



## Role of Infrainguinal Bypass in Buerger's Disease: An Eighteen-year Experience

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**Objectives:** The role of bypass to the distal arteries for patients with Buerger's disease (thromboangiitis or TAO) remains controversial because of the high incidence of graft failure. We retrospectively reviewed the results of 71 bypasses to evaluate their efficacy.

**Materials and methods:** We performed 71 autogenous vein bypasses in 61 patients with TAO. Of the patients, 97% were heavy smokers. The indications for surgery were claudication in 41%, and ischaemic ulcer or gangrene in 59%. Of the bypasses 85% were to the crural arteries or to the arteries below the ankle. The grafts used were 53 single saphenous veins, and 18 venovenous composite grafts.

**Results:** There were 38 graft failures, the main causes including anastomosis to a diseased artery, disease progression (which occurred in smokers after surgery), and vein graft stenosis. Of 38, 10 were restored to patency by revision surgery. Primary and secondary patency rates were 48.8% and 62.5% at 5 years, and 43.0% and 56.3% at 10 years, respectively. The patency rates of the postoperative non-smoking group was significantly higher than that of the smoking group (66.8% vs. 34.7%,  $p < 0.05$ ). Thirty-six patients (59%) had successful revascularisation and returned to full-time work. However, of 28 with secondary failure, 11 underwent amputation, while 14 had persistent disabling claudication.

**Conclusion:** Bypass to the distal arteries is an effective treatment for TAO patients, and the long-term patency is quite satisfactory as long as patients stop smoking.

*Key Words:* Buerger's disease; Infrainguinal bypass; Autogenous vein; Smoking; Claudication

### Introduction

The most common initial symptom of Buerger's disease (thromboangiitis obliterans or TAO) is a painful ischaemic ulcer on the one of the toes, and the disease progression is considered to be closely related to cigarette smoking. The ulcers are commonly accompanied by severe pain and usually prove intractable to medical therapy, even after the cessation of smoking. Patients often need opiate analgesia to obtain pain relief and sufficient sleep. Thus, the only alternatives for these patients are bypass surgery or amputation.

Bypasses to the distal arteries for TAO patients with lower limb ischaemia were aggressively performed in Japan until 15 years ago. Although the number of cases at each institute was too small to provide sufficient statistical analyses of the results, bypass surgery for TAO is now less common because of the technical difficulties involved and the poor results achieved.<sup>1,2</sup> Hence the role of bypass surgery for TAO

patients remains controversial and unclear,<sup>3,4</sup> and significant evaluation for long-term results has yet to be reported. The objectives of this paper are to assess the efficacy and durability of bypass for patients with TAO and the factors influencing the long-term results.

### Patients and Methods

Following the guidelines for the diagnosis of TAO reported by the Buerger's Disease Research Committee of the Ministry of Health and Welfare of Japan in 1973 (which was partially revised in 1990),<sup>5,6</sup> the diagnosis of TAO in the majority of patients was made when those patients exhibiting infrainguinal arterial occlusion with angiographic features characteristic of TAO (Fig. 1) and no evidence of atherosclerotic lesions or other vascular diseases satisfied the following criteria: (1) a history of smoking; (2) onset before 50 years of age; and (3) an absence of arteriosclerotic risk factors such as diabetes, hyperlipidaemia, or hypertension. Even if the onset was after the age of 50 years,

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when patients had typical arteriographic findings of TAO without any evidence of atherosclerotic lesions, we included them in the TAO group. Coexistent upper limb involvement and/or phlebitis migrans were corroborative, but not essential, signs for the diagnosis of TAO.

Between April 1977 and July 1995, surgical treatment was performed on 84 consecutive patients (98 limbs) with TAO. Of the 84, 23 underwent sympathectomy alone, while the remaining 61 patients underwent 71 autogenous vein bypasses to the infrageniculate arteries. All bypasses were performed after obtaining a promise from each patient to quit smoking postoperatively. The ages at onset and at the time of bypass surgery ranged from 22 to 61 years (mean age:  $39.8 \pm 4.8$ ) and 24 to 66 years (mean age:  $42.8 \pm 4.4$ ), respectively. The mean duration of symptoms was 34 months. The 61 patients included 52 men and nine women; 97% were heavy smokers (more than 20 cigarettes a day), and 18% had coexistent upper limb involvement, while 36% of all patients had a history of



Fig. 1. Arteriogram of a 41-year-old man with TAO, showing typical angiographic findings of TAO. The superficial femoral artery is disease free, and occluded abruptly at the Hunter's canal. The popliteal and crural arteries have segmental occlusions.

Table 1. Demographics of TAO patients who underwent bypass surgery.

	61 cases/71 limbs
Mean age	
at onset	39.8±4.8 (22–61) years
at bypass surgery	42.8±4.4 (24–66) years
Duration of symptoms	34.0±16.0 (2–120) months
Gender	
Male	52 (85%)
Female	9 (15%)
History	
Smokers	59 (97%)
Non-smokers	2* (3%)
Upper extremity involvement	11 (18%)
Bypass surgery	4 (7%)
Sympathectomy	14 (20%)
Contralateral major amputation	4 (7%)

\*=probable passive female smokers.

bypass surgery, sympathectomy, or contralateral major amputation (Table 1). Ten patients had onset after 50 years of age, including a 61-year-old male, but all patients satisfied the other criteria. Although there were two female patients who were actually non-smokers, they had a history of passive inhalation of heavy amounts of secondary smoke in their workplace. Indications for surgery were claudication in 41%, small single ischaemic ulcer of the toes in 22%, and foot or limb salvage in 37%.

Of the 71 bypasses, 75% were to the crural arteries, 17% were to the arteries below the ankle, and only 8% were to the popliteal artery below the knee. The superficial femoral artery or infrageniculate arteries were selected as the proximal anastomotic site in 75% of bypasses. The grafts used were 53 single saphenous veins, which included 38 reversed, six non-reversed, and nine *in situ* saphenous veins, and 18 venovenous composite grafts. Seven arm veins were used for composite grafts (Table 2). Sympathectomy in combination with bypass surgery was performed on 38 patients who had a history of recurrent toe ulceration or multiple occlusive lesions in the arteries below the

Table 2. Types of veins used for bypass.

	No. of grafts
Long saphenous veins	53
Reversed	38
Non-reversed	6
<i>In situ</i>	9
Venovenous composite grafts	18
Two	13
Three or more	5
Arm vein	7
Accessory saphenous vein	2
Total	71

ankle. The graft should be anastomosed to a normal arterial segment, which is shown by a clear outline on the preoperative arteriogram and also confirmed by the operative finding of an artery without adhesions. The wall of the distal artery is very thin, and dissection of arterial segments inevitably provokes severe spasm (Fig. 2), leading to a predisposition to technical error. It is important to wait until spasm is relieved before starting the anastomosis by applying a moist pad soaked with warm 2% xylocaine to the wound. While waiting, it is usually possible to complete the dissection of the artery for the proximal anastomosis and to fashion the tunnel for the graft. The distal anastomosis was performed mainly with three interrupted 8-0 polypropylene sutures for the toe of the anastomosis, and then with continuous lateral sutures. In the cases of bypass to the medial plantar artery, 9-0 nylon sutures were used. A satisfactory technical result was confirmed by intraoperative arteriography. Blood flow through the graft was also measured by electromagnetic flow probe on completion of the procedure.

All of the patients were followed up monthly for the first 3 months, then at 3 month intervals for 2 years,

and every 6 months thereafter. Graft function was assessed by the ankle brachial pressure index (ABI) and analysis of the Doppler ultrasonography spectrum. When the reduction of wave height along with disappearance of the reverse-flow component in Doppler analysis or the ABI decreased by 0.2 or more, the follow-up interval was shortened to 2 weeks in order to detect the early onset of vein graft abnormality. To obtain objective evidence of non-smoking after surgery, the carboxy-haemoglobin level in the venous blood was monitored in all patients. Low-dose aspirin (81 mg/day) or trapidil<sup>7</sup> (300 mg/day, Rocornal<sup>®</sup>, Mochida Co., Ltd., Tokyo), an antagonist to platelet-derived growth factor, were administered to 51 patients (59 grafts). Of the 51, 31 (35 grafts) were also given warfarin concomitantly. All medical therapy was discontinued after 2 years, if the graft was functioning well.

All data is presented as the mean  $\pm$  2 s.e. Statistical analyses were performed using the Student's *t*-test, the Chi-square test or the one-way ANOVA. The patency rates were determined in accordance with the Ad Hoc Committee on Reporting Standards, the Society for Vascular Surgery/North American Chap-



Fig. 2. Arteriograms of a 38-year-old man who underwent femoroposterior tibial bypass. (a) compression arteriogram showing severe arterial spasm at the anastomosis; (b) arteriogram 3 weeks after surgery showing no spasm.

ter, International Society for Cardiovascular Surgery, and compared with use of the log-rank test.

**Results**

The mean follow-up period was 62.6 months. There were 14 early failures, the causes including poor quality vein, inadequate technique for anastomosis or tunneling, and anastomosis to a diseased arterial segment. Of 24 late failures, the main causes were disease progression, which commonly occurred in continued smokers, and vein graft stenosis due to intimal hyperplasia (Table 3). All causes were confirmed by arteriography and/or intraoperative findings at revision surgery. Of the total of 38 graft failures, 10 were restored to patency by partial graft replacement for a poor quality vein segment or jump bypass grafting for a diseased arterial segment. The primary, assisted primary, and secondary cumulative patency rates for the 71 grafts were 48.8%, 58.0%, 62.5% at 5 years, and 43.0%, 52.1%, 56.3% at 10 years, respectively (Fig. 3). There was no significant difference between them. Of the 28 limbs with secondary graft failures, three had a successful redo bypass, whereas 11 underwent amputation (8 minor, 3 major) and the remaining 14 had persistent disabling claudication which affected their ability to work. Of these 14 claudicators, five developed atrophy of the foot or calf

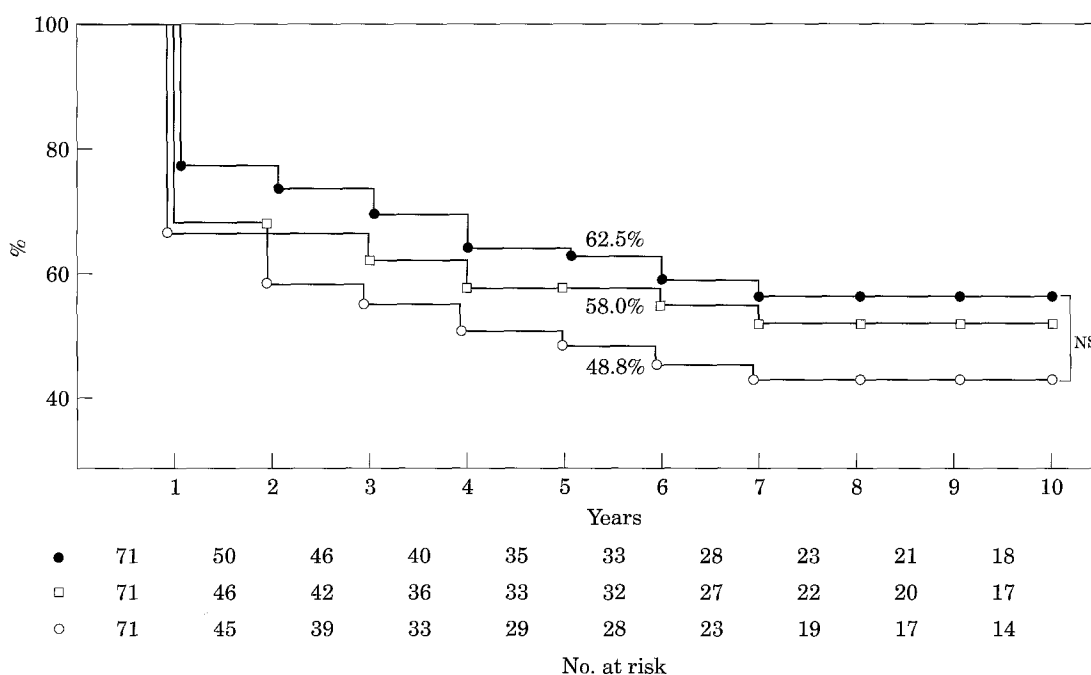
as a result of long-standing ischaemia. The longest duration of follow-up in 36 patients (59%) with patent grafts was 16 years, and all of them returned to full-time work.

The influence of the following variables on graft patency was examined: age at onset and surgery; gender; duration of morbidity; indication for surgery; sympathectomy; number of diseased segments; site of the distal anastomosis; vein quality; graft blood flow; and smoking after surgery. Of the 71 bypasses, when

**Table 3. Causes of primary graft failure.**

	No. of grafts
Early failures	14 (5)
Poor quality vein	5 (2)
Inadequate technique for anastomosis	4 (1*)
Inadequate tunneling	1 (1)
Anastomosis to diseased artery	2 (1*)
Arterial spasm during postoperative angiography	1
Vein graft stenosis due to intimal hyperplasia	1
Late failures (>3 months)	24 (7)
Disease progression in smokers after surgery	8*
in non-smokers after surgery	1 (1)
Vein graft stenosis due to intimal hyperplasia	10 (4)
Atherosclerosis	2 (1)
Vein graft aneurysm	1 (1)
Completion with collateral flow	1
Undetermined	1
<b>Total</b>	<b>38 (12)</b>

( )=successful revision; (\*)=late failure after revision; \*=including one female passive smoker.



**Fig. 3.** The primary, the assisted primary, and the secondary cumulative patency rates for 71 autogenous vein grafts, showing no significant difference between them. (●) secondary patency rate; (□) assisted primary patency rate; (○) primary patency rate.

63 (exclusive of 8 secondary failures within 1 month after surgery) were divided into groups of non-smokers and smokers after surgery, the 5-year life-table patency rates for both groups were 66.8% and 34.7%, respectively ( $p < 0.05$ ) (Fig. 4). The mean graft blood flow rates at the completion of bypass surgery were significantly associated with patency. Poor vein graft quality was also significant risk factors for early graft failure, but none of the other variables appeared to have a significant influence on the patency of grafts (Table 4). There was no evidence that anticoagulant and antiplatelet therapies were effective in preventing late graft failure.

### Discussion

The guidelines for the diagnosis of TAO which we have employed are widely accepted in Japan. Shionoya<sup>8</sup> described the clinical criteria, which do not include angiographic findings, for the diagnosis of TAO as follows: (1) smoking history; (2) onset before 50 years of age; (3) infrapopliteal arterial occlusive lesions; (4) either upper limb involvement or phlebitis migrans; and (5) absence of atherosclerotic risk factors other than smoking. Our series included 10 patients with the onset in their 50s and two female non-smokers. However, Shionoya also found that TAO may affect smokers in their 50s, with the possibility of

TAO in non-smokers who are continuously exposed to environmental tobacco smoke. Olin *et al.*<sup>9</sup> reported that his series included 23% women and 7% patients with the onset after 60 years. Hence, we considered that these 12 patients were unequivocal cases of TAO.

The indications of the primary bypass surgery were disabling claudication in the calf as well as limb or foot salvage. Patients with ulcers are usually initially treated medically or by lumbar sympathectomy, and some of them may well respond to such therapy. Fiessinger and Schafer<sup>10</sup> reported iloprost, a chemically stable prostacyclin analogue, was effective for ischaemic ulcers of TAO patients. However, since the arterial occlusion is commonly multisegmental,<sup>11</sup> the ulcer goes through repeated cycles of healing and recurrence.<sup>12</sup> Even when the ulcers can be healed conservatively, this requires several months of treatment and disabling claudication remains. Since TAO patients are generally relatively young and active, their claudication often affects their ability to work. The need to repeatedly take time off work for conservative therapy will often compel a patient to cease working or at least to change the type of work performed. There is no reliable medical therapy for claudication,<sup>13</sup> whereas the results of a prospective randomised study indicated that, compared with physical training, surgical reconstruction was a superior treatment modality for claudicators.<sup>14</sup> Moreover, as Regensteiner *et al.*<sup>15</sup> reported, we observed that one-

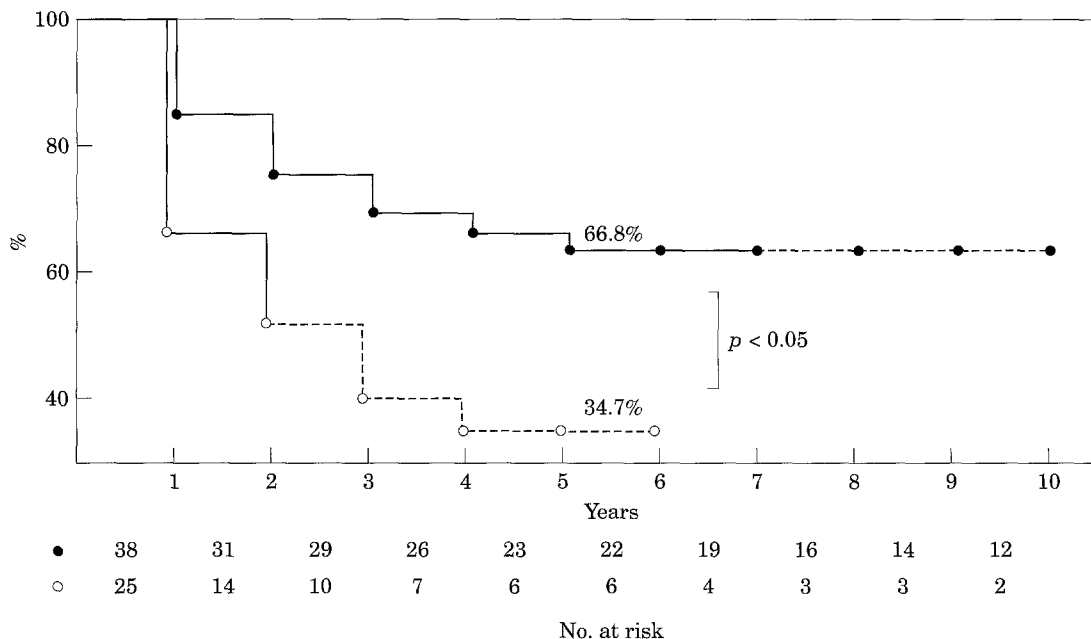


Fig. 4. The cumulative patency curves comparing groups of non-smokers and smokers after surgery (exclusive of secondary early failures), demonstrating a significant difference between them ( $p < 0.05$ ). Interrupted line indicates an s.e. greater than 10%. (●) non-smoking after surgery; (○) smoking after surgery.

third of claudicators who had no choice but medical therapy due to graft failure developed atrophy of the ischaemic foot or calf. These results justify the aggressive bypass surgery in TAO patients with lower limb ischaemia.

Our present results for TAO patients were not as good as those for patients with arteriosclerosis obliterans (ASO). This is thought to be due to the technical difficulties in grafting and the disease progression caused by continued smoking.<sup>16</sup> Poor quality veins due to phlebitis were also an important influencing factor. To improve the early patency rate, evaluation of the angiographic and intraoperative features of the diseased arterial segments, exquisite surgical technique, and the use of disease-free vein grafts are all essential. The technical difficulties we encountered consisted of severe arterial spasm after dissection and the existence of multiple segmental TAO lesions. The anastomosis should be performed to the healthiest vessel segment available whenever possible. A recanalised or diseased arterial segment develops periarterial adhesions and oedematous intimal thickening. To avoid anastomosis to a diseased arterial segment, a segment with sharp clear margins on the arteriogram should be chosen,<sup>6,11</sup> even if it is more distal, as

anastomosis to a diseased artery is technically more demanding and less likely to be successful.

The poor quality of veins in TAO patients tends to predispose the early graft failure. This is caused by the migrating phlebitis, which is confirmed by skin pigmentation along the veins, a thickened and whitish appearance at the time of initial exploration, and poor distensibility on preparation. When the ipsilateral veins show such findings, aggressive use of the contralateral saphenous vein or arm veins is strongly recommended to avoid graft failure. Vein graft stenosis due to progressive intimal hyperplasia, which is common in bypass grafting on ASO patients, is the main cause of failure in bypass, and frequently occurs in poor quality veins.<sup>17,18</sup>

To prevent the late graft failures due to the disease progression, cessation of smoking by the patient himself is an essential requirement.<sup>3,4</sup> Of nine patients with graft failure due to disease progression, eight were smokers who continued smoking after surgery, whereas the disease progression was rarely seen in non-smokers, demonstrating a long-term patency comparable to that of ASO. Hence, the most important part of postoperative surveillance is to check for smoking as well as vein graft stenosis. Therefore, bypass surgery is not indicated in patients who cannot stop smoking and in whom careful surveillance is difficult. Redo bypass for smokers after the primary bypass surgery is not recommended for the same reason. In these patients, amputation of the foot or the lower leg may eventually be required.

In conclusion, patients with TAO are relatively young and active, and disabling claudication often affects their ability to work. Medical therapy is of little help in significantly relieving their symptoms whereas the long-term results obtained with infrainguinal bypasses were durable and provided excellent results as long as patients quit smoking after surgery. Thus we conclude that it is reasonable to aggressively pursue the use of bypass surgery in patients who can stop smoking.

Table 4. Factors affecting primary vein graft failure in TAO patients.

Characteristics	Patent grafts (n=33)	Primary failures		p-value
		Early (n=14)	Late (n=24)	
Age*				
Onset	42.4±3.6	37.9±5.0	37.0±3.2	0.0880
Surgery	44.3±3.6	41.4±5.0	41.6±3.6	0.4798
Gender				
Male (%)	29 (88%)	10 (71%)	22 (92%)	0.2030
Duration of symptoms* (months)	24.6±9.8	42.0±17.4	41.8±16.4	0.1042
Indication for surgery				
Claudication	17 (52%)	5 (36%)	7 (29%)	0.2163
Limb or foot salvage	16 (49%)	9 (64%)	17 (71%)	
Sympathectomy				
Yes	20 (61%)	10 (71%)	22 (92%)	0.0322#
No	13 (39%)	4 (29%)	2 (8%)	
No. of diseased segments				
1	8 (24%)	2 (14%)	4 (17%)	0.6607
2 or more	25 (76%)	12 (86%)	20 (83%)	
Site of distal anastomosis				
Popliteal artery	1 (3%)	1 (7%)	4 (17%)	0.2368
Crural arteries	28 (85%)	9 (64%)	16 (67%)	
Below the ankle	4 (12%)	4 (29%)	4 (17%)	
Quality of vein graft				
Good or fair	29 (88%)	7 (50%)	20 (83%)	0.0117
Poor	4 (12%)	7 (50%)	4 (17%)	
Graft blood flow*	103.3±20.8	62.3±18.8	83.8±17.4	0.0483

\*=One-way ANOVA; #=Sympathectomy adversely affected patency.

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