JACC Vol. 30, No. 7
December 1997:1722–8

Short-Term Results and Intermediate-Term Follow-Up of Laser Wire Recanalization of Chronic Coronary Artery Occlusions: A Single-Center Experience

JOACHIM SCHOFER, MD, THOMAS RAU, MD, MICHAEL SCHLÜTER, PHD, DETLEF G. MATHEY, MD, FACC

Hamburg, Germany

Objectives. **This study sought to elucidate the short-term efficacy and intermediate-term outcome of excimer laser recanalization of chronic coronary artery occlusions in patients in whom attempts at mechanical revascularization had failed.**

Background. **Recanalization of chronic coronary occlusions with the use of a mechanical guide wire fails in 30% to 50% of cases, mostly because of inability to pass the wire through the lesion. The value of using excimer laser energy in this setting has not yet been determined.**

Methods. **The study group comprised 66 consecutive patients with 68 chronic coronary occlusions. Patients were eligible for inclusion in the study if a previous attempt at mechanical revascularization had failed and if their angiographic status was such that 1) the vessel segment distal to the occlusion could be visualized by way of collateral vessels, 2) the entry point of the occlusion was clearly outlined, and 3) not more than one anatomic bend was expected within the occlusion. Excimer laser energy was applied to the lesion through a 0.018-in. (0.046 cm) fiber-optic guide wire. Adjunctive balloon angioplasty and stenting were performed in all successfully treated patients but one.**

Results. **Thirty-four occlusions (50%) in 32 patients (48%) could be crossed with the laser wire. Location and age of the occlusion had no adverse influence on the outcome of laser wire recanalization, nor did the presence of bridging collateral vessels, a major side branch at the site of the lesion or a blunt stump of the occlusion. An inverse relation was found between the success rate and the length of the occlusion, such that a 19% reduction of the success rate accompanied each 10-mm increment of the mean occlusion length. Thus, the success rate was 68% for lesions ≤10 mm but only 25% for lesions >30 to ≤40 mm. The presence of a bend in the lesion exceeding 60° was strongly related to procedural failure. During a median angiographic follow-up period of 18 weeks, restenosis >50% (n = 6) or reocclusion (n = 4) was found in 10 of the 32 successfully treated patients, for an intermediate-term success rate of 33% (22 of 66). Clinical follow-up revealed improved anginal status in 21 patients (66%) after a median of 24 weeks. Major complications (death, myocardial infarction, emergency operation) were not encountered.**

Conclusions. **Successful recanalization of a chronic coronary occlusion by using currently available laser wires can be expected in 50% of selected patients in whom attempts at mechanical revascularization fail. Restenosis or reocclusion accounts for an overall 6-month success rate of 35%.**

(J Am Coll Cardiol 1997;30:1722–8)

The treatment of chronic total coronary occlusions remains a challenge for interventional cardiologists, despite the continued improvement of mechanical devices for coronary angioplasty. With conventional techniques, only 50% to 70% of chronic occlusions can be recanalized (1–8). Failure is mostly related to the inability to cross the occlusion with the mechanical guide wire. Recently, a fiber-optic guide wire that can be connected to a laser source has become available (9). This device may facilitate the penetration of coronary occlusions through direct application of excimer laser energy to the occluding lesion. The aims of the present study were to assess, in patients with chronic total coronary occlusions that could not be recanalized by conventional methods, the short-term and intermediate-term outcome of laser wire recanalization and to analyze factors influencing the short-term success rate.

Methods

Patients. Between November 1994 and July 1996, 66 consecutive patients with 68 chronic total coronary occlusions were included in the study. Flow in the affected coronary artery was graded according to the criteria of the Thrombolysis in Myocardial Infarction (TIMI) trial as grade 0 in 60 occlusions and as grade 1 in 8 occlusions. The mean age of the 58 men and 8 women was 57 ± 11 years (range 34 to 76). Left ventricular ejection fraction was 0.65 ± 0.13 (range 0.26 to 0.89). Twenty-one patients had one-vessel disease, 36 had two-vessel disease and 9 had three-vessel disease. All patients were either symp-

From the Center for Cardiology Othmarschen, Hamburg, Germany.

Manuscript received November 4, 1996; revised manuscript received July 29, 1997, accepted August 21, 1997.

Address for correspondence: Dr. Joachim Schofer, Othmarscher Kirchenweg 168, 22763 Hamburg, Germany.

0735-1097/97/$17.00
PII S0735-1097(97)00367-7

Abbreviations and Acronyms

CCS = Canadian Cardiovascular Society
LAD = left anterior descending coronary artery
LCx = left circumflex coronary artery
RCA = right coronary artery
TIMI = Thrombolysis in Myocardial Infarction

tomatic (n = 56, median Canadian Cardiovascular Society [CCS] class III [10]) or had documented myocardial ischemia related to the occluded vessel (n = 10).

The study protocol was approved by the ethics committee of the City of Hamburg board of physicians. All patients were informed about the investigational nature of this study and gave written consent.

Patients included in this study had the following angiographic status: 1) the vessel lumen distal to the occlusion could be visualized by way of collateral vessels (classification grade of Cohen and Rentrop [11] ≥2); 2) the entry point of the occlusion was clearly visible; and 3) not more than one anatomic bend was expected throughout the extent of the occlusion.

Conventional recanalization. Twenty-six patients had undergone a separate attempt at mechanical recanalization before the laser wire procedure, whereas the remaining 40 patients underwent both procedures during the same session. In the latter group, the attempt at mechanical recanalization was usually terminated when fluoroscopy time had reached 15 min. Standard guide wires were used in 41 patients (62%); in 20 patients, multiple (up to four) guide wires were employed, including intermediate and nitinol (in 6 patients) guide wires.

Laser guide wire recanalization. Eight-French coronary guiding catheters were used. In patients with contralateral collateral vessels, bilateral simultaneous angiography was performed with the use of 5F catheters for the contralateral injection to visualize the distal vessel lumen.

Laser guide wire recanalization was performed by using a 0.018-in. (0.046 cm) fiber-optic guide wire containing 12 glass fibers (Prima, Spectranetics Corporation). Before the guide wire was introduced, its tip was manually preshaped to possibly fit the targeted coronary anatomy. The guide wire was then connected to a 308-nm xenon chloride excimer laser unit (CVX-300, Spectranetics) that emits 135- to 165-ns pulses at repetition rates of 25 to 40 s^{-1} in trains of 0.04- to 5.0-s duration. After calibration of laser energy density (fluence), the wire was advanced to the site of the occlusion through a Spectranetics 518004 support catheter. Laser fluence was set at 50 to 60 mJ/mm^2. Delivery of laser energy was begun after alignment of the guide wire tip with the assumed anatomic course of the occlusion. Advancement of the laser wire was monitored on monoplane fluoroscopy.

When the guide wire had successfully crossed the occlusion, its intravascular position was ascertained by angiographic visualization of the distal vessel lumen in at least two projections, by verifying the free maneuverability of the guide wire tip and by the ability to easily introduce the wire into side branches. Thereafter, two approaches were optionally employed for adjunctive angioplasty. In general, the laser guide wire was exchanged over the support catheter with a conventional 0.014-in. (0.036 cm) guide wire to be used for subsequent balloon angioplasty. However, in cases where the lesion could not be crossed with the support catheter, a 1.4-mm laser catheter (Vitesse C 1.4, Spectranetics) was advanced over the laser guide wire for subsequent laser angioplasty. Procedural success was defined as restoration of anterograde TIMI grade 3 flow in the vessel segment distal to the occlusion with or without adjunctive angioplasty.

After angioplasty, the site of the occlusion was stented to reduce the rate of reocclusion and restenosis. Angiographic verification of the final result was obtained. Patients were discharged on a regimen of aspirin (100 mg/day) and ticlopidine (500 mg/day) for 1 to 3 months.

Follow-up. It was recommended that each patient undergo repeat angiography within 4 to 6 months. In patients in whom angiographic follow-up was not available by mid-October 1996, the clinical status was assessed by interview.

Statistics. Continuous variables are presented as mean value ± 1 SD or as median and range, where appropriate. In the two patients with two occlusions, only one occlusion was selected at random from each patient for analyses relating to successful versus failed attempts at recanalization. Group differences among continuous variables were assessed with the Mann-Whitney *U* test; proportions were compared by using the chi-square test. Statistical significance was assumed at the level of $p < 0.05$.

Results

Sixty-four patients had a single occluded vessel, with the proximal or mid-left anterior descending coronary artery (LAD) affected in 18 patients (28%), the proximal or mid-right coronary artery (RCA) in 39 patients (61%) and the mid-left circumflex coronary artery (LCx) in 7 patients (11%). Both the LAD and the RCA were occluded in two patients, for a total of 68 occlusions. Thirty-four occlusions (50%) could be successfully crossed with the laser guide wire in 32 patients (48%). An example from a patient with occlusions of both the LAD and the RCA is shown in Figure 1. Both occlusions were eventually recanalized in a single procedure.

Success rates relative to the affected coronary vessel. Recanalization rates relative to the coronary vessels were 50% (10 of 20 occlusions) for the LAD, 54% (22 of 41 occlusions) for the RCA and 29% (2 of 7 occlusions) for the LCx. These differences were statistically not significant.

Vessel diameter. The mean proximal vessel diameter for successfully recanalized occlusions was 3.16 ± 0.53 mm; this was statistically not different from that of unsuccessfully treated vessels (3.00 ± 0.73 mm, $p = 0.309$).

Occlusion length. The lengths of the occlusions ranged from 3.5 to 48.9 mm (median 14.0). To assess the influence of

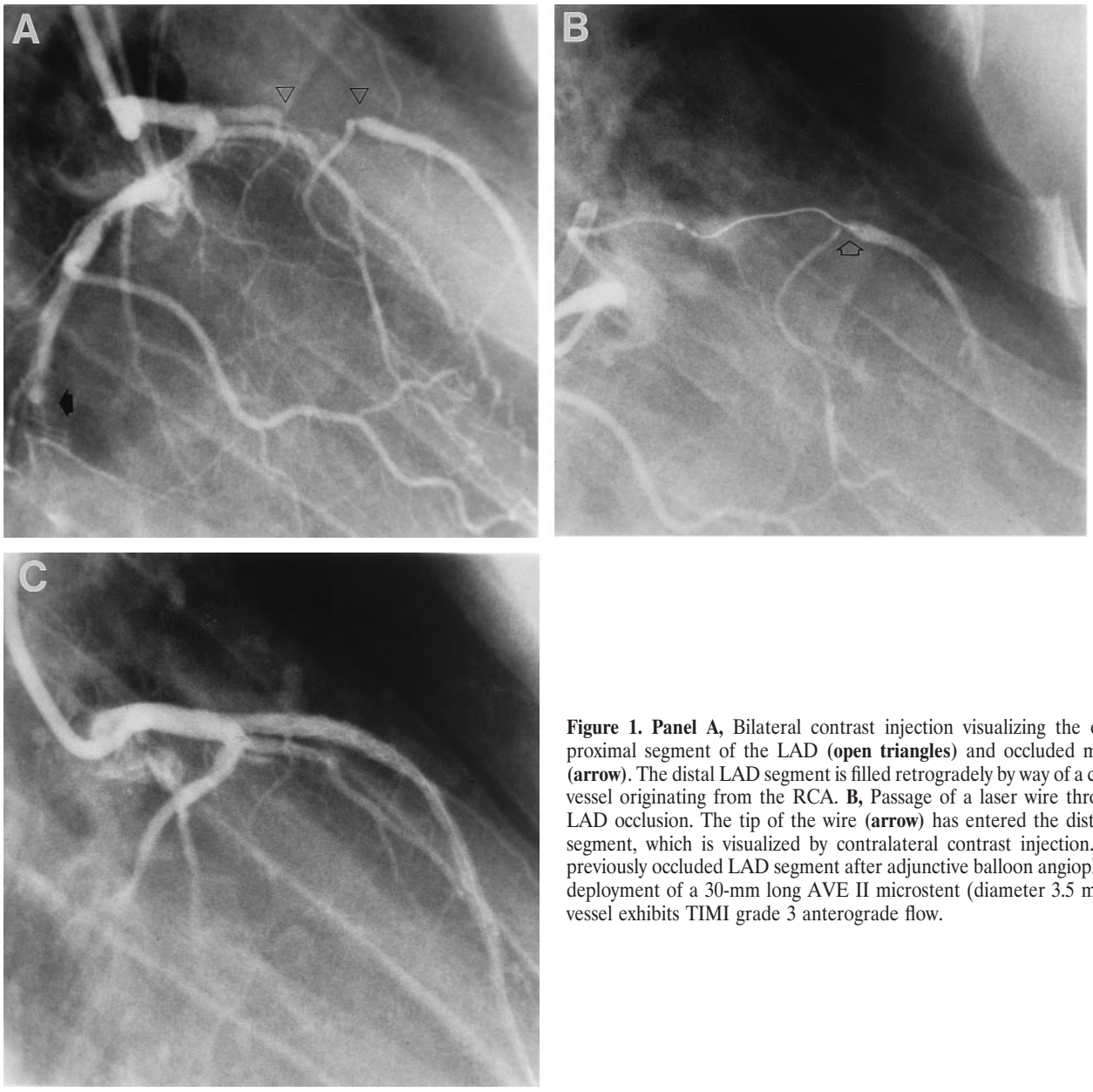


Figure 1. Panel A, Bilateral contrast injection visualizing the occluded proximal segment of the LAD **(open triangles)** and occluded mid-RCA **(arrow)**. The distal LAD segment is filled retrogradely by way of a collateral vessel originating from the RCA. **B,** Passage of a laser wire through the LAD occlusion. The tip of the wire **(arrow)** has entered the distal vessel segment, which is visualized by contralateral contrast injection. **C,** The previously occluded LAD segment after adjunctive balloon angioplasty and deployment of a 30-mm long AVE II microstent (diameter 3.5 mm). The vessel exhibits TIMI grade 3 anterograde flow.

occlusion length on the success rate of laser recanalization, the lengths were grouped in 10-mm intervals. The number and mean lengths of the occlusions per interval and the corresponding success rates are given in Table 1 and illustrated in Figure 2. Table 1 also shows the differences in occlusion length and success rate between adjacent intervals. This analysis indicates that an average increase of 10 mm in occlusion length is associated with an average reduction of 19% in success rate.

Lesion morphology. The morphology of the proximal stump of the occlusion was graded angiographically as blunt, concentric or eccentric. No significant difference was found for the prevalence of these stump types between successful (44%, 9% and 50%, respectively) and failed attempts at recanalization (44%, 15% and 41%, respectively; chi-square 2.496, $p = 0.287$ vs. successful attempts). Eight lesions appeared to be calcified (five moderately, three heavily); recanalization was successful in three moderately calcified lesions.

A bend in the lesion >60° was found significantly less often in successfully recanalized occlusions (23% vs. 67% in failed attempts at recanalization; chi-square 10.82, $p = 0.001$).

Side branch from funnel. A major side branch exiting immediately proximal to the occlusion was present in 50% of successfully recanalized occlusions and 53% of occlusions not recanalized.

Bridging collateral vessels. Bridging (i.e., ipsilateral) collateral vessels were present in 31% of successfully opened occlusions and in 56% of unopened occlusions (chi-square 3.122, $p = 0.077$).

TIMI flow grade. Of the eight vessels with "functional" occlusions (TIMI flow grade 1), 3 (38%) were successfully

Table 1. Analysis of Procedural Success Rate by Occlusion Length

Range of Occlusion Length (mm)	No. of Occlusions	Occlusion Length (mm)		Procedural Success Rate (%)	
		Mean	Δ*	Mean	Δ†
≤10	19	7.2 ± 1.9	–	68	–
>10 to ≤20	31	14.4 ± 2.8	7.2	45	−23
>20 to ≤30	10	24.0 ± 2.9	9.6	40	−13
>30 to ≤40	4	31.3 ± 1.6	7.3	25	−15
>40 to ≤50	2	45.3 ± 5.1	14.0	0	−25
Mean			10 ± 3		−19 ± 6

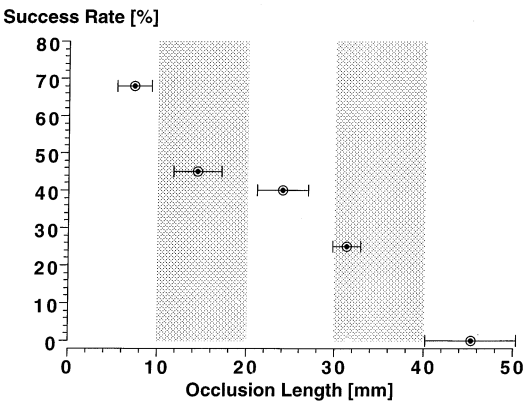
*Difference in mean occlusion length versus that of preceding 10-mm interval. †Difference in success rate versus that of preceding 10-mm interval.

recanalized. The mean length of these three lesions was at 21 ± 6 mm longer than that of the five lesions for which the attempt at recanalization failed (12 ± 5 mm, p = 0.053). Statistically, the recanalization rate of functionally occluded vessels did not differ from that of absolutely occluded (TIMI flow grade 0) vessels (29 [50%] of 58, chi-square 0.082, p = 0.775).

Occlusion age. Occlusion age could be determined clinically for 58 occlusions (85%). Of these occlusions, 33 (57%) were <1 year old, including 7 considered "early chronic" (6 to 9 weeks old). Table 2 summarizes the number of occlusions, the mean occlusion age (±1 SD), and the success rate for seven age intervals. Figure 3 shows the success rates in dependence on the mean occlusion age per age interval. The success rate was ~50% for all intervals, except for occlusions between 1 and 2 years old (success rate 33%) and occlusions between 7 and 10 years old (success rate 83%, p = 0.23 vs. all other age intervals). In the latter subgroup of six occlusions, failure was encountered only with the longest (34-mm) lesion; the five successfully recanalized occlusions were 5 to 18 mm in length.

Adjunctive therapy. After successful recanalization, conventional balloon angioplasty was performed in 19 (59%) of the 32 patients. In another 12 patients (with 13 occlusions), laser angioplasty preceded balloon angioplasty. In one patient, no attempt at adjunctive angioplasty was made because the recanalization attempt of a 7-mm long occlusion had resulted in a presumably extraluminal channel connecting with the distal vessel segment. Except for this patient, all occlusion sites were subsequently supplied with a median of two stents (range one to four) using high pressure (16 ± 2 atm) stent expansion. TIMI grade 3 flow was achieved in all 34 vessels, with a mean minimal lumen diameter of 2.86 ± 0.30 mm and a residual stenosis of 1 ± 17% within the stented region.

Figure 2. Success rate of laser recanalization versus occlusion length. Occlusion lengths are represented by the mean values of five 10-mm intervals (every other interval is **stippled**). **Error bars** represent 1 SD.



Failures. Thirty-four occlusions (50%) could not be crossed with the laser wire. In 12 cases (18% of all occlusions), the wire penetrated the vessel wall, leading to myocardial or pericardial contrast staining in 8; no clinical sequelae were observed in any of these patients. Perforation of the coronary artery tended to be related to the presence of a bend in the lesion exceeding 60° (9 vs. 3 lesions, chi-square 3.81, p = 0.051). In five cases, the wire was stuck after entering the lesion; four of these lesions were calcified. Subintimal tracking of the wire that could not be corrected was encountered in the remaining 17 occlusions, leading to termination of the procedure.

Complications. Major complications such as death, myocardial infarction, pericardial tamponade or emergency bypass surgery did not occur.

Procedural data. Procedure duration, fluoroscopy time and amount of contrast medium were 74 ± 28 min (range 30 to 215), 32 ± 13 min (range 7 to 61) and 350 ml (median; range 80 to 900 ml), respectively. Renal failure due to dye overload was not observed.

Follow-up. Angiographic follow-up was obtained from 21 of the 32 successfully treated patients after a median of 18

Table 2. Analysis of Procedural Success Rate by Occlusion Age

Occlusion Age Range (yr)	No. of Occlusions	Mean (±SD) Occlusion Age (yr)	Procedural Success Rate (%)
≤0.5	20	0.31 ± 0.13	45
>0.5 to ≤1.0	13	0.77 ± 0.16	54
>1.0 to ≤2.0	3	1.40 ± 0.17	33
>2.0 to ≤3.0	6	2.66 ± 0.28	50
>3.0 to ≤7.0	6	5.52 ± 1.25	50
>7.0 to ≤10.0	6	8.92 ± 1.08	83
>10.0	2	10.16 ± 0.02	50

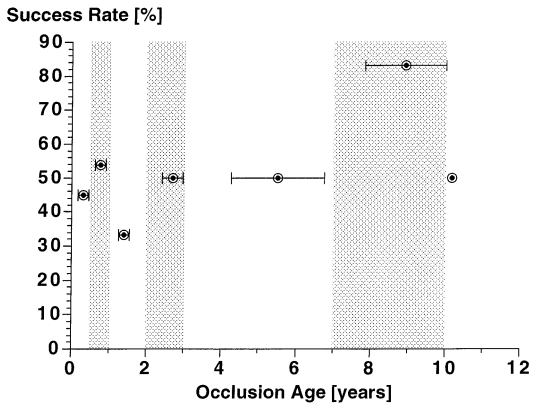
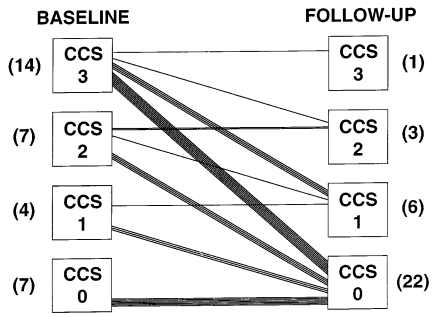


Figure 3. Success rate of laser recanalization versus occlusion age, based on the data from 56 patients. Shown are success rates for seven occlusion age intervals (every other interval is **stippled**) represented by their mean age. **Error bars** represent 1 SD.

weeks (range 4 to 56). In 11 patients, TIMI grade 3 flow was still present in the affected vessel, requiring no further intervention; this group included the patient in whom no adjunctive angioplasty had been performed and who underwent control angiography after 11 weeks. In six patients (19%), a restenosis >50% (adjacent to the stented segment in four, within the stent in two) necessitated repeat balloon angioplasty. Reocclusion within the stented segment was observed in another four patients (12%); two of them underwent successful revascularization (coronary artery bypass grafting in one, balloon angioplasty plus stenting in the other); two patients were kept on a medical regimen.

Clinical follow-up was obtained from all 32 successfully treated patients within a median of 24 weeks (range 4 to 98). An improvement in CCS functional class was found in 21 patients; no change was observed in the remaining 11 (Fig. 4). Of the latter 11 patients, 7 had been asymptomatic before the intervention, 1 remained in CCS functional class 1 and 3 had a reocclusion or restenosis necessitating reintervention.

Figure 4. Clinical course of 32 successfully treated patients, represented by CCS functional class at baseline and after a median follow-up interval of 24 weeks. The **numbers in parentheses** denote the total number of patients in the corresponding CCS class. The overall improvement in the patients' functional status is readily appreciated.



Discussion

Major findings. For angioplasty of chronic total coronary occlusions to be successfully performed, a channel through the length of the occlusion must be provided to guide the angioplasty device. When mechanical guide wires have been used, failure to cross the occlusion has been encountered in 30% to 50% of cases (6,12). The present study of 66 selected patients showed that, after failed attempts at mechanical recanalization, native artery chronic occlusions were revascularized in close to 50% of cases with use of the laser wire, regardless of lesion location. Patency of the recanalized vessel had been augmented in all patients but one by adjunctive angioplasty and stenting. Clinical follow-up at 6 months revealed improvement in anginal status by at least one CCS class in two thirds of successfully treated patients. During that period, reocclusion within the stented segment had occurred in 12% of patients and restenosis >50% within or adjacent to the stented segment had been assessed in 6 of 21 successfully treated patients who underwent repeat angiography.

Patient selection. Patients in this study represent a highly selected cohort. In all, a previous attempt at mechanical recanalization of the occlusion had failed. Laser wire revascularization was subsequently attempted only in patients in whom three angiographic conditions were met: 1) The vessel lumen distal to the occlusion was adequately visualized by collateral vessels (either anterogradely by bridging collateral vessels or retrogradely by contralateral vessels); 2) the entry point of the occlusion could be clearly identified; and 3) not more than one anatomic bend was expected throughout the extent of the lesion.

Variables affecting procedural outcome. The basic difference between mechanical and excimer laser wire recanalization is that tissue is pushed aside by physical force in the former, whereas photochemical ablation is the presumed primary mechanism of the latter (13,14). This difference is reflected in the variables influencing or not influencing the procedural outcome of either technique.

Mechanical revascularization is known to be adversely influenced by the age of the occlusion. The chance of procedural success declines rapidly during the 1st 4 weeks after occlusion (3), and several studies (3,7,8,12,15,16) have shown that occlusions >3 months old, as opposed to occlusions ≤3 months old, are associated with a significantly reduced success rate. Bridging collateral vessels are thought to develop proportional to the age of the occlusion, and their presence has also been associated with failure of mechanical revascularization (7,12,17). Other adverse factors are the presence of a major side branch at the site of the occlusion (7,12,17), a blunt stump (7,12,17) and TIMI flow grade 0 as opposed to TIMI flow grade 1 (3,7,18,19).

This study revealed no dependence of the procedural success of laser wire recanalization on any of these variables. The age of the occlusions varied between 6 weeks and 10.2 years, yet the success rate for seven relevant age ranges was fairly constant at ~50%. For the six occlusions aged 7 to 10

years, a success rate as high as 83% was encountered. Thus, the debulking efficacy of excimer laser energy appears to be independent of the differences in tissue composition that accompany the aging process of a coronary occlusion. In concordance with this finding was that neither the presence of bridging collateral vessels nor the morphology of the proximal stump of the occlusion had an adverse impact on the procedural outcome.

TIMI grade 1 flow through an occlusion that does supply the distal vessel segment anterogradely yet fails on angiography to opacify the entire distal coronary bed suggests that some kind of path through the occlusion facilitates the passage of a mechanical wire. For the laser wire, the presence or absence of a physical opening supplying residual anterograde flow through the lesion had no influence on the recanalization rate in this study. However, it must be taken into consideration that TIMI grade 1 flow through the occlusion may have been mimicked by flow through an adjacent bridging collateral vessel.

As a strictly "forward-looking" procedure, laser wire recanalization is less likely than the mechanical approach to be misdirected into a major side branch exiting proximal to the occlusion.

Predictors of success. Two variables in this study had a statistically significant impact on the procedural outcome of laser wire recanalization. The length of the occlusion was inversely related to the success rate. Whereas the overall success rate was 50%, the success rate was 68% for lesions ≤10 mm and then declined in a roughly linear fashion such that a 10-mm increase in the mean occlusion length was associated with an average 19% decrease in success rate. Thus, occlusions >30 to ≤40 mm had only a 25% chance of success and lesions >40 mm could not be successfully recanalized at all (however, there were only two of the latter).

The presence of a bend in the lesion >60° was strongly related to procedural failure. In view of the front-firing characteristic of the laser wire, it appears plausible that markedly bent lesions tended to be associated with an increased incidence of vessel wall perforation.

Reasons for procedural failure. As the exact anatomic course of the target lesion itself cannot be visualized on fluoroscopy during the procedure (only the vessel lumen distal to the lesion can be visualized, by way of collateral vessels), the investigator needs to mentally visualize in three dimensions the correct path of the laser wire through the occluded segment. With monoplane fluoroscopy it is therefore mandatory that the advancement of the laser wire be repeatedly interrupted to check the direction of the wire tip in different, preferably orthogonal, projections.

Complications. The ablative laser energy makes no distinction between the vessel wall and intraluminal tissue. Therefore, subtle changes in the direction of the laser wire may result in loss of its intraluminal axial alignment at any point along the occlusion and subsequent direction of laser energy at the vessel wall. A subintimal wire position may be corrected by withdrawal and subsequent realignment, but inability to achieve the latter was the reason for procedural failure in 50% of cases. In another 35% of failed procedures (12 occlusions), the laser wire had penetrated the vessel wall. Although this occurrence required no immediate intervention, it precluded continuation of the recanalization attempt. Extravascular appearance of discrete amounts of contrast agent was observed in 75% of patients with this complication. However, clinical sequelae were not encountered with coronary artery perforation, probably because of the small diameter of the puncture, which closed spontaneously. It is conceivable that more frequent verifications of laser wire orientation in different projections before the activation of laser energy would have lowered the perforation rate.

Inability to advance the laser wire through the occlusion ("stuck wire") accounted for procedural failure in the remaining 5 (15%) of the 34 unopened lesions. Evidence of moderate and heavy calcification was seen on fluoroscopy in one and three of these lesions, respectively, suggesting that the laser energy used in this study was not high enough to ablate calcified tissue.

Adjunctive therapy. Successful recanalization was usually followed by balloon angioplasty, provided that a support catheter could be passed through the reopened lesion to exchange the laser wire with a 0.014-in. guide wire. In cases where this could not be accomplished, laser angioplasty was first employed to create a wider channel through the lesion for subsequent balloon angioplasty. The rationale behind this strategy is that low profile balloons capable of crossing narrow lesions are currently available only for 0.014-in. guide wires.

To reduce the incidence of restenosis and reocclusion, all expanded lesions were stented (20–22). The preliminary restenosis and reocclusion rates of 19% and 12%, respectively, found in this study are in concordance with previous reports (20,21).

Clinical relevance. The benefit versus risk ratio of laser wire recanalization has not yet been determined. Therefore, it appears prudent to perform the procedure only in experienced centers. Major complications, such as death, myocardial infarction or the need for emergency coronary artery bypass grafting were not encountered in our patients. Nevertheless, the indication for laser wire therapy should be restricted to patients whose clinical status unequivocally calls for such an intervention, in whom an attempt at mechanical revascularization has failed and who fulfill the angiographic inclusion criteria. The ongoing randomized European multicenter Total Occlusion Trial with Angioplasty assisted by Laser guidewire (TOTAL [23]) will help to clarify issues relating to the benefit or harm of the laser wire versus the mechanical wire.

The significant clinical improvement as well as the satisfying angiographic outcome of our patients in retrospect confirm the decision to perform laser wire recanalization after the mechanical attempt had failed.

Limitations of the study. This study was observational, rather than randomized, and performed in a limited number of patients. In particular, there were very few patients with TIMI grade 1 flow, probably reflecting the fact that TIMI grade 1

occlusions can frequently be reopened by mechanical means (3,7,18,19). Thus, the true efficacy of the laser wire in recanalizing TIMI grade 1 occlusions needs to be assessed in a future study. The follow-up period in our study was relatively short, and angiographic control was not obtained in all successfully treated patients. Therefore, the true incidence of restenosis may have been underestimated and the long-term outcome of laser wire recanalization needs to be clarified.

Biplane fluoroscopy was not available in our study. It is conceivable that the improved evaluation of wire orientation provided by this modality would have reduced the number of failures due to subintimal tracking or vessel perforation. An improved steerability of the laser wire as well as an incorporated means for forward detection of tissue composition (24,25) are technical challenges that—if met—may further improve the success rate of laser wire recanalization.

Conclusions. This single-center study showed that with use of the laser wire, recanalization of chronic total coronary occlusions was achieved in ~50% of selected patients in whom a previous attempt at mechanical recanalization had failed. Restenosis or reocclusion accounted for an overall 6-month success rate of 33%. The technique provides the experienced cardiologist with an apparently safe and efficacious interventional means to alleviate symptoms and circumvent bypass surgery in a wider range of patients than was previously possible.

References

1. Holmes DR Jr, Vlietstra RE, Reeder GS, et al. Angioplasty in total coronary artery occlusion. J Am Coll Cardiol 1984;3:845–9.
2. Kereiakes DJ, Selmon MR, McAuley BJ, McAuley DB, Sheehan DJ, Simpson JB. Angioplasty in total coronary artery occlusion: experience in 76 consecutive patients. J Am Coll Cardiol 1985;6:526–33.
3. DiSciascio G, Vetrovec GW, Cowley MJ, Wolfgang TC. Early and late outcome of percutaneous transluminal coronary angioplasty for subacute and chronic total coronary occlusion. Am Heart J 1986;111:833–9.
4. Melchior JP, Meier B, Urban P, et al. Percutaneous transluminal coronary angioplasty for chronic total coronary arterial occlusion. Am J Cardiol 1987;59:535–8.
5. Ellis SG, Shaw RE, Gershony G, et al. Risk factors, time course and treatment effect for restenosis after successful percutaneous transluminal coronary angioplasty of chronic total occlusion. Am J Cardiol 1989;63:897–901.
6. Hamm CW, Kupper W, Kuck KH, Hofmann D, Bleifeld W. Recanalization of chronic, totally occluded coronary arteries by new angioplasty systems. Am J Cardiol 1990;66:1459–63.
7. Stone GW, Rutherford BD, McConahay DR, et al. Procedural outcome of angioplasty for total coronary artery occlusion: an analysis of 971 lesions in 905 patients. J Am Coll Cardiol 1990;15:849–56.
8. Bell MR, Berger PB, Bresnahan JF, Reeder GS, Bailey KR, Holmes DR Jr. Initial and long-term outcome of 354 patients after coronary balloon angioplasty of total coronary artery occlusions. Circulation 1992;85:1003–11.
9. Henson KD, Leon MB, Popma JJ, et al. Treatment of refractory coronary occlusions with a new excimer laser catheter: preliminary clinical observations. Coron Artery Dis 1993;4:1001–6.
10. Campeau L. Grading of angina pectoris. Circulation 1976;54:522–3.
11. Cohen M, Rentrop KP. Limitation of myocardial ischemia by collateral circulation during sudden controlled coronary artery occlusion in human subjects: a prospective study. Circulation 1986;74:469–76.
12. Tan KH, Sulke N, Taub NA, Watts E, Karani S, Sowton E. Determinants of success of coronary angioplasty in patients with a chronic total occlusion: a multiple logistic regression model to improve selection of patients. Br Heart J 1993;70:126–31.
13. Grundfest WS, Litvack F, Forrester JS, et al. Laser ablation of human atherosclerotic plaque without adjacent tissue injury. J Am Coll Cardiol 1985;5:929–33.
14. Isner JM, Rosenfield K, White CJ, et al. In vivo assessment of vascular pathology resulting from laser irradiation: analysis of 23 patients studied by directional atherectomy immediately after laser angioplasty. Circulation 1992;85:2185–96.
15. Ruocco NA Jr, Ring ME, Holubkov R, Jacobs AK, Detre KM, Faxon DP. Results of coronary angioplasty of chronic total occlusions (the National Heart, Lung, and Blood Institute 1985–1986 Percutaneous Transluminal Angioplasty Registry). Am J Cardiol 1992;69:69–76.
16. Finci L, Meier B, Favre J, Righetti A, Rutishauser W. Long-term results of successful and failed angioplasty for chronic total coronary arterial occlusion. Am J Cardiol 1990;66:660–2.
17. Maiello L, Colombo A, Gianrossi R, et al. Coronary angioplasty of chronic occlusions: factors predictive of procedural success. Am Heart J 1992;124:581–4.
18. Safian RD, McCabe CH, Sipperly ME, McKay RG, Baim DS. Initial success and long-term follow-up of percutaneous transluminal coronary angioplasty in chronic total occlusions versus conventional stenoses. Am J Cardiol 1988;61:23G–8G.
19. Ivanhoe RJ, Weintraub WS, Douglas JS Jr, et al. Percutaneous transluminal coronary angioplasty of chronic total occlusions: primary success, restenosis, and long-term clinical follow-up. Circulation 1992;85:106–15.
20. Goldberg SL, Colombo A, Maiello L, Borrione M, Finci L, Almagor Y. Intracoronary stent insertion after balloon angioplasty of chronic total occlusions. J Am Coll Cardiol 1995;26:713–9.
21. Sirnes PA, Golf S, Myreng Y, et al. Stenting in Chronic Coronary Occlusion (SICCO): a randomized, controlled trial of adding stent implantation after successful angioplasty. J Am Coll Cardiol 1996;28:1444–51.
22. Mathey DG, Seidensticker A, Rau T, Kunze KP, Schofer J. Chronic coronary occlusions: reduction of the reocclusion rate by primary stent treatment [abstract]. Eur Heart J 1996;17 Abstract Suppl:516.
23. Serruys PW, Hamburger JN, Rutsch W, et al. Recanalization of chronic total coronary occlusions using a laser guidewire: the European TOTAL multicentre surveillance study [abstract]. Eur Heart J 1996;17 Abstract Suppl:516.
24. Leon MB, Almagor Y, Bartorelli AL, et al. Fluorescence-guided laser-assisted balloon angioplasty in patients with femoropopliteal occlusions. Circulation 1990;81:143–55.
25. Bartorelli AL, Leon MB, Almagor Y, et al. In vivo human atherosclerotic plaque recognition by laser-excited fluorescence spectroscopy. J Am Coll Cardiol 1991;17 Suppl B:160B–8B.