THE TRANSPLA… REPAIR O…

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Loss of substance in a skull bone was so rare, previous to this War, that it was seen only occasionally where trephining had been performed for fracture of the skull or decompression for intracranial lesion. During the past three and and a half years the number of cases suffering from cranial defects has been rapidly increasing, probably resulting from the modern system of trench fighting. The injuries to the skull have, like wounds received in other parts of the body, been practically always infected, often being complicated by a foreign body lodging in the meninges or brain substance. This condition has necessitated free removal of bone either at the casualty clearing station or base hospital, according to the methods of Sargeant [1] or Cushing [2], and the patient arrives in England with a wound which is usually healed completely or may have a small discharging sinus.

This hospital receives cases directly from France and also transfers of Canadians from Imperial hospitals. On January 1, 1918, the surgical service of this hospital had under treatment 1,317 cases, of which 1,031 had been admitted in convoys from France, the remainder having been transferred from hospitals in England. From examination of the 1,317 cases, twenty-eight were found to be suffering from cranial defects. Of these twenty-eight cases, sixteen had been admitted in convoys from France, and twelve had been transferred from Imperial hospitals in England. From these figures it will be seen that the average of cranial defects admitted to this hospital is over 2 per cent. of the total surgical casualties.

This report is based upon twenty cases in which we performed a bone-grafting operation for the repair of cranial defects. The practical use of bone graft has been a subject of much study to surgeons for more than a century. Professor Arthur Keith [3] has recently pointed out to us that John Hunter was one of the pioneers in bone grafting and fully realized its usefulness and value, but failed to carry it to a successful issue on account of sepsis. In 1867 Ollier, of Lyons, published an important work in which he proved that transplanted compact bone could live without its periosteum. Recently (1917) Major Hey Groves [4] has published a review of the work performed by Ollier, Barth, Axhausen, and Macewen during the past three decades, and in the same article published the results of his own experiments with the grafting of bone in cats. From a careful analysis of their work it is found that they all agree on several main points.

(1) That compact bone can live and proliferate when transplanted.

(2) That periosteum does not reproduce bone.

(3) That the viability of the graft is increased if both periosteum and endosteum have been retained.

In 1914 Gallie [5], of Toronto, published a report of a series of interesting experiments. The conclusion he arrived at, as a result of these experiments, was that grafted bone dies, but at the same time acts as a scaffold which becom… vascularized, and which is invaded by osteogenetic cells from the host. From these invading cells new bone is produced. That grafted bone does not die, as Gallie believed, has been proven in a case reported by Sir Robert Jones [6], in which he had transplanted a long strip of tibia from the sound limb into the epiphyseal ends of a tibia whose shaft had been removed for osteomyelitis. The graft united to the host and grew rapidly, according to Wolff's law, and the case was discharged from the hospital. Six months from the time of the grafting operation the patient was knocked down by a bus and the grafted bone fractured in the centre. The care of Sir Robert Jones, who had a series of skiagrams taken during the recovery. These pictures show callus forming at the point of fracture, and firm union resulted within the average time allowed for normal bone. Albee [7] has reported a large number of cases in which he has performed his sliding graft operation in simple fractures of the long bones. Skiagrams taken later show firm union between the grafts and the hosts. Sir William Macewen [8] reports a case in which he removed a large piece of a parietal bone when operating for the relief of cystic intracranial disease. The bone was preserved in warm saline solution for half an hour and then re-implanted. Five years later the patient died from a pulmonary condition, and on reflecting the scalp it was found that firm osseous union had occurred between the re-implanted bone and the skull.

McWilliams [9] in his review concludes that the survival of a graft depends on the establishment of a sufficient blood supply, and that blood supply is more quickly and efficiently established when both periosteum and endosteum are transplanted. Of the different theories advanced on the growth of bone, it is now generally conceded that the one taught by Sir William Macewen is the most definite. Macewen proved in his experiments that periosteum does not reproduce bone, but merely acts as a limiting membrane, and that new bone is formed by the proliferation of osteoblasts within the grafted bone itself and quite independent of the periosteum.

As a result of the conclusions of these investigators we believed that a very extensive field had opened in which bone could be used in the repair of cranial defects. It will be seen by the statistics of this hospital alone that the number of cases in which there has been a loss of bone substance will average fairly high in the total casualties. It is realized that a cranial defect usually makes a man unfit for any active occupation, and, indeed, judging from the marked degree of depression, suffering, and fear seen in many of these cases, they will become wards of the State during their lifetime. Realizing this, we have endeavoured to develop a form of treatment which will help these men to become an economic part of the man power of the nation and not mere helpless dependents.

To ensure a successful result in our transplanting of bone we found there were several fundamental principles to be carried out in all cases.

(1) No graft should be attempted until all discharge has ceased and the wound has been perfectly healed for three months. This time differs from the period we wait after the healing in long bones. In compound fractures of the long bones we insist that the wound must be healed for at least six months before operating. However, we have found that operations on the skull can be performed after a waiting period of three months without fear of stirring up a latent infection. The great vascularity of the scalp is probably responsible for this difference.

(2) Most careful aseptic technique both in preparation of patient and during operation.

(3) The graft should be autogenous, the crest and inner surface of the tibia being most suitable.

(4) The periosteum of both the host and grafted bones should be retained, as well as some of the endosteum, in the graft.

(5) Close apposition and immobilization of graft into host.

(6) Small drainage tube in one corner of the wound for twenty-four hours to allow drainage for the slight oozing which it is impossible to control in the flap.

In studying the case sheets of this series it is found that consciousness is lost at the time of injury in a large percentage of cases, and is not regained for some hours at least, and, indeed, often for several days. The notes on the field medical card accompanying the man, although brief, usually give most valuable and interesting data: it is from these we learn the extent of injury and the form and type of treatment carried out. When these cases are evacuated to England some weeks have elapsed, and they are convalescent from their first operation.

On examination of the head a loss of bone substance is found, usually showing a definite depression which markedly pulsates. The scar and area around the depression are sensitive and painful to touch. On interrogation, the patient's cerebration is found to be slow and the memory poor. A constant symptom is an extreme degree of depres-

[1] [Reference should be made to the full and careful studies of Berg and Thalhimer (*Annals of Surgery*, 1918, 67, 331), published since this article was completed. In it Macewen's doctrine is apparently successfully confuted; but while it is shown that periosteum transplanted can develop bone, it is also demonstrated, in harmony with the views here put forward, that the endosteum and osteoblasts lining Haversian canals in autogenous bone transplants produce bone actively.—ED.]