The officer with the watch came up to the foot of the bed and announced 37 minutes. Then he shook hands heartily with Carpue.

The nose had been covered with a dressing, and the sick room was kept at a torrid temperature in order to simulate the temperature of India. On the third day Carpue removed the dressing in the presence of his assistants and the officer who kept time during the operation. When the dressing was removed, the officer exclaimed, "My God, there is a nose."

Carpue's second patient was Captain Latham, whose nose was mutilated in the Battle of Albusera in Spain on May 16, 1810, during the Napoleonic Wars; the operation was performed 5 years later.

**Rapid Adoption of Rhinoplasty.** Von Graefe, who became Professor of Surgery at the University of Berlin, interrupting his academic career to assume the responsibilities of Surgeon General of the Prussian Army at the end of the Napoleonic Wars (1813 to 1815), reported three cases of reconstructive rhinoplasty in 1818 in which he had employed the Tagliacotian, the Indian, and a modification of the original Tagliacotian procedure, consisting of the immediate application of the flap to the nose without a period of delay; he also shortened to 6 days, when possible, the period during which the arm was attached to the head. Other than Carpue's report (1816), Von Graefe's *Rhinoplastik* (1818) was the first treatise on plastic surgery after Tagliacozzi (1597), and his work stimulated the development of plastic surgery throughout Europe and the United States.

The recognition of the historical contribution of Tagliacozzi was epitomized by Delpech in his two volumes (1823-1828): "Nothing is more exact than his observations, nothing more wise than his precepts ... Tagliacozzi's method was a stroke of genius which can become extremely fruitful in skilled hands..." Delpech wrote not only about his rhinoplastic operations but also on reconstruction of the lips, urethroplasty, and other plastic surgical procedures.

Dieffenbach, a younger contemporary of von Graefe, was instrumental in enlarging the scope of plastic surgery. His clinical work was monumental in its variety, inventiveness, and breadth of scope. Among his numerous publications, the best known is his *Die operative Chirurgie*, published in 1845 and 1848 in two volumes. John Staige Davis (1941) stated that his "methods and principles have not been improved upon and are still constantly employed."

During the first half of the nineteenth century Labat (1834) and Blandin (1836) wrote the first treatises on plastic surgery in France.

Serre in 1842 published his "Traité sur l'art de restaurer les déformités de la face" (treatise on the art of repairing deformities of the face). Serre was the chief exponent of the sliding (advancement) flap technique, the so-called French method, an adaptation of the technique of Celsus.

The names of two great surgeons of the nineteenth century cannot be omitted: Dupuytren, particularly for his operations for Dupuytren's contracture and his classification
of burns according to their depth, and von Langenbeck, who succeeded Dieffenbach, for his contributions to cleft palate and jaw surgery.

During the remainder of the nineteenth century, hundreds of papers appeared on the subject of plastic surgery and either surgical treatises devoted entirely to plastic surgery (Zeis's *Handbuch der plastischen Chirurgie*, published in 1838; Jobert's* Traite de Chirurgie Plastique*, published in 1849) or substantive portions of surgical treatises, such as the works of Roux in 1854 and Verneuil in 1877, were published.

* Jobert was often referred to as "Jobert (de Lamballe)" after the custom of the time of designating the man by the city from which he originated.

A book which also included plastic surgery in its title was published in 1842 by von Ammon and Baumgarten and was translated into French and Italian. In England, Liston devoted a considerable discussion to various plastic surgical procedures in his textbooks published in 1831 and 1837. In France the textbooks of Velpeau (1839) and Malgaigne (1849) also contained sections on plastic surgery. A number of Italian surgeons were performing plastic surgical operations. Sabbatini published a book in 1838 describing the history of plastic surgery. The American edition of Velpeau's *Operative Surgery* published in 1851 included, in the first volume under the section "Anaplasty or Autoplasty," a concluding American appendix which described a variety of reconstructive procedures by Pancoast and Mutter of Philadelphia as well as by Mott, Post, and Buck of New York. The publications of Blasius (1839-1843) and a number of other surgeons give an excellent picture of the great advances made during the first half of the nineteenth century. One of the outstanding works published in Russia in 1869 was the *Manual of Operative Surgery* by Szymanowski.

The Birth of Skin Grafting

Although Bünger, a colleague of von Graefe, had applied a skin graft from the thigh to the nose in 1823, Baronio (1804) had performed experimental skin grafts on sheep, and later Warren (1840) in Boston had transplanted a full-thickness skin graft to the ala of the nose, the full clinical import of skin grafting was recognized only near the last quarter of the century.

An event took place shortly before the Franco-Prussian War which was to add to the armamentarium of the plastic surgeon: the development of the skin graft. In 1869 Reverdin reported the hastening of the healing of granulating wounds by what he called "epidermic" grafts. On December 8, 1869, before the Imperial Society of Surgery of Paris, Reverdin showed a patient on whom he had applied, on a granulating surface, a segment of skin excised from the superficial portion of the integument approximately 2 by 3 mm in size. Reverdin was an intern working in the service of Guyon. In the discussion that followed, Guyon stated, "A single experiment is not conclusive ... The question of the future of the epidermic graft is today before you ... Dr Reverdin has, on my advice, presented this patient to draw attention to this new method and to receive the recognition which it merits." Claude Bernard, in person, presented Reverdin's work before the Academy of Sciences.

The technique of skin grafting was further developed when Ollier in 1872 described the clinical application of a dermoepidermic graft 4 by 8 cm in size; Thiersch (1874)
advocated the use of larger sheets of dermoeipidermic grafts to cover wounds and emphasized the importance of the dermal component. The grafts were thin split-thickness skin grafts often referred to in the English and German literature as "Thiersch" grafts; credit should be given to Ollier and the grafts designated as "Ollier-Thiersch" grafts. Lawson (1870), Lefort (1872), and Wolfe (1876) described the use of a full-thickness graft for the treatment of eyelid ectropion; Krause (1893) perfected the technique.

The nineteenth century literature was compiled and classified by Nélaton and Ombrédanne in two books published in 1904 and 1907, and the first American textbook, *Plastic Surgery - Its Principles and Practice*, by Staige Davis, was published in 1919.

It is significant that the early development of plastic surgery appears to have been closely linked to the development of reconstruction of the nose; a parallel is found during the twentieth century when corrective rhinoplasty preceded the development of esthetic surgery (see Chapters 29 and 37).

**The Twentieth Century**

**The Period of Growth (1914 to 1939).** World War I (1914 to 1918), often referred to as the Great War, appears to have been the crucial starting point for the development of the concept of plastic surgery which we know today. One may consider that World War II marks the beginning of the period of healthy adolescence; the period of 25 years extending from 1914 to 1939 then represents the period of growth.

Tactical maneuvering rapidly became limited during the first World War as the war of movement ceased and the conflict became stabilized on the western front. Casualties mounted to appalling figures, and trench warfare was responsible for ever-increasing numbers of maxillofacial wounds.

The influx of patients with gunshot wounds of the face into the military hospitals during World War I required the organization of specialized centers. Few surgeons knew how to cope with the problem. It was realized that the makeshift methods employed in the past were inadequate and that these patients would require specialized care. A number of treatment centers were established by the French Army, one of which was headed by an outstanding reconstructive surgeon, Morestin. Morestin was a native of the Caribbean island of Martinique and was of part Negro extraction. Well known prior to World War I for his work in the application of the Z-plasty technique to linear contractures and for developing techniques of cartilage grafting, Morestin conducted an active service at the Val-de-Grâce Military Hospital in Paris. Morestin was one of the first surgeons to show that the skin and subcutaneous tissue could be widely undermined without being subject to necrosis (Converse, 1968).

Morestin died prematurely, a victim of the great influenza epidemic of 1917-1918, and left a void in French plastic surgery. The concept of adapting dental techniques to the treatment of gunshot wounds of the face was foreign to Morestin, who disdained the services of the dental surgeons and claimed, "I can do everything with my scalpel." He rendered an incommensurable service by unwittingly being responsible for Sir Harold Gillies' interest in plastic surgery.
Gillies was an otolaryngologist attached to a British general hospital at Rouen, France. A friend of his, an American dentist named Roberts, having returned from a trip to Paris where he had seen Morestin operate, urged Gillies to go to Paris. Gillies told me that he watched Morestin repair a large facial defect by means of a large undelayed cervicothoracic flap. Gillies was inspired by what he saw and with the help of Sir William Arbuthnot Lane, his army consultant, a unit was established at the Aldershot Military Hospital. This measure was taken as part of the preparation being made for the Somme offensive (Clarkson, 1966). It is interesting that there appears to have been no further contact between Gillies and Morestin until Morestin's death; Morestin even closed the door of his operating room to Gillies.

A center was subsequently established at the Queen Mary Hospital, Sidcup, Kent. Here Gillies, assisted by Kilner, developed a vast treatment center for British and allied military casualties. Many allied medical officers came to Sidcup to learn plastic surgery; among these were Ferris Smith from the United States, Waldron and Risdon from Canada, and Newland and Pickerill from Australia and New Zealand. Gillies was fortunate to have as an associate a dental officer, Kelsey Fry, who applied dental techniques to the many maxillofacial reconstructive problems the surgeons were trying to solve.

Paralleling the development at Sidcup, another center situated not far from the front lines was actively functioning at Etaples, near Bulogne, under the direction of Varaztad H. Kazanjian. Kazanjian, a dental surgeon on the faculty of the Harvard Dental School, had volunteered to serve in the First Harvard Unit attached to the British Expeditionary Force. Kazanjian applied his knowledge of prosthetic dentistry to the early treatment of gunshot wounds of the face. He perfected methods of fixation of jaw fragments and of the utilization of prosthetic devices prior to the late primary closure of facial wounds. Gillies told me of the remarkable condition of those patients received by him at Sidcup who had been treated by Kazanjian at Etaples before their evacuation to England.

Kazanjian's participation in the Harvard Unit was the result of a chance encounter in Boston; he was invited to join as the dental surgeon of the unit and accepted. In 1920 he returned to the United States, entered Harvard Medical School, and continued his unusual career to become one of the world's leading plastic surgeons. Kazanjian was an immigrant to the United States at the age of 16, and his is truly one of the great success stories. His enthusiasm and interest never flagged, as I can personally attest, from the many long evenings we spent together writing our first book (Kazanjian and Converse, 1949).

There was American participation in World War I prior to the official entry of the United States in 1917. Volunteers such as Kazanjian, Waldron, and Ferris Smith have already been mentioned. Others served with the American Ambulance Hospital in Neuilly, a Paris suburb. A hospital was installed in a school, symbolically called the Lycée Pasteur, through donations given by supporters of the American Hospital of Paris. Blake, a surgeon at St Luke's Hospital in New York, had moved to Paris and did much surgery on the war wounded, including bone grafting for loss of bone in the mandible. Two American dental surgeon who had practiced for years in Paris - Davenport and Hayes - did outstanding work in the fixation of jaw fragments in wounded French soldiers at the American Hospital.
At the outbreak of World War I there was no recognized specialty of plastic surgery in the United States. Most general surgeons practiced reconstructive surgery and a few showed interest in this type of work. There were a considerable number of oral surgeons, such as Brophy, Gilmer, Cryer, Marshall, G. V. I. Brown, and Chalmers J. Lyons who, as a result of their dental training, took a special interest in surgical diseases of the mouth and jaws, particularly cleft lip and palate.

When the United States entered the War in 1917, Surgeon General Gorgas organized, under the Division of Surgery, certain sections in the Surgeon General's office, among them a section on head surgery which included subsections of ophthalmology, otolaryngology, brain surgery, and oral and plastic surgery. Vilray P. Blair of Saint Louis headed the last-named section and chose Robert H. Ivy as his assistant. Blair was well known for his work and had written a book, *Surgery and Diseases of the Mouth and Jaws* (1912). As early as 1907 Blair had attempted the surgical correction of mandibular prognathism in collaboration with Edward H. Angle, the orthodontist who is often considered the father of the American school of orthodontics. Blair conceived the idea of setting up teams, each consisting of a general surgeon and a dental surgeon who could pool their respective talents. Officers assigned to these teams were sent to special short courses of instruction in several medical and dental schools. A revised edition of Blair's textbook was prepared and distributed to Army hospitals. A number of officers were sent for short periods of observation and training at British and French hospital centers. Attempts were made to concentrate on patients with face and jaw injuries at Base Hospital 115, Vichy.

In the United States three centers were established where most of the patients with face and jaw injuries were sent on arrival from overseas. These were General Hospital No 11 at Cape May, New Jersey; General Hospital No 2, Fort McKinley, Maryland; and Walter Reed General Hospital, Washington, DC. Later, two other centers were established at Columbus Barracks, Ohio, and Jefferson Barracks, Missouri (Ivy, 1948). By the end of the war, names such as Gillies in England, Morestin in France, Lexer, Ganzler and Lindemann in Germany, Esser and Pichler in Austria, and Burian in Czechoslovakia became widely known, these men being characterized as specialists in plastic surgery or in jaw and face surgery.

One can consider, therefore, that World War I was the beginning of the era during which plastic surgery became a surgical specialty. After the war, national and international congresses began to include in their scientific programs papers concerned with the methods of treatment of the victims of the war and demonstrating new surgical possibilities. This was the period when one saw the facially mutilated. Ernest Hemingway (1964), recalling the clients of a particular Parisian café, wrote: "There were other people too who lived in the quarter and came to Lilas, and some of them wore Croix de Guerre ribbons in their lapels and others also had the yellow and green of the Médaille Militaire, and I watched how well they were overcoming the handicap of the loss of limbs, and saw the quality of their artificial eyes and the degree of skill with which their faces had been reconstructed. There was always an almost iridescent shiny cast about the considerably reconstructed face, rather like that of a well packed ski run and we respected these clients..." There were many others whose faces contained gaping holes, who had no lower jaws; these were the veterans whose faces could not be reconstructed. They formed an organization of mutual aid, "Les Gueules Cassées" ("the broken faces"). In view of the vast number of casualties, the rehabilitation task did not end...
with the war but continued for a number of years until as many as possible of the mutilated veterans were rehabilitated.

A number of publications appeared at this time. Important books were written by Staige Davis (1919) and Gillies (1920), and the contributions of surgeons and dentists during the war were described in a publication, "La Revue Maxillo-faciale," which appeared in 1919 and 1920. Ivy (1918, 1923) summarized the new knowledge in plastic surgery acquired during the war. A 1921 paper by Blair, "Reconstructive surgery of the face," illustrates the high degree of proficiency achieved in the rehabilitation of the war disfigured. Other important publications during this period included those of Velter (1917), Steinschneider (1917), Lexer (1919, 1920), Delangenière (1921), and Mauclaire (1922).

Gillies has told me that, following the closure of the Queen's Hospital in Sidcup, Kilner and he wondered how they were going to be able to specialize in the field of plastic surgery. When one thinks of the rapid development of plastic surgery during the past 25 years, it is difficult to realize that there was so little demand in civilian life for the services of the plastic surgeon in the early 1920s. The increase in birth defects, automobile and industrial accidents, ablative cancer surgery and burns; the rapid rise in requests for esthetic surgery; and the competitive industrial society are some of the causes for the increased demands for plastic surgery.

With the advent of peace and a period of relative prosperity, there appeared a new branch of plastic surgery which was designated as "esthetic" or "cosmetic." Joseph, an orthopedic surgeon in Berlin, who is justly regarded as the founder of modern corrective rhinoplasty, was at the apogee of his career; he gave courses which were attended by two pioneers of modern corrective rhinoplasty in the United States, Aufricht and Safian. In France, Passot, Noel, and others were performing surgical procedures for the correction of the aging face.

A considerable emphasis given to the teaching of plastic surgery during this period by the organization of international courses by Lemaitre, an associate professor at the Faculty of Medicine of Paris and chief of an otolaryngologic service in a Paris hospital. Lemaitre had been in charge of a large maxillofacial center at Vichy during the war and had met a number of Allied officers, notably Blair and Ivy. In 1925 he organized an international clinic in his service at the Hôpital Saint-Louis, which was conducted on a yearly basis until 1928. Gillies also held a series of operative demonstrations, and in the following years Eastman Sheehan, Ferris Smith, Kilner, and Joseph conducted courses which were well attended. There being no other way of learning plastic surgery at this time, a number of surgeons from various parts of Europe and from the United States received their training at these courses. Among these the most illustrious was Sanvenero-Rosselli of Milan, the president of the Fourth International Congress of Plastic Surgery held in Rome in October, 1967.

An important contribution to the literature of plastic surgery in the 1920s was Ferris Smith's *Reconstructive Surgery*, which appeared in 1928. Ferris Smith, who had acquired a reputation as a distinguished otolaryngologist, was particularly interested in the technique of repeated partial excision and the use of local flaps on the face. Many considered him one of the finest technicians of his day. Even in those days he had an appreciation of atraumatic technique, and, above all, he placed emphasis on detail.
In the 1920s and 1930s three personalities - John Staige Davis, Vilray Papin Blair, and Harold Delf Gillies - helped to shape the present concepts of plastic surgery as it is practiced in the English-speaking world.

Staige Davis was probably the first outstanding surgeon to devote his entire practice to plastic surgery. When there was little recognition for plastic surgery, Davis, working alone and with little encouragement from his own medical school, made many important contributions over the years - contributions that remain significant even today. His textbook *Plastic Surgery*, published in 1919, was the first book of its kind in the English language. This textbook provided the reader with an extensive review of the literature, a critical appraisal by the author of the methods described, and a voluminous description of his own experience.

A significant surgical contribution by Staige Davis was "the small deep skin graft," often referred to, particularly in foreign countries, as the Davis graft. (The "small deep skin graft" is usually referred to as a "pinch graft.") Halsted had devised the technique, but to Davis belongs the merit of its diffusion in the surgical world. Prior to the development of modern methods of skin grafting, the small deep graft was invaluable in resurfacing granulating areas. Many of Davis' papers remain classics even today. Among these are his papers concerning the theory and practical applications of the Z-plasty (1931), which he often referred to as the "Z-incision." He stressed the value of partial excision of scars (1929), a technique that was to be widely used. His studies on the vascularization of skin grafts in 1925 and the delay of skin flaps in 1933 (German, Finesilver, and Davis) remain valid today and have been repeatedly confirmed by later workers.

Blair and Gillies had a profound influence on the development of plastic surgery, not only in English-speaking countries but also throughout the world at large. Their influence was exerted not only in scientific aspects but also in helping to shape plastic surgery into its present organizational lines.

Each of these men contributed outstandingly to the field of skin transplantation. Gillies developed the tube flap, coincidentally with Filatov (1917), and showed many applications of the new technique in his book *Plastic Surgery of the Face* (1920). Blair defined the process of delay in nontubulated flaps in his paper, "The delayed transfer of long pedicled flaps in plastic surgery," published in 1921.

The development of the technique of split-thickness skin grafting and the paper on the subject by Blair and his pupil Barrett Brown (1929) constitute a landmark in the history of skin grafting. The thicker split-thickness graft gave a more durable type of repair with less shrinkage and wrinkling than the thin Thiersch graft generally used by surgeons for covering raw surfaces and granulating wounds, or the small, deep, so-called "pinch" grafts which resulted in even more contraction and scarring.

To facilitate removal of the split-thickness skin graft, Blair developed a special skin grafting knife and the Blair suction box, which, connected with a negative pressure apparatus, facilitated traction of the skin and flattening of the donor area during the cutting of the graft. In numerous articles written in subsequent years, the St Louis group emphasized the value of early grafting in skin defects resulting from burns and other types of injuries, and the
principle that the best dressing for a wound with loss of skin was a skin graft. *Skin Grafting* by Brown and McDowell (1939) rendered a great service to patients and surgeons during World War II. Converse (1942) emphasized the importance of early skin grafting in war wounds.

**The Development of the Dermatome.** Skin grafting was greatly facilitated by the development of the dermatome by Earl C. Padgett and George F. Hood, the latter a mechanical engineer. Padgett described the three-quarter skin graft, with qualities comparable to those of a full-thickness graft, in 1939. Webster (1956), in a beautifully written and sensitive eulogy of Vilray Blair, recounted an incident that took place during his period of observation at Blair's clinic in the fall of 1927. "One day, while scrubbing for an operation, dressed in his white shirt and trousers, and all white sneakers, with a gauze swathe tied about his face and head, he walked away from the sink and paced up and down, scrubbing his hands and humming to himself. Suddenly he whirled about and burst out in his high reedy voice: 'Webster, did you ever see 'em split leather with a machine?' " It was undoubtedly his interest in an invention of this kind that stimulated Padgett to produce the dermatome ten years later. Padgett had been trained by Blair.

The idea of calibration, one of the chief advantages of the dermatome, was not a new one. Finochietto, an Argentine surgeon, had devised a calibrated knife as early as 1920. Humby, while serving as a house surgeon at the Great Ormond Street Hospital for Sick Children in London, added a roller to the Blair knife which permitted calibration of the graft. The Padgett dermatome, by providing a relatively easy mechanical means for the removal of split-thickness grafts, placed the technique of skin grafting into the hands of all surgeons. I can recall, during my period of training, a group of general surgeons at the Massachusetts General Hospital gathering around Kazanjian to watch him cut a large split-thickness graft free hand. In those days skin grafting was a specialized technique of the plastic surgeon; today it should be a routine procedure in the hands of all surgeons. The service rendered by the dermatome in making possible the frequent use of split-thickness grafting during World War II was immeasurable in terms of saving many lives and limbs.

The development of split-thickness grafting was essentially an American contribution. When I arrived in England to work with Gillies in August, 1940, the first Padgett dermatomes had just been received. In Gillies' hands, skin grafting was still an exceptional procedure in reconstructive surgery of the face, and local or distant skin flaps were more commonly employed. Skin grafting was mostly of the thin Thiersch graft variety, or of the relatively small full-thickness type, known in England as Wolfe grafts. Gillies, in the course of his characteristically humorous and very instructive teaching clinics, would ask us how we would repair a certain defect. Then he would turn to me and say: "If you tell me you are going to use a graft I will send you back to America!" Of course, in many cases he was right, for certainly his was a great school for learning the art of utilization of local tissue. Archibald H. McIndoe, his pupil, was the first British surgeon to utilize split-thickness skin grafting on a large scale for the early and also the definitive repair of burns. Skin grafting was not extensively used in either France or Germany. A visit to a number of German plastic surgery centers a few weeks after the end of World War II showed a predilection for skin flap repair; the dermatome was not known in these countries on the European continent.
Aside from their many scientific contributions, too numerous to be included in this short historical review, Blair and Gillies were instrumental in establishing the specialty of plastic surgery on a solid footing.

Blair can justly be considered the father of the American Board of Plastic Surgery, which was established in 1937. In 1936, in an editorial entitled "Surgery, Specialty Surgery, and 'Plastic Surgery,'" Blair had intimated the need for a Plastic Surgery Board.

It is difficult for a young plastic surgeon to realize the flimsy status of plastic surgery 40 years ago. That status is well exemplified by a personal experience. At the end of World War I, my family moved to Paris where my father was sent by the United States Public Health Service to supervise the health status (preventive medicine) of the returning American Expeditionary Force, and a few years later my father joined the staff of the American Hospital in Paris. After graduating from medical school in Paris and being trained in general surgery, I decided to become a plastic surgeon. On my way to Boston, I spent a few days in New York. My father had corresponded with a former fellow resident, now a general practitioner, who was kind enough to invite me to dinner. At coffee time he turned to me and said, "Now young man, what are you going to do?" When I told him I intended to be trained as a plastic surgeon he fell silent, and I could guess the workings of his mind: "How disappointing it must be for my old friend George to have a son who wants to become a plastic surgeon!"

Again, to quote Webster: "At that time the public generally considered plastic surgeons as 'face lifters' and 'nose whitters.' To be sure, a few surgeons throughout the country were known for their capabilities in the special fields known for their capabilities in the special fields of plastic surgery. There were also those who were close to the border of being ethical, if not unethical, in their practice, and some were definitely below that level. Blair felt that those slightly below the ethical line could be raised if given proper recognition, and those with special abilities should be recognized and their qualities brought to bear for the good of the specialty of plastic surgery."

Staige Davis in Baltimore, Ivy and Warren B. Davis in Philadelphia, Kazanjian in Boston, Blair, Brown, Byars, and their associates in St Louis, Pierce in San Francisco, Peer in Newark, Ferris Smith in Grand Rapids, Webster, Eastman Sheehan, Maliniac, and John M. Wheeler and Wendell L. Hughes, the latter two ophthalmic plastic surgeons in New York, were well known and respected. Safian and Aufricht in New York were perfecting the techniques of corrective rhinoplasty. Many surgeons were practicing corrective rhinoplasty after having taken courses in Europe either with Joseph in Berlin in the 1920s, or in other centers such as Vienna, where such courses were also available.

Opportunities for learning plastic surgery were few in the 1930s. Preceptorships were not numerous, and there were few well-organized plastic surgery services in the hospitals. One of the first active hospital services in the United States was that organized by Eastman Sheehan at the Postgraduate Hospital, the predecessor to our own Institute of Reconstructive Plastic Surgery at the New York University Medical Center. Sheehan trained Straatsma, Milton Adams, Peer, and Barsky. Sheehan was a brilliant technician who had a predilection for operating upon members of the European nobility and was not averse to publicity. He wrote a number of books and did much work on the wounded of the armies of General Franco during the Spanish Civil War.
By an unusual set of circumstances, Sheehan was responsible for the establishment of the Nuffield Professorship of Plastic Surgery at Oxford University. Through personal friendship with Lord and Lady Nuffield (he had sutured the thyroid incision following an operation by Lahey upon Lady Nuffield - with goat hair!), he was offered the Nuffield chair of Plastic Surgery. Because Sheehan had been classified as a Fascist following his activities in Spain, Lord Nuffield was obliged to intervene with Prime Minister Churchill in order to obtain a visa permitting him to enter England. The Council of Oxford University, however, disapproved of his appointment, and T. Pomfret Kilner was appointed the first (and unfortunately last) Nuffield Professor of Plastic Surgery.

Before the establishment of approved residencies and with the exception of the few available preceptorships, the only method of learning was observation, and there were well-trodden paths to St Louis, Baltimore, New York, Boston, and London. One of the most active and well-organized hospital services was that of Burian in Prague. I had the privilege of spending two weeks with Burian in 1938 in his new hospital service, which had been established with the aid of the Rockefeller Foundation.

A residency in maxillofacial surgery was established by Ivy in Philadelphia. Another residency was started at King's County Hospital in Brooklyn by Coakley. For a number of years Ivy's residents spent an additional year in Coakley's service. Webster established his residency program in New York on January 1, 1939, the first resident being the late Milton Dupertuis, Webster's residency program graduated a whole generation of plastic surgeons, many of whom are today leaders in the field.

A curious phenomenon was the publication in 1939 of a book, *Surgery of Injury and Plastic Repair*, by Fomon. Not a plastic surgeon but a medical writer, Fomon had proposed to Kazanjian that he write a book for him. When Kazanjian declined the offer, Fomon made a similar proposition to Eastman Sheehan, who accepted. Some disagreement occurred subsequently, and Fomon published a book under his own name. Although deficient in many ways, the deficiencies reflecting the author's inexperience, the book rendered a service by collecting the known techniques, some of which were well illustrated, and assembling a vast and accurate bibliography.

In Great Britain, prior to World War II, plastic surgery was a monopoly in the hands of Gillies, McIndoe, Mowlem, all from New Zealand, and Kilner, an Englishman. McIndoe, who had been trained in surgery at the Mayo Clinic, was consultant to the Royal Air Force, and Kilner was in charge of plastic surgery at the Ministry of Pensions. These surgeons were active in a number of London hospitals.

A Swedish surgeon, Ragnell, was trained in England by Gillies, returning to Stockholm in the 1930s, where he later headed a service established at the Karolinska Institute. This was the beginning of the Swedish school of plastic surgery.

Léon Dufourmentel, an otolaryngologist, son-in-law of Sébileau, who was professor of otolaryngology at the University of Paris during World War I and during the immediate postwar period, unfortunately was not appointed head of one of the Paris hospital services and was obliged to restrict his activities to private practice. This fact, in addition to the untimely death of Morestin, was responsible for a long period of stagnation in the development of
reconstructive plastic surgery in France. Plastic surgery became commonly known as "chirurgie esthetique," and it was not until after World War II that a new and dynamic generation of plastic surgeons arose. This generation has reached surgical maturity and is making notable contributions to our surgical specialty.

Victor Veau, a pediatric surgeon (Converse, 1962), started making his surgical contributions to the treatment of cleft lip and palate in the early 1920s and doing his outstanding research in the embryology of cleft lip in the 1930s. Lexer, a general surgeon (May, 1962) in Germany, summarized his own work in reconstructive surgery in his treatise Die gesamte Widerherstellungschirurgie, published in 1931.

The period between the two wars also saw the birth of the oldest plastic surgery society, the American Association of Oral and Plastic Surgeons, which was established in 1921. The name of the society was changed to American Association of Plastic Surgeons in 1941. Annual meetings were held; these were small, intimate gatherings until World War II. The meetings comprised operating room sessions at which members gathered around their host and watched him operate. Under the leadership of Maliniac, Aufricht, Palmer, and Peer, another society, the American Society of Plastic and Reconstructive Surgeons, was established in 1931. The proceedings of the Society were published in a European publication, Revue de Chirurgie Plastique, until 1940, after which the Society published its own proceedings.

A picturesque individualist between the two World Wars was Esser, a Dutch surgeon who had volunteered to work with the Austrian army during World War I. Esser did much of his work in Vienna during the war and made a number of notable contributions, such as the application of the rotation flap to the repair of facial defects, the artery island flap which he termed the "biologic flap," and the important contribution of the "epithelial" or skin graft inlay technique.

Following the war, Esser appears to have led the life of a wandering surgeon. For a long period of time he was established in Munich and then in Monte Carlo. In the late 1930s he conceived the grandiose plan of establishing a world center for plastic surgery. For this purpose he requested an audience with Benito Mussolini. In the Palazzo Venezia, Mussolini had his desk at the end of an enormous room, and the visitor walked the long distance under the steady gaze of the head of the Fascist state. It is said that Esser picked up a chair and sat down next to Il Duce, much to the latter's amazement. He then requested an island in "Mare Nostrum" (Mussolini’s Imperial Roman term for the Mediterranean Sea) in which to establish the world center for plastic surgery! The advent of World War II put an end to this grandiose plan.

The first issue of the Revue de Chirurgie Plastique was published in 1931 under the editorship of Coelst. Coelst was a practitioner in Brussels, Belgium, who does not appear to have had any official university or hospital appointments. Through his personal initiative and efforts, he assembled a series of papers of good quality for the period. At the suggestion of Esser, the name of the publication was later changed to Revue de Chirurgie Structive. Esser pointed out, quite correctly, that "plastic" was a poor term which did not define the specialty, and that the term "structive," derived from the Latin structo (I build), was more appropriate. Coelst brought together an international editorial board of high quality which included many
well-known names. The papers were published in whatever language was preferred by the
author and summarized in English, German, and French. By contrast with this early effort,
the American journal *Plastic and Reconstructive Surgery* and the *British Journal of Plastic
Surgery* commenced publication only after World War II.

In 1931 the first congress of the French Society of Reparative and Esthetic Surgery
was held in Paris. This group published in book form the papers read at the congress, edited
by Claoué and Dartigues. Participants in the congress and authors of the papers published in
the *Revue* comprised, in addition to the few full-time practicing plastic surgeons, general
surgeons, otolaryngologists, ophthalmologists, oral and dental surgeons, and orthodontists who
were involved either full or part time in the various aspects of plastic surgery.

Of major interest in the history of this period was the establishment in 1936 of a
European Society of Structural Surgery, which held its first congress in Brussels in that year.
Eminent personalities in the field such as Gillies, Esser, and Kilner participated. The second
congress was held in the following year in London, and the third in Milan in 1938. At the
time of the Milan congress there appeared the first issue of a new international review entitled
*Plastica Chirurgica*, edited by Sanvenero-Rosselli, who established a teaching course for the
training of plastic surgeons in Italy. The publication of subsequent issues was interrupted by
the advent of World War II. These international congresses of the European Society of
Structural Surgery represented the high point of development of plastic surgery prior to World
War II. The contributions to the congresses were of high quality and represented milestones
of progress toward recognition, not only by the public at large but also by the academic
world, of the existence of this new branch of surgery.

Throughout the period between the wars looms the towering figure of Sterling Bunnell.
Bunnell, along with other great pioneers - Alan Kanavel, Sumner L. Koch, Hugh Auchincloss,
Condict W. Cutler, in the United States; Frederick Wood-Jones, the anatomist, in Great
Britain; and Marc Iselin in France - originated the anatomical and physiologic concepts of
reconstructive hand surgery. This type of reconstructive hand surgery. This type of
reconstructive plastic surgery reached its fruition during World War II after the establishment
of specialized hand centers under the consultanship of Bunnell.

Plastic surgery has long passed the stage when it was more or less confined to the
correction of nasal deformities or earlier, during World War I, to maxillofacial surgery. The
pioneers of plastic surgery were actually individualists who operated within the framework
of their own specialized fields - dental surgeons, otolaryngologists, ophthalmologists,
orthopaedic surgeons, and others. Many had little or no training in general surgery.

**World War II and the Growth to Maturity.** Since World War II the scope of plastic
surgery has changed. During this conflict it was necessary to treat a great many complicated
fractures, to replace lost structures, to treat paraplegic pressure sores, frostbite, and burns, and
to prepare soft tissues for orthopedic surgery and the repair of peripheral nerves. Impetus was
given to the development of surgery of the hand and the treatment of burns, as well as
research in tissue transplantation. In this way, reconstructive plastic surgery, as it is now
known, came into being.
As its scope increased over the years, the training of plastic surgeons had to be extended. The additional training entails extensive experience in the basic disciplines, primarily those of general surgery. Only when equipped with the knowledge of general principles common to all fields of surgery can the surgeon be admitted to specialized training in plastic surgery. He should not work in isolation but should be in close contact with all other fields of surgery and medicine, from which he draws benefits and, in return, to which he contributes his specialized knowledge.

World War II saw considerable development in plastic surgery. Because of the fear of massive civilian casualties resulting from air raids, special centers were established in strategic locations in Great Britain for the treatment of both civilian and military casualties under the direction of the Emergency Medical Service. Gillies was the leader in insisting on adequate facilities for the treatment of all patients requiring plastic surgery, military or civilian, including those with severe burns. From the beginning of the war it became obvious that tank warfare would cause numerous burns. During the Battle of Britain the pilots of fighter aircraft were ordered to land their planes in flame in order that they could be repaired and returned to intercept German bombers. As a result many of the Royal Air Force pilots were severely burned.

The Plastic Surgery and Jaw Centers in Great Britain became teaching centers for surgeons of the Western Allies, and considerable progress resulted during this period. Similar units were organized in the United States in a certain number of Army and Navy General Hospitals. Hand surgery centers were also established and generally associated with Plastic Surgery Centers under the guidance of Bunnell.

Plastic surgery gained much stature among the medical profession and the public at large as a result of the accomplishments of plastic surgeons during World War II. Since World War II plastic surgeons have contributed much, not only to the clinical field of plastic and reconstructive surgery but also to research, especially in the field of transplantation (see Chapter 5).

Plastic surgery today offers a wide field for research in transplantation, implantation, genetics, growth and development, speech pathology, and the newer fields of microsurgery and craniofacial surgery pioneered by plastic surgeons.

**The Scope of Plastic Surgery**

Verdan stated in his opening speech on the occasion of the tenth anniversary of the foundation of the Swiss Society of Plastic and Reconstructive Surgery in 1974:

"It is true that plastic surgery is a specialty that is difficult to define and that all the other surgical specialties with the exception of pediatric surgery have a regional character which is anatomically defined. The plastic surgeon extends his surgical activities not only to the skin and its adnexa but also to certain subjacent tissues in locations as diverse as the face and hands, the neck and abdominal wall, the extremities and the genitourinary apparatus, the breasts and scalp. To the term plastic surgery is added the adjective "reconstructive" which implies an extension of the plastic surgeon's activities to the most diverse reconstructive procedures such as vascular and microvascular surgery, peripheral nerve surgery,
transplantation of muscles and tendons and arthroplasties thus overlapping the specialty of orthopedic surgery."

With the development of craniofacial surgery by Tessier and his associates (1967), the plastic surgeon finds himself invading the interior of the cranium, the private domain of the neurosurgeon. Thus, as Vilain (1965) has stated, the plastic surgeon is probably the last of the general surgeons. Unfortunately the general public often envisions plastic surgery as esthetic surgery, essentially the correction of relatively minor defects and the repair of the manifestations of the ravages of aging. The increased popularity of plastic surgery has not lessened this misconception.

It is interesting that the development of the modern era of plastic surgery dating from World War I originated from the activities of surgeons of disparate specialties. Morestin and Blair were general surgeons; Ivy and Kazanjian were originally dental surgeons; Gillies was an otolaryngologist, to name only a few who were the pioneers of the modern era. It is therefore understandable that practitioners of other surgical specialties lay claim to certain plastic surgical procedures which fall into the domain of their specialty. It is just as reasonable that the plastic surgeon abstain from performing operations for which he has not been trained as for the specialists in allied specialties to engage in plastic surgery procedures for which they are not qualified. In many cases plastic surgery is competently performed in specialized areas of oral surgery, otolaryngology, ophthalmology and orthopedic surgery.

J. William Littler, who acquired extensive experience in hand surgery during World War II under the overall guidance of Sterling Bunnell, played a decisive role in bringing hand surgery into the field of plastic surgery in the United States. Littler, the editor of the hand section of this text, decided to become a plastic surgeon. His influence has been preponderant, and he has trained innumerable plastic surgeons in this special field of surgery.

Prior to World War II, Burian in Prague had established one of the world's best plastic surgery services; in 1948 Burian was appointed Professor and Chairman of the Department of Plastic Surgery at Charles University. However, the fragmentation of plastic surgery occurred early on the European continent probably because of the emphasis on maxillofacial surgery needed for the large number of facial gunshot wounds inflicted upon the thousands of survivors of World War I.

In Vienna von Eiselsberg, the general surgeon and professor of surgery at the Allgemeines Krankenhaus, sought a close and intimate collaboration with Pichler, a dentist and physician, as early as 1903. Pichler, the son of a dentist, was sent to Chicago by his father to study under Black at the Northwestern University. After his return to Vienna he started to practice dentistry and worked closely with Eiselsberg. Eiselsberg applied for a maxillofacial unit to furnish Pichler with a position. In 1915, the Austrian Imperial Reserve Hospital No 17 was organized, and Foramitti and Esser from Holland were among its experienced surgeons, capable of performing plastic surgery. In 1917 the outpatient department was also opened to civilians, but the beneficial work of the unit was terminated at the end of the war. It was Eiselsberg who made every effort to preserve the facilities. He succeeded by applying to the university and the government by stating that "the unit would not only be most beneficial for so many patients and the teaching of students, but also to attract foreign physicians and patients."
Thus it was the personal efforts of a general surgeon that led to the foundation of one of the schools of maxillofacial surgery in Austria.

Wilflingseder, who trained under Gillies, became the head of a division of plastic surgery at the University Hospital in Innsbruck in 1957. In 1966 a chair of Plastic and Reconstructive Surgery was founded for Wilflingseder, and a Department of Plastic Surgery was placed under his direction.

In Germany, departments of maxillofacial surgery originated in the military hospitals for the facially disfigured early in the 1920s. These were headed by Axhausen in Berlin, Rosenthal in Leipzig, and Lindemann in Düsseldorf. These three men became the founders of German face and jaw surgery and were later joined by the much younger Wassmund. The pupils of these men, especially Schuchardt and Schmid, led the transition from maxillofacial to plastic surgery.

In Hamburg the Nordwestdeutschen Kieferklinik was established after World War II, when Schuchardt was asked to come to Hamburg, and he transferred 200 wounded soldiers from a hospital in Schleswig-Holstein, the province north of Hamburg. Schuchardt had managed to bring these soldiers out of an area occupied by the Russians.

These separate origins explain why there are two disparate German societies of plastic surgeons. The Vereinigung Deutscher Plastischer Chirurgen strives to have plastic surgery considered as a specialty in its own right; the older, dental-oriented group clings to a regional specialty concept (Kiefer und Gesichtschirurgie: jaw and face surgery). There is also the Society of Plastic and Reconstructive Surgery, which developed as a section, later a branch, of the Deutsche Gesellschaft für Chirurgie. Its membership is open to all doctors who are interested in plastic surgery.

In France, surgeons trained in Great Britain and the United States after World War II rapidly established the French School under the leadership of Claude Dufourmentel (the son of Léon Dufourmentel) and Morel-Fatio; they were followed by surgeons in Switzerland and other countries of Europe and throughout the world. Marino and Malbec provided leadership for the specialty in South America.

Ten years after the end of World War II, in 1955, the International Association of Plastic Surgeons was organized under the aegis of Tord Skoog and held its first International Congress in Stockholm.

The presently thriving specialty of plastic surgery in Australia began under the leadership of Rank and Wakefield after they had acquired additional training in England and experience during World War II. Penn, who had served as chief of a hospital for the wounded requiring plastic surgery during World War II, was the founder of the specialty in South Africa. As a specialist in dermatology and urology, Ohmori, the founder of the Japanese Society of Plastic and Reconstructive Surgery, treated patients with scar contractures from burns at the Tokyo Metropolitan Police Hospital. While attending a course on dermatology at Harvard Medical School in 1952, Ohmori spent most of his time watching Bradford Cannon performing plastic surgical operations at the Massachusetts General Hospital. He acquired further knowledge in England and Scotland, the United States and Australia. A
training program was started in 1958 at Tokyo University Hospital and the Tokyo Metropolitan Police Hospital.

**Plastic Surgery as a Specialty: Its Future**

During the early part of the nineteenth century prior to the discovery of general anaesthesia and prior to the surgeon's entry into the abdominal cavity, the surgeon was mostly concerned with what was referred to as "external pathology." This explains the large number of reconstructive plastic surgical operations performed during this period.

Specialization came much later, especially during the present century with increasing impetus. Even the "general" surgeon is becoming a specialist in many respects. Let us read the words of a Professor of Surgery, Francis Moore (quoted by Edgerton, 1974): "Are we to go along with the concept that those who operate on the face, the neck, the head, the lip, the eye, the hand, and the breast are the only persons who should do any of those operations?" A plastic surgeon's answer is: "Of course, the answer is 'no,' but in the case of many particular operations in those regions, if the plastic surgeon can do these operations not only better, but also more safely and more efficiently without increasing the medical cost, then those operations probably should be done by a plastic surgeon whenever one is available. We must deliver reconstruction not only better, but also more efficiently" (Edgerton, 1974).

The principles of plastic surgical techniques are special, and the conceptual application of these principles requires indoctrination. Once indoctrinated, the plastic surgeon can apply these concepts in any area of the body if he has had basic training in "general" surgery. During his surgical training he must seek training in as many areas of surgical endeavor as possible.

Postresidency fellowships in various countries and continuing education symposia such as those organized by the Educational Foundation of the American Society of Plastic and Reconstructive Surgeons are available to those who require additional training. The education of the plastic surgeon, as for all members of the medical profession, is a continuing obligation during his entire professional career.

Whether in a university setting or in large-city private practice, the answer to complete, efficient coverage of all phases of plastic surgery is the team approach. After a broad training in general surgery with periods of training in the surgical specialties and in plastic surgery, each plastic surgeon of the team subspecializes in his area of preference. The team should include not only plastic surgeons but also members of allied specialties in the field of medicine and dentistry. Thus the various talents are centralized for the benefit of the patient. The multidisciplinary approach has been brought to the foreground in the treatment of craniofacial malformations. Various surgical, medical, and dental specialists and representatives of the basic sciences are members of the team. It is the interdisciplinary interchange that makes for surgical progress and provides for the optimal care of the patient.

In smaller cities and towns the plastic surgeon will find himself called upon to solve problems which the general surgeon or other specialists will find necessary to refer to him. He will cover the broad field of plastic surgery, seek collaboration with other specialists, and refer to the large centers those patients he feels he is not equipped to treat.
Esthetic surgery is here to stay as a legitimate subspecialty of plastic surgery. Because of the psychological component in the patient's motivation in this type of corrective surgery (see Chapters 21 and 22), the indications for surgery should be carefully evaluated. The psychological and, often, vocational gains resulting from esthetic surgery, whether large or small, often have a considerable impact on the patient's life style. It is appreciation by the lay public of the results obtained that has led to increasing demands for this type of surgery.

Tagliacozzi wrote, "We reconstruct and complete parts which nature had given but which were destroyed by fate, and we do so not so much for the enjoyment of the eyes as for psychic comfort of the afflicted."

Tagliacozzi was damned, exhumed, and buried in an unconsecrated ground because of his reconstructive nasal operations, which were against nature and illegal. Only in our time have the problems and purpose of plastic surgery been valued theologically. Pope Pius XII declared on October 14, 1958:

"If we consider physical beauty in its Christian light and if we respect the conditions set by our moral teachings, then esthetic surgery is not in contradiction to the will of God, in that it restores the perfection of that greatest work of creation, man" (Wilflingseder, 1975).
Face to Face With Deformity

The plastic surgeon must first make an accurate evaluation of the deformity, of the degree of displacement of the tissues, of the extent of the defect, and of the functional disability. Is the deformity apparent or real? What is the extent of the true defect? Having made his appraisal, he must then consider various methods of treatment in relation to the type of deformity, the age of the patient, and the patient's mental attitude toward the surgery. The methods to be employed are also considered: a simple and rapid technique may give an adequate result; a more intricate type of repair may give a better permanent result. Which is the best suited to the particular patient? A primary defect may be satisfactorily repaired, but the result may be obtained at the expense of a secondary defect which is a more serious deformity than the original one.

Certainly, detailed plastic surgery and a superior final result are possible only in the patient who is willing to give the highest degree of cooperation. The demands of the patient stimulate the surgeon towards progress. In the developing countries the patient may be satisfied with a type of result that would not satisfy the patient who lives in a country where competition for employment and social status requires that he achieve the best result possible in appearance and function. Careful diagnosis for the restoration of function is of particular importance in hand surgery.

Planning Repair

In planning the repair, the surgeon must choose from many methods of treatment: shifting of local tissue; transplantation of tissue from a distance; skin flaps; grafts of skin, dermis, fat, fascia, tendon, or muscle; the restoration of the skeletal framework by bone or cartilage; suture or grafting of nerves; the transposition or grafting of muscles. He must consider the advisability of the use of inorganic implants in certain favorable sites.

The unhurried, deliberate, judicious approach to the problem at hand is the key to success in plastic surgery. Only if the true extent of the deformity is fully appreciated can an adequate plan of treatment be established. It is true that in some types of cases the "wait and see" approach can be employed with impunity. The motto may be: "Let's get in and see!" A retracted, scarred area is excised, the true defect becomes evident after retraction of the surrounding soft tissues, and the defect is covered with skin grafts. With this approach the surgeon would find himself in trouble had he planned a skin flap from a distant area, for the flap would not fit the defect unless careful measurements had been made prior to surgery.

The Apparent Versus the True Defect

In many cases the defect is evident. In a deformity of the mandible, the change in the occlusal relationships of the teeth provides a satisfactory guide to the size of the defect. A retracted, everted lower eyelid may be compared to the contralateral lower eyelid and an accurate estimate of the required amount of skin readily obtained; a missing ala may be compared to its unaffected twin and the size of the composite graft to repair the nasal defect readily evaluated.
A method of actually mapping the extent of the true defect and comparing it with the apparent defect is illustrated. Measurements are made from landmarks such as the acromion and the styloid process, and in this manner the size of the area to be covered by grafts or a flap can be evaluated with a certain degree of precision. When the defect is bilateral, as in an extensive contracture of the cervical area resulting from burns, fixed points at the mental symphysis and the sternal notch permit one to obtain a fairly accurate evaluation of the amount of missing skin by measuring the distance between these two points in another individuals of approximately the same size and comparing this distance with that between similar points in the patient.

The apparent defect is often the result of the loss of tissue followed by the contraction and contracture of the adjacent parts. The apparent defect may also be a relative one: the chin may appear deviated to one side because of a deviation of the nose; the nose may appear too prominent in the profile because of lack of development of the mental symphysis. In establishing the diagnosis of a facial deformity, it is essential to place the face according to the Frankfort horizontal and the midsagittal plane. In this position many facial discrepancies become evident.

**Aids in Planning**

There is no substitute for the careful clinical examination of the patient. In deformities of the face, photographs taken in standardized positions according to the Frankfort horizontal and the midsagittal plane of the face are of assistance in establishing a diagnosis and a plan of treatment. Serial photographs are indispensable for following progress. Facial casts aid in planning contour restoration or other changes in form but are usually not required in the average case. Bony deformities require a careful roentgenographic examination; cephalometric roentgenograms are of invaluable assistance in planning changes in the form of the skeletal framework of the face.

The team approach is essential for progress. Many problems in plastic surgery require consultation with specialists in other fields. The collaboration of dental specialists is essential in the treatment of such problems as jaw fractures, cleft lip and palate, and other craniofacial malformations and in reconstruction following excisional surgery for malignant disease. Postoperative physiotherapy, guided by the surgeon, is an important part of hand rehabilitation.

There are certain intangible qualities which make for excellence in plastic surgery; a sense of proportion and contour, esthetic judgment, and attention to minute detail may spell the difference between success and failure. The part-time plastic surgeon may not have these qualities. The everyday preoccupation with problems which require solution makes for excellence.

Not the least of the aspects of treatment is the psychological support provided by the surgeon and his team; psychiatric treatment is obligatory in some cases. The psychological make-up of the patient often influences the technique or repair; simple methods may be required in problem cases.
A characteristic of plastic surgery is its diversity, both in the problems to be solved and in the methods available to solve the problems. "There are more ways than one to skin a cat": there is the simple and effective way, and there is also the complicated way. The beginner will often choose the most devious route when he is blind to the most obviously simple. One of the most important aspects of residency training is to impart the importance, after a diagnosis of the deformity has been made, of considering in turn all possible methods of treatment, weighing the alternatives, and choosing the most suitable.

Regional Entities of the Face and Neck

In reconstructive procedures in the face, for example, in skin grafting for burn contractures, it is important to observe the confines of the regional entity of the face. The first of these is the forehead, extending from the eyebrows to the hairline. The regional entity of the forehead should be preserved when a large forehead flap is employed in reconstructing the cheek; for example, a one-piece split-thickness skin graft will provide a satisfactory esthetic result. Other regional entities are the orbital region, the nasal region, the region of the lips, limited laterally by the nasolabial folds and secondary lines of expression situated laterally to the angle of the mouth, and the labiomental fold. The region of the cheek is subdivided into two entities, an anterior, which is soft, pliable and mobile, and a posterior, extending over the parotid-masseteric region, which is relatively firm and less mobile.

Interpretation of the Deformity

The deformity may be minor to an impartial observer. To the patient, however, the deformity may assume a magnitude out of all proportion to reality. One of the main purposes of plastic surgery is to restore the mental health of the patient, thus permitting a return to active social participation. The psychological trauma suffered by the patient may be related to the injury and the circumstances of the accident or may be due to comments of relatives or friends. One of the distressing aspects of this type of surgery is that the successful repair of even major traumatic deformities is not necessarily followed by a cure. Deep seated psychological disturbances may persist.

In major deformities, physical diagnosis is more obvious, but in many serious disfigurements, despite the significant progress made in surgery, the appreciable improvement achieved does not always restore the physical appearance of the patient. The severity of the psychological disturbance is not necessarily related to the severity of the deformity, nor is it directly proportional to the degree of improvement accomplished by surgery. Cultural aspects complicate this picture. A classic example is the scar resulting from the Heidelberg duels, considered an emblem of an individual's manliness rather than a disfigurement. Severe facial disfigurement is one of the worst physical psychosocial handicaps (see Chapters 21 and 22).

In civilized man the face alone remains unclothed and exposed. An injury resulting in distortion of the features thus sets the unfortunate individual apart in a highly organized society where a premium is placed upon beauty and facial symmetry. Because disfigurement of the face becomes a serious social handicap, the surgical treatment of facial injuries is of special significance, as it serves to restore the inner feelings of happiness and well-being in addition to the outer appearance and function.
The need for the rehabilitation of the facially disfigured is well recognized in the present era. Around 1950 a change took place in regard to the treatment of patients requiring massive resection for head and neck cancer. The disease-oriented surgeon proceeded, in the past, with the necessary mutilating surgery following the philosophy that all means are good to preserve life, irrespective of the esthetic and functional consequences to the patient. This philosophy no longer prevails: the patient demands more than the preservation of life. The quality of life is important to the patient as is the quantity of life which the wide resection of hard and soft tissues is able to achieve. While the anticipation that radical extirpative surgery gives the best chance for a cure is reassuring to the surgeon, the expectation that satisfactory reconstruction is feasible is also comforting to the patient.

**Body Image**

The body image is a basic component of our self concept and our feeling of personal identity. It includes both the mental picture we have of our physical characteristics and our attitudes toward these characteristics. It stems from both conscious and unconscious sources (Macgregor, 1974a, b).

The body image develops slowly and undergoes many changes in the course of growth and development. The perception of one's physical characteristics begins to take shape probably around the age of 6 months of life when the infant explores and discovers his body. Later, as he begins to play with other children, he gradually develops a vague idea of what his body can or cannot do. This is the beginning of the body concept. As time goes on, the attitudes of others play a major role in the image he has of his body and its parts.

A patient can incur a deformity or undergo correction of the deformity, but his reactions may well depend on the reaction of others, which may in turn bring about a change in his body concept. Some people incorporate defects or corrections in the body image, while others retain a distorted image. By using preoperative photographs of the patient or a mirror to determine how the patient views himself, it is often possible to learn to what extent the patient's perception of himself is realistic or unrealistic.

**Aids in Diagnosis**

The diagnosis of a defect and the distinction between the true defect and the apparent defect has been discussed earlier in the chapter. The plastic surgeon is confronted with difficult decisions and diagnoses in facial deformities and abnormalities. In addition to the clinical examination, clinical photographs and a summary knowledge of artistic anatomy are of invaluable assistance.

**Anthropometric Points of the Face**

Physical anthropologists employ methods of measurement which permit determination of significant likeness and differences between individuals and races. These standardized measurements are useful when attempting to restore the structure and contour of the deformed face. Among the commonly employed anthropometric points are: trichion, an imprecise landmark, the midpoint of the hairline on the forehead; nasion, the most anterior point of the midline of the frontonasal suture; subnasale, the point beneath the nasal spine where the nasal
columella merges with the upper lip in the mid-sagittal plane; pogonion, the most anterior point on the contour of the chin; menton, the lowest point on the symphyseal outline; and gnathion, the point obtained by bisecting the facial and mandibular planes. The mid-sagittal line, a vertical line passing through these points, divides the face into halves. Tragion is the notch immediately above the tragus of the ear; orbitale is the lowest point on the infraorbital margin; the Frankfort horizontal passes through these points.

Measurements of facial dimensions are taken according to three planes: vertical (facial length), frontal (facial width), and sagittal (facial depth). Facial width is obtained by measuring the distance between the most prominent points on the zygomatic bones. Facial depth is determined by measuring the distance from the external auditory canal to various points such as nasion, subnasale, and gnathion. The distance between pogonion and gonion, the tip of the angle of the jaw, determines the length of the body of the mandible; the distance from the nasion to the tip of the nose equals the length of the nose.

Horizontal lines passing through trichion, nasion, subnasale, and menton divide the physiognomic face into thirds, theoretically of equal height; in practice, however, each third of the face differs in size from the others.

Some Principles of Artistic Anatomy

Beauty has no universal criteria and varies from culture to culture and from century to century. Burkhardt (1929) cites the work of Firenzuola (1802) on female beauty written in the 16th century: "The nose, which chiefly determines the value of the profile, must recede gently and uniformly in the direction of the eyes; where the cartilage ceases there may be a slight elevation, but not so marked so as to make the nose aquiline, which is not pleasing in women..." As delicacies of details, he mentions a dimple in the upper lip, a certain fullness of the lower lip, and a tempting smile in the left corner of the mouth. Such a description would infer that the smile of "La Gioconda" (the Mona Lisa) is not necessarily one of mystery but rather a habit induced by what was considered the style of the period. Large hips and a robust body were much admired as recently as the Victorian age; crease lines around the neck were called the "necklace of Venus".

Contemporary standards of beauty are epitomized in advertisements showing young, slender-bodied models with perfectly proportioned facial features. Beauty basically reflects an assemblage of esthetic properties which commands approbation in the specific culture.

Today people are turning to plastic surgeons in increasing numbers to give them these valued features, to correct minor defects, and to repair the ravages of age. It is their hope that such surgery will improve their life style in a highly competitive society which places considerable emphasis on youth and accepted standards of beauty.

The illustration shows in tracings from pre- and postoperative photographs how far nature may stray from ideals of beauty, and the results of the surgeon's attempt to correct nature's mistakes.

Proportions of Human Form. In making his corrections, the surgeon tries to reform the affected body or face to an acceptable cultural standard. In doing so, he must also be as
well acquainted with the accepted proportions of the human form as are the artists who specialize in portraits or nudes.

Leonardo da Vinci sketched and measured many faces and figures to determine geometrically what he called "the divine proportions." Many of his measurements and divisions remain the basic tools in art school for teaching life classes in drawing. The illustration is a pen-line copy of a well known crayon sketch by Leonardo in which he appears to have analyzed the shape and relationships of the various features of the face. No descriptive accompanying notes explain his geometric lines. The following illustration is also a tracing of a sketch by Leonardo. A translation of his notes reads as follows: "Proportions of the head. From the eyebrow to the junction of the lip with the chin, and from there to the upper edge of the ear near the temple, there is a perfect square, the side of which measures half a head, and the hollow of the cheek bone is halfway between the tip of the nose and the back portion of the jaw." Next figure shows distortion of the square in Apert's syndrome.

If one takes the same Leonardo sketch and superimposes the ear, his following note is understood. "From the edge of the orbit to the ear, there is the same distance as the length of the ear, in other words one-third of the head." It would then apparently follow that the distance from the hairline to the chin is three ears long and also three noses long. He wrote, "The distances from the chin to the nose and from the hairline to the eyebrows are equal, each of them to the height of the ear and to one-third of the face."

Other proportions of the face taught in art schools today are still credited to Leonardo. For example, the distance between the eyes is equal to the width of one eye. It is also pointed out that, in the ideal Caucasian form, the nostrils should not flare more laterally than a line dropped vertically from the medial canthus. The mouth should extend laterally to a line dropped from the medial margin of the limbus. Beyond this point the mouth is too large. The figure is a tracing from a photograph of a patient with orbital hypertelorism, showing the wide deviation from normal measurements. The eyes are two lengths apart, and lines "e" and "f" are not longer vertical.

In considering the face in relation to the body, one should remember that the face from chin to hairline is the same length as the hand, and the nose is the same length as that of the thumb. The eyes are situated in the exact center of the head, between the top of the skull and the chin. The patient shown has, if the mouth were closed, eyes placed three-fifths of the distance down from the top of the head to the chin. His appearance suggests mental deficiency. This impression is corrected in the sketch by placing a normal-sized cranium above the same features and closing the mouth so that the chin is shorter and the teeth are in occlusion. This figure shows a patient with the eyes set too high in the face.

Eyebrows should always lift as they follow the rim of the orbit laterally, to give a youthful appearance. The brow should never follow the same curvature as the two lines just below it - the line of the contour of the globe and the line of the upper rim of the orbital cavity. The repetition of three lines of the same curvature is not artistic and gives an uninteresting appearance. An older, more serious appearance is characteristic of individuals with brows slanting downward as they progress laterally.
On straightforward vision, the rim of the upper eyelid should touch the edge of the pupil; the lower lid touches the limbus. It was pointed out by Max Brödel, the father of medical art in America, that the white of the eye showing between the limbus and the lower lid was considered to be a sign of psychoneurosis or psychosis. It is doubtful whether many psychiatrists would agree with Brödel's observation. Certainly this would not hold true with elderly people.

George Bridgman, long considered the finest instructor of life drawing in America, at the Art Students League in New York City, evolved a system of simplifying and blocking masses of human figures into geometric shapes and giving them increased definition. Constructive anatomy was an integral part of the course. Bridgman saw four distinct forms in the face: (1) the square or rectangular forehead; (2) the flat cheekbone area; (3) the triangular form of the lower jaw; and (4) an erect cylindrical form on which are placed the base of the nose and the mouth. Bridgman (1973) saw the nose as a wedge, with its root in the forehead and its base in the upper lip. While Bridgman's knowledge of the substructures of the nose leaves something to be desired, he was able to simplify the nose in his drawings. He described two wedges meeting on the bridge of the nose and tapering toward the forehead and the bulbous tip, and remarked that the bulb rises from the middle of the upper lip (septum), expands into a bulbous tip, flows over the sides, and flares out to form the wings of the nostrils.

Artists of the past have taught that the upper lip is composed of three muscles and the lower lip of two muscles. They taught that the preliminary sketch should be diagrammed to show these divisions and thereby facilitate production of the finished product by giving the student a simple understanding of the subtle lip form.

Most artists have difficulty in drawing the ear because of a lack of understanding of the anatomy. It appears to be a complex structure because of the intricate convolutions. Simplification of the structure into an elongated "C" for the helix, a "Y" for the superior and inferior crura, the triangular fossa, and the concha, and a "U" for the lobule renders it understandable. Any surgeon planning reconstruction of the ear should first practice drawing it or modeling it in clay.

The length of the body in relation to the head varies according to the artist. Leonardo claimed the head to be one-eighth the length of the body, the leg from the crest of the ilium to the base of the heel one-half the length of the body, and the distance from the fingertip to the center of the chin one-half the length of the body. At that time Leonardo was interested in the Platonic theory of the geometric representation of the universe as discussed in the book of Fra Luca Pacciolia (circa 1445-1514), with whom Leonardo collaborated. According to the position in which one places the human body, the body may be enclosed within a square because of the equal dimensions of the arm-span and the body height when they are perpendicular to each other, in a circle when the limbs are more or less in abduction, and in a pentagon (the Pythagorean symbol of a microcosm). Leonardo's plates to this effect expressed an esthetic rule rather than anthropologic fact, and he later abandoned that concept. Richer (1920) of the Ecole des Beaux Arts in Paris taught that the body length equaled 7.5 heads. Richer further divided the body into masses for study and analysis.
The diagram by Lanteri of the Ecole des Beaux Arts shows his view of the circumscribed forms or masses of the face. It should be noted that both Lanteri and Bridgman see the infraorbital area as part of the flat zygomatic area, not as a separate mass, as the cosmetic surgeon would see it. Leonardo paid considerable attention to the infraorbital area in many drawings, emphasizing the area in older faces and in his own self-portrait.

Photography

Photography is essential for diagnostic purposes, as a record of the progress made in multiple-stage operations and as a "before" and "after" record of the surgical result. Photographs are also important medicolegal records.

Gillies, at the First International Congress of Plastic Surgery in Stockholm in his speech at the Congress banquet, said facetiously, "I have been asked to speak about the important advances in plastic surgery. I think the most important advance is photography!"

In facial surgery the photograph serves as a means of determining how the patient views himself and thus of learning to what extent the patient's perception of himself is realistic or unrealistic. In the severely disfigured patient, total rehabilitation often cannot be achieved; the comparison of the preoperative and postoperative photographs will help the patient to perceive the improvement achieved. "Did I really look like that?" is his frequent comment.

Consistency in Medical Photography: Standards for Comparison. Any surgeon attending a convention or congress will notice the frequent absence of any type of standard of comparison between preoperative and postoperative photographs of patients; the position, the lighting, and the exposure vary. Often the preoperative photographs shows the patient in the position and under the lighting and exposure which show the deformity at its worst; the postoperative view may be taken at an angle, with flat lighting, and with the most favorable photographic exposure. The surgeon does not mean to be dishonest, but he is. The same observation applies to publications. When the surgeon takes his own photographs with a direct flash attachment, he is bound to obtain differences in exposure, and he is also dependent upon the developer of the pictures.

A professional photographer is always desirable but is not always available. Some advice from Mr. Don Allen, the photographer of the Institute of Reconstructive Plastic Surgery since 1947, is pertinent.

The Role of the Medical Photographer. The medical photographer must ask himself the following questions: What is the purpose of the photographs? How do they differ from ordinary photography? The photographer must be closely associated with the field of medicine, usually through a hospital affiliation. Most of his work is governed by a strict set of rules. Photographers outside the medical field remark that they are nearly totally bound up by confining limitations; this is true. The main confining limitation is consistency. Consistency is the constant challenge.

A medical photograph must be an accurate, pictorial (visual) record relative to a certain condition. It may stand alone as a single photograph tied to a single date, or as part
of a continuing, comparable record of the progress achieved by staged surgical procedures over an indeterminate period. To ensure its reliability the photograph must be consistent in quality, position, and accuracy.

Color transparencies serve a dual purpose, since good black and white photographs can be made through internegatives. There are many good color processing laboratories available throughout the world to give anyone fast, quality service. Color transparencies are also useful in illustrating lectures.

Vast amounts of visual records would be lost if it were not for the color-loaded, single lens reflex camera in hands of either the doctor, nurse, or technician. When the original color photograph or its black and white reproduction is not of top quality, more than likely the culprit is the lighting. Most of the camera units incorporate a single-source strobe light, which is almost always mounted close to the lens axis, a feature which tends to produce a photograph without the contour details obtained by adequate lighting. This is an unavoidable characteristic, but the fact that the unit will produce consistently good color and exposure makes the unit most valuable.

The four major factors relating to these goals are the studio, the camera, the patient, and the lighting.

The studio should be large enough to make use of a focal length lens angle long enough to yield no distortion and to permit photographic patients full length. Appropriate eye level markers - or fixed points to aid the patient in holding a given position - should be available. This requires a secure and comfortable chair of the correct height that can easily be moved.

The camera should be of the single-lens, reflex type with interchangeable lenses, and good optics, capable of strobe-synchronization. The single-lens reflex helps to achieve a correct camera angle.

The patient should be photographed in a comfortable atmosphere, without make-up, distracting clothes, interfering hair, or jewelry. Long hair should be cleared from the face.

The lighting is usually achieved by employing a set of at least three studio-type strobe light heads equipped with modeling lights. Strict lighting rules produce constant results. One must remember that the camera does not lie, but the lighting can and will unless careful attention is given at all times.

The patient's face should be placed in a position in accord with the horizontal (Frankfort) and mid-sagittal planes of the face.

Illustrations. There are several basic views to demonstrate proper alignment, correct and consistent lighting, and relative magnification: full-face view, submental views (2), matching three-quarter anterior views (2), and matching left and right profile views.
The production of each patient photograph must be guided by (1) proper positioning of the patient; (2) proper camera angle approach; (3) controlled lighting; (4) consistent photographic technique; and (5) proper laboratory finishing.

The photographic laboratory offers the final control. Magnification and alignment must be maintained at this, the final stage.

**The Black and White Print Versus the Color Transparency.** If the photographs are taken under the conditions described above, a transparency is as accurate a document as a black and white print. The print has the advantage, however, that it can be more easily examined and placed on the wall of the operating room, where, because of its larger size, it can be readily and more accurately examined.

**The Plastic Surgeon and the Integument**

Although the plastic surgeon is concerned with the repair of the skeletal framework, muscles, tendons, nerves, and vessels, he must, in order to ensure a successful result, obtain adequate cutaneous covering of his underlying surgical procedures. He must, therefore, be an expert in the management of soft tissue wounds, whether operative or traumatic in origin.

**Elasticity, Extensibility, and Resiliency of the Skin**

The plastic surgeon's tasks in repair and reconstruction involve both soft and hard tissue. The tissue that occupies the majority of his operating time is the integument, the skin (see Anatomy of the Skin in Chapter 6). The skin is elastic, extensible, and resilient; these characteristics vary from birth to old age.

**Lines of Tension.** Skin possesses a degree of elasticity owing to the presence of elastic fibers in the dermis. Elastic fibers are disposed in bundles with the collagen fibers, many of them looped spirally around collagen fibers, and are distributed through the dermis, becoming finer toward the surface of the dermis (see Chapter 2). The elasticity maintains the skin in a state of constant tension. This is demonstrated by the gaping of wounds following incision, and also by the immediate contraction of skin grafts as they are removed from the donor site; the thicker the skin graft, the greater the amount of elastic tissue and associated contraction. The elasticity and extensibility of the skin facilitates the shifting of skin flaps. Degeneration of the elastic tissue in the skin of the aged is a contributing factor in the relaxation of the skin of the face and the formation of excess skin folds, which serve as a source of skin for flap repair.

The collagen and elastic fiber bundles of the skin are arranged along "lines of tension." The existence of lines of tension in the skin was first noted by Dupuytren (1832) in describing wounds of the skin made by penetrating instruments. He reported the case of a cobbler who committed suicide by stabbing himself with an awl; the awl was pointed at the tip and round in section, but the wounds in the cobbler's skin were linear in outline, as though made by the blade of a knife.

Langer (1861) found that, following puncture of the skin in various parts of the body, the puncture holes had a tendency to open in a direction corresponding to the normal tension
of the skin. Langer considered that human skin was less extensible in the direction of the lines of tension than across them. He attributed this fact to the structure of skin, which he described as consisting of a network of rhomboid meshes permitting greater tension in the direction of the shorter diameter. When placed under tension, the fibers straighten and the meshes are stretched; the fibers themselves are stretched when tension is continued.

Langer's concept was not corroborated by practical experience, as Langer's lines were found to run across natural creases and flexion lines. Practical experience has shown that wounds heal better and scars are less conspicuous when incisions are made within, or parallel to, natural flexion lines of lines of facial expression. Cox (1941), working under the direction of Wood-Jones, made sections of tissue removed from a wound incised parallel to a flexion line. Sections of skin made in two planes, one exactly at right angles and another exactly parallel to the long axis of a wound, indicated a striking difference in structure according to the plane of the section. Sections taken at right angles to the long axis of the wound showed a marked preponderance of connective tissue and elastic fibers cut transversely; sections parallel to the long axis of the wound showed that the majority of fibers extended longitudinally.

Gibson (1967) has shown that, when skin is stretched, collagen and elastic fibers become aligned in the direction of the stretch (see Chapter 2). This condition exists in the lines of expression or creases of flexion. Wounds within or parallel to these lines are less subject to tension from the activity of the underlying musculature which has produced the lines of tension.

The Lines of Minimal Tension. In a cutaneous defect, maximal contraction results in a scar (contracture) whose long axis crosses the lines of minimal tension at right angles. The lines of minimal tension are the result of adaptation to function, the skin being constantly pulled and stretched by the underlying muscle and joint. The connective tissue, collagen, and elastic fibers are arranged in bundles which are perpendicular to the underlying muscles. A scar parallel to the lines is not subject to the intermittent pull of the subjacent muscles - thus the term "lines of minimal tension" (Converse, 1964), indicating that a scar placed within a line of minimal tension or parallel to it will be submitted to minimal tension during the period of healing. Gibson (see Chapter 2) refers to these lines as "lines of maximal tension," indicating thereby that the bundles of connective tissue, collagen, and elastic fibers are submitted to a longitudinal maximum tension within or parallel to the line of tension. Borges (1974) prefers the term "relaxed skin tension lines" in describing these lines.

In an ordinary section of human skin, the collagen fibers of the dermis appear to be arranged haphazardly. If the skin is held in a stretch position during fixation, a proportion of the fibers will be found oriented along the lines of stretch.

In the head and neck, the lines of minimal tension are the response to adaptation to two different types of functional mechanisms. The first type is represented by the lines of habitual expression in the face, such as the lines in the forehead, the eyelids, the nasolabial folds, and other lines of expression around the mouth. The second type, the lines of skin relaxation (such as the horizontal circular lines in the neck), results from movements of flexion and extension. Lines of relaxation, of flexion and extension, are formed in the various areas of the body - the trunk, the limbs, the hands and feet.
A scar which traverses the lines of minimal tension of the skin at right angles is subject to constant changes in tension as the result of the activity of the underlying musculature; hypertrophy of the scar develops. Only a slightly visible scar results when incisions in the neck are made within a skin fold or crease, or are parallel to the fold. Considerable width can be excised on either side of an incision parallel to or in the skin folds without materially increasing tension when the wound is closed, for the skin around the folds is loose and redundant.

**Lines of Expression.** Lines of expression are produced by repeated and habitual contraction of the underlying muscles of facial expression. In some regions a number of muscles act in unison. The nasolabial fold, for example, represents the area of junction between the skin of the lip, which is tightly bound to the underlying orbicularis oris muscle, and the more loosely bound skin of the cheek over the buccal fat pad. The nasolabial fold is also formed by muscular contraction of the zygomaticus, quadratus labii superioris, and caninus muscles, and in part by the risorius and buccinator muscles.

The supraorbital wrinkle lines and the transverse lines of the forehead are caused by the contraction of the frontalis muscle, which is inserted into the skin of the lower forehead. In the upper eyelids, many fine perpendicular strands of fibers of the levator aponeurosis terminate in the dermis of the skin and in the tarsus to form the tarsal fold. Similar insertions in the lower lid create the fine horizontal lines of the lower lid, which are accentuated by the contraction of the orbicularis oculi muscle. The sphincter action of the orbicularis oculi muscle is altered by its origin and insertion at two fixed points, the canthal tendon at the medial canthus and the lateral canthal tendon and raphé at the lateral canthus. Contraction of the lateral portion of the muscle produces lines; wrinkles are at right angles to the action of the muscle. In the upper portion of the dorsum of the nose, the corrugator supercilii and orbicularis oculi muscles act somewhat antagonistically to the frontalis to form the almost vertical lines observed during the act of frowning.

The oblique lines on the side of the nose are the consequence of the action of the angular head of the quadratus labii superioris and the procerus muscles. The vertical lines in the lower part of the nose are caused by the contraction of the transverse portion of the nasalis muscle. Crease lines develop radially from the oral fissure. At the angles of the mouth, however, the combined action of the quadratus labii superioris and other muscles in this region causes the lines to blend with those of the nasolabial fold. The formation of the lines on the lateral aspect of the chin results from the action of the triangularis, quadratus labii inferioris, and mentalis muscles.

The transverse lines across the neck separate folds of excess skin, permitting extension of the neck. Near the chest the horizontal neck lines assume a more oblique direction.

Every individual possesses lines of expression that become more apparent when the muscles contract. Wrinkles are less evident in young individuals; however, in old age skin creases and wrinkles are more numerous because the skin, through degenerative changes, has lost its elasticity and becomes redundant. Because the skin is less elastic and also redundant, it is incapable of assuming its smooth appearance at the termination of muscular contraction.
Choice of the Site of Incision. The size and direction of an elective incision should always be chosen in relation to the lines of minimal tension. For example, when planning an incision in the thorax for the removal of costal cartilage, flexion of the thorax shows the position of the skin folds, and the incision is placed in this position. When the incision thus placed does not provide the best exposure of the underlying structures, it is lengthened. Because of the better quality of scar obtained, the longer incision will still be less visible than a shorter incision placed at right angles to the skin fold; in children, incisions in this area have a notable tendency to hypertrophy. No amount of care in sutting or in the approximation of wound edges will help if the scar is in a position unfavorable to minimal scarring, ie, at right angles or oblique to the lines of minimal tension.

Although the lines of expression and flexion creases generally coincide with the lines of minimal tension and are the best guide to the placing of incisions, there are exceptions. On the hand, for example, wrinkles produced by hyperextending the thumb and flexing the metacarpal joint of the index finger do not represent the lines of minimal tension. Another exception is the submental fold. An incision made within this fold often heals in an inverted manner, resulting in a bulging of the adjacent tissue; an incision made along the posterior aspect of the inferior border of the mental symphysis is preferable.

Certain areas are particularly unfavorable and tend to heal in a hypertrophic manner (see Chapter 16) following wounds and surgical incisions. The most notable of these areas are the shoulder and the presternal area, which involves exceptions skin tension, especially in the woman with pendulous breasts. Man, originally a quadriped, became a biped; in the erect position the upper extremities hang loosely, and the skin of the shoulder is thus placed under tension. Only in the elderly do anteroposterior folds appear in this area as the skin loses its elasticity and becomes lax.

The Influence of Age. During infancy and the major part of childhood, the skin has its maximum elasticity; it is also padded by a type of adipose tissue, familiarly termed "baby fat," which maintains the skin at its maximum distention. As the aging process takes place, the skin loses much of its elasticity, and the subcutaneous fat changes in character and quantity; the skin folds and wrinkles increase with the progressive relaxation of the skin (see Chapter 37).

The greater elasticity and extensibility of the skin in infants and young children make possible the use of large rotation and advancement flaps to cover defects. The aged patient with relaxed skin has a similar advantage, making possible types of reconstructive procedures which would not provide satisfactory results in young adults.

One of the few compensations of old age is the inconspicuous scar, the result of the relaxation of the skin.

Timing of Repair

In the treatment of congenital deformities, a number of problems are posed. A major problem is the age at which surgical treatment should be administered. Some deformities must be remedied within a few days after birth, and a number of surgeons have made it their practice to repair a cleft lip in the newborn baby before the mother and child leave the hospital.
hospital; many other surgeons prefer to wait until the child is 3 or 4 months old before performing the corrective surgery, feeling that the increase in the size of the structures will allow for more accurate repair and that the child is also more physiologically equipped to withstand surgical trauma. Other elective procedures are best postponed until the infant is at least 1 year old, as the morbidity at this age is decreased; a postponement until the child is 5 years old may be advisable if cooperation of the patient is required. In congenital hypoplasia of the auricle or microtia, it is usually preferable to reconstruct a new auricle prior to school age in order to avoid psychologic trauma, although the construction of the auricle is easier when the child is older because of the greater availability of costal cartilage and the larger area of available skin in the auricular area.

In developmental malformations, it has been the practice in the past to wait until completion of growth before undertaking reconstructive surgery. This philosophy has been the practice in craniofacial malformations, for example, although postponement of surgery often resulted in progressive accentuation of the malformation. Should these malformations be surgically corrected prior to the achievement of growth? Such a problem is also posed in the treatment of the patient with a cleft lip and/or palate; it has been felt by some that surgery interfered with growth and that postponement of operation was desirable in order to permit growth to progress unimpeded. A change of attitude in recent years has lead to a more selective approach to the timing of reconstructive surgery during the growth and development of the patient.

In craniofacial malformations, such as craniofacial dysostosis (Crouzon), acrocephalosyndactyly (Apert), or hemifacial microsomia, it is preferable to wait until the eruption of a sufficient number of permanent teeth (age 9 or 10 years) to provide sufficient anchorage for orthodontic or other types of appliances for intermaxillary fixation.

The type of plastic surgery that is practiced in cancer differs from the definitive type of surgery done for the repair of congenital malformations or deformities following trauma. Preoccupation with the eradication of malignant disease predominates in the plan of treatment.

In the treatment of oromandibular cancer, if primary reconstruction is not performed after resection of the soft tissues of the lips, cheeks, floor of the mouth, and mandible, constant drooling is present and retention of food is difficult. Unable to feed himself, having to be fed through a tube, the patient has a repulsive appearance to onlookers and even to himself. Outwardly alive, he is inwardly dead (see Chapters 57 to 67).

In other types of cases - after resection of the nose, for example - primary reconstructive surgery is not indicated. A secondary procedure to reconstruct the nose after an interval of a few months is preferable (see Chapter 29).

**Choice of the Method of Repair**

**Consideration of the Age and Sex of the Patient**

The quality of the repair depends upon the surgeon's operative skill and judgment in selecting the operative procedure. Sound clinical judgment in the choice of the method of repair is one of the difficult aspects in the teaching of plastic surgery. The student of plastic
surgery peruses books and publications which contain the description, both textual and illustrative, of many operative procedures. Certain procedures are an excellent choice for the patient in the older age group, in whom the relaxed, aging tissues provide an ample supply of tissue to permit closure of the donor site with minimal tension and a relatively inconspicuous scar. Secondary deformities caused by the transfer of regional flaps to repair the defects are also of relatively lesser import in the aged patient, whose main problem may be solely functional. A similar technique may be totally inapplicable in the younger patient.

The method of repair is also influenced by the sex of the patient. For example, flaps may be transferred from the chest in male patients, a procedure which may not be cosmetically acceptable to the female patient.

**Camouflage versus Osteotomy**

Facial appearance may be improved by a type of camouflage exemplified by the procedure employed in malunited fracture of the zygoma. By this procedure contour is restored by an onlay bone graft in preference to attempting to reposition the zygoma, a more difficult surgical task in some cases.

**Color and Texture Match**

When transferring skin to the face, a satisfactory match in color, thickness, and texture is important, for the skin of the transplant must harmonize with the surrounding tissue. The choice of tissue borrowed from another area of the body to repair a defect of the soft tissue of the face requires careful consideration. The texture and color of the skin of the face and neck differ from those of other areas. Unsuccessful matching of the skin results in a conspicuous "patch."

**The Barter Principle**

When skin is borrowed from one area of the face to repair another, the secondary deformity may be discernible, but the procedure is often desirable because a closer match of tissue is obtained than when a flap is transferred from a distant area. The principle simplifies reconstruction and avoids conspicuous disparity in the color and texture of the skin. In this process of "robbing Peter to pay Paul," the price paid is at the discretion of the surgeon. It seems obvious that good clinical judgment reduces the cost of the barter to a minimum.

One example of the principle of barter is the use of a forehead flap for subtotal reconstruction of the nose. The forehead tissue is employed for this procedure because the best results in terms of color and texture match are obtained by the use of forehead skin. A major portion of the flap is replaced in its original site after detaching the pedicle, leaving a portion of the flap to form the reconstructed nose. A secondary defect remains on the forehead. This defect is repaired by the most suitable skin available in order to minimize the secondary deformity. Full-thickness skin removed from the supraclavicular or retroauricular areas offers a suitable color match. The supraclavicular defect can usually be closed primarily, and the defect behind the ear is repaired by a split-thickness skin graft from the thigh or abdomen, which, although darker than the surrounding skin, is camouflaged behind the ear.
This is a good barter; by contrast, a split-thickness graft placed upon the forehead represents an unsatisfactory repair of the secondary defect.

**The Principle of Shifting the Defect**

This principle is applied in the transfer of a defect from an area which is either less conspicuous or less important from a functional point of view. For example, a defect may require a flap of tissue from the adjacent skin in order to provide the thickness of both skin and underlying subcutaneous tissue. The procedure is accomplished by closing the primary defect with an adjacent rotation or transposition flap; the secondary defect is then repaired quite satisfactorily by a skin graft or another local flap. For example, when a flap is raised from the preauricular area and is shifted forward to repair a zygomatic defect, skin of suitable color and texture is used in addition to the subcutaneous tissue removed with the flap from over the parotid-masseter fascia. The secondary defect can be repaired by a full-thickness retroauricular graft; the vascularization of the graft is assured, and the esthetic result is excellent. The deficiency in the subcutaneous tissue is less obvious in the preauricular area, a less conspicuous portion of the face than the zygomatic area.

Other examples of the principle of shifting the defect are the closure of a median forehead defect by two rotation flaps and the use of skin grafts to repair the secondary defects produced by the mobilization of the rotation flaps; the restoration of an alar defect by shifting the remaining nasal tissue downward to form the new alar border and reconstructing the resulting full-thickness defect of the side of the nose by flaps; and the reconstruction of a median defect of the lower lip by shifting the remaining lateral portion of the lower lip to the midline and repairing the laterally situated secondary defect by means of an Estlander flap from the upper lip.

**Reasons for Postponing the Operation**

Temporary or even indefinite postponement of reconstructive or esthetic surgery may occasionally be necessary for reasons which include infection, insufficient lapse of time after healing of the primary wound, and psychological factors. Varying periods of time, depending upon the vascularity of the region, should be permitted to elapse after the healing of the original wound before reconstruction is initiated. Latent infection disappears during this period, and gradual softening of scar tissue occurs by reestablishment of the hemic and lymphatic circulation.

The passage of time softens and smooths scars, skin grafts, and flaps, permitting the repaired tissues to adapt themselves to the underlying structures. The surgeon must allow sufficient time to elapse to permit revascularization and softening of scar before proceeding to a later stage in reconstruction.

The initial tendency to hypertrophic scarring diminishes with the passage of time; this is particularly true in deformities due to burns. Reconstructive procedures are more successful after the tendency to hypertrophic scarring has disappeared. The disruption of the immunologic machinery of a severely burned patient may necessitate postponement of reconstruction for six months to one year (see Chapter 33).
After other types of traumatic injuries, at least four to six months should elapse before undertaking the secondary repair of scars, skin grafts and flaps, and bone and cartilage grafts. Secondary corrective operations on the nose should be postponed for at least six months.

**Plastic Surgical Technique**

The modern plastic surgeon has at his disposal an armamentarium including special needle-holders capable of holding small, fine-honed needles, delicate forceps, hooks, hemostatic forceps, and many other instruments which are used manually or driven mechanically or by a turbine. The basic principles of plastic surgery technique have been admirably reviewed in the English language by McGregor (1975) and Grabb and Smith (1973).

The making of incisions at right angles to the skin, careful hemostasis with fine-tipped hemostats which grasp only the blood vessel itself with as little surrounding tissue as possible, gentleness in handling the tissues to avoid devitalization: these are points of technique that are well known but cannot be over-stressed. Hematoma is the most frequent cause of failure in plastic surgical operations. The use of precise electrocoagulation, with fine-tipped instruments grasping the bleeding vessel, is an efficient and rapid method of obtaining hemostasis. The use of small, flat, perforated suction tubes attached to a suction apparatus has reduced the incidence of hematoma and infection when they are placed under widely undermined areas and skin flaps.

**Suturing**

Various techniques were used in the period of Ambroise Paré (1575). Figures are redrawn from Paré's works. First figure represents the "twisted suture" (la suture entortillée); a straight needle penetrated both edges of the wound and suture material was twisted in a figure-of-eight fashion around the ends of the needle. This technique was employed until the discovery of anesthesia in the nineteenth century and was used in early cleft lip repairs. Another technique shown by Paré approximates the wound edges by means of sutures passed through cloth glued to the skin surface (la suture agglutinée). These methods of suturing wounds were still being used until the first part of the nineteenth century. Approximation of the wound edges, or reinforcement of the sutured wound, was revived by the introduction of porous paper-tape Steri-strips.

Precise approximation of skin edges without under tension ensures primary healing with minimum scarring. The *everting interrupted suture* is the most frequently employed type of suture in plastic surgery. The needle penetrates the skin close to the incision line, diverging from the edge of the wound in order to encircle a larger amount of tissue in the lower depths of the skin than at the periphery. In this manner the suture everts as well as approximates.

The *inverting suture* is required in approximating the skin in the construction of a tube flap or in the establishment of a skin fold in the upper lid by inverting the skin edge toward the upper edge of the tarsus. Inversion is obtained by changing the pathway of the needle to encircle a larger amount of tissue at the periphery of the wound than in the depth of the wound; inversion is also obtained by placing the sutures superficially in the skin.
Subcuticular (subdermal) buried sutures are placed on the undersurface of the cutis (dermis) with the knot downward beneath the dermis; these are useful approximating sutures if tension is present and a widened scar is feared. Special sutures such as vertical mattress sutures are also useful to evert the wound edges and maintain the skin coapted to the underlying fascial layer.

The mattress suture, either horizontal or vertical, with a dermal component, the suture being placed through the undersurface of the dermis, is useful at the scalp-skin junction if there is tension. The dermal component avoids suture marks in the skin. The suture also gives excellent approximation of the edge of a skin flap to the edge of the recipient site; the dermal component is placed through the dermis of the flap. The suture assists in joining a thicker wound edge to a thinner wound edge and equalizing the level of the epithelial layers.

In some areas, as satisfactory an approximation can be obtained by the use of a carefully inserted continuous running suture as by interrupted sutures.

Subcutaneous sutures are also employed to obtain layer by layer closure in deep wounds, to eliminate dead space under a flap, and to assist in relieving tension in an advancement flap. The removable continuous subcuticular suture is of particular value in children, whose skin is normally under greater tension than that of the adult and in whom suture marks are apt to occur. Each suture should penetrate the undersurface of the dermis 1 or 2 mm from the wound edge in order to obtain slight eversion and good approximation. The continuous subcuticular suture may be left in place for a longer period, thus ensuring the maturation of collagen in the wound with danger of suture marks. A precaution must be taken in using a subcuticular suture; the suture must be looped through the skin at intervals, depending on the length of the wound and the area of the body in which it is located. If this precaution is not taken, the suture may resist removal. One solution, in this eventuality, is to leave the suture subcutaneously. Nylon is well tolerated. The protruding ends of the suture are buried by the procedure illustrated whereby the protruding end is grasped with a hemostat. Traction is exerted by the hemostat, and pressure is applied on the skin by the blades of scissors. The end of the suture retracts under the skin. Stainless steel wire has also proved satisfactory as a removable continuous subcuticular suture.

Variations in Technique in Wound Suturing. It may be advisable to leave a base of scar tissue and suture the wound edges over the base after excising the superficial portion of a depressed scar. An ingenious technique to diminish tension on skin is that advocated by Millard (1970). A flap of subcutaneous fat may also be advanced from beneath one wound edge to bolster up a thinner opposing wound edge.

"Depuckering" the Pucker. When the two sides of an elliptical wound are of equal length, the wound may be closed without a resulting pucker at one end. If the two sides are unequal of if the ellipse has a wide curvature, a pucker or "dog-ear" is inevitable. The problem then is to "depucker" without unduly extending the length of the wound. The technique is shown that has given the best results. The excessive tissue is retracted by a hook placed at the end of the incision. The hook retracts the tissue laterally, and a sharp, pointed blade (No 11) makes an incision in direct prolongation of the sutured wound. The resultant flap is retracted and overlapped over the proposed line of suture. The hook is exerting traction...
at the end of the incision line. The excess tissue is removed and the remainder of the wound sutured.

**Pressure Dressings**

A pressure dressing eliminates dead space, prevents hematoma formation, and immobilizes skin-grafted areas. A compressive dressing also encourages venous return, enhancing circulation in the area which it covers. Circulation is also promoted by elevation of the operated part. The need for a compressive dressing varies according to the type of operation and the area in which the operation is performed. In most skin grafting procedures, the compressive dressing may be the most important part of the operation, ensuring as it does the close coaptation of the graft to the recipient site. Skin grafting may be done without a compressive dressing in certain selected cases in which careful observation ensures that the graft remains in contact with the recipient bed (see Chapter 6). Compressive dressings are not necessary in certain types of procedures in which only the integument is involved, and may be dispensed with if they are uncomfortable to the patient. The open method of treatment (Wallace, 1949) may be preferable in the treatment of burns or of abraded areas, as the absence of a dressing appears to favor epithelization. A pressure dressing may also be unnecessary when the wound has been closed without undermining the edges of the wound.

Suction tubes have replaced pressure dressings in areas where they are difficult to apply, e.g., the cervical area following the elevation of skin flaps for a neck dissection. Hematoma is probably the most frequent complication in plastic surgery.

**Infections in Plastic Surgery**

It is an undeniable fact that two factors have been responsible for progress in plastic surgery: the advent of antibiotics, and progress in the techniques of anesthesia and postoperative support of the patient.

Prior to the discovery of sulfanilamide, penicillin, and other antibiotics, the plastic surgeon lived under a Sword of Damocles: infection, that threatened to ruin the result of a carefully planned operation.

In general, plastic surgical procedures in the region of the head and neck are relatively immune from infection because of the rich vascular supply of the head and neck. However, if there is possible contamination by oral bacteria and if craniofacial operations are undertaken in which the risk of meningeal infection is high, antibiotic prophylaxis should be considered. If antibiotics are administered, they should be given 24 hours preoperatively.

*Staphylococcus aureus* is the most common offending pathogen in recent surveys of plastic surgery units (Converse and McCarthy, 1972; Morrison, Lister and Holmes, 1972). In view of this fact, an antistaphylococcal agent is indicated, either for antibiotic prophylaxis or for treatment of established infections.

Absolute indications for antibiotic prophylaxis are: traumatic wounds that are heavily contaminated; wounds in which debridement or cleansing are not possible; thermal burns; operative sites associated with heavy contamination or established infection; operations in
which inorganic implants are inserted; operations in patients prone to infections (impoverished blood supply, carrier state, undernutrition, changes in host defense mechanisms, and remove preexisting infection).

The two major causes of postoperative infection remain: rough handling of tissues, resulting in devitalized tissue in the wound, and hematoma, a natural culture medium.

A survey studying the role of preoperative antibiotics in plastic surgery was conducted by Krizek, Ross, and Robson (1975). Questionnaires were distributed to plastic surgeons, and 1025 responded. According to Krizek and his coworkers, who have quoted Ellis (1969), the availability of antibiotics has "neither eliminated surgical infection as a threat nor even reduced the incidence of infection in most cases." Plastic surgeons who practiced prior to the advent of antibiotics (personal communications from Aufricht, Kazanjian and Straatsma) have told me that in simple rhinoplastic operations, osteitis along the lines of osteotomy and abscess formation were occasional complications. Would craniofacial surgery be feasible without antibiotics? Or bone grafting through the intraoral approach?

Transplantation

"To transplant" (from the Latin verb transplantare) designates the removal of a colony of living cells from a donor area and its transfer to a recipient site where it is capable of propagating a lineage of living cells. The term is employed for the transfer of tissues or an organ from one part of the body to another, or from one individual to another. The term "graft" (from the French greffe) is essentially synonymous with the term "transplant."

Various terms have become accepted to define the modes of transplantation: "autograft" designates a graft transferred from one area to another in the same individual; "allograft" ("homograft") defines a graft transplanted between individuals of the same species; "xenograft" ("heterograft") indicates the transplantation of tissue between individuals of different species.

The term "isograft" is usually employed to designate an allograft between highly inbred (genetically pure) strains of animals. "Syngenesiotransplantation" is the grafting of tissue, not between two individuals of ordinary genetic diversity, as in the homograft, but between individuals of close genetic relationship. "Brephoplasty" (May, 1934) indicates the grafting of embryonic tissues.

"Replantation" designates the surgical procedure whereby tissue or a structure is replaced into its original site.

The term "implantation" is employed in this text to designate the insertion into the tissues of a foreign, relatively inert material referred to as an "inorganic implant" (see Chapter 15).

Two methods of skin transplantation are available, mediate and immediate. In mediate transplantation of skin, the survival of the transplant is ensured by a pedicle to which it remains attached until vessels have grown into the flap from the recipient site, thus the term "skin flap" (see Chapter 6).
In immediate transplantation of skin, a portion of skin is completely detached from its vascular connections, and revascularization of the transplant is accomplished by vascular connections and ingrowth of vessels from the host site; this type of free transplant is known as a "skin graft" (see Chapter 6). The development of microvascular surgery has permitted the immediate transfer of a skin flap, the microvascular skin flap (see Chapter 14).

Transplantation of other tissues, such as dermis (Chapter 7), fat (Chapter 8), fascia (Chapter 9), tendon (Chapter 10), muscle (Chapter 11), cartilage (Chapter 12), bone (Chapter 13), and nerve (Chapter 76), is discussed in individual chapters.

There are specific indications for the use of inorganic implants as useful adjuncts to other surgical procedures (Chapter 15).

**The Raw Area, the Straight Line, and Wound Tension**

**Three Enemies of the Plastic Surgeon**

The first enemy is a wound devoid of integument. The wound contracts; the result is an uncontrollable contracture with deformity and functional impairment. If it cannot contract, the wound may progress toward an indolent ulcer. Skin covering should always be provided by direct approximation, the transplantation of a skin graft, or the transfer of a flap. In the reconstruction of a full-thickness defect of the cheek or the nose, for example, a lining as well as a surface covering should be provided.

The straight line not situated within, or parallel to, a line of minimal tension is the second enemy of the plastic surgeon since contraction along the straight line causes distortion and contracture and results in hypertrophy of the resulting scar. The straight line must be interrupted by a Z-plasty or W-plasty in order to distribute the contractile forces in more than one direction. This principle is the basis of techniques developed to avoid retraction of straight scars that run at variance with the lines of minimal tension. The Z-plasty is the plastic surgeon's best friend, and the W-plasty, rapidly increasing in popularity, is the plastic surgeon's second best friend. The straight line, when situated in a favorable site and when the wound edges are sutured meticulously and with precision, is not an enemy: the resulting hairline scar will be inconspicuous (see Chapter 16).

Wound tension should be avoided at all costs. Undermining the wound edges is helpful but usually gives only partial relief of tension. Disruption of wounds, cross-hatching stitch marks, widening of scars, and necrosis of flaps are the consequences of excessive wound tension. Skin grafts or skin flaps are required when direct approximation of the wound edges cannot be achieved without tension.

**The Z-Plasty**

One of the most widely employed techniques in plastic surgery is the Z-plasty, characterized by the transposition of two triangularly shaped flaps. The Z-plasty serves three purposes: (1) lengthening of a linear scar contracture; (2) dispersal of the scar, thus breaking up the straight scar; and (3) realigning the scar within the lines of minimal tension. Elongation and interruption of the straight line and release of linear scar contracture prevents its recurrence.
Development of Z-Plasty. Borges (1974) has researched the origin and development of the Z-plasty. The first procedures consisted of a single transpositioned flap, hardly what we could call a true Z-plasty. Such procedures were described by Fricke (1829), Horner (1837), and Denonvilliers (1854). These procedures involved the transposition of a flap from the temporal area or from the cheek to correct ectropion of the upper or lower eyelid. McCurdy published a number of articles on what he called the "Z-plastic method" between 1898 and 1924. Although his first Z-plasty procedures were not true Z-plasties, he is credited with the current popularization of the Z-plasty technique. Berger in 1904 was the first to describe a true Z-plasty.

The first description of multiple Z-plasties was written by Morestin in 1914. The flaps were incised and allowed to shift in place without undermining. According to Woolf and Broadbent (1972), the geometric principles involved in the Z-plasty were first described by Limberg in 1929. Limberg's classic book (1946) contains a description of the many applications of the Z-plasty technique. Davis and Kitlowski (1939) reviewed their experience with the use of the Z-plasty, and Davis reviewed the practical applications of the principle in 1946. McGregor (1957) also discussed the theoretical basis of the Z-plasty. The books of Kazanjian and Converse (1959, 1974) and of Grabb and Smith (1968, 1973) have also discussed this technique in considerable detail. Borges (1973) published a book, the subject matter of which is entirely devoted to the Z- and W-plasties.

Technique of the Z-Plasty. In the classic Z-plasty the two triangular flaps of skin and subcutaneous tissue of equal size are delimited by the three incisions of equal length cut at a 60° angle; the line of contracture is thus broken and also lengthened. The length of the central limb and the angles of the Z determine the size of the flaps. The longer the central limb, the more lengthening is obtained, all the limbs being of the same length. If the incisions outlining the Z-plasty are not of the same length, puckering of the flaps will result. (See exceptions under Variations in the Z-plasty Technique.)

In addition to its lengthening effect, the value of the Z-plasty lies in the redistribution of tension and dispersal of the scar.

Staige Davis has noted (1931) that release of scar contracture by means of the Z-plasty technique resulted in an improvement in the quality of the scar tissue, the tissue becoming softer and better appearing. He reaffirmed this observation in subsequent papers (Davis and Kitlowski, 1939; Davis, 1946).

A modification of collagen structure has been demonstrated in the scarred area following a Z-plasty procedure (Longacre and associates, 1966). Both depressed scars and hypertrophic scars often become inconspicuous following excision and the breaking up of the linear contracture by one or multiple Z-plasties.

A Z-plasty in the middle of a long scar breaks the continuity and elongates the scar. Multiple Z-plasties have been employed successfully in long, linear, contracted scars.

Amount of Elongation According to the Z-Flap Design. Much has been written about the degree of elongation obtained by varying the angles of the segments of the Z-plasty. While the geometric calculations appear accurate on paper, there are too many unpredictable
factors in the patient to make them reliable. Theoretical considerations, while they are demonstrable on a piece of rubber sheeting or chamois skin, where the tension is equally distributed, are useless from a clinical point of view. Skin tension varies because of the presence of scar tissue which is unequally distributed, and is not the same on both sides of the contracture. In the usual clinical situation when one needs to elongate an area because of distortion of landmarks or web formation (frequently following burns), one uses the most useful Z-plasty angle, which is 60 degrees. Greater elongation can be obtained by the use of wide flaps (see The Four-Flap Z-plasty).

**The Use of the Z-Plasty to Realign the Scar within the Lines of Minimal Tension.**
The Z-plasty or (W-plasty) should not be used if the scar does not cross a line of minimal tension. Resection by elliptical incision (fusiform excision) is indicated.

*It takes courage deliberately to increase the length of a clean linear scar, even though it is unsatisfactory because it crosses the lines of minimal tension. No amount of care in meticulously suturing the wound will help if the scar is in an unfavorable position.*

The application of the Z-plasty principle for the realignment of a scar crossing a line of minimal tension is most useful but requires careful consideration. The angles of the Z-flaps vary according to the obliquity of the scar in relation to the lines of minimal tension and may be considerably less than 60°. The more oblique the scar, the more acute the angle of the Z-flaps. This concept is illustrated; in the realignment of a scar crossing the nasolabial fold, the angles of the Z-flaps may be more acute. It is necessary to design the Z so that the end of the limbs fall into the nasolabial fold.

The closer the scar is directed toward a right angle crossing of the lines of minimal tension, the more the angles of the Z-plasty limbs approach 60°.

In the design of any Z-plasty, the limbs should follow the lines of minimal tension. Thus, after transposition, the limbs follow the lines of minimal tension. Should the design be made in the opposite direction, the Z would cross the lines of minimal tension.

The advantage of two small Z-plasties over one large Z-plasty are illustrated in breaking up the scar into smaller components separated by normal tissue. A Z-plasty whose central limb is placed in the middle of a long scar is illustrated. As stated earlier, an improvement is achieved by the lengthening, relaxation, and interruption of the longitudinal tension.

**Variations in the Z-Plasty Technique**

**Unequal Triangles.** Triangles of an unequal size are indicated in the Z-plasty when the skin on one side of the central segment is loose and the other side requires more elongation, particularly in burn patients when the resection of the scar tissue on that side is not indicated. This is an application of the "half-Z" procedure, which consists of a flap which is fitted into an incision made in the opposing wound edge and is a technique for lengthening the short side. One incision is made almost at right angles to the border of the defect on the short side, while the other forms a more acute triangular flap on the long side. The width of
the base of the triangle determines the amount of lengthening of the short side, into which it is inserted. This technique can be employed only when the tissues are soft and pliable. The length of the limbs of the Z-plasty may also vary when the irregular scar requires lengthening and relaxation. The S-plasty is employed in cervical contractures, as the tips of the flaps are less susceptible to necrosis than those with the acute angle of the classic Z-plasty. It is especially indicated when the involved area includes healed, burned skin or skin graft (Converse, 1964).

**Double Opposing Z-Plasties.** Double opposing Z-plasties are particularly effective in breaking up a line of contracture when the anatomical position of the contracture does not permit the use of large flaps, such as in the medial canthal region for the correction of epicanthal folds (Converse and Smith, 1966). Double opposing Z-plasties are also useful in diminishing the size of the Z-flaps when the vascularization of the flaps is precarious, such as is frequent in burn contractures. Double opposing Z-plasties with small flaps are as effective in contracture release as the single Z-plasty with larger flaps. Opposing Z-plasties may also be placed at each end of a linear scar for the purpose of elongating a retractile scar (Converse, 1964).

**The Four-Flap Z-Plasty.** The four-flap Z-plasty was described in Limberg's book in 1946. It has been utilized to achieve a maximum gain in length with the ease of the classic 60° angle flaps and without the difficulty of transfer of flaps with a wider angle.

The technique consists of outlining wide angle flaps, each flap then being divided into two separate flaps, thus converting the usual two-flap Z-plasty into a four-flap Z-plasty.

A modification was introduced by Iselin (1962). His "plastie en Z rectifiés" was used to correct a contracture of the thumb web.

Iselin's technique has been employed by Woolf and Broadbent (1972) for a contracted web space in the hand, for axillary contractures following burns, and for minor cases of syndactyly. Furnas (1965) has studied the four-flap Z-plasty in considerable detail and has suggested a number of applications of the technique (stenosis of external auditory canal, of a tracheal stoma, of the urethral meatus, of a colostomy and end-to-side vessel anastomosis).

**The W-Plasty**

The W-plasty (Borges, 1959) consists of the imbrication of triangles of skin on each side of the excised scar.

A surgical technique resembling the W-plasty was describe by Ombrédanne in 1937 and was employed by him for the correction of a congenital constricting band of the lower extremity.

Hazrati (1952) has described a compound right angle Z-plasty. Borges (1973) has pointed out that this technique might well represent the missing link between the multiple Z-plasties and the W-plasty technique.
In order to produce triangles of equal size, a metal pattern can be employed. A large hemostat bends the soft metal band into a series of 60° angles. The size of the triangle is determined by the width of the limb of the particular hemostat.

The pattern is painted with surgical ink and applied to one side of the scar; a similar procedure is repeated on the opposite side of the scar. The metal pattern is not essential, as the design can be easily made freehand by the operator.

At the end of the scar, the triangles are smaller and the length of the limbs of the W are tapered. With a sharp pointed scalpel, the limbs of the W-plasty are incised on each side alternatively. In this fashion the tissues are firmer and easier to incise than if one entire edge is prepared before incision the opposing edge. After each triangle is outlined, the tip of the triangle on the contralateral side should be placed at the midpoint of the base of the opposing triangle.

Each triangular flap is approximately 5 mm in length and has an angle of approximately 55° in vertical or almost vertical scars (scars that cross the lines of minimal tension at right angles). As the inclination of a scar in relation to the minimal tension lines becomes more acute, the angles of each triangular flap become more obtuse. Borges (1971) advocates gradually increasing the angles until they reach 90°, when the scar traverses the line of minimal tension at an angle of more than 60°.

A continuous subcuticular suture of 4-0 monofilament nylon should be employed to approximate the angles. The subcuticular suture should be placed halfway between the apex and the base of each triangle in order to avoid buckling of the flaps. Additional approximation is obtained with interrupted 6-0 nylon sutures.

**Indications and Contraindications of Z- and W-Plasties.** Two Z-plasty and W-plasty techniques have two common denominators: they break up the straight linear scar into smaller components, and they improve the direction of the scar in relation to the lines of minimal tension.

The Z-plasty has the advantage that it elongates a contractile scar, changes the direction of the scar, when correctly done, and places it more nearly parallel to the lines of minimal tension. The Z-plasty also has the advantage of utilizing all of the available skin, as it is possible in some cases to perform the Z-plasty without excising the scar, if tissue is scarce. The change that takes place in the character and quality of the scar when tension is relaxed was mentioned earlier in the chapter. The Z-plasty elongates the linear scar, thereby relaxing tension; it also permits readjustment of displaced tissue.

Rarely are two cicatricial deformities exactly alike; each case must be studied carefully on its own merits and the various methods of repair weighed from every standpoint in relation to that particular scar.

The Z-plasty is preferable to the W-plasty in areas where there is either too much skin tension or too little skin tension. Other areas on the face permit the use of the W-plasty
(forehead, temporal skin, and the skin of the cheeks and chin). A horizontal scar extending across the lower lip or chin can be repaired by a W-plasty.

The main disadvantage of the Z-plasty, when improperly designed and/or placed, is that it elongates the scar excessively and enlarges the area it occupies. However, the Z-plasty nearly always improves the condition for which it is applied. The longer segments of the Z-plasty are another disadvantage over the W-plasty. It is possible to counteract this danger by Z-plasties with smaller limbs, such as the double opposing Z-plasty, and by multiple Z-plasties. In oblique scars traversing the lines of minimal tension at an angle of less than 30°, a Z-plasty procedure is preferable to a W-plasty. When the scar is almost parallel to the lines of minimal tension, the entire scar or the major portion of the scar should be excised by elliptical incisions parallel to the lines of minimal tension.

The W-plasty also has the advantage of having smaller triangular limbs, which break up the scar into smaller components and relieve the bowstring effect.

When the W-plasty is employed, there is no displacement of anatomical landmarks, as there is no transposition of tissue. W-plasties are indicated on scars of the face that are perpendicular or nearly perpendicular to the lines of minimal tension. As stated earlier, they find their best application in scars that cross the lines of minimal tension on the forehead, cheeks, temporal area and chin. They also have the ability to restore the normal contour of the scarred cheek.

The W-plasty has the disadvantage of increasing rather than decreasing the tension in the area of the scar because of the necessary sacrifice of tissue. It should be reserved, therefore, for scars surrounded by plentiful tissue. When elongation of the linear scar is required, the Z-plasty is always preferable.

The W-plasty and the Z-plasty may have application in patients with multiple scars, or in different parts of the same scar.

If irregularities (and not hypertrophic scars) in the surface area persist following either a Z-plasty or a W-plasty, a single (or a repeated) dermabrasion done at a suitable time interval after the operation will improve the surface contour.

**Excision, Z-Plasty, and Skin Grafting in Wide Hypertrophic Scars.** Wide hypertrophic scars require excision, Z-plasty, and skin grafting to cover the remaining defect. The thicker the skin graft, the better the result (Skoog, 1963). After an area of hypertrophic scarring has been dissected along the subcicatricial plane of loose connective tissue and resected, only a full-thickness or three-quarter thickness graft will minimize subsequent contraction, wrinkling, and possible recurrence of hypertrophic scarring (see also Chapter 16).

**Z-Plasty and W-Plasty in Depressed Scars of Partially Avulsed Trapdoor Flaps.** The patient whose photographs are shown suffered a massive partial avulsion of the soft tissue of the face when she was projected through the windshield of the automobile in which she was a right front seat passenger when it was involved in a head-on collision with another vehicle.

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Lymphatic obstruction by the deeply penetrating scar resulted in long-term lymphedema of the soft tissues of the face, which accentuated the deep indentation produced by the scar. Interdigitation between edematous and normal tissue bordering the scar by Z-plasty and W-plasty, as well as excision of the scar, assists in promoting lymphatic vessel regrowth across the scar and progressive amelioration of the lymphedema.

The same principles apply to the U-shaped scar which follows the healing of the trapdoor flaps. Excision of the scar, partial or total, combined with Z-plasty, W-plasty, and surgical abrasion, often results in an acceptable appearance (see Chapter 16).

Repeate Partial Excisions
(Morestin, 1915; Davis, 1929; Smith, 1950)

Partial excision may be preferable in the eradication of pigmented nevi or of wide scars in which total excision and suture cannot be accomplished without tension. Multiple repeated partial excisions are indicated in areas surrounded by loose tissue. Serial excisions are done at suitable intervals, provided that sufficient loose tissue is available and that distortion of the eyelids, nose, or lips does not result; distortion must be avoided. Wide undermining of the surrounding skin is essential. The technique has its limitations, however, as excessive repeated excisions may cause contracture.

The technique of multiple partial excision has its best application in infants in whom the skin is more elastic than in the adult; closure of the resulting defect is thus facilitated. In the aged patient the looseness of the skin and the excess of skin also favors this technique.