

HOMOPLASTIC TRANSPLANTATION OF A BOILED SEGMENT OF A RADIUS

RESULT AFTER THREE AND A HALF YEARS

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THROUGH the kindness of Dr. George E. Brewer, of New York, I am enabled to report this case, which he operated upon at Roosevelt Hospital on January 27, 1912. The patient was a man of twenty-seven years of age, who complained of a painless lump on the flexor surface of the right forearm. Röntgenogram showed that the lower portion of the radius was involved in a tumor growth. At operation the tumor was found to be covered anteriorly by a thin shell of bone and it consisted of a spongy mass of rather soft vascular tissue, in a cavity lined by a smooth wall of dense bone. Microscopical examination showed it to be a giant-celled sarcoma. An excision of the entire lower $2\frac{3}{4}$ inches of the radius, with its periosteum, was performed and the soft parts were sewn together about the defect. Two days later an adult pistol-wound suicide was brought into the hospital and from his radius was removed a piece of bone of exactly the same length as that which had been removed. This bone was boiled for an hour and then kept in sterile salt solution for four days, when the original wound was reopened and the boiled homoplastic radius was inserted in the defect, which it accurately filled up. It was not sutured in place but simply laid in, and about it the soft parts were accurately sutured. A plaster splint was applied. The patient was followed for a year and a half and röntgenograms were taken at different periods. The graft healed in perfectly by primary union and there has never been any discharge from it. The pictures showed some honeycombing of the graft and some bowing of the forearm.

The result was supposed to have been good until the author, in his zest for bone grafting cases, located the man after some search and elicited the following röntgenogram. The hand is much radially abducted, in fact there is a well-marked dislocation of the hand on the ulna, which latter can be distinctly palpated. The function of the hand is much injured, there is almost no abduction, and flexion and extension of the wrist are slight. The grasp of the hand is very weak. The röntgenogram is very interesting. The entire graft (*D*) can be roughly divided into three sections

(*A, B, C*). *C* is that portion of the graft which has been completely and perfectly regenerated and is thoroughly united to the old bone at *E*. *B* is that portion of the graft which has incompletely been regenerated, while *A* is that part of the graft which has been completely absorbed with no attempt at reformation of the bone in the slightest degree. The time elapsed since the operation has been over three and a half years, it is safe to say that the regeneration of bone has taken place as much as it ever will, so that we may regard this as the permanent result. Several things are evident at once—first, the result of this transplantation speaks for the value of contact with living bone, for section *C* is so perfectly regenerated because of its immediate contact with living bone at *E*. Section *B* is farther away from living bone, and as a result the new bone is only partially regenerated, being honeycombed, while section *A* is farthest away and shows absolutely no regeneration of bone after absorption of the original dead matrix, the distance away from the old live bone being evidently too great to produce new bone. It would seem reasonable to suppose that had there been live bone impinging on the carpal side of the graft the whole graft might have been regenerated. This transplantation then bears out Murphy's idea of the value of contact certainly in dead homoplastic bone graftings. That the new bone did not come from the *surrounding* connective tissue is evidenced by the progressive lessening of its formation as one proceeds towards the hand. Had this connective tissue a great influence in the formation of the new bone, then there should be as much new bone formed in section *A* as in *C*, whereas the fact is that in section *C* the new bone formation is perfect while in section *A* it entirely fails. It seems reasonable then to assume that the new bone in *C* was formed through the growing into it from the old, live stump of blood-vessels which penetrated a certain distance thoroughly and then these gradually faded out, producing less and less bone as they advanced. A better method to have employed at the time of the original transplantation than this homoplastic grafting would have been to transplant a corresponding section of the patient's own fibula with its periosteum, the upper articular fibula extremity impinging on the carpus.

To correct the present dislocation seems now to be the main indication of treatment. To do this all that would be necessary would be to resect a sufficient amount of the lower end of the ulna, which would allow of the straightening of the hand.

Homoplasty.—Homoplastic bone transplantation is the grafting of bone from *another* individual, of the same species, into the person who is to be grafted. The graft has been transplanted either living or dead.



FIG. 1.—D is the 2 3/8 inches long, boiled, homoplastic transplant after three and one-half years. C is the completely reformed adjacent section, consolidated at E with the old, live stump. B is the but partially reformed segment, osteogenesis apparently beginning to fail. A is the segment in which the old dead bone matrix has been entirely absorbed and there is no reformation of new bone in this section, osteogenesis having entirely given out.

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Dead human bone, just as animal bone and foreign material, plays the rôle of an internal prothesis rather than that of a true graft. It simply furnishes a conductor, a matrix for the periosteal regeneration of bone coming from the neighboring, living old bone. How much exciting or stimulating influence dead bone will have on this formation of new bone is questionable. The graft can certainly furnish no new bone of itself. This form of dead bone transplantation has largely been given up for good reasons. Homoplastic bone grafts are far inferior in results to autoplasic bone grafts; but if they should be used, the grafts should be taken *living* from another individual and always *with* periosteum. In transplanting joints, it will be necessary to make a homoplastic transplantation. To obtain a living graft, it will be consequently necessary to obtain it from a fresh amputation or from a cadaver soon after death.

The success of such a living graft will depend on the serological relations between the individual from whom the graft is taken and the individual into whom the graft is to be transplanted. For in the one case the bone is originally laid down in serum of a certain composition. Bone from this individual may be transplanted into an individual whose serum may be of somewhat different composition, hence the graft will be foredoomed to more or less chemical change. The chance for success of such a graft in homoplasty will be just about in the same proportion of success as will be attained in attempting to find two bloods in blood transfusion which will agree and not haemolize when mixed. This is advanced as a more or less theoretical suggestion. Certainly bones from different individuals have probably different chemical compositions and the chance of grafting, from one individual into another, bone of exactly the same composition would theoretically appear to be doubtful, resulting in cytolysis. In addition, the danger of sepsis and transmitting disease as well as the inconvenience of waiting for a corpse or an amputation from an assured healthy individual have caused this method to be almost given up. Homoplastic transplants have occasionally been successful, but not as many of the osteogenetic cells remain alive and actively proliferate as in autoplasic grafts; hence the formation of new bone is slower, and its extent is less, consequently it is more uncertain as to its ultimate success.

The following instances of both living and dead homoplastic bone transplantations I have come across in the literature. The results must in many instances be taken *cum grano salis*, since many were reported as successful which, had a greater time been given, would have proved far more successful. The results are given, however, as reported.

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(a) LIVING HOMOPLASTIC BONE TRANSPLANTATIONS

KUTTNER resected the upper third of a tibia for malignant chondroma in a man aged forty-five. The resected bone was replaced by a fragment of a tibia taken from a cadaver 27 hours after death. This graft was very well tolerated. The patient has a movable knee and can walk.

A successful case combining a heteroplastic transplantation of a kid's bone with a homoplastic graft from an asphyxiated new-born foetus is given by PONCET.

LEXER replaced the upper humerus end, including joint surface, by a piece of a freshly amputated femur. Good result.

FRANGENHEIM reports 4 cases of dowelling with homoplastic material.

V. HABERER resected two-thirds of the upper arm and filled the defect with a periosteum-covered fibula freshly obtained from an amputation. Primary union, and the arm in 5 months fully functionated.

BAUM implanted into 4 cases of pseudarthrosis, twice bones of freshly amputated extremities, and twice fetal bones. All four cases gave negative results.

ANSCHUTZ achieved a relative good result in a 7 cm. long congenital tibial defect, which had been autoplastically grafted several times with no success, by transplanting bone from a perforated foetus. A second smaller attempt with the bone of a 7 months' foetus was unsuccessful.

OLLIER replaced the totally necrosed ulna by a bony piece obtained in a fracture operation. After 5 months the transplant was absorbed.

PONCET filled the defect in a pseudarthrosis of the tibia by half the first phalanx of an amputated great toe. No consolidation. He then transplanted bony pieces taken from a child asphyxiated at birth. These were extruded.

SAMTER in an osteomyelitic total defect of the tibial diaphysis transplanted a pedunculated periosteal bony flap, which led to very small new bony formation. He then implanted a 14 cm. long cadaver bone, which after some time must again be removed. Final consolidation.

BARTH reports the implantation into a tibial defect of a piece of bone without periosteum taken from a freshly amputated leg. Resorption without consolidation. He also reports a case of ununited fracture of left leg. A graft of a piece of bone without periosteum was taken from a fresh amputation. Absorption of graft without consolidation.

GROSSE, of Halle, reported a case of pseudarthrosis of the tibia. Implantation of a fragment from a fresh amputation in an adult. Consolidation in a year between the fragments and the graft. Radiographically demonstrated. The graft appears to have undergone complete reorganization and the child can walk well. This case was reported 12 years after the transplantation by Stieda, who says that the graft now cannot be differentiated from the old bone. The child limps because of the shortness of the limb due to the destruction of the epiphyseal cartilage.

ROBERTSON resected the lower ends of radius and ulna for sarcoma. Implantation of radius and ulna with periosteum from a fresh amputated arm, the radius being wired. Amputation 12 months later because of recurrent tumor. Examination showed obliteration of the wrist-joint by fibrous tissue, also that the grafts were living. There was some motion between the fragments.

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MORRISON reports removing the diaphysis of a tibia for osteomyelitis and transplanting a portion of a fibula taken from a fresh amputation. Six years later the leg had to be amputated on account of a failure to grow and of deformity. The foreign fibula was not more than a third of the size that it was when the operation was done.

KUTTNER transplanted into the defect caused by the resection of the superior extremity of the femur for sarcoma, an equal upper extremity of a femur removed from a cadaver 3 hours after death. This fragment was well tolerated. There were two local recurrences which were operated upon with success. Later, at the end of 7 months, the patient suffered a spontaneous fracture at the point of union of the dead bone with the old bone. This fracture *consolidated* and the patient had a very satisfactory function of his limb. Kuttner attaches great importance to this consolidation of the fracture and he thinks "that it shows better than any other proof could, that the bony graft had been truly alive."

STUCKEY reports a case of pseudarthrosis in the middle third of the tibia. Osteoperiosteal skin-flap with base external was taken from the upper fragment. Fragments were freshened and the marrow removed. A dowel of a portion of the entire thickness of a fibula without periosteum was taken from an amputated leg. The dowel was 11 cm. long. Its narrow canal was filled with iodoform plug and it was placed in the medullary cavities of the fragments and over this the osteoperiosteal flap was fixed with the same periosteal silk sutures. Complete consolidation in 90 days. Nine months after the operation the patient fell and fractured the graft, but this soon healed. A curved deformity resulted which had to be remedied by osteotomy. Was not this new bone formed from the old periosteum?

TERMIER resected the inferior half of the radius for sarcoma. He implanted into the defect sufficient of the fibula taken from an amputation made a few minutes before; primary union. For nine months he followed the gradual incessant destruction which by "lacunar corrosion and decalcification" produced a gradual and complete disappearance of the graft. Termier concludes that the pretended osteogenetic property of the graft does not exist, and that cytotoxicity and progressive absorption are almost the rule for transplanted foreign tissues.

ROVSTING replaced the lower part of the femur, which he had resected for sarcoma, by a section from an old humerus, sterilized with care. The result was bad because the graft broke and there was no consolidation. He waited until he amputated a leg and took a section from the femur which he implanted into the defect 20 minutes after the amputation. A year after the grafting, there was a small fistula upon the inferior surface of the thigh. The patient has resumed his occupation as a venter and gets about on two canes, the limb being strengthened by a leather apparatus.

MACEWEN in his book mentions a living homoplastic transplantation in a boy, the whole of whose diaphysis he was compelled to remove for necrosis. There was no subsequent osseous deposition. Fifteen months later he was re-admitted with the request by the parents that the boy's useless arm be removed. Two wedges of bone were excised from another patient of six years of age afflicted with anterior curves. These were cut into minute fragments, quite irrespective of the periosteum, and were then deposited into the muscular sulcus

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in the boy's arm. There was no pus formation. Two months later a portion of new bone, an inch in length and three-quarters of an inch in thickness, was found firmly attached to the upper fragment of the humerus. Here all the grafts proliferated, grew to one another, and also to the extremity of the proximal portion. Two other wedges of bone of larger size than the first were similarly dealt with and inserted two months subsequently to the first graft, and a third couple were placed in position five months after the first. These all fused together and to the condyles of the humerus, filling the gap in the arm to the extent of $4\frac{1}{4}$ inches. It is now 30 years since the humeral shaft was rebuilt, and during all this time the man has depended upon his physical exertions for the earning of his living. He worked as a joiner for many years, and is now an engineer's pattern-maker.

TROUT reports a very successful transplantation of a section of a father's tibia into a spina bifida of his child.

(b) DEAD HOMOPLASTIC TRANSPLANTS EITHER BOILED OR IN ANTISEPTICS

V. BRAMAN implanted into a humerus defect a 16 cm. long piece from the fibula which was boiled for two hours. Successful result.

FRIEDRICH resected the entire right femoral diaphysis and implanted a dead fibula from a tuberculous boy; good result. He resected also 12 cm. of the femoral diaphysis. Into this defect was implanted a boiled 17 cm. long femoral diaphysis of a sixty-five year old man who died of carcinoma. Perfect healing in of implant.

FRANKE implanted into a resected defect of the carpus, dead bone. No result. Then autoplasty from the tibia with good result.

KAUSCH in 1906 reported up to this time the greatest case of implanted dead bone which healed in the tissues. A 9 cm. long piece of the whole diameter of a tibia was obtained the day before from an amputation. It was boiled and then implanted between the resected tibial and femoral ends, these being held by ivory pegs. Primary union. After three-quarters of a year recurrence. Amputation. Autopsy showed good healing in of transplant, which was surrounded by new-formed periosteum. Case 2: Pseudarthrosis of the tibia. Implantation of a freshly-obtained phalanx from a previous operation. This was boiled. Fistula developed. Removal of implant. Case 3: Sarcoma of the upper arm. Implantation of two sterilized cadaver humeri. Removal of the same after 5 months on account of fistula formation. Case 4: Sarcoma of the upper arm. Resection. Implantation of a freshly-obtained cadaver humerus which was boiled for an hour. Removal after one month on account of infection. Case 5: Sarcoma of the internal femoral condyle. Oblique resection of this condyle. Implantation of an old anatomical lower femoral bone which was boiled. Removal of the same on account of purulent secretion on the eighteenth day. Case 6: Sarcoma of the lower femur. Implantation of a boiled anatomical department bone. Removal on account of infection.

GROSSE implanted in a pseudarthrosis of the tibia, a living exostosis from a ten-year-old girl. Primary union but absorption of the graft. The same result occurred after implanting a section from an amputated ulna without periosteum. Then complete consolidation occurred after the implantation of a boiled piece of a tibia without periosteum from an amputation. Eleven years afterwards the röntgenogram gave a single shadow of the tibia.

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STIEDA implanted in a pseudarthrosis of the arm of a girl, a 16 cm. piece of a boiled fibula from an amputation. After a year there was a pseudarthrosis at the upper end of the implant. There developed fistula with final sequestration, compelling the removal of the dead implanted fibula.

KUTTNER resected, in a man thirty-one years of age, the entire upper extremity of the femur for sarcoma. He replaced the segment of resected bone by the upper extremity of a masculine femur, taken aseptically 11 hours after death from a cadaver. This segment was preserved for 24 hours in Ringer's solution with added chloroform. The dead femur was united to the remains of the healthy femur by an intramedullary ivory dowel and the tendons were united to this graft so far as possible. Death occurred 13 months later from metastases. Autopsy of the graft showed perfect insertion of the muscular tendons of the bone into the dead graft. The functional result besides was very good and the patient, 6 months after the operation, could make numerous movements of the hip. The microscopical examination of the fragment of the dead graft showed that it was "little living," and it is very probable that this dead bone was simply tolerated as an aseptic foreign body. Its utility had been considerable since new muscular insertions were made on its surface and functionally it fulfilled its rôle.

STREISSLER reports a case of comminuted compound fracture of both bones of the leg, resulting in a defect of 5 cm. in the tibia, and with overriding of the fibula fragments. After several months the granulating wound was opened, the tibial ends were freshened and the attached fibula ends separated. A 10 cm. long section from a tibia of a fresh amputation was taken and was boiled for 20 minutes in soda solution. The graft was then dowelled into the upper and the lower medullary cavities and fixed by silver sutures. The granulating surface soon became closed in. Progressive radiograms showed lacunar erosions of the graft with gradual absorption. The upper tibial fragment became consolidated with the lower fibula fragment. Final removal of remains of the dead graft. The fibula gradually increased to three times its normal dimensions, and bore the whole body weight.

In conclusion the author desires to express his indebtedness to Dr. Brewer for the privilege of reporting his interesting and instructive case.