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Dacron Felt Wrapping and Prosthetic Vascular Anastomosis

(Dacron felt wrapping/prosthetic vascular anastomosis/microangiography)

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An experimental study of the Dacron felt wrapping to reinforce the prosthetic vascular anastomosis was done on the infrarenal aorta of the dog. Gross inspection, histological examination and microangiography were performed at various intervals after the operation. Tensile strength was examined two months after grafting.

Histological examination revealed that the Dacron felt remained fixed to the both aortic wall and the prosthetic vascular graft even 40 days after the operation. Microangiogram also showed good neovascular infiltration in the Dacron felt. Tensinometry revealed that the strength of the wrapping group was stronger than that of the non-wrapped group. Thus, Dacron felt wrapping is considered to be a safe and effective method of reinforcing the prosthetic vascular anastomosis.

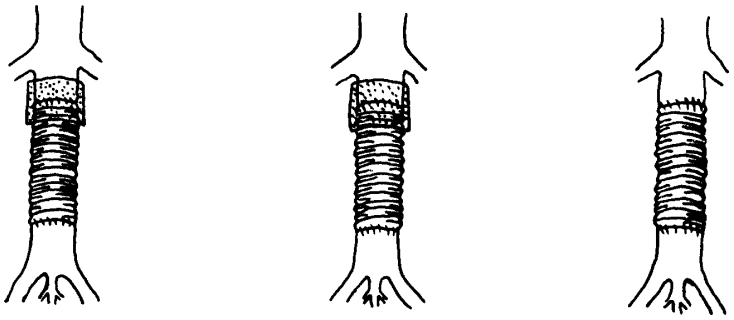
Disruption of the suture line between the major artery and synthetic prosthesis is not so common, but when it does occur the sequence is formidable. As the late anastomotic rupture occurs on the host arterial wall in the presence of residual disease or of the gradual weakening of the arterial wall, reinforcement of the anastomotic site should prevent this complication. Animal experiments using Dacron felt to reinforce the prosthetic vascular anastomotic site were performed and the results are reported herein.

MATERIALS AND METHODS

Twenty-five adult mongrel dogs weighing about 13 kg were anesthetized with pentobarbital sodium 25 mg/kg given intravenously. A laparotomy was performed under aseptic conditions and the infrarenal aorta was freed distally to the trifurcation. The infrarenal aorta was severed and the defect in the aorta was repaired with the knitted Dacron (Vascular D, 8 mm in diameter, 4 cm in length). The experimental animals were separated into the following three groups (Fig. 1).

Group 1) : Fifteen dogs were used. 6—0 Nylon continuous sutures were used for the proximal and distal anastomosis.

Group 2) : Five dogs were used. 5—0 Dexon continuous suture was used



Group 1
6—0 Nylon suture
Dacron felt wrapping

Group 2
5—0 Dexon suture
Dacron felt wrapping

Group 3
5—0 Dexon suture

Fig. 1. Schematic drawing of experimental groups.

for the proximal and distal anastomoses. The proximal anastomosis was wrapped with Dacron felt 2.8 cm in width.

Group 3) : Five dogs were used. 5—0 Dexon continuous suture was used for the proximal and distal anastomoses. The proximal anastomosis was not wrapped.

In group one, the animals were sacrificed at 7, 14, 40, 80 days, 6 months and one year after operation ; specimens were removed for gross and histological examination. Microangiography was performed 40, 42 days and 7 months after operation to observe neovascularization of the Dacron felt.

The specimens from groups two and three were removed two months postoperatively for tensinometric examination. The effect of the Dexon sutures may be excluded from the tensinometric examination because of the absorbability of this suture material.

Method of Microangiography

Under general anesthesia, the descending aorta and unilateral external iliac artery were exposed. The celiac artery, superior mesenteric artery and both renal arteries were ligated at their origins. Normal saline containing heparin 10 U/ml was used for irrigation through a vinyl tube inserted into the descending aorta ; the outlet of the fluid was from the external iliac artery. The dogs died during these procedures. The descending aorta was ligated proximal to the insertion site of the vinyl tube. The micropaque mixture (9 grams gelatin was dissolved in 45 ml of distilled water mixed with 45 ml of micropaque and 10 ml of 100 % formalin) was instilled via the vinyl tube. Twenty-four hours after the micropaque injection, the fixed specimens were cut into 1.5 to 2 mm width. Microangiography was performed using Softex film at the distance of 40 cm with the electric voltage of 24 kvp, electric current of 3 mA and exposure time of 1 to 2 minutes.

Method of Tensinometry Examination

The specimens were removed en bloc including the proximal aorta, distal aorta and the surrounding loose connective tissues. The loose connective tissue was carefully removed in the normal saline solution containing heparin.

Specimens of longitudinal strips 1 cm in width were then applied to the tensinometer, as in Fig. 2. The tension of the proximal anastomotic line

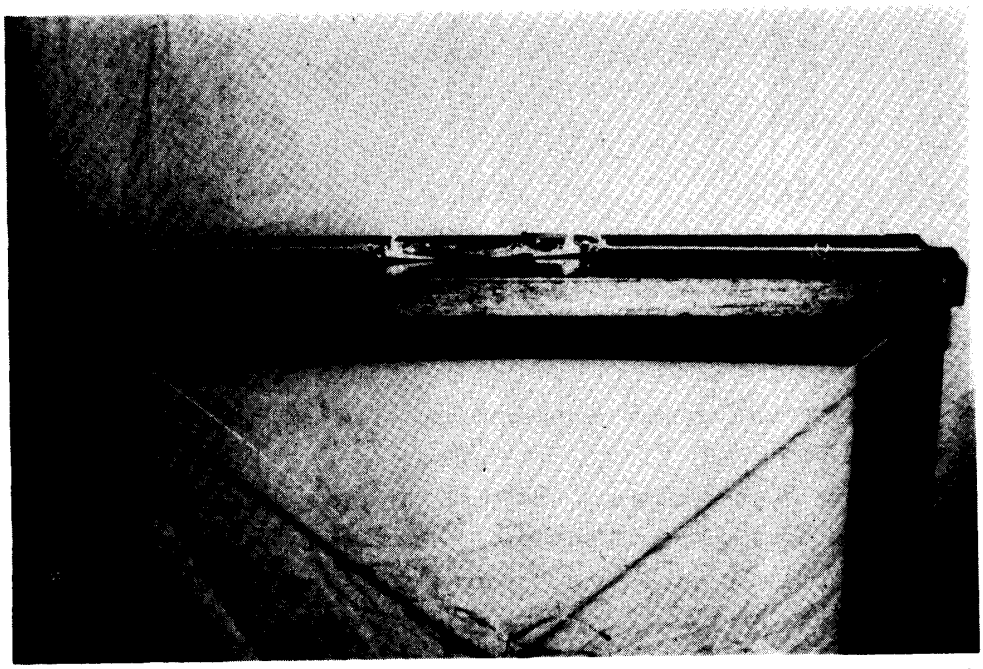


Fig. 2. A tensinometer. The clip is applied to the both ends 2 cm from the proximal anastomotic line.

was expressed as the weight in grams capable of inducing anastomotic rupture. The statistical comparison of findings in groups two and three was carried out using student's t-test.

RESULTS

Gross Inspection

Specimens removed 7 days postoperatively revealed that the Dacron felt could be separated easily from the vascular graft and the host arterial wall; luminal surface of the graft was covered with a thin reddish brown membrane.

Specimens removed 14 days postoperatively were found to be firmly fixed to the host arterial wall as well as the anastomotic site, but not to the prosthetic vascular graft. The luminal surface of the graft was a light red colored thin layer except at the anastomotic site which was covered with a milky white pseudointima.

The specimens removed 40 days postoperatively showed the Dacron felt to be firmly fixed to the host arterial wall and to the prosthetic vascular graft. The luminal surface of the graft was covered with a light-red membrane except 5 to 6 mm adjacent the anastomotic site which was covered with pseudointima.

Specimens removed 6 months postoperatively showed the Dacron felt to be firmly fixed to the anastomotic site, host arterial wall and prosthetic vascualr graft. The luminal surface of the graft was completely lined with pseudo-

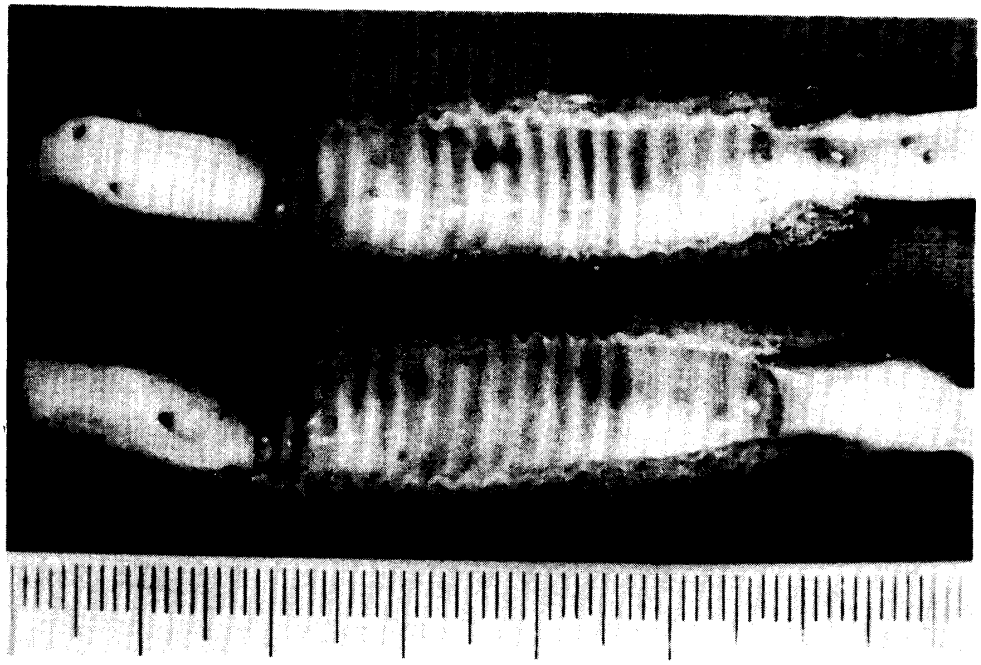


Fig. 3. Specimen removed one year postoperatively. Dacron felt is fixed firmly to the anastomotic site and there is no thinning of the aortic wall.

Fig. 4. Microscopic section near the anastomotic site of the 14 days specimen. Dacron felt is infiltrated by the newly formed connective tissue. H-E stain, ×87.

intima.

Specimens removed one year postoperatively showed the Dacron felt to be firmly fixed to the prosthetic vascular graft which was completely lined with the pseudointima. No thinning of the host arterial wall under the Dacron felt was noted (Fig. 3).

Microscopic Examination

Specimens removed 14 days postoperatively showed the Dacron felt to be surrounded by newly formed connective tissue. This tissue infiltration was seen in that portion of the Dacron felt covering the host arterial wall (Fig.4). Most of the luminal surface of the prosthetic vascular graft was covered with a fibrin membrane. Only the portion of the graft near the anastomosis was covered with the newly formed tissue.

The 40 day specimens showed the entire length of the Dacron felt to be infiltrated by immature connective tissue (Fig. 5). The fibrous element between the Dacron felt and the host arterial wall was richer than that of the 14 day specimens, but the collagenous fibers in this area were rather edematous. The luminal side of the prosthetic vascular graft near the anastomotic site was covered by a fibrous connective tissue layer and the central portion of the prosthetic vascular graft was covered by mural thrombi. The portion of thrombus adjacent to the graft was organized but the luminal surface was not organized. Connective tissue infiltration was recognized in the interstices of the prosthetic graft.

The 80 day specimens showed almost the same findings as the 40 day specimen, but organization of the pseudointima was more advanced.

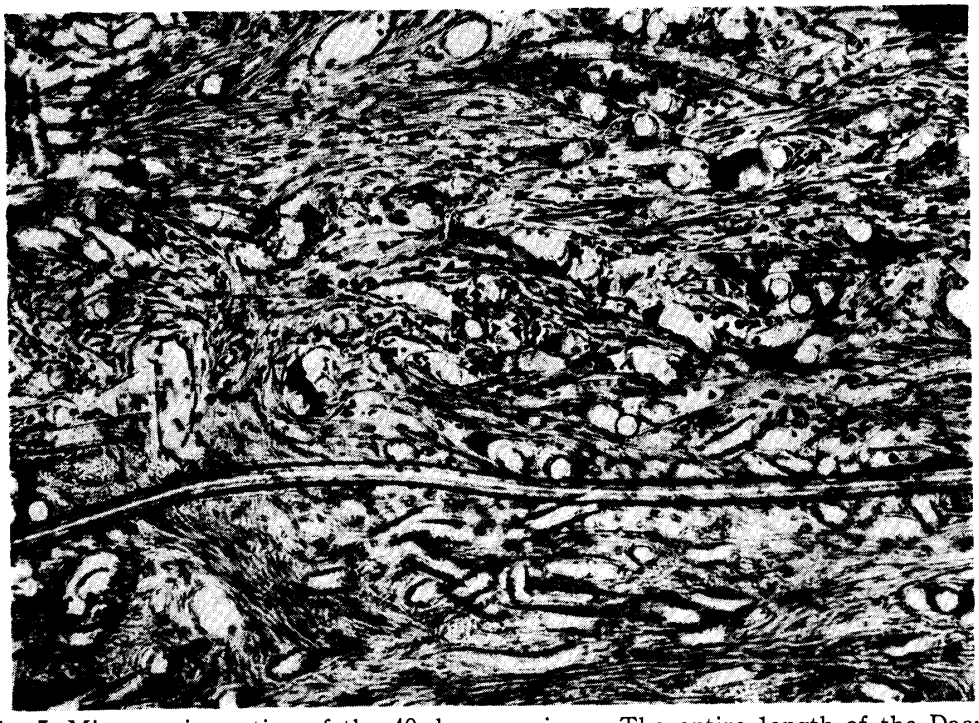


Fig. 5. Microscopic section of the 40 days specimen. The entire length of the Dacron felt is infiltrated by the newly formed connective tissue, H-E stain, ×164,

The 180 day specimens showed proliferation of the immature collagenous fibers between the Dacron felt and host arterial wall. The inner surface along the entire length of the Dacton felt was covered with a completely organized pseudointima.

The specimens removed one year postoperatively showed a decrease in the cellular element of the connective tissue between the Dacron felt and the host arterial wall. The luminal surface of the prosthetic graft was completely lined with pseudointima (Fig. 6).

Microangiogram

All the 40 days, 42 days and 7 months postoperative specimens showed invasion by new vessels into the Dacron felt (Fig. 7). These new vascular channels were observed to be organized from vessels outside the Dacron felt and adventitial vessels of the host arterial wall.

Tensinometry Examination (Table I)

The tensile strength of group 2 specimens (5—0 Dexon sutured, Dacron

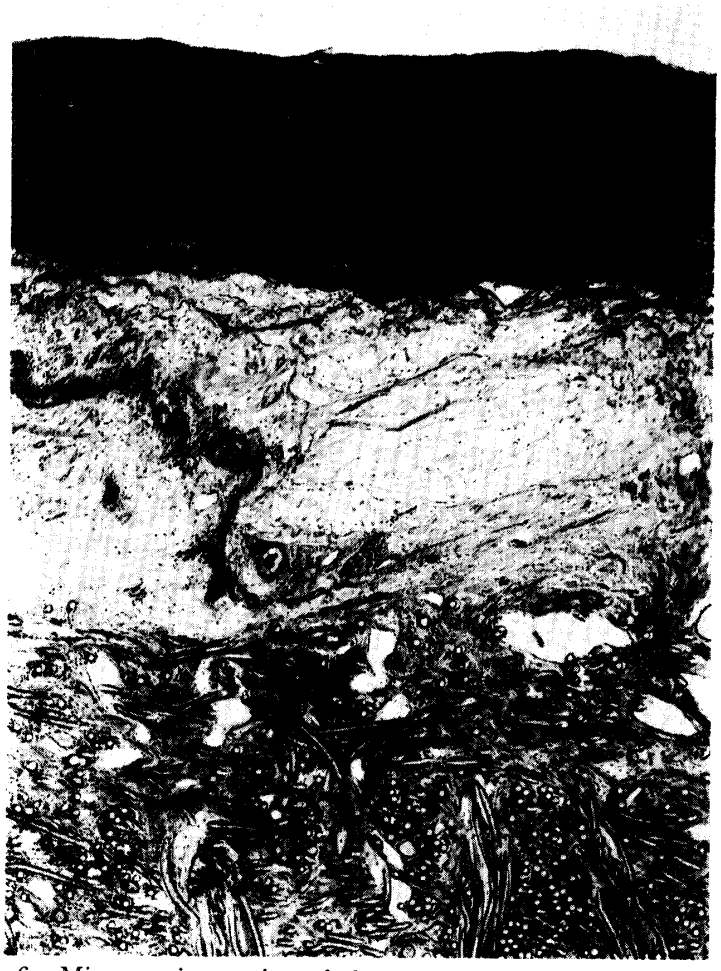


Fig. 6. Microscopic section of the one year specimen. Fibrous connective tissue is infiltrated between the Dacron felt and the aortic wall with no apparent thinning of the aortic wall. H-E stain, ×50.

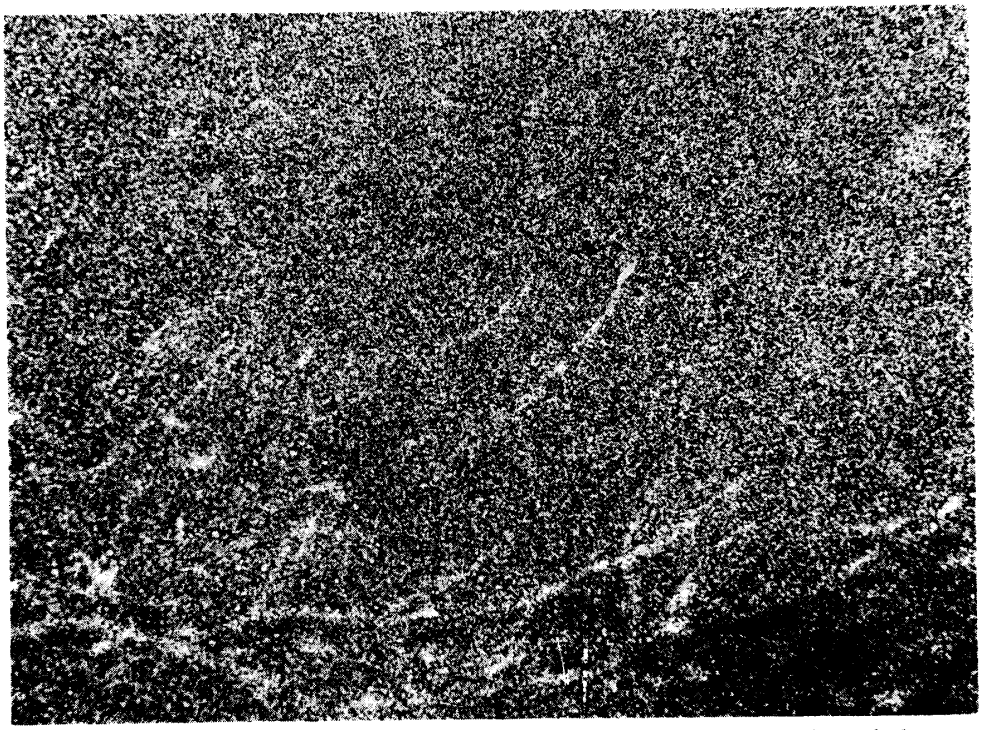


Fig. 7. Microangiogram of the 7 months specimen. There is invasion of the new vessels into the Dacron felt.

TABLE I. *Result of Tensinometry*

	No. of cases	Result
Group 2 Wrapping (+)	5	1120± 83.7 g
Group 3 Wrapping (−)	5	764± 226.3 g

$(0.01<p<0.02)$

felt wrapping performed) was 1120 ± 83.7 gm, that of group 3 specimens (5 −0 Dexon sutured, Dacron felt wrapping non-performed) was 764 ± 226.3 gm. The difference in these values is statistically significant $(0.01<p<0.02)$.

DISCUSSUION

From the 1940's to the 1950's, "wrapping" was used experimentally and clinically in the treatment of aneurysms (2, 4, 6, 10). Artificial materials such as Cellophane (6, 10), Sponge (4), and Polyethylene (2) were used, but the usefulness of these materials was doubtful and this approach was abandoned. Aneurysm repair with arterial homograft (5, 9) and later prosthetic vascular grafts (26) became the standard operation. Recently, prosthetic vascular grafts have been used for the treatment of arterial aneurysms. Long term follow-up of the prosthetic vascular grafting has shown late anastomotic

rupture or pseudoaneuryem formation does occur in a certain percentage of cases. The incidence of the late anastomotic rupture of the prosthetic vascular grafting in the United States has been reported to be between 3 and 24% (16, 21—23). In Japan, the rates are about 10% (12, 14).

Excluding the cases of infection, the main cause of the late anastomotic rupture is considered to be the rupture or absorption of the silk suture (11), but late anastomotic rupture still occurred despite use of the synthetic sutures (16).

Rupture of the host arterial wall with intact and retained sutures in the graft wall has been documented (12). Recently, the main cause of the late anastomotic rupture is attributed to the residual disease or progression of the disease in the host arterial wall (13, 20, 21). Furthermore, physical properties of the vascular grafts are different from those of the host artery, so late anastomotic rupture appears unavoidable (23).

Since the 1960's, several artificial materials have been used to reinforce the vascular anastomosis (3, 15, 17, 27). These materials have also been used to enclose arterial aneurysm which was too difficult to resect, thus the so-called "external grafting" (7, 18, 19, 24).

According to the literature, the following materials have been used for "external grafting" or anastomosis reinforcement : Nylon (1), vascular prosthesis (15, 18, 19, 27), Marlex mesh (Polypropylene mesh) (27), Teflon mesh (7), Tetoron mesh and Teflon felt (18). Zimberg (27) compared the effect of the Dacron Knitted graft to that of the Teflon weave graft and Marlex mesh and reported that the latter was superior to the other materials. Robicsek *et al.* (18) reported that healing of the Teflon felt to the host arterial wall was inadequate therefore not suitable for the reinforcement of the vascular anastomosis and that cuffed vascular graft be used. DeBakey *et al.* (2) reported that polyethylene was not suitable for "wrapping" because of insufficient connective tissue formation.

According to our experiments, the healing process of the Dacron felt with the vascular anastomotic site was excellent. Two weeks postoperatively, the Dacton felt was covered with a thick layer of connective tissue. Forty days postoperatively, the Dacron felt was completely fixed to the anastomotic site with connective tissue, neovascular invasion of the Dacron felt was evident along the entire length. The host arterial wall of the one year specimens showed no changes in the medial layer and no thinning of the arterial wall. This result is contrary to the report of Takahashi (25) who found that thinning of the host arterial wall had occurred in Tetoron mesh wrapping cases. The reason for these differences is not clear but it may be due to the differences in the physical properties of these materials.

The course of the pseudointima formation of the prosthetic vascular graft with Dacron felt wrapping was the same as that in cases where "wrapping" was not performed. That is, wrapping of the anastomotic site with the Dacron felt did not interfere with the pseudointima formation of the prosthetic vascular graft. Postoperative microangiography confirmed that the

vascular channels in the Dacron felt originated from the host arterial wall and the outer side of the Dacron felt. Thus, the host arterial wall, Dacron felt and adjacent connective tissue were firmly connected.

The procedure of the Dacron felt wrapping described herein has already been used clinically on 38 patients and 60 anastomoses in Kyushu University (8). There was no occurrence of anastomotic rupture or late obstruction during the postoperative period of one year eleven months to three years.

According to the experimental and clinical results, the Dacron felt wrapping may be an effective method to reinforce the prosthetic vascular anastomosis.

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