

Institute for Experimental Research in Surgery,
(Director: H. H. Wandall, M. D.), University of Copenhagen, and
Surgical Department A (Head: R. Movin, M.D.), Frederiksberg Hospital,
Copenhagen, Denmark.

HEALING OF MUSCLE-PEDICLE BONE GRAFTS

An Experimental Study

By

SANDOR MEDGYESI

A muscle-pedicle graft receives its blood supply through a soft-tissue pedicle, so that grafting over a fairly short distance ought to be compatible with the survival of some of its cells. The graft may be compact or cancellous, and the pedicle usually consists of a muscle and tendon or subcutaneous tissue and skin, depending on the donor site.

In a previous paper (1) the reported clinical and experimental studies on muscle-pedicle bone grafts were reviewed. Only a few experimental studies have been published (2, 3, 4 and 7), and the results have differed. Our results are among the positive ones, and the present study marks a further step forward in the series. This time, the transplantation was performed in a way which eliminated the osteogenetic activity of the recipient site in order to assess the role of the graft itself in the healing process.

The method was as follows: The experimental animals were white rabbits weighing 2.5-3.5 kg. The rabbits were mature, but in some of them the epiphyseal cartilage could be discerned. The operation was carried out under Nembutal anaesthesia. A graft, $10 \times 5 \times 5$ mm, was removed from the greater trochanter on both sides. The pedicle consisted of half the gluteus medius and minimus which were dissected to a length of 1 cm. From the iliac crest a somewhat larger piece of bone was removed, freed entirely and denuded of muscle tissue. The pedicle grafts and the pieces of bone were tied together with a silk

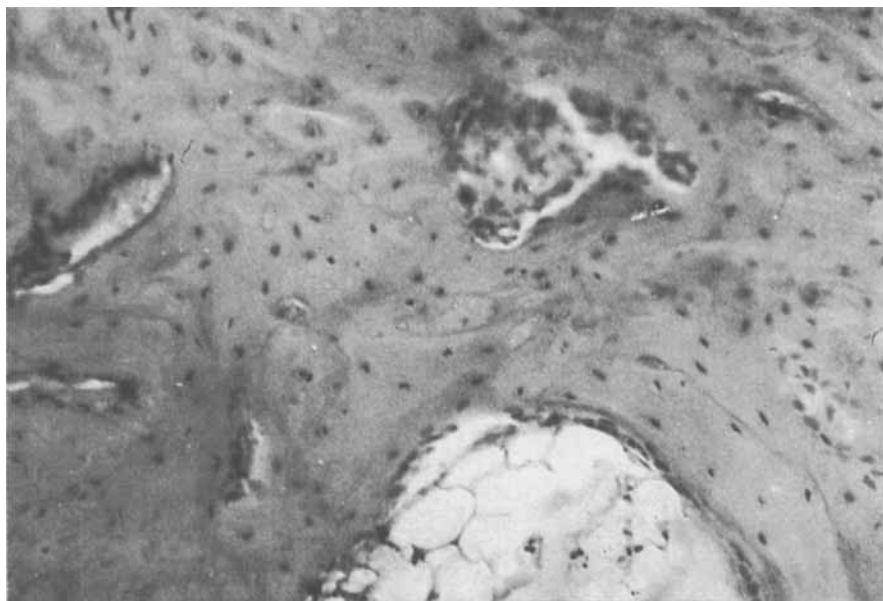


Fig. 1.

A 4-week-old preparation. Haematoxylin-eosin staining. $\times 225$.

The preparation is from the middle of the pedicle graft. The lacunae contain living osteocytes, and there are living osteoblasts on the surface of the trabeculae.

suture, spongiosa facing spongiosa. Thereafter, the tied bones were isolated by polyethylene foil, 0.05 mm thick, to prevent possible in-growth of vessels from the surrounding structures. The bones were cut with a rotating saw. A total of 13 rabbits had this type of operation. Another 2 were treated in fundamentally the same way except that the muscle-pedicle graft was removed from the iliac crest and the free graft from the trochanter. The rabbits were killed from 1–5 weeks after the operation, one 12 weeks after. The specimens were studied by gross inspection and histologically after decalcification with formic acid and staining with haematoxylin-eosin and van Gieson.

RESULTS

Out of the 30 grafts two were infected (abscess formation) and 2 could not be examined histologically. Among the 26 preparations studied the entire pedicle graft was alive in 15 (Fig. 1). However, in these grafts too there was a narrow rim of empty lacunae close to the cut edge. In 7 grafts parts of the bony tissue had undergone aseptic



Fig. 2.

A 2-week-old preparation. Haematoxylin-eosin staining. $\times 75$.

At the bottom a segment of the pedicle graft and at the top the dead, free graft in its entire thickness. A net of ample endosteal callus extends from the pedicle graft attaching itself to the trabeculae in the free graft.

necrosis which involved up to 75 per cent of the graft, indicating serious disturbance of the blood supply. In 4 grafts there were apparently no living osteocytes. However, one of these grafts (a 2-week-old specimen) was surrounded by so much new-formed bone that it was attached to the free graft by callus. Callus formation could be observed between the two grafts as early as one week after the grafting, and it increased during the subsequent weeks. The callus included subperiosteal and pronounced endosteal proliferation of osteoblasts

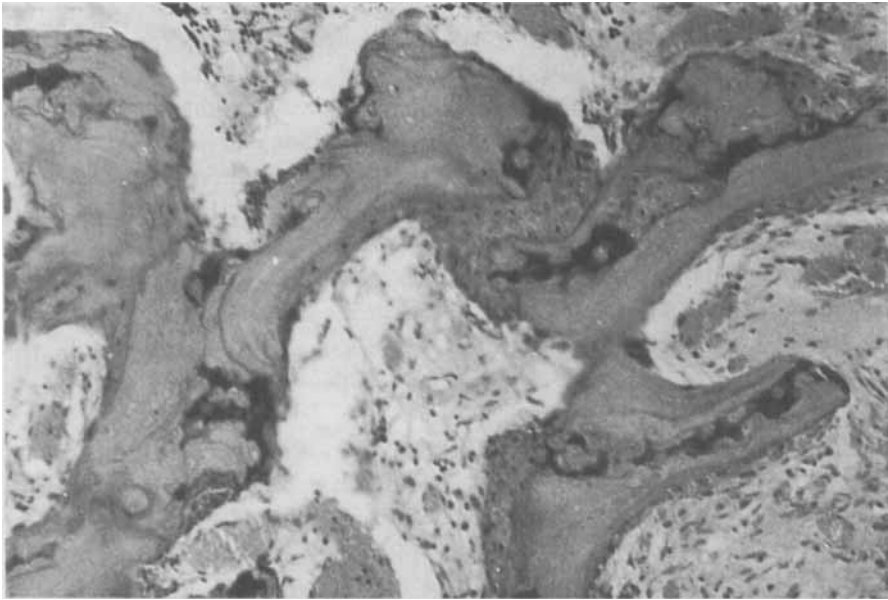


Fig. 3.

A 4-week-old preparation. Haematoxylin-eosin staining. $\times 160$.

A segment from the inside of the free bone. There is vascular ingrowth and newformed bony tissue on the surface of the dead trabeculae.

and matrix formation, followed by deposition of calcium. The endosteal callus was of a spongy nature, but the new trabeculae were more densely arranged than seen in the trochanter and iliac crest (Fig. 2). In 23 cases there was bony union. At the end of 3-4 weeks there was ingrowth of vessels and scanty new-bone formation inside the free bone grafts (Fig. 3). The newformed bone was in the form of thin linings on the surface of the old trabeculae.

DISCUSSION

Upon transplantation of fresh autogenous bone the majority of the osteocytes and the included soft parts undergo necrosis before revascularization has taken place. If the donor site is favourable, a slow revascularization sets in, followed by new-bone formation in the graft, and healing occurs. Thus, the most important factors are the mechanical properties of the graft and its inductor function, whereas it probably has no major active share in osteogenesis. Where the donor site has a poor blood supply and little osteogenetic ability, the result

may be poor healing of the graft. Consequently, it is a reasonable idea to find a graft whose vitality is wholly or partially preserved and which can take active part in the healing process. Interest in such grafting material has been evident in this country as well as abroad (5, 6).

In a previous study (1) we demonstrated that considerable parts of the muscle-pedicle grafts survive and form callus. However, the question remained whether it was sufficient to tie the graft to a site with little osteogenetic ability. The author, therefore, selected a surgical method involving polyethylene isolation which appears to have afforded sufficient guarantee that the healing can be ascribed exclusively to the pedicle grafts. Although a few cells may have survived in the free grafts, their presence was entirely dependent upon nutrition *via* the pedicle grafts.

Union occurred in 23 cases (88 per cent), also in cases where part of the pedicle graft was necrotic. In one case all the osteocytes were apparently necrotic. A possible explanation is that the graft preserved part of its blood supply or that a rapid revascularization took place, sufficient to supply the proliferating osteoblasts with nutrition.

It should be emphasized that in some of the older preparations there was vascular ingrowth and new-bone formation inside the free bone grafts. In these cases the pedicle grafts have not merely survived, but also been able to supply part of the other bone graft with nutrition.

The grafts were cancellous bone grafts with a good, thick pedicle. Something entirely different seems to apply to compact grafts (1) which show poorer survival despite a great osteogenetic activity.

SUMMARY

A series of 30 muscle-pedicle grafting operations on 15 rabbits is reported. The object was to investigate whether the grafts were able to heal unaided. Therefore, the "recipient site" was cut off from blood supply and isolated.

Out of the 26 cases 22 grafts survived wholly or partially.

In 23 cases bony union had taken place.

There was a certain revascularization and new-bone formation at the "recipient site", *via* the muscle-pedicle grafts.

RESUME

Rapport sur un matériel d'observation de 30 greffes d'opération de pédicules musculaires chez 15 lapins. Le but de cette investigation était

de voir si les greffes peuvent vivre d'elles-mêmes sans aide. C'est pour-quoi le site récepteur a été coupé de l'apport de sang et isolé.

Sur ces 26 cas, 22 greffes ont survécu entièrement ou partiellement. Dans 23 cas, la soudure osseuse s'était faite.

Une certaine vascularisation s'est établie et il y avait une nouvelle formation osseuse dans le site récepteur, sur la base des greffes de pédicules musculaires.

ZUSAMMENFASSUNG

Über ein Material von 30 gestielten Muskel-Knochenverpflanzungen an 15 Kaninchen wird berichtet. Das Ziel der Untersuchung war, herauszufinden ob das Transplantat von selbst einheilen konnte. Es wurde daher der Empfängersitz von der Blutzufuhr abgeschnitten und isoliert.

Von 26 Transplantaten überlebten 22 vollständig oder teilweise.

In 23 Fällen hatte eine knöcherne Vereinigung stattgefunden.

Eine gewisse Revaskularisierung und Knochenneubildung am Empfängersitze über das Muskelstiel-Transplantat wurde gesehen.

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