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CLINICAL INVESTIGATION

Angioplasty or Primary Stenting for Infrapopliteal Lesions: Results of a Prospective Randomized Trial

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Abstract Excellent results with small stents in coronary arteries have led endovascular therapists to their use in infrapopliteal vessels. However, to date no level I evidence exists to recommend primary stenting over infrapopliteal angioplasty alone. The aim of this randomized single-center trial was to compare their 1-year outcome. A total of 38 limbs in 35 patients with critical limb ischemia were randomized to angioplasty (22 pts) or primary stenting (16 pts). Target lesions were infrapopliteal occluded (36) or stenotic (20) lesions ranging from <2 to >15 cm in length. The mean age was 72 years. At 12 months, there was no statistical difference in survival (angioplasty, 69.3%; primary stenting, 74.7%), in limb salvage (angioplasty, 90%; primary stenting, 91.7%), or in primary and secondary patency (angioplasty, 66 and 79.5%; primary stenting, 56 and 64%) between the groups Renal insufficiency was the only significant negative predicting factor for limb salvage in both groups. In conclusion, the 1-year results for both groups were broadly similar. Stenting has its place in infrapopliteal angioplasty if the procedure is jeopardized by a dissection or recoil, but our results do not support primary stenting in all cases.

Keywords Infrapopliteal stenting · Infrapopliteal angioplasty · Crural angioplasty · Crural stenting

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Introduction

Critical limb ischemia (CLI) resulting from occluded or stenotic crural vessels remains a challenge for vascular surgeons and radiologists. Most of these patients have extended diffuse three-vessel disease only 20–30% present with a simple focal lesion and good runoff. Patients are usually elderly people, with severe comorbidity, at high risk for surgery, and with a limited life expectancy. Twenty-five percent will die during the first year of follow-up from vascular or nonvascular events (TASC II) [1]. The primary goal in the treatment of CLI is relief of ischemic rest pain, healing of ulcers or gangrene, and prevention of limb loss. A procedure less invasive than tibial bypass surgery, which is associated with a 1.8–6% perioperative mortality [1] and a considerable procedural morbidity, may be appropriate even with lower patency if the hospital stay and rehabilitation period after surgery can be reduced. Endovascular treatment of infrapopliteal vessels is a low-risk, minimally invasive procedure which rarely compromises later distal bypass surgery and can be performed under local anesthesia. It shortens the operation and hospitalization time and has an acceptable complication rate.

Thanks to the development in recent years of lower-profile angioplasty catheters for long segmental lesions, dedicated stents [2], and guidewires and advanced techniques such as subintimal angioplasty [3–5], kissing technique, and pedal puncture, angioplasty is now considered a feasible alternative for treatment of chronic atherosclerotic occlusive disease in crural and pedal vessels. In a recent meta-analysis of infrapopliteal angioplasty, technical and clinical success rates for short lesions of approximately 90 and 65% were obtained at 6 months [6]. Limb salvage rates were even slightly higher, and the complication rate not more than 7.8 %. For that reason, many vascular surgeons

now consider endovascular treatment, when anatomically feasible, the first option in the treatment of CLI.

The use of newly developed dedicated stents could increase the application rate of infrapopliteal PTA by increasing the technical success rate when PTA results are suboptimal and improving overall late results. The good results obtained in the coronary circulation back this approach and have led many interventionalists to use these on a regular basis also in infrapopliteal vessels [1]. Given the lack of level I evidence for primary stenting in infrapopliteal arterial disease, we started a randomized prospective trial to evaluate the value of primary stenting in crural angioplasty. Our study was set up as a pilot study to evaluate the feasibility of a larger, multicenter trial: our statistics department calculated that 390 patients would be needed for each treatment to reach a 90% power and an α level of 5%, to detect a 15% difference in patency and limb salvage. We decided to perform an interim analysis after 38 procedures because of the quick changes in balloons and stents during the last 3 years, resulting in difficulties comparing the first with the last patients.

Materials and Methods

Patient Selection

All patients with CLI hospitalized at our service (Department of Vascular Surgery, Ghent University Hospital) for primary angioplasty of one or more crural vessels were randomized to either primary stenting or angioplasty alone. Patients who needed bypass surgery for popliteal or superficial femoral occlusions, or patients who needed simultaneous angioplasty of the crural and more then one proximal vessel, were excluded (for $\sim$400 pts). This single-center randomized trial was conducted between September 2004 and April 2008. CLI was defined as rest pain for more than 2 weeks or a nonhealing ulcer/gangrene (Rutherford 4–6, Fontaine 3 and 4). For most patients this was a last attempt before major amputation because of intractable pain or tissue loss. Some had no adequate venous conduit or no surgical target vessel and the level of comorbidity was generally too high for general anesthesia (ASA scores, III and IV). All patients with stenosis of $>$70% or occlusions of the crural arteries were considered suitable for endovascular therapy. The length of the lesion was not an exclusion criterium as even stenoses or occlusions greater than 10 cm were accepted (an exclusion criterion in most angioplasty studies and registries). Exclusion criteria were acute limb ischemia, multisegmental inflow lesions (longer than 3 cm) above the knee, sepsis, myocardial infarction during the previous 14 days, blue toe syndrome (microembolization), and inability to ambulate.

In nearly 3 years, 38 limbs in 35 patients with CLI Rutherford 4 and 5 (rest pain and/or foot ulcer) were recruited and followed. All agreed to randomization. Even if they had not been included in this trial, they would have preferentially been treated by endovascular means due to their comorbidity. The follow-up was 2 years or until major amputation or death. Nine patients needed concomitant proximal angioplasty for stenosis: six patients at the level of the popliteal artery, two patients at the level of the superficial femoral artery, and one patient at the level of the common iliac artery. There were 20 men and 18 women. The mean age of all the atients did not diverge statistically from the mean age of the subgroups (72 ± 9.8 years; range, 50–88 years). The baseline characteristics of the patients are reported in Table 1.

Thirty-three limbs (87%) were classified as Rutherford 5:7 ulcers were located at the heel or Achilles tendon, 4 ulcers at the plantar surface or at the lateral margin of the foot, and 22 ulcers or gangrene were located at the forefoot. Nine wounds were contaminated or had signs of osteomyelitis. Anatomical data are reported in Table 2. In 15 limbs two arteries were treated, and in one patient, all three crural arteries: only one of these vessels was included in the study.

Randomization

Eligibility was assessed and consent obtained by the vascular surgeon. Participants were randomly assigned to one of the two groups. Randomization was performed by computer-generated randomization sequence. The allocation sequence was concealed by means of sealed, consecutively numbered envelopes.

Intervention

Before intervention, angiography was performed to evaluate the runoff vessels and to quantify the extent of the disease. Whenever possible, the anterior tibial artery was selected for ischemic forefoot lesions and the posterior tibial artery for calcaneal lesions. In cases of untreatable occlusion of both tibial vessels, the peroneal artery was treated to improve the development of collaterals and to maximize inflow.

All procedures were performed under local anesthesia by experienced vascular surgeons through an antegrade puncture of the ipsilateral common femoral artery. In one patient a crossover approach was chosen to dilate a 50% stenosis of the common iliac artery in the same intervention. According to the randomization and the available stent a 4- to 6-Fr introducer was placed. Heparin was administrated at a dose of 5000 IU. A 0.014 or 0.035 hydrophilic guidewire was used to cross the lesion. The

Table 1 Baseline characteristics of trial patients/limbs (values are absolute numbers)

	Whole group ($n = 38$)	Angioplasty group ($n = 22$)	Stent group (n = 16)	p value
Mean age, year (SD\)	72 (9.8)	72 (10)	72 (9)	0.891
Gender ratio, M:F	20:18	14:8	6 :10	0.492
Rutherford IV/V	5 (13%)/33 (87%)	1 (4.5%)/21 (95.5%)	4 (25%)/12 (75%)	0.303
Diabetes	22	12	10	0.355
Dialysis or kidney Tx	7	4	3	0.277
Renal failure (creatinine $\geq$ 1.5 mg%)	10	8	2	0.457
Previous vascular reconstructions in this or other leg	16	13	3	0.255
PTA, AFS or iliac artery	8			
Bypass surgery	8			
PTA + bypass surgery	2			
Smoking (active or ceased)	5	4	1	0.120
Hypertension	38	22	16	–
Dyslipemia	16	9	7	0.996
Coronary artery disease	30	18	12	0.561
Previous CABG/PTCA	14	7	7	0.432
Stroke	5	1	4	*0.030*
Previous major amputation	2	2	0	*0.010*
Previous minor amputation	10	5	5	0.325

Table 2 Anatomic data

	Whole group	PTA	PTA + stenting
Occlusion	36 (64%)	19	17
<2 cm	4	3	1
2–5 cm	12	8	4
5–10 cm	7	4	3
10–15 cm	9	3	6
>15 cm	4	1	3
Stenosis	20 (36%)	13	7
< 2 cm	15	10	5
2–5 cm	3	2	1
5–10 cm	1	0	1
10–15 cm	0	0	0
>15 cm	1	1	0
Arteries treated			
Tibiofibular trunk	13	9	4
Peroneal	14	7	7
Anterior tibial	16	9	7
Posterior tibial	13	7	6
Intention to treat	1	0	1

PTA percutaneous transluminal angioplasty

goal was to restore continuous in-line flow in at least one below-knee vessel to the ankle. If crossing was not possible a straight 4-Fr angiographic catheter was used as a support catheter. In five patients we performed a subintimal instead of a transluminal recanalization (two in the stent group and three in the PTA group). The angioplasty balloon was chosen according to the diameter of the vessel lumen and the length of the lesion: the mean balloon diameter used was 3 mm (range, 2–4 mm), with a mean length of 39 mm (range, 20 to 100 mm) and a mean inflation time of 2 min. In the earliest cases, only a Bijou dilatation balloon (Boston Scientific, Natick, MA, USA) was available; in time we switched to Fox SV balloons (Abbott) or cutting balloons (Boston Scientific) if necessary. When randomized for stenting, a variety of balloon-expandable and self-expandable stents was used, according to indication and availability. Only one stent was implanted in each patient. The mean size of the implanted stents was 3 mm (range, 2.5–5 mm), with a mean length of 21.5 mm (range, 12–40 mm). A total of 15 stents were implanted: one in each patient.

Stents were positioned in long lesions at the site of residual stenosis after predilatation. As those were mainly occlusions, predilatation was necessary to pass with the stent device. If there was no residual stenosis, the stent was placed at the entry site of the angioplasty or at the origin of the occlusion. Primary stenting was preferred in short lesions

Initially coronary balloon-expandable stents (Jostent, Jomed Benelux, multilink vision coronary stent; Abbott,

USA) were used but we switched to self-expandable stents when these became available (Astron pulsar stent [Biotronik, Berlin] and Xpert stent [Abbott]). Recoil of a lesion in the PTA group was treated by prolonged high-pressure (up to 14 atm, 2-min inflation time) dilatation. Additional devices were used in four patients: one patient in the PTA group had a residual stenosis of 50%, which was treated during the same procedure with a cutting balloon (Boston Scientific), and in three patients an Excimer laser was used to cross the lesion.

When it was impossible to cross the lesion, even with the use of an Excimer laser (used in three patients), the procedure was considered a technical failure and patients were treated conservatively, by bypass surgery, or with a major amputation, according to the runoff state of the vessels and patient condition.

Technical success was defined as the absence of residual stenosis of >30% and absence of flow -limiting dissections on final angiogram. All sheaths were removed immediately. All patients were discharged on antiplatelet drugs: low molecular weight heparin at a therapeutic dose for 1 week, 75 mg clopidogrel per day for 2 months, and low-dose aspirin (<160 mg) indefinitely. The mean overall operation time was 108.92 min (range, 25–310 min) including perioperative endovascular treatment of other lesions or concomitant minor amputation.

Outcome Measures

The clinical end points of this trial were freedom from amputation and primary patency. Primary patency was defined as clinical primary patency: this means freedom from restenosis; occlusion with recurrence of ischemic rest pain or recurrence of ulceration, leading to redo angioplasty; bypass surgery; or major amputation.

We considered limb salvage to be successful when a full-length limb was preserved; an above-the-ankle amputation was considered a failure. Secondary outcomes were patient survival and secondary patency. Secondary patency was defined as freedom from redo angioplasty until recurrence of symptoms. Technical success was defined as the ability to cross the lesion and perform an angioplasty with >30% restenosis.

Patients were examined every 3–6 months after discharge till the end of the trial. Standard duplex scanning was performed every 6 months by one independent experienced investigator to exclude bias. The peak systolic velocity (PSV) was measured over the stent if possible. In the case of angioplasty alone the PSV was measured over the whole length of the treated artery. When the PSV was >400 cm/s or when the treated artery was reoccluded, and the patients showed recurrence of rest pain, cessation of ulcer healing, or a new ulcer, a new angiography was performed. In most of the patients ABPI measurements were not possible or not reliable due to calcifications of the vessels. We preferred duplex over angiography for follow-up because of the renal comorbidity of our patients and the fact that the most important outcome for these patients is not patency of the vessel but relief of rest pain and healing of their ulcers.

Statistics

All patients fulfilling the inclusion criteria were included in the trial. The results were analyzed according to the intention-to-treat principle (Fig. 1). Descriptive data are

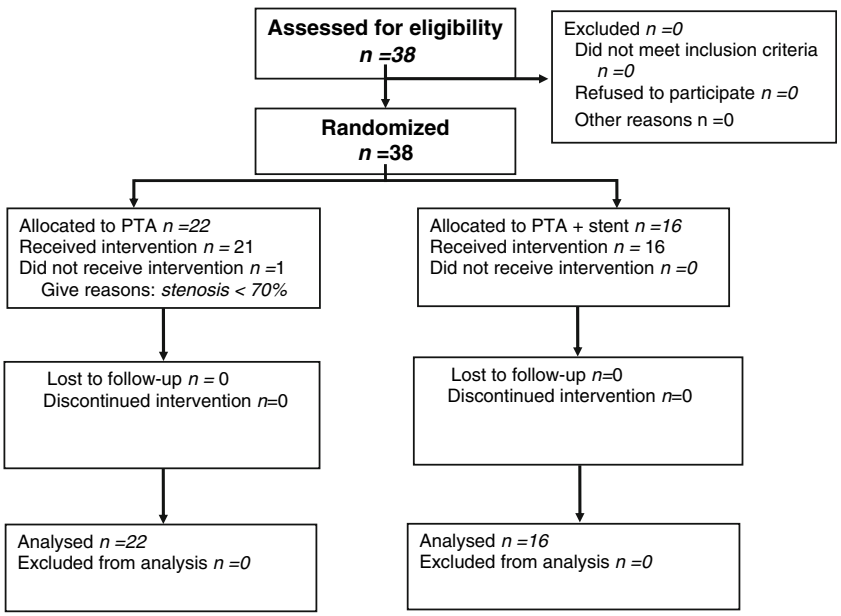

Fig. 1 Consort flowchart for angioplasty and primary stenting of admitted patients

presented as the mean value ± SD. A p value < 0.05 was considered significant. The cumulative rates of limb salvage, patient survival, and primary and secondary patency for each group and the combined group were calculated with the Kaplan-Meier method. The difference in primary outcome for the two groups was assessed by means of the log rank test. Mann-Whitney U test was applied for comparison of continuous variables for both groups. Covariate interactions with treatment for different risk factors (diabetes, clinical stratification group, renal failure, etc.) were examined, and the hazard score calculated and compared with a Cox proportional hazard model. Multivariate logistic regression analyses were used for evaluation of differences between treatments.

SPSS 16.0 for Windows (SPSS) and Sigmastat 3.1 (Systat Software Inc., Port Richmond, CA, USA) were used for statistic analysis. This prospective study complied with the Declaration of Helsinki, was approved by the Ethics Committee of Ghent University Hospital, and is registered at http://www.clinicaltrials.gov (no. NCT00134277). Inclusion, exclusion, and all categorizations were determined prior to initiation of the study. A written informed consent was signed by all patients before randomization.

Results

Twenty-two procedures (limbs) were allocated to angioplasty alone (below the knee; BTK) and 16 procedures to primary stenting (with bare metal stents; BMSs). One patient in the BTK group did not receive PTA because of overestimation of the stenosis (30% instead of 70%) on preoperative MR angiography. He died of an unrelated cause 6 months postprocedure. There was no crossover of one group to the other. In four patients (two in each group) no recanalization was possible; these were considered technical failures, resulting in a technical success rate for all de novo lesions of 89.5%. There were two major complications: a pseudoaneurysm at the access site, which was treated by echo-guided thrombin injection, and a large rupture of a tibial artery during predilatation, which was covered with a Jomed PTFE stent. There was no evidence of peripheral embolization or arterial spasm.

Table 3 summarizes the procedural major and minor complications. The average hospital stay was 3 days (range, 2–41 days). Prolonged hospital stays were due to amputation, in-hospital rehabilitation, or vacuum-assisted therapy for treatment of tissue defects.

Early Results

There were no procedure-related deaths. Two patients died of acute myocardial infarction in the early postoperative period: one in each group. One patient in the stent group showed an early reocclusion of the recanalized artery that was treated by thrombolysis. Two of the four patients with a procedural technical failure needed a subsequent femorodistal bypass; one of them still ended in a major amputation. The other two patients were treated conservatively because of nonreconstructable distal vessels and extreme comorbidity. They died during the 2 years of follow-up. All patients with resting ischemic pain improved and these improvements were sustained until the end of the follow-up.

Table 3 Major and minor procedural complications

	Whole group	PTA	PTA + stenting
Total	20	8	12
Pseudoaneurysm	1	1	0
Hematoma, groin	1	0	1
Dissection	4	2	2
Stent dislocation	1	0	1
Rupture of artery	1	0	1

PTA percutaneous transluminal angioplasty

Late Results

At 30 days 36 procedures were available for late result analysis. Long-term follow-up was assessed through postoperative visits. The follow-up lasted until April 2008, major amputation, or death.

Ten patients (26%) died of unrelated causes during the follow-up period and five patients (13%) needed a major amputation. All others were followed for 2 years. During follow-up four patients (11%) underwent a femorodistal bypass with a cryopreserved saphenous vein for limb salvage and three patients had a redo angioplasty for nonhealing ulcer, all in the angioplasty group. Two patients required a forefoot amputation for wound healing and three patients still had an ulcer at the end of their follow-up. A fourth patient developed a new ulceration during follow-up. Complete wound healing was achieved in 89% (of living nonamputated patients) and overall limb salvage in 85% of the patients (Table 4).

Table 4 Late results

	Whole group	PTA	PTA + stenting	p value
Death	10	7	3	0.069
Major amputation	5	2	3	0.092
Minor amputation	2	1	1	0.654
Femorodistal bypass	4	2	2	0.515
Re−PTA	3	3	0	0.001
Persistent ulcer	4	2	2	0.515

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Using Kaplan-Meier survival analysis the 6- and 12-month patient survival rates were 94 and 69.3% in the PTA group and 79.8 and 74.7% in the BMS group (Fig. 2). Limb salvage at 6 and 12 months was 90% in the PTA group and 91.7% in the BMS group (Fig. 2). All amputations occurred in the first 6 months. We could see no difference in mortality rate ($p = 0.848$) or limb salvage ($p = 0.764$) between the two groups. The patient survival and limb salvage rates for the whole group were 86 and 91.2% at 6 months and 72 and 90.8% at 12 months.

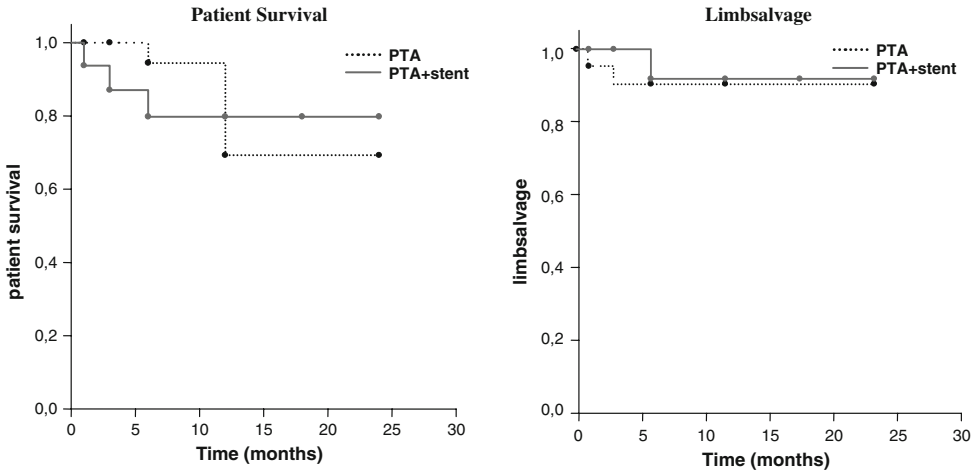
Cumulative primary and secondary patency rates for the angioplasty group were 76 and 85% at 6 months and 66 and 79.5% at 12 months. Primary and secondary patency rates for the primary stenting group were 80 and 91% at 6 months and 56 and 64% at 12 months (Fig. 3). There was no significant difference in primary or secondary patency between the two groups. The primary patency of the combined group was 78% at 6 months, 59% at 12 months, and 44% at 18 months (Table 5).

A large number of predicting factors were evaluated for their influence on primary patency, limb salvage, and patient survival. Among the analyzed patient-related factors, single or combined, only renal insufficiency ($p < 0.04$; RR = 36,761; 95% confidence interval, 1.141–1184.74) was a negative predicting factor for limb salvage in both groups.

Discussion

In the literature the durability of BTK angioplasty has been questioned for a long time. Venous bypass surgery is a more durable method of arterial reconstruction (1- and 5-year primary patency rates, 80 and 30.5%; 5-year secondary patency rate, 39.7%; and 1-year limb salvage rate, 90%) [6]. However, because of medical comorbidities or the lack of an adequate conduit, many CLI patients are not optimal candidates for surgery. Still, revascularization remains indicated, as the risk of limb loss is substantial and the avoidance of major amputation implies an improvement in the quality of life as well as in life expectancy [7]. Angioplasty is a less invasive procedure with proven efficacy and a very good safety profile: most infrapopliteal angioplasties can be performed under local anesthesia, there are no surgical wounds, and side effects are minimal except for contrast-induced acute renal failure (6%) [6]. Mortality and morbidity are very low in comparison to those for surgical revascularization, and failed PTA does not preclude a subsequent bypass operation. PTA preserves and enhances the development of collaterals so that when the angioplasty site occludes, symptoms may not return. In these patients the question remains whether primary stenting (BMSs) can improve outcome.

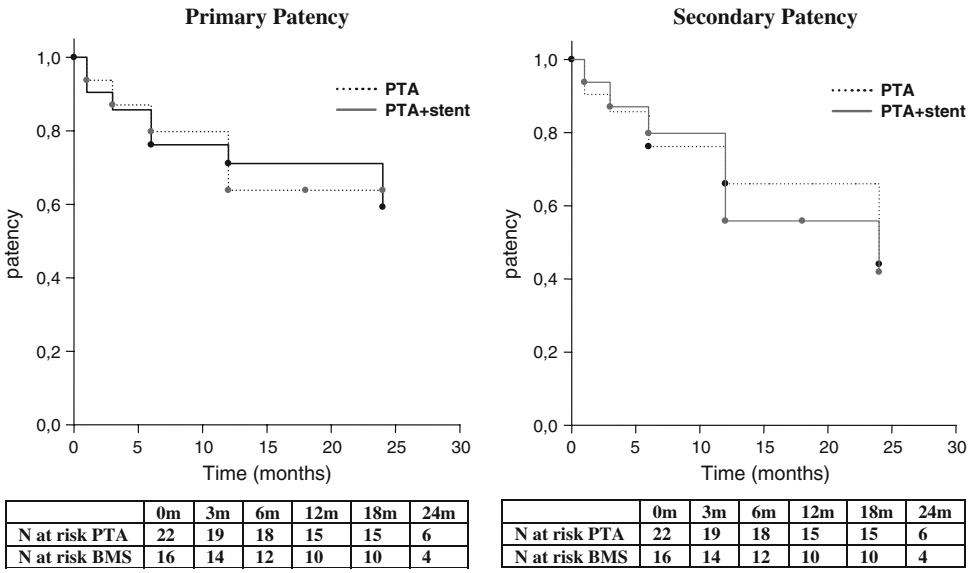
To validate both our PTA group and our primary stent group we compared our results to the literature. The PTA group was compared to the angioplasty group in the meta-analysis performed by Romiti et al. [6] and to all other PTA registries or trials published since then in level A journals, including 20 or more patients for whom outcome was available (Table 6): Romiti et al. published a meta-analysis of infrapopliteal angioplasty and compared it to popliteal-to-distal bypass surgery. Primary and secondary patencies were significantly better for bypass surgery, but limb salvage rates were equal. They concluded that the technical success and subsequent durability of crural angioplasty are limited compared with those of bypass surgery, but the clinical benefit is acceptable because limb salvage rates are equivalent to those for bypass surgery. Their primary patency rates at 6 months and 1 year and their limb salvage rate for crural PTA were 65, 58.1, and 90%, respectively;



	0m	3m	6m	12m	18m	24m
N at risk PTA	22	22	18	15	15	6
N at risk BMS	16	14	12	12	12	4

	0m	3m	6m	12m	18m	24m
N at risk PTA	22	19	18	15	15	6
N at risk BMS	16	12	12	12	12	4

Fig. 2 Kaplan–Meier survival curve for patient survival and limb salvage



	0m	3m	6m	12m	18m	24m
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	0m	3m	6m	12m	18m	24m
N at risk PTA	22	19	18	15	15	6
N at risk BMS	16	14	12	10	10	4

Fig. 3 Kaplan–Meier survival curve for primary and secondary patency

Table 5 Patency rates at 6 and 12 months

	Whole group (%)	PTA (%)	PTA + stent (%)	*P* value
Primary patency				
6 months	78	76	80	0.974
12 months	59	66	56	
Secondary patency				
6 months	88	85	91	0.805
12 months	71.7	79.5	64	
Limb salvage				
6 months	91.2	90	91.7	0.764
12 months	90.8	90	91.7	
Patient survival				
6 months	86	94	79.8	0.848
12 months	72	69.3	74.1	

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ours were 76, 66, and 86%. However, there was a significant difference in patient survival at 1 year: 69.3% in our PTA group, which is far below the 87% 1-year survival rate in the meta-analysis. This reflects the advanced stage of atherosclerosis of our patients: all were hypertensive (53% in the meta-analysis), 79% of our patients had a history of cardiac failure (58% in the meta-analysis), and the percentages of previously treated occlusive lesions and patients with tissue loss were 64 and 87% in our trial vs. 41 and 76% in the meta-analysis. Just as in our study, no association was found between patency and any demographic or clinical variable [6, 8, 9]. Procedure-related complication rate for infrapopliteal angioplasty was 7.8% in the meta-analysis and was mostly due to groin hematoma, perforations, embolism, and acute occlusions. In our trial the complication rate was 7.9% if dissection and failed recanalization are not taken into account. Our patency rates were in line with and actually compared favorably to other published results (Table 6). This might reflect the improvement in techniques and materials during the last years.

Many vascular surgeons still prefer tibial bypass surgery to belowBTK angioplasty due to the high restenosis rate and the risk of complications such as abrupt vessel closure, thrombus formation, perforation, embolization, and lack of hemodynamic improvement [4]. The question is whether stenting can improve the results and avoid complications. No randomized trial has been published so far comparing BMSs to angioplasty in infrapopliteal vessels. Only a few small trials have compared coated or drug-eluting stents (DESs) to angioplasty or BMSs.

Comparing our primary stent group to the registries and trials of more than 15 patients published in the literature (Table 7), we see that our 6-months and 1-year primary patency rates of 80 and 56% are similar to the results obtained in most studies. The question remains whether DESs and carbon-coated stents are superior to BMSs, as we used for this trial, for this indication. Most randomized and nonrandomized trials [10–12] of carbon-coated stents and DESs (Cypher stents: sirolimus-eluting stents) had nearly the same patency that we obtained for BMSs. However, most of their patients were Rutherford three class and had a mean lesion length of 10–20 mm (16.5 mm) to stent. We treated lesions up to 15 cm, which is reflected in our outcomes. The main disadvantage of DESs remains their price. So, as long as no clearly superior long-term results are shown, their use should be limited to clinical studies. This is why we preferred BMSs in our trial.

Table 6 Infrapopliteal angioplasty (below the knee) in the literature (minimum, 20 patients)

First author [ref. no.]	Year	No. limbs	CLI (%)	Primary patency	Secondary patency	Sul Limb salvage e	Pt survival
Marzelle [13]	1994	23	100	1 year, 34%		1 year, 71%	
Favre [14]	1996	25	80	2 year, 46%	2 year, 64%		
Löfberg [15]	1996	86	100	1 year, 51%	3 year, 44%	3 year, 72%	
Nydahl [16]	1997	28		12 months, 56%		1 year, 81%	1 year, 85%
Dorros [17]	1998	312	57			5 year, 91%	5 year, 56%
Parsons [18]	1998	66	100	1 year, 13%		1 year, 25%	
Boyer [19]	2000	49	100	3 year, 81%	3 year, 88%	3 year, 87%	3 year, 75%
Söder [9]	2000	72	100	1 year, 48%	18 months, 90%	21 months, 80%	
Wölfle [20]	2000	89	100			1 year, 82%	
Brillu [21]	2001	37	100	1 year, 72%		1 year, 82.3%	1 year, 85.7%
Ingle [22]	2002	70	100			3 year, 94%	
Tisi [23]	2002	51		1 year, 27%	1 year, 33%	1 year, 88%	
Spinosa [24]	2004	44	100			1 year, 60%	1 year, 71%
Ascher [25]	2005	32	63	3 months, 85%		3 months, 100%	3 months, 100%
Atar [26]	2005	38	100	1 year, 14.8%		1 year, 74%	
Aulivola [27]	2005	90	100			1 year, 84.4%; 52.5% renal failure	1 year, 82.2%
Brosi [28]	2005	38	66	1 year, 11%			1 year, 72%
Krankenberg [29]	2005	78	0	12 months, 66.3%	12 months, 91.5%		
Kudo [30]	2005	52	100	3 year PP, 23.5%	3 year SP, 46.1%	3 year, 77.3%	
Sigala [31]	2005	52	100			1 year, 85%	1 year, 85%
Bosiers [32]	2006	79	100	1 year, 68.6%		1 year, 96.7%	
Faglia [33]	2006	564	100		5 year, 78%		
Haider [34]	2006	32	100	2 year, 60%		2 year, 76%	2 year, 82%
Lazaris [35]	2006	51	100	1 year, 50%			
Vraux [36]	2006	50		1 year, 46%	1 year, 55%	1 year, 87%	1 year, 74%
Randon (current study)	2008	22	100	1 year, 66%	1 year, 79.5%	1 year, 90%	1 year, 69.3%

CLI critical limb ischemia

Based on the literature analysis, both groups in our trial can be considered to be representative, and the results obtained in both groups after 6 months were equivalent: primary patency rates and limb salvage rate were 80 and 91.7% for stenting and 76 and 90% for PTA ($p = 0.780$ and 0.764, respectively). There was a statistical difference only for need for redo angioplasty after 6 months in the PTA group (three, vs. none in the BMS group), but this was performed easily, without any complications, in a 1-night hospitalization.

Limitations of the Study

Due to the relatively limited size of the study population and the fact that this was a single-center study, a potential bias in the results cannot be excluded. A large-scale randomized trial comparing stenting and angioplasty in crural vessels is recommended to validate these findings. Although our follow-up was not long enough to allow evaluation of the long-term durability of these approaches, it is worth remembering that the majority of patients who are in need of this treatment have a longevity that is markedly diminished. In this rapid developing field, new materials become regularly available. This is reflected in the fact that different stents were used during the course of this study. Newer, dedicated stents might result in better outcomes than obtained in this study. However, to date, there are is no formal proof to support this statement.

Conclusion

In this randomized prospective pilot trial comparing angioplasty and primary stenting in crural arteries, no difference in outcome was observed. Therefore we conclude that stenting can be used for specific indications—when PTA fails, such as in the case of a flow-limiting dissection or elastic recoil, or in residual stenosis of at least 50% after angioplasty—but

Table 7 Infrapopliteal stenting in the literature (minimum, 15 pts)

First author [ref. no.]	Year	Limbs	Stent(s)	CLI (%)	Primary patency	Secondary patency	Limb salvage
Rand [10]	2005	51	Carbofilm−coated vs. BTK stent	100	6 months, 83.7% stent/ 61.1% PTA		6 months, 95% BTK/92% stent
Bosiers [37]	2006	18	Sirolimus stent		6 months, 100%		6 months, 94%
Commeau [38]	2006	30	Sirolimus stents	87	6 months, 82%		6 months, 100%
Bosiers [39]	2007	51	Nitinol self-expandable stent	100	1 year, 76.3%		1 year, 95.9%
Kickuth [40]	2007	35	Nitinol self-expandable stent	46	6 months, 82%		6 months, 100%
Scheinert [11]	2007	60	Sirolimus vs. BMS	68.9	1 year, 94.1%	1 year, 95.9%	0% amput. sirolimus/10% amput. BMS
Siablis [12]	2007	58	Sirolimus vs. BMS	100	1 year, 40.5% BMS/1 year, 86.4% DES		1 year, 100% BMS/1 year, 96% sirolimus
Siablis [41]	2007	32	Paclitaxel stents	100	1 year, 30%		1 year, 88.5%
Randon (current)	2008	38	BMS vs. BTK	100	1 year, 56%/1 year, 66%	1 year, 64%/1 year, 79.5%	1 year, 91.7%/1 year, 90%

CLI critical limb ischemia, *BTK* below the knee, *PTA* percutaneous transluminal angioplasty, *BMS* bare metal stent, *amput*. amputation

should not be used on a routine basis. Our trial consisted of relatively few patients, and these observations and conclusions still need verification in larger studies.

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