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RECENT ADVANCES IN PLASTIC SURGERY OF THE BONES *

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Plastic or reconstructive surgery has made many advances since its revival in the first half of the nineteenth century by Dieffenbach and his followers in Europe and Muetter and his contemporaries in America. These surgeons were probably preceded many centuries ago in plastic work, for the Egyptian papyrus named after Ebers and attributed to 1500 B. C. is said to mention rhinoplasty performed by flaps. The Hindu specialists made new noses from the frontal tissues before the time of Taliacotius in Italy. They replaced the cartilaginous portion, cut off as a punishment for adultery or for other reasons, by a cellular-cutaneous flap turned down from the forehead. Taliacotius in the sixteenth century made noses and lips from the tissues of the arm. He thus improved the features of European victims of nasal deformity, resulting from misfortune in war or by disease, many years before the time of Dieffenbach.

The history of the development of this branch of our art is as attractive as that of aviation. Both would easily evoke in one's mind a pleasure akin to that responding to the touch of a novelist's pen, had I the skill to mold phrases into the pleasing sentences of the trained essayist.

The modern surgeon was finally convinced that cutaneous flaps with pedicles, given new positions in the body, would live and become integral parts of the surrounding tissues. Doubt remained, however, as to the truthfulness of the occasional reports that sliced-off noses, ears or finger-tips had adhered and lived after being reapplied to the raw surfaces from which they had been severed.

Wolfe of Scotland, however, was able to convince a few ophthalmic and general surgeons that a free flap or graft of skin cut from a distant region could be successfully used to correct eversion of the eyelid. His method of dissecting up the ectropion, replacing the eyelid and filling the raw gap with a piece of detached skin was often tried; but the operation failed too frequently to become a standard procedure. It only occasionally happened that the graft lived, became united with the surrounding skin of the cheek or forehead and relieved the deformity. It remained for another Scot, Lord Lister, who has only recently died, to show that the failures in Wolfe's method usually occurred when the operator did not preclude septic contamination of the

wound. It was Krause of the continent of Europe, however, who developed and increased the usefulness of the free flap, or graft, of Wolfe by utilizing it in general surgery and subjecting it to the safe surroundings of an aseptic technic.

During the last forty years thoughtful men of broad mental grasp have pondered on the facts that skin would survive when its blood-supply was cut off partially, as in pediculated flaps, or entirely, as in Wolfe grafts, and when planted in a new site would live. As a result, experimental research and clinical observation proved that other tissues are governed by physiologic laws similar to those regulating the cell life and cell death of skin.

Hence it is now known that teeth, tendon, blood-vessel, fascia, nerve, cartilage and bone may be shifted from one spot to another with comparative certainty of a preserved vitality. The essential is that septic infection be absent until the pediculated flap or the graft has time to become physiologically one with the surrounding living structures. Under some circumstances even a mild infection may be tolerated without causing entire failure of the plastic reparation. It is better to use the patient's own tissues for these operations than those of another person; and tissues of the young answer better than those of the aged. It is possible, however, to get success with tissues taken from another human being, from an amputated limb, or even from the body of a person who has recently died. Carrel has found that aseptic tissue preserved by cold storage may be successfully used for grafts weeks after removal from the parent body. It maintains its latent life for a long period. Under these circumstances, therefore, the employment of grafts from the lower animals, which do not answer as well for man as human grafts, has gradually been discontinued.

It apparently has been established that the cells of aseptic animal tissue may continue to grow even when detached entirely from the body. This is accomplished by placing small sheets or blocks of tissue in a suitable aseptic medium, which is contained in a sterile tube and subjected to a required temperature. Horticulturists will see the similarity of these physiologic facts with what they have long known and utilized in plant life.

Our interest to-day, however, is to be restricted to a discussion of the plastic surgery of bones. The preceding remarks were necessary as a preliminary to this discussion, because bone surgery and the surgery of the soft parts are in essence the same.

Bone is hard, to be sure, because of its inorganic constituents, which are required to give it the resistance and permanent shape that make the skeleton the protector of viscera, the framework on which organs and other structures hang and the levers through which efficient movements and locomotion are performed. The

* The Address in Surgery at the meeting of the Michigan State Medical Society, July 10, 1912.

lime salts, which give the desired contour and the necessary rigidity to bones, are extracted by a selective influence from the blood; but otherwise the vital processes of growth, repair and inflammation are similar to the same changes in soft tissues. Osteogenesis resides in the lower layer of the periosteum, the marrow and the soft structures within the haversian canals and lacunae. The inorganic portion may be likened to a trellis or a filigree mold on which or in which the osteoblasts which create bone are supported and protected. To Ollier of Lyons should be given the greatest honor in the field of osteoplastic surgery, because it was his work and the stimulus which he gave to his immediate colleagues that established the possibility of using bone in plastic procedures. It is about thirty or forty years since Ollier first gave special attention to this branch of surgery. His interest continued until his comparatively recent death. The great development now seen in bone reparations is merely the march of progress found in all plastic operative work. The early methods of Ollier have been modified as a result of increasing knowledge; but his labors were those of an earnest, sincere, successful and far-seeing pioneer. He has had worthy followers in Tomita, Grohe, Morpurgo, Laewen, Murphy, Jane-way, Albee, Hibbs, Axhausen and others in bone surgery.

When a piece of bone is transplanted, its raw surface should be placed and maintained in contact with living bone. This is said to make the probability of its living and growing much more certain than if such permanent contact is not secured. The actual contact of the two portions without the intervention of the fibrous periosteum may be kept up by nailing or suturing. This phase of the desired osteogenesis resembles the regenerative process in cerebrospinal nerves after suture, grafting or degeneration.

While the new osseous tissue is being deposited after bone grafting, the old bony tissue in the graft probably is being absorbed. Consequently, when the gap has been completely filled by new bone, as a result of what may be termed molecular deposit, the model or framework has really been removed by a molecular absorption. The latter process has gone on contemporaneously with the former. The result is a new model replacing the old but retaining the original contour.

Osteoplastic procedures are strategic and reconstructive. The former term describes those operations in which bone is displaced temporarily, in order that the surgeon may gain access to organs behind a bony wall or an obstructing barrier. When a rectangular section of the cranium is cut and turned outward on a musculo-cutaneous hinge, like a trap-door, to permit the removal of a subdural clot or a brain tumor, and is replaced after that task has been accomplished, a strategic osteoplastic operation has been performed. Such also are the temporary resections of the zygoma to permit excision of the sphenopalatine ganglion for neuralgia of the second division of the trifacial nerve, and of the squamous portion of the temporal bone to obtain access to the gasserian ganglion or the sensory root of the same cranial nerve.

Some nasopharyngeal tumors are removable only after temporary displacement of the halves of the hard palate or of the bones and cartilages of the nose. Suture of the pericardium and heart may demand for its proper and rapid performance a strategic trap-door displacement of the cartilages of several ribs, with perhaps some part of the ribs also. A temporary costal resection is needed to permit operation on the thoracic esophagus.

A similar displacement of the lamina of the vertebra is at times adopted as a step in the removal of a tumor of the spinal marrow or its membranes.

These operations are, as is readily seen, of the nature of the pedunculated flap method of using cutaneous tissue for the repair of deficiencies in the skin. They therefore were found to be practical aids in surgical interventions and were accordingly given a place in the technic of bone surgery earlier than the use of free bone flaps, or grafts, to remedy actual loss of bone.

The reconstructive plastic use of bone differs from the strategic in that the object of the operator is to repair or build again a bony region, which has had its efficiency lessened or destroyed by injury or disease. The most familiar illustration of this surgical activity is the treatment of fractures. Its application to open comminuted fractures is probably as old as surgery itself. It is likely that in the earliest ages a bone broken into several pieces and exposed to view had its fragments readjusted by the would-be curer of the injury in the manner suggested by experience as effectual in remodeling shattered pottery or a broken branch of a tree. It was seldom that success was obtained, for septic contamination, suppuration and necrosis were until late years the fate of open fractures. The axiom of treatment therefore prior to the antiseptic period was that fragments devoid of periosteum should be removed, and that those with adherent periosteum might be retained, though there was but small hope of preventing death of these pieces.

Success in combating septic infection of wounds soon led Lister to apply his methods to open fractures; and the osteoplastic cure of fractures was founded. Thus came the impulse which made bone-grafting a reasonably certain operation and has made possible almost incredible bony reparations.

An early step in this direction was the replacing of the disk of bone cut from the cranium after exploratory trephining. With what doubt many surgeons still in practice first dropped the button of bone into the hole made in the skull and sewed the scalp over it! How delightful it was to discover that in a few weeks the brain case was as solidly repaired as before perforation, instead of being left with a fibromembranous imperfection at the seat of operation! A succeeding step was replacing fragments after relieving depressions from comminuted fracture of the cranium. Later, when the surgeon needed to work behind bony impediments or wished to replace loss of bone so as to gain a requisite stability or rigidity, bone flaps and bone grafts were tried.

Probably the latest application of osteoplasty in brain operations is McArthur's successful attack on the hypophysis, as the pituitary body is now called, by a strategic osteoplasty of the frontal bone. He cuts out a section of that bone in the region of the eyebrow, including a part of the roof of the orbit, operates aseptically on the hypophysis and then replaces the bone. The patient subsequently shows only a slight scarring in the middle line of the forehead and within the eyebrow.

This epitome of the history of osteoplastic surgery brings us to a point where it is proper to mention illustrations of other conditions amenable to osteoplastic therapy.

Deformities of the nose due to congenital defects, injury or syphilitic necrosis may require rigidity in the tegumentary flaps used for the rhinoplasty. This can be given by pedunculated osteoplastic flaps cut from the

forehead, by cartilage or bone grafts taken from the ribs, or by bone grafts chiseled from the tibia. If this choice does not satisfy the operator, he may use a finger of the patient to make the new nose firm, or he may graft a toe on the patient's hand and then repair the nose by placing the hand against the face and inserting the transported toe into the nasal defect, where it will become attached in two weeks.

What shall be done for a deep ugly cicatricial furrow in the frontal region, caused by previous necrosis of the anterior wall of the frontal sinus? Open the skin with a sharp knife, set a properly shaped piece of the tibia in the frontal pit and sew up the skin. A smooth comely forehead with but a slight linear scar is the result. A similar procedure may be used to fill the depression left behind the ear by a complete mastoid extirpation. Suppose a surgeon is obliged to remove much of the upper jaw for tumor, and must excise the bony floor of the orbit. How will he give support to the eyeball? He may saw a piece of bone from the coronoid process of the lower jaw and, leaving some of the temporal muscle attached, twist the bone flap around under the eye, so as to act as a substitute for the orbital floor.

After removal of the ramus of the mandible for tumor or the loss of a portion of that bone from a gunshot wound, a new section of jaw may be obtained by transplanting a piece of tibia, rib or clavicle into the gap. If the clavicle is employed, it may be cut as an osseotranscaneous flap with a pedicle. A piece of ivory of the proper length imbedded in the aseptic scar tissue may answer perhaps to hold the two portions of jaw in position; but living bone from the patient himself would be more likely to cause the formation of a new jaw.

Almost a miracle seems to have been accomplished by Esau, who operated on a patient with deficient prominence of the chin, due to temporomandibular ankylosis in childhood. First, he made new joints by the ordinary arthroplastic methods. Then he sawed the lower jaw into two halves at the symphysis. At the point of section he pulled the two halves apart and inserted 20 cm. of rib, abutting at each end against the sawed surfaces of the lower jaw. The piece of rib was fractured so as to bend at its middle to give the curved mental prominence. This bone graft restored the lower part of the woman's face to the normal shape in a fair degree.

The reference to ankylosis and its cure by arthroplasty in Esau's case brings to mind the restoration of the larger joints possible by osteoplastic methods. Surgeons now treat stiff knees, hips and elbows, resulting from fractures or osseous inflammations, by chiseling away the bony adhesions or irregularities and turning fibrofatty flaps in between the ends of the bones. Thus an almost normal mobility is secured and a much more stable joint made than by the former resection method.

Lexer in Europe and Vaughan in America have detailed cases showing that whole knee-joints may be taken from amputated limbs and placed between the sawn ends of the femur and tibia, after a total excision of the knee, with a fair prospect of obtaining a movable articulation. The hinge-joint from the limb of a person who has recently died is nailed or wired in position, and acts as a mold for the deposit of new bone derived from the blood by the action of the bone-forming cells in the living bone.

When a flail-like knee-joint is useless for locomotion, it may be made rigid by mortising the patella denuded of periosteum and turned on its edge into the joint like a dowel. This solidifies the joint and gives the stiff and firm synostosis desired.

Habitual dislocation of the patella may be prevented by stitching the detached tendon of the semitendinosus to a strip raised from the inner border of the patellar ligament.

The necrotic and infected bone in osteomyelitis, destroying the shaft of the tibia or radius, for example, may be removed by scraping, and a long graft, cut from the other tibia or a fibula, may be inserted between the two epiphyses. A new tibia will thus be formed. If the tibial shaft is lost by fracture or otherwise, the surgeon may utilize the fibula as a substitute. It will, if compelled to bear the weight of the patient in walking, become hypertrophied to bear the strain.

In a case of congenital absence of the shafts of both radii seen a couple of years ago, I have proposed to use the fibula to take the place of the radius. This could be done by using a piece of the fibula as a graft or taking a graft from the tibial crest. A fibular pediculated flap might be used instead of a graft.

In a few cases a finger has been supplied by grafting the great toe on the hand. Many fingers, as the result of accidental wounds in factories, are undoubtedly sacrificed by inexperienced operators, because of the non-use of plastic or osteoplastic methods in an effort to preserve portions of these digits.

One of the latest novelties in this line of surgery is making the posterior portion of the vertebral column rigid in tuberculous spondylitis by producing a continuous synostosis of the spines and lamina. This osteoplastic operation is better than supporting the bending spine with external gypsum jackets or spinal braces.

Hibbs does this by fracturing the spinous processes in the diseased region at their bases and bending them downward to bridge the gaps between the successive vertebrae. Albee has accomplished a similar result by using strips from the tibia laid in grooves previously channeled down the back of the spinal column. This procedure resembles the inlaying of furniture.

Plastic methods have done a great deal to improve the results in fractures, as is well illustrated in the technic of fixation by screws, nails and plates. Recently Murphy has reported a case in which he nailed the aseptic head of the humerus into place after its removal in a bad fracture and made practically a graft of it. Murphy also tells of having reconstructed the hip-joint by cutting a section of the great trochanter off and nailing it in the position of the femoral head to act as an efficient substitute for that part of the articulation.

These various uses of bone flaps, bone grafts and bone substitutes are a rich development of the art of surgery. Pirogoff's osteoplastic amputation of the foot was a forerunner of these operations. The names already mentioned were worthy followers of that Russian surgeon.

Will man like a crab ever be able to reproduce on his body an entire limb? Perhaps so. Morgan thinks that man does not regenerate an arm or leg, as crabs and some vertebrates do, because his tissues regenerate with different degrees of rapidity. The bones, which are important in such complex reformations, generate very slowly, but the vessels, nerves, muscles and skin generate rapidly. There is, therefore, no tendency to synchronous reproduction of the lost limb. The lizard can reproduce a tail, but not legs. Morgan, who has studied these physiologic questions with care, has occasionally seen an imperfect foreleg in an adult frog.

May not the time come when the surgeon will regulate these processes in the same manner as the other human functions which gradually have come under control?

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