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SEGMENTAL MICROVENOUS GRAFT TO ARTERY

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There are many clinical situations where a microvenous graft is essential, either as a primary, or as a salvage, procedure. The question arises—how reliable are microvenous grafts? Some surgeons are reluctant to use these venous grafts as a primary procedure, particularly grafts with an external diameter around 1 mm in size. So far the highest patency rate in vein grafts of 1 to 2 mm in diameter has been reported by Buchler and Buncke (1979) to be 90 per cent based on various macro and microscopical observations. Though vein grafting in larger veins had been critically evaluated (King and Royal, 1971), microvenous grafts require further investigation (Biemer, 1977; O'Brien, 1977; Buncke *et al.*, 1978). The purpose of this study was to determine the patency rate in 1 to 2 mm diameter vein grafts in the femoral vessels of the rabbit in the short term and compare these results with scanning electron microscopy studies over the same period. The microvenous grafting experiments were performed at intervals of several years and highlight the improvements in technique and instrumentation over the last 8 years.

METHODS AND MATERIALS

New Zealand white rabbits ranging from 2 to 2·5 kg in weight were used. The operations were carried out in three series by three surgeons. The first was in 1971 (Table I), consisting of 45 vein grafts: a second series of 25 vein

TABLE I
Microvenous graft—Series I
1971–1972

No. of grafts	Time of exploration (weeks)	No. of patent grafts	% Patency rate
1	1	1	
5	2	5	
2	3	1	
3	6	3	
8	7	5	
3	8	2	
4	9	2	
19	10+	13	
TOTAL 45		32	71

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grafts was carried out in 1975 (Table II) and the third series of 35 vein grafts was performed in early 1979 (Table III). The same standard procedure was followed in all three series. Anaesthesia was induced with intravenous Nembutal and maintained with oxygen, nitrous oxide and halothane using a mask. With the thigh externally rotated and abducted, a longitudinal incision

TABLE II
Microvenous graft—Series II
1975

No. of grafts	Time of exploration (weeks)	No. of patent grafts	% Patency rate
25	2	24	96

TABLE III
Microvenous graft—Series III
February to June 1979

No. of grafts	Time of exploration (weeks)	No. of patent grafts	% Patency rate
25	2	25	100
5	3	5	100
5	4	5	100
TOTAL 35		35	100

was made over the femoral vessels which were dissected out from their sheath distal to the profunda vessels. Both the artery and vein were cleared of all extraneous tissue and two ligatures were placed around the femoral vein just over a centimeter apart, the proximal ligature lying just beyond the level of the profunda artery. This provided an excised vein graft of exactly 1 cm in length. A double clamp was applied to the femoral artery with its arms opposite the ligatures on the femoral vein. A 0·5 cm segment of femoral artery was then excised from the middle of the artery held within the clamp. The lumen of the artery was irrigated with heparinised saline and the peri-adventitia gently cleared off. A 1 cm length of venous graft was then removed, irrigated with heparinised saline, reversed and placed in the defect created in the artery. At this stage, the exact size of the artery and the collapsed vein were measured with a millimetre ruler under the microscope. The proximal and distal anatomoses were performed with 10–0 monofilament nylon on a BV-2 needle*, using an average of 12 interrupted sutures for each complete anastomosis. At the end of the repair the distal clamp was released first so that blood flowed retrogradely across the distal anastomosis, then the proximal clamp was released to establish forward flow. An anastomosis was accepted as successful when there was filling of the grafted segment, visible

*The English equivalent of this needle is a 6·35 mm curved needle carrying 10-0 nylon (0·2 metric gauge) BV. 130-5, Ethicon -W 2810 Code No.).

pulsation in the graft and a positive patency test in the artery distal to the distal anastomosis. At this stage 2 per cent Xylocaine solution was applied to relieve any spasm and the area left undisturbed for 3 to 5 minutes before washing with normal saline prior to skin closure. The levels of the microvascular clamps were marked by the insertion of 6–0 nylon sutures into the muscles on either side so that later the clamp sites could be clearly identified by the scanning electron microscope.

Investigations

1. *Exploration and Evaluation of Patency*: Exploration was carried out at weekly intervals from 1 to 21 weeks in Series I; importance being given to the second week since it was felt that if a graft was patent at 2 weeks, it would more than likely be patent permanently. In Series II explorations were carried out at 2 weeks and in Series III from 2 to 4 weeks. Under general anaesthesia the previous incision was opened. The operating microscope was used to help free all the adhesions and expose the femoral artery and the vein graft. The graft was deemed patent if the following criteria were satisfied:

(i) the graft was full and pulsation was seen in the segment of the venous graft.

(ii) by patency test (a) over the graft (Hayhurst and O'Brien, 1975), demonstrating patency of the proximal anastomosis; (b) distal to the graft segment demonstrating patency of the distal anastomosis;

(iii) during removal of the graft segment for histology, pulsatile bleeding was observed through the vein segment.

2. *Perfusion for Scanning Electromicroscopy*: After patency was established in 5 animals at 2 weeks the abdomen was opened and the aorta cannulated in order to perfuse the femoral vessels with fixative. Details of this technique have been published in other papers by Nightingale *et al.* (1980) (in the press) and De La Pava *et al.* (1979).

3. *Excisional Biopsy*: In most animals after patency has been established, the entire graft segment was removed for histological examination, together with a cuff of artery on either end. The findings will be reported in detail in a later publication.

Results

Patency. *Series I* (1971). In Series I of 45 venous grafts, 32 were patent giving an overall patency rate of 71 per cent (Table I).

Series II (1975). Of 25 venous grafts, 24 were patent (Table II). All grafts were explored at 2 weeks. Only 1 graft, explored at 2 weeks, was found to be thrombosed. The thrombosis appeared to originate at the proximal clamp site and it seems likely that this had been applied too lightly.

Series III (1979). Of the 35 grafts, 25 were explored at 2 weeks, 5 at 3 weeks and 5 at 4 weeks. All the grafts were patent, giving an overall patency rate of 100 per cent (Table III).

Scanning electronmicroscopy. At 2 weeks endothelial coverage of the anastomosis and of the venous graft was complete. However, there was a secondary patchy loss of endothelium apparently occurring as a result of leucocyte migrations (Figs. 1 and 2). This was not severe in extent but

FIG. 1. Two week vein to artery graft showing the anastomotic site with the arterial segment above and venous graft velow. The anastomotic site is completely re-endothelialised. ×100 (original magnification).

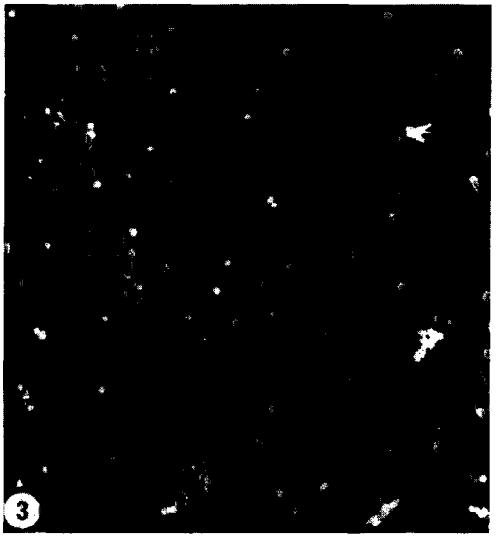

FIG. 2. Higher magnification of Figure 1, showing detail of endothelium. A leucocyte appears to be present beneath the endothelial sheet and a crater seen in one endothelial cell is probably the result of migration of a leucocyte. ×900.

FIG. 3. Representative area from middle of the vein graft at 2 weeks. This shows complete endothelialisation of the graft and areas of leucocyte migration occurring through the vessel wall. ×200.

evidence of leucocyte migration was present throughout 4 of the 5 specimens and to a lesser extent in the fifth, throughout the venous and arterial segments. The whole graft was endothelialised by 2 weeks (Fig. 3).

The formation of new vessels was a common finding at the anastomotic sites. Very little thickening of the endothelium was seen as described by Melka *et al.* (1979), nor was there any microaneurysm formation as described by Buchler and Buncke (1978) and Maxwell *et al.* (1979). Of the 60 grafts in the 1975 and 1979 series, there was infection in 5 with localised abscess formation, but this did not interfere functionally with the patency of the grafts. A more detailed scanning electron microscopic study will be published later.

Discussion

A standardised technique of microvenous grafting has been used on three different occasions in three sets of animal experiments. The mean external diameter of the femoral artery was 0·9 mm whereas the mean external diameter of the femoral vein was 1·1 mm. The mean operating time for each graft, from the time of commencing exploration to skin closure was 45 minutes: the actual grafting procedure taking, on average, half an hour. The technique, when perfected, can achieve a success rate of almost 100 per cent, equal to that attainable by end-to-end suture. This paper highlights the expertise and experience of the team over a considerable time period and the way in which improvements in overall microsurgical technique have improved the patency rate of the microvenous grafts from 71 per cent in 1971, to 96 per cent in 1975, and 100 per cent in 1979.

As far as the short term changes in the grafts are concerned, no microaneurysm formation has been observed (Buchler and Buncke, 1979).

It is possible that this phenomenon may be a feature peculiar to vessels in the rat rather than in the rabbit. At short term little fibrotic narrowing of the lumen of the graft was seen, as described by Melka *et al.* (1979). The size of the vein graft was almost the same as at the time of insertion. Scanning electronmicroscopy showed very little endothelial thickening at 2 weeks and minimal narrowing of the lumen.

As far as the length of the graft is concerned it has been well documented by Fujikawa and O'Brien (1975) that the patency rate is unrelated to the length of the grafts.

Summary

One hundred and five microvenous grafts were carried out during three periods of time. Forty-five were performed in 1971, 25 were performed in 1975 and 35 were performed in 1979. The rabbits weighed 2 to 2·5 kg and a standard technique was followed by inserting a 1 cm vein graft after creating a defect of 0·5 cm in the femoral artery, taking the graft from the femoral vein on the same side. Exploration was carried out from 1 to 21 weeks at weekly intervals. The patency rate in Series I (1971) was 71 per cent, whereas the patency rate in Series II (1975) was 96 per cent and in Series III (1979) was 100 per cent. The scanning electron microscope showed that in the short term there was no narrowing of the lumen, nor any microaneurysm formation as reported previously by Buchler and Buncke (1979).

Conclusion

Microvenous grafting is an important procedure for the microvascular surgeon who may be faced in the operating theatre with major defects in the arteries or veins. Often the only way a flow can be established, or a defect bridged, is by a vein graft. With perfection of the technique a 100 per cent patency rate has been achieved with microvenous grafts in the experimental animal. There is no good reason why similar defects in man cannot be bridged in the same way with comparable success.

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