THE APPLICATION OF THE WEDGE PRINCIPLE IN THE FASHIONING OF A TIBIAL 'BRIDGE' GRAFT.

By R. E. KELLY, LIVERPOOL.

THE weak point in all sliding bone-grafts has always been their fixation. It has been generally conceded that a firm fixation gives the best results, although some authorities have stated that a too firm fixation is deleterious on account of the destruction of the bone-forming cells by excessive pressure. A moment's consideration of the actual pressure exerted by the muscles on the broken ends of any fracture ought to convince anyone that the pressure cannot be too great or the fixation too perfect.

If the surgeon uses a twin saw and cuts his graft with parallel sides, it is obvious that the bed is wider than the graft by the thickness of two saw-cuts. If he elects to bevel the sides of such an inlay, he certainly will get a closer union; but to ensure absolute contact and firm fixation, the bevelled graft must be fixed by pegs or sutures. Obviously, a better fit could be obtained by making the inlay exactly the width of the bed, but that would necessitate cutting the graft from the opposite limb. A 'bridge' graft, fashioned after the method of Hey Groves (the cricket-bail graft), is difficult to make, requires careful fitting, and is exceedingly difficult to insert. The usual method of splitting the fractured bone in order to get the 'cricket bail' in place sometimes requires great force, and may even result in such splintering that the fixation becomes imperfect.

In a short paper in the *BRITISH JOURNAL OF SURGERY*, Vol. vii, No. 28, I described an operation for the relief of slipping peroneal tendons. Here a tiny graft of the fibula was cut with double-wedged sides. Mere pushing backwards of the graft fixed it firmly in its new position without the aid of a peg or suture. The application of this wedge principle may be used in any sliding graft. The inlay is fashioned in the form of a long wedge, so that, in moving it to its new position, it is gripped along its whole extent by the bed. The diagram (*Fig. 171*) serves to illustrate the method. I also append *x*-ray photographs of a patient on whom I operated last year.

Mr. X., age 34, was knocked down by a char-à-banc, sustaining a bad compound comminuted fracture of the lower ends of the left leg. He thinks that the wheel went right over his left leg. The wounds were excised, together with innumerable small contaminated fragments of the tibia.

After a prolonged convalescence of a year, he had recovered, with overlapping of the fibula and non-union of the tibia, the ends of this bone being about $1\frac{1}{2}$ in. apart. The destruction of so much tibia was accounted for by the loss at the first operation, and the further subsequent removal of loose and necrosed fragments. At one time amputation was seriously considered, but as he retained a good blood- and nerve-supply to the foot, one refrained from the major operation in the hope of grafting

FIG. 171.—Illustrating the method of applying the bridge graft.

WEDGE PRINCIPLE IN TIBIAL 'BRIDGE' GRAFT 233

later on. The position at the time of grafting (October, 1921) was as follows: Overlapping of the fibula; contact, but no bony union, between the upper fibular fragment and the lower end of the tibia; fair movement at the ankle, and an intact foot, but quite useless for weight support (*Fig. 172*). There was marked atrophy of the bones.

Operating with a tourniquet, a long incision was made over the internal surface of the tibia, right down to bone, exposing almost the complete tibia. The periosteum was lifted with the flaps, and the whole operation carried out subperiosteally. If there is any virtue in the deeper layer of the periosteum from a bone-producing point of view, surely it is better to leave it *in situ* with its blood-supply intact, than to move it with the graft but sequestered completely from all vascular connections. I have so often seen the periosteum destroyed or torn off an inlay graft, despite special efforts made to preserve it, that I am convinced it is safer to leave it attached to the tissues overlying it.

FIG. 172.—Before grafting.

FIG. 173.—Immediately after grafting.

When the whole internal surface of the tibia had been exposed, a wedge-shaped graft about 7 in. long was cut with an Albee circular saw, in such a way that the upper end was about $\frac{7}{8}$ in. wide, and the lower about $\frac{1}{2}$ in. In other words, the angle of wedge was about 1 in 20. Both saw-cuts were made at right angles to the internal surface of the bone. With a chisel the graft was freed from its bed and pushed down until its lower end impinged on and entered into a hole bored in the lower fragment of the tibia. This was done by tapping the top end of the graft, using a hammer and chisel in the same way that a joiner works, the flat of the chisel placed on the top of the graft and the hammer used to tap the back of the chisel. The graft soon begins to bite into its bed, the amount of transposition being of course dependent on the width of the saw-cuts and the angle of the wedge. If one knows these exactly, the amount of translation of the graft before it is tight may be calculated with mathematical precision.

Care must be taken that the wedge is not too blunt, otherwise the tibia may be

cracked before the required extension is attained. A further safeguard, however, to prevent the graft slipping upwards was made by placing a stop or catch at its upper end. A thin sliver of bone was cut with an Albee saw, about $\frac{1}{16}$ in. wide and $1\frac{1}{2}$ in. long, upon the side of the bed above the graft. This was sawn through at its lower end, but left attached at its upper. A chisel was inserted into the saw-cut, and the lower end of the slice levered inwards, and fixed into its new position by the insertion of a tiny fragment of bone. This latch prevented any movement upwards of the wedge (see Fig. 171). It could, of course, be done on both sides, but apparently this was not necessary. Fig. 173 shows an x-ray photograph taken immediately after the operation. Note the atrophic character of the graft. The 'latch' does not show well, but it can be faintly seen on the fibular side of the tibia. Figs. 174 and 175 were taken five and seven months later. The increase in strength and in thickness is well shown. Note also the

FIG. 171.—Five months after grafting.

FIG. 175.—Seven months after grafting.

development of buttresses. It is perhaps superfluous to add that all fibrous union, muscle, etc., were removed from between the fractured ends before sliding the bridge graft into its new position. Further, the rounded fibrous ends of the bone were sliced off.

I think this method of using a wedged graft to be of distinct value in cases of a similar nature where, from atrophy of the bone, a surgeon is disinclined to use a graft about whose stability he is somewhat uncertain. Obviously it may also be used for a recent fracture, the only point to remember being that the fractured ends must be in perfect anatomical apposition, and kept so whilst the graft is being cut. The portion of graft which is not used, namely, that from the lower end, may be put back in the space left in the upper fragment. If the angle of the wedge is correct, the fixation is perfect.

Joiners often use a double wedge. Any graft, even a parallel-sided one, may be sawn in two by cutting it diagonally. By sliding these wedges in opposite directions, the graft may be wedged in its bed so firmly that extraneous fixation is not necessary.