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INVESTIGATION INTO THE CARRYING ABILITY OF PEDICLED BONE GRAFTS DURING TRANSPLANTATION

By

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It is well-known that pedicled grafts are vulnerable, and in order to preserve the blood supply it is necessary to handle them by an atraumatic technique. Their transport from the donor site must take place without too much strain upon the pedicle. However, it is not always possible to avoid a certain torsion, flexion, or extension of the pedicle when placing it on the recipient site. In dealing with tubed pedicles, rotation flaps, and other types of skin flaps, however, there can be ample inspection of the graft, so that measures may be taken in time. On the other hand, the pedicled bone grafts cannot of course be inspected. When a poor result manifests itself radiologically or clinically, several weeks or months may have passed.

Good results have previously been obtained by pedicled bone grafts under experimental conditions (3, 5). Under these conditions, however, care is taken not to strain the pedicle, as the sole object has been to ascertain whether these pedicled bone grafts do survive at all, and whether they preserve their osteogenetic activity and healing ability.

To find out what happens to the graft if the pedicle is placed into positions to which it would otherwise be exposed when placed in the recipient site, the following experiment was carried out.

METHOD

The experimental animals were adult rabbits. The grafts were removed from the greater trochanter on both sides, using the gluteus med. and part of the rotator muscles as pedicle. The grafts were wrapped in polyethylene foil to avoid ingrowth of blood vessels from the surroundings. The pedicles were exposed in a length of 1 cm. On the right side nothing further was done, as this side served as a control.

In 5 of the rabbits the pedicle on the left side was torquated 180° and fixed in this position. In the next 5 rabbits the grafts were pulled 1 cm distal to the donor site and fixed there. This procedure causes great tension on the pedicle—measured by a spring balance while pulling the graft from the donor site to the recipient site—corresponding to 2 kg. In the last 5 cases the pedicle was flexed so that the sawn surface of the graft faced the side opposite to the original.

The rabbits were killed two weeks after the operation. The specimens were studied histologically after being stained with haematoxylin-eosin. Two of each group of rabbits had microangiography by the method of Spalteholz, filling the abdominal aorta with Prussian blue.

In addition, absorption experiments were done on 4 recently operated rabbits, using radioactive sodium. $0.2 \mu\text{C Na}^{24}$ in 0.1 ml physiological saline was injected subperiosteally into the graft, followed by counting with a Geiger-Müller counter. The rate of absorption was taken to represent the circulation in the pedicle. The absorption rate for the normal trochanter was fixed in an experiment on two trochanters.

RESULTS

The torsion was indubitably the most detrimental action. In three grafts all the original osteocytes perished. In two very slight survival could be traced. Nevertheless, the osteogenetic activity in these grafts was surprisingly good (Figure 1). All the control grafts survived and showed relatively little new-formed bone (Figure 2). Extension and flexion of the pedicle exerted a considerably less detrimental effect. Total necrosis of the graft was found in only one rabbit after extension and in one after flexion of the pedicle. On the average, half the osteo-

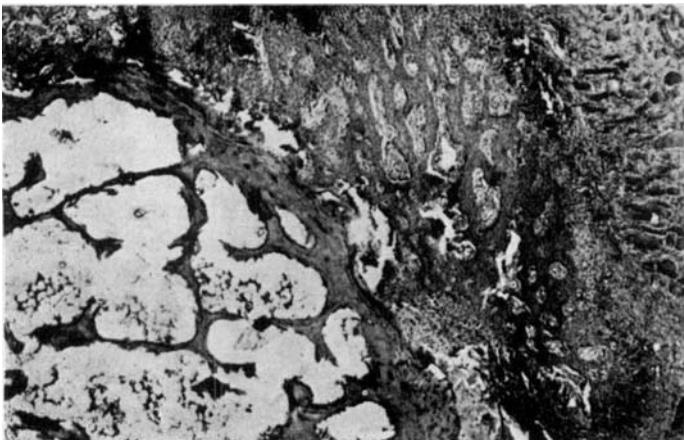


Figure 1. Complete necrosis of the graft. Pronounced subperiosteal callus formation. Torsion of pedicle 180° .

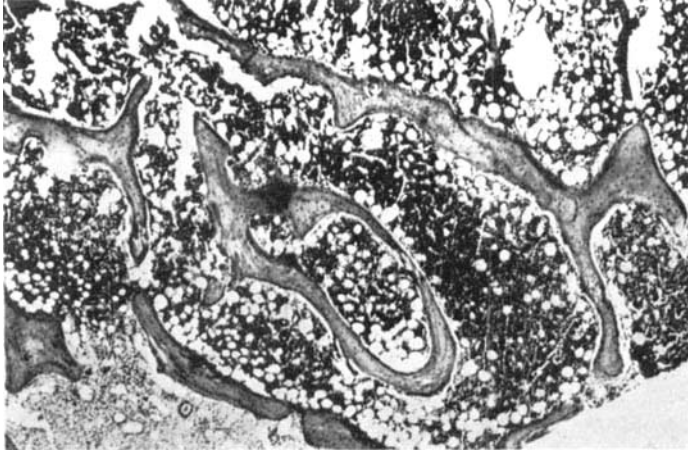


Figure 2. Graft with intact pedicle. Bony tissue alive throughout. The picture is taken in the vicinity of the sawn site.

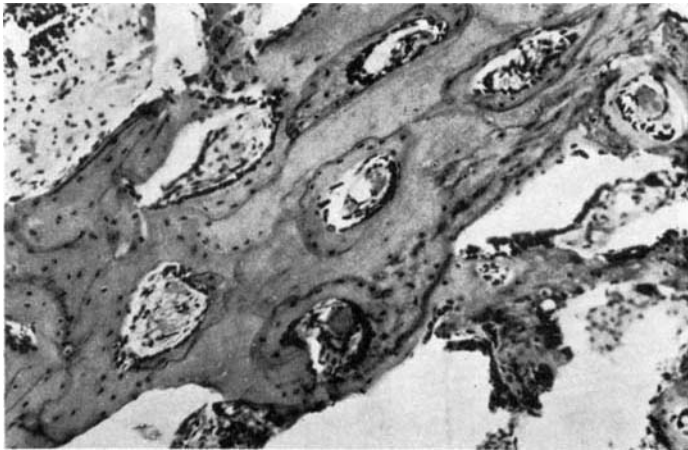


Figure 3. Graft with extended pedicle. About half the original osteocytes are alive in this trabecule which is from the middle of the graft. Some newformation of bone at the bottom.

cytes survived in the remaining grafts—in three up to 75 per cent (Figure 3). However, in this group too the control grafts showed better survival of the original cells.

Microangiography in a few cases gave a result somewhat divergent from the histological findings, the number of blood vessels that filled with Prussian blue being larger than might be expected according to

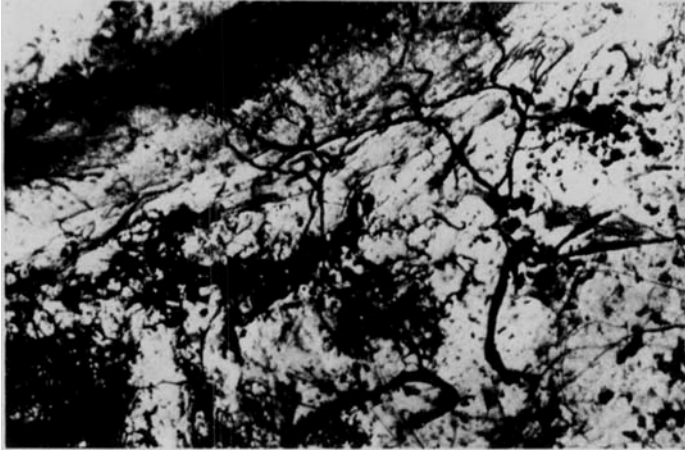


Figure 4. Microangiography by the method of Spalteholtz. The graft with intact pedicle. Good filling of periosteal blood vessels (superiorly) as well as of blood vessels and sinusoids in the graft proper.

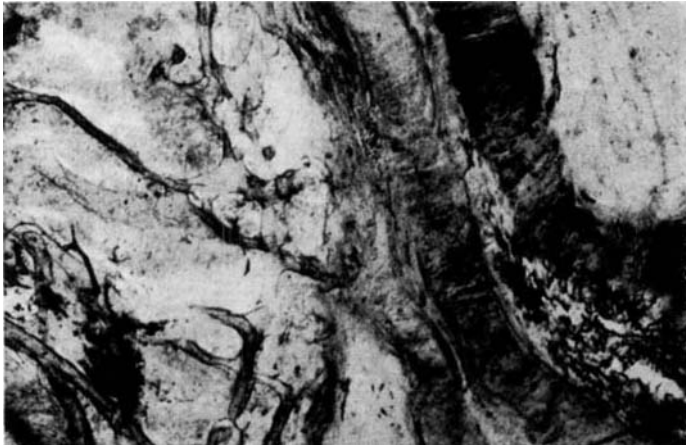


Figure 5. Graft with torquated pedicle in the same rabbit as Figure 4. Minimal number of blood vessels filled with Prussian blue.

the demonstrated osteocyte survival. In other cases, however, there was a pronounced difference between the two sides (Figures 4 and 5), in closer conformity with the histology. In these cases re-vascularization had presumably not yet taken place.

Radioactive sodium clearance test showed the absorption rate through an un-strained pedicle to be the same as in an intact trochanter. The

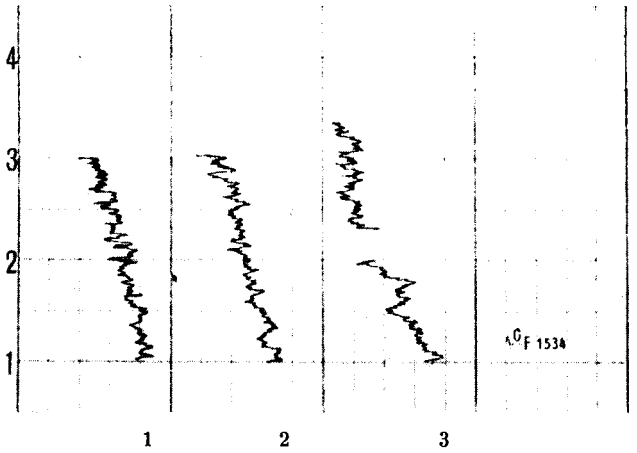


Figure 6. Absorption curves as traced by the Geiger-Müller counter. The curves start at the bottom. The absorption was studied for 20 minutes. 1. Normal trochanter. 2. Pedicled graft. 3. Pedicled graft before and after torsion.

torsion caused an extreme reduction in the absorption. Extension also entailed marked reduction, while flexion, in the studied case, had no effect (Figure 6).

DISCUSSION

Strainful forced positions of the grafts were deliberately chosen, mainly in order to ascertain the utmost carrying ability. It is not surprising, therefore, that *e.g.* a torsion of 180° of a relatively short and thick pedicle entailed primary closure of most veins and arteries in it, leading to total necrosis of the bone. A somewhat unexpected finding was the pronounced new-formation of bone around these grafts. It is known, however, that an osteogenetic factor exists in connexion with a dead bone (1, 7). This factor is released by the dying osteocytes and is presumably a protein (2, 6). The mechanism of its effect has not been fully clarified. It is believed that it takes place through stimulation of capillary proliferation (6). Under the present experimental conditions, therefore, the grafts have not lost their value as transplantation material, in spite of the cell death, because of the preserved osteogenetic ability. The strong traction did not harm the graft as much as did torsion, presumably because the blood vessels are not destroyed before the muscular tissue. Incidentally, the tense condition always decreases as time goes by, because the tissue yields.

A radioactive sodium clearance test was performed as is done in

connection with pedicled skin flaps (4). The test was illustrative, and the results were on the whole in conformity with the histological findings. The method is simple and appears to afford good orientation concerning the circulation in the pedicled grafts.

SUMMARY

An experiment on rabbits is reported. Pedicled bone grafts were removed from the trochanters, the stalks were torquated, extended, and flexed to obtain an impression of their tolerance. The histological and microangiographic investigations of the specimens were supplemented by absorption experiments using Na^{24} . The most detrimental process was the torsion which caused total necrosis of the bone. The other two procedures did less to reduce the survival of the original cells. The grafts preserved an osteogenetic activity in all cases.

RESUME

Il est rapporté une expérience à laquelle on a procédé chez des lapins. Des greffes osseuses pédiculées ont été retirées des trochanters. Les pédoncules ont ensuite été tordus, étirés et fléchis pour avoir une impression de leur résistance. Les examens histologiques et microangiographiques des spécimens ont été complétés par des expériences d'absorption en utilisant du Na^{24} radioactif. Le processus le plus préjudiciable a été la torsion qui causa une nécrose totale de l'os. Les deux autres procédés ont moins contribué à réduire la survie des cellules originales. Dans tous les cas, les greffes ont conservé une activité ostéogénétique.

ZUSAMMENFASSUNG

Ein Versuch mit Kaninchen wird berichtet. Gestielte Knochenspähne wurden von den Trochantern entfernt. Die Stiele wurden torquiert, gestreckt und gebeugt um einen Eindruck ihrer Widerstandskraft zu erhalten. Die histologischen und mikroangiographischen Untersuchungen der Proben wurden mittels Absorbtionsexperimenten ergänzt, indem man radioaktives Na^{24} verwendete. Das schädlichste Vorgehen war die Torsion, da sie vollständige Nekrose des Knochens hervorrief. Die beiden anderen Verfahren führten in geringerem Grade zu einer Herabsetzung des Überlebens der ursprünglichen Zellen. Die Spähne bewahrten in allen Fällen eine osteogenetische Aktivität.

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