Reappraisal of Percutaneous Transluminal Laser Angioplasty

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Background and aims: We devised a technique to treat peripheral arterial disease (PAD) with laser, i.e., percutaneous transluminal laser angioplasty (PTLA). Considerable good results were obtained with PTLA, but it is apparently considered obsolete as a technique to treat occlusive arterial disease of peripheral arteries, perhaps because of the development and improvement of stents and the ease of their use compared to the somewhat intricate technique required for PTLA. Although the author admits the usefulness of stents, they are foreign to a human body. PTLA does not use a foreign body and contributes to the regeneration of the body’s own artery.

The aim of this article is to elucidate the beneficial effects of laser procedures in the treatment of PAD and to show the resulting good long-term patency, and to propose PTLA as an option to treat PAD.

Some basic experiments and their results useful for PTLA will be introduced.

Materials and Methods: Ninety cases with occlusive peripheral arterial diseases were treated with PTLA during the period of March 1985 to March 1991.

Our method of PTLA consists of occlusion of the proximal artery by a dilated balloon of a percutaneously introduced balloon catheter, and flushing with normal saline during irradiation by Nd:YAG laser.

We used a ceramic tip attached to a laser catheter most of the time and a bare laser fiber under angioscopy or a bare laser fiber itself to treat smaller arteries in the legs.

Results: The initial success rate was 90%.

The patency rates of PAD at 6 years are 91.4% (iliac artery) and 85.8% (femoropopliteal artery), and the patency rate of leg artery lesions is 100% at 5 years.

Some clinical cases with long-term patency (6 and 30 years) will be introduced.

Some fundamental experiments useful to the application of laser to atheroma or thrombi will be introduced.

Conclusions: PTLA could be a useful option to treat occlusive PAD, because it can produce long-term patency of natural arteries, provided a proper lesion was selected.

Key words: Laser · Laser angioplasty · percutaneous transluminal laser angioplasty · PAD
for iliac and femoral arteries were 97.7% and 94.4% respectively. They concluded that in both iliac and femoral arteries, the success rate by the ipsilateral femoral approach was higher than the other approaches (comprising contralateral and left axillary approaches).

However, some cases are resistant to conventional PTA due to recoil, dissection or thrombosis resulting in restenosis due to stiffness of high-grade arteriosclerosis. Such cases led us to start the fundamental and clinical investigation of percutaneous transluminal laser angioplasty (PTLA).

Ginsburg, Geschwind and Choy had obtained good results employing LASER in the treatment of difficult cases of occlusive arterial disease.

Ginsburg and his associates reported that they saved an ischemic limb from amputation by laser angioplasty. Geschwind et al. reported successful recanalization of peripheral arteries by PTLA in a short communication in the form of a letter to the editor of Lancet. Choy and his associates reported successful coronary laser angioplasty in the surgical operating room with one complication of perforation, which was repaired immediately.

After reviewing these reports and their preceding fundamental experimental research, the author and his associates also aimed to improve the technique of PTA by percutaneous transluminal laser angioplasty (PTLA).

It is the purpose of this article to review the past results with PTLA in our series and others, and analyze results from the use of a PTLA technique developed by us.

Some cases showing long-term patency will be introduced as evidence of the favorable effects of laser treatment on the arterial wall.

It is a further purpose of this paper to discuss the merits and demerits of PTLA.

Materials and Methods

Between March, 1985 and March, 1991, PTLA was carried out in 90 cases on 61 patients. The procedures were performed at two institutions: Dokkyo University Koshigaya Hospital and Hirosaki University Hospital.

Several cases in this series were followed up to 8 to 30 years after treatment by PTLA. In these cases the treated arteries had been patent until the last visits to the hospitals.

Our technique of PTLA is a percutaneous angioplasty for peripheral occlusive arterial diseases, utilizing the energy of laser.

Our method of PTLA consists of occlusion of the proximal artery by a dilated balloon of a percutaneously introduced balloon catheter, and flushing of normal saline during irradiation by Nd:YAG laser.

This technique has been progressively improved from time to time. The initial method was a non-contact method of laser irradiation with a distance of 0.5 cm between the plaque and the tip of the laser fiber or probe in the clear lumen while flushing with normal saline (Fig. 1). The proximal arterial lumen of the iliac artery was occluded by an inflated balloon before

Fig. 1: Technique of percutaneous transluminal laser angioplasty (PTLA).

A: Laser angioplasty for iliac lesions.
B: Laser angioplasty for femoropopliteal arteries.
flushing with normal saline (Fig. 1A). In case of femoral artery stenosis the proximal common femoral artery was compressed by hand over the sheath to occlude or decrease the blood flow before flushing with normal saline (Fig. 1B). In most cases the occluding lesions were observed by vascular endoscopes before laser irradiation.

Later, a contact method of laser irradiation of atheromatous plaque became possible via a ceramic tip attached to the laser probe. Eventually, thrombolysis and aspiration of thrombi occupying the occluded arterial lumen were introduced before laser irradiation.

In our technique, in most cases laser irradiation was delivered through either a bare laser fiber or ceramic tip attached to the end of a laser catheter. The holes created by the laser through the ceramic tip were easier to control because the tip could be placed in contact with the lesion and could be pressed directly on the occluding lesion. A bare laser fiber was used to treat smaller arteries in the legs. A van Andel catheter was used to supplement the dilatation of smaller arteries.

We used continuous wave 1064 nm Nd:YAG laser for the treatments.

**Results**

1. **Success rates and Patency rates.**

From March, 1985 through March, 1991, ninety lesions in 61 patients with peripheral occlusive arterial diseases were treated by PTLA. In this series the success rate was 90% (81/90). The cumulative patency rate in total lesions at 5 years was over 85%. The 5-year patency rates according to the sites of stenosis or occlusion were as follows: the rates for iliac artery, femoropopliteal artery and leg arteries were 91.4%, 85.8% and 100% respectively (Fig. 2A).

However, the patency rate of PTLA for long segment occlusion (more than 10 cm in length) of PAD was not favorable with a 65% patency rate at 36 months, although earlier treatments were with an inferior technique not employing thorough thrombolysis and aspiration of thrombi (Fig. 2B).

When the five-year patency rates of PTA and PTLA were compared, the patency rate of PTLA exceeded the patency rate of PTA (Fig. 3A-B).
2. Cases.

Some cases will be illustrated as examples of successful results of PTLA for long-segment occlusion, heavily calcified iliac artery stenosis and occluded popliteal arteries.

Case 1: A 77-year-old man presented with a complaint of 100 m claudication. His ankle-brachial pressure index (ABI) was 0.59 on the right and 0.92 on the left. An initial right femoral arteriography showed complete occlusion (26 cm) of the right superficial femoral artery (Fig. 4A). Fearing post-surgical pneumonia, the patient requested a less invasive treatment such as PTLA.

Thrombolysis was carried out by intra-arterial injection of 480,000 units of Urokinase over 30 minutes. After thrombolysis and aspiration, partial flow in the right superficial femoral artery (SFA) was obtained, but three localized stenoses and an occlusion of the distal portion remained. The localized stenoses were 90% for 2 cm, 85% for 2.5 cm and 85% for 2 cm. The occlusion was for 1.3 cm. Laser irradiation was applied to the atheromas and occlusion selectively. The power of the laser was 25 watts at 1-second exposures. Altogether, irradiation was done ten times. Balloon dilatation was added. Some narrowing remained, but good flow in the right SFA was obtained (Fig. 4B) and the segments became gradually wider (FIG. 4C-D).

The patient’s ABI after treatment rose to 0.98 at the anterior tibial artery and 1.00 at posterior tibial artery on the right, and his intermittent claudication was cured.

Long-term follow-up showed successful recanalization of the SFA was patent for six years at the time of the patient’s death due to cerebral hemorrhage and pneumonia.

Case 2: Heavy calcification of the iliac artery and its treatment by PTLA.

Heavily calcified PAD is usually resistant to PTA. We did, however, experience successful recanalization of a heavily calcified common iliac artery using PTLA.

A 64-year-old man presented with pain in the right hip and weariness of the right thigh on exertion. His ABI was 0.6-0.7 on the right. An X-ray of the lower abdomen showed marked calcification of the iliac arteries (Fig. 5A-B) and a CT of the abdomen showed the proximal right common iliac artery almost occluded with heavy calcification.
Pelvic angiography showed severe stenosis of the right common iliac artery (Fig. 5D) which was confirmed by retrograde right common iliac arteriography (Fig. 5E). The occluding lesion in the proximal right common iliac artery was irradiated by laser with incremental irradiation of 20 watts for two seconds. The procedure was repeated five times, at which point the tip of the laser probe penetrated the occlusion. Balloon dilatation was added, using a balloon 8 mm in diameter and 4 cm in length. The balloon was well expanded without appreciable resistance (Fig. 5F). Final angiography showed fairly good recanalization of the right common iliac artery (Fig. 5G).

Regions of interest were set at the distal external iliac arteries on the angiographic position and simultaneous densitometry of the distal external iliac arteries on both sides in order to assess the flow of blood in the external iliac arteries after injection of the contrast medium (Fig. 5H-I).

The densitometry showed similar flows of the contrast medium in both iliac arteries.

Fig. 5: PTLA for heavily calcified common iliac artery.
A and B: Plain X-ray of the abdomen.
(Arrows indicate calcification)
C: Plain CT of the abdomen.
D: Pelvic angiography.
E: Retrograde injection to the right common iliac artery shows severe stenosis of the proximal common iliac artery.
F: Balloon dilatation of the right common iliac artery after laser irradiation.
G: Pelvic angiography by retrograde injection of the contrast medium into the iliac artery.
H: Serial pelvic angiography with the tip of a catheter in the abdominal aorta.
I: Curves of the density in both external iliac arteries.
The patient was followed-up until 8 1/2 years later, but no recurrence of iliac artery stenosis was noted.

Case 3: Dissection of the popliteal artery after balloon dilatation and PTLA; treatment resulted in long-term patency even after 30 years.

A 46-year-old man presented with intermittent claudication and coldness of the right foot. Right calf pain while skating was noted.

Angiography of the right femoral artery

**Fig. 6:** PTLA for occlusion of the right popliteal artery due to popliteal artery entrapment syndrome (PAES).

A and B: Popliteal arteriography in the early and late phases. Distal arteries are opacified in the late phase of arteriography.

C: Recanalized popliteal artery after PTLA. Day 0.

D: Recanalized popliteal artery after PTLA. Day 16.

E: Angiography after the third PTLA. The popliteal artery was recanalized, but there is dissection of the popliteal artery. Dissection was noted after balloon dilatation at the second PTLA.

F: Stress angiography of the popliteal artery showed narrowing of the popliteal artery, consistent with PAES.

G: CT angiography (CTA) 17 years after PTLA showed patent popliteal artery with a shape of remaining dissection.

H and I: Stereoscopic display of non-contrast enhanced MR angiography (MRA). These MRA show patent right popliteal artery with some narrowing and remaining form of dissection. Taken 30 years after PTLA.
showed occlusion of the distal superficial femoral artery and popliteal artery. Tibial and peroneal arteries were not opacified (Fig. 6A-B).

Initially, PTLA was carried out under endoscopy with a non-contact method without recognizing popliteal artery entrapment syndrome (PAES) until the third treatment. Initial PTLA was successful (Fig. 6C-D). At the time of the second PTLA for the recurrence of the occlusion, the 6 mm diameter balloon of a balloon catheter burst and dissection of the popliteal artery was noted on angiograms. At the third PTLA, dissection of the popliteal artery was noted again, but the artery was recanalized (Fig. 6E). Since there was a peculiar concave figure (see arrow) at the margin of the right popliteal artery, stress angiography was carried out and it revealed PAES (Fig. 6F). The abnormal tendon (anomalous course of medial head of the gastrocnemius) in the popliteal fossa was dissected by vascular surgeons and the popliteal artery was freed from the entrapping tendon. The diseased popliteal artery with dissection was left in place as it was and without grafting of the artery since the popliteal artery was successfully recanalized by PTLA. This was the surgeon’s decision. The patient was followed-up and has been repeatedly examined (Fig. 6G: CTA of peripheral arteries at 17 years) (Fig. 6H-I: MR angiograms for stereoscopic view at 30 years). The right popliteal artery was revealed to be patent even after 30 years despite the residual deformity due to dissection. The patient’s ABI on the right was 1.06 at 30 years after treatment (PTLA). PAES on the left popliteal artery was also observed, but there were no symptoms because of well-developed collateral circulation.

The patient is currently doing well, enjoying sports and walking.

Discussion:

The outcome of recanalization of occlusive arteries by interventional procedures is evaluated by how long the treated artery is patent. The main treatment options for PAD are surgical revascularization (graft), PTA, thrombolysis, aspiration, PTLA and stent. Surgical intervention is the gold standard, but other treatments may be employed depending on the patient’s wishes and physical condition. Some patients, fearing pneumonia or death following surgery, prefer less invasive treatments. The selection of the treatment is decided by the patient after consulting with the attending doctor and discussion between patients and doctors.

We selected patients who preferred noninvasive treatment or who had bilateral iliac artery stenoses and were referred by a surgeon to our section for treatment of a lesion on one side by PTLA in order to minimize the operating time for surgical treatment of the opposite side.

Initially we treated even rather long segment occlusions without sufficient thrombolysis and aspiration of thrombi, resulting in poorer results (65% patency rate at three years when the lesions were over ten cm in length). In some later cases, we succeeded in recanalizing an occluded artery by a combined method with thrombolysis and aspiration before administration of laser irradiation and balloon dilatation (Fig. 4).

In short segment lesions we initially treated only those located in a straight artery. Later we devised and used a curved-tip sheath introducer to treat lesions in curved arteries (Fig. 7).

We also conducted various laboratory studies to determine the effect of laser irradiation on vascular and
other tissue. With laser irradiation in normal saline, we found that the lateral effect of the heat caused by the irradiation was limited to a very short distance from the center of vaporization.13

We observed a rapid temperature rise in tissue irradiated by Nd:YAG LASER (bare laser fiber in contact application at 20 W for about 2 seconds) to about 90°C at a point 2 mm from the center, whereas the temperature at a point 4 mm from the center was only about 50°C (Fig. 8A). Looking at energy-dependent temperature increases in the arterial wall at a point 1 mm lateral to the center of vaporization, the maximum temperatures measured at 1 mm from the ceramic tip of a laser probe after six seconds were 106.3°C (30W), 104.4°C (25W), 97.6°C (20W) and 81.1°C (15W) (Fig. 8B).

Such fundamental studies support our finding that short laser irradiation for 2 to 3 seconds does not cause damage to the arterial wall laterally when atheroma or thrombi are irradiated.

In further basic research into the effect of laser irradiation on atheroma, we noted that the holes (cratering) created by vaporization or cutting were greater in size in atheromatous plaque-laden arterial walls than in normal arterial walls (Fig. 9).

It is noteworthy that severe calcified stenosis of the iliac artery was recanalized by laser angioplasty. Welch and his associates stated “Visual analysis suggests that there may have been two different mechanisms responsible for plaque removal. There appeared to be a melting process resulting in the dissolution of fatty plaques, and a disintegration process appeared to destroy the calcified plaques.”

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**Fig. 8:** Temperature of the arterial wall after laser irradiation.
**A:** Rapid drop of temperature in the arterial wall as the site is far from the vaporization site. (Bare laser fiber)
**B:** Temperature of arterial wall irradiated at different powers of laser. The temperature was measured at 1.0 mm from the center of laser spot.

**Fig. 9:** Vaporized volume of normal artery and atheromatous wall (iliac arteries). As energy of laser goes up the vaporized volume in the atheromatous wall grows larger than that of normal wall. Laser was irradiated through a ceramic tip at 25W.
The author considers that the treated arterial wall became softer, expanded and healed well after laser irradiation. The cause may lie in a welding effect as Whipple\textsuperscript{20} stated that there was good evidence that laser anastomoses of small-caliber vessels may be at least as successful as, and considerably faster than, suture techniques. The procedure is accomplished by denaturing the collagen of opposing ends into a confluent bridge that “welds” the tissues together.

Stents for use in the treatment of occlusive arterial disease were devised by Dotter\textsuperscript{21}, Gianturco\textsuperscript{22}, Palmaz\textsuperscript{23} and others to improve conventional balloon PTA.

The author recognizes the merits of stents in the treatment of iliac artery stenosis or short occlusion and renal artery stenosis due to arteriosclerosis, and that stents are further being improved with drug-eluting stents and other developments, but also proposes that PTLA is another option to treat PAD without placing foreign bodies in the human artery.

One of the merits of PTLA is smooth healing of the arterial wall after laser irradiation. This was shown in live animal experiments by Gerrity, et al.\textsuperscript{24}. We also observed the same phenomenon in clinical cases, as we have previously reported\textsuperscript{16}.

The author suggests that laser ablation of atheroma and small portions of surrounding arterial wall by heat and photochemolysis caused welding of the remaining wall and some dilatation effect on the artery, leading to gradual widening of the lumen without recoil of the artery as seen in the case of balloon PTA.

**Long-term patency**

As to long-term patency, it is the author’s opinion that the favorable results seem to have been caused by the combined effects of laser treatment (welding effect, softening of the wall, eradication of atheroma) and also removal of thrombi by aspiration.

Long-term patency (30 years) of the popliteal artery after PTLA in Case 3 suggested the beneficial effect of laser treatment.

Another contributing factor to long-term patency might be added, which is a thin covering layer of carbon particles on the surface of the created hole or crater in the arterial wall. It is speculated that this thin layer of carbon (Fig. 10) prevented production of thrombi on the surface of the defect in the wall after laser irradiation and induced smooth endothelialization.

The author noted the antithrombotic effect of carbonization of a stent material in an experiment on carbonized stents, using contact angle measurement, at the cardiovascular laboratory of Drs. Palmaz and Sprague at University of Texas Health Science Center in San Antonio. The carbonated stent pieces showed continued low contact angle, which was reported at the Northern Chapter of the Japanese Society of Interventional Radiology in Sendai on September 12, 1998\textsuperscript{25}.

Schatz\textsuperscript{26} reviewed the advantages and disadvantages of stents, and introduced previous research on blood and metal compatibility. The results of that research may be summarized as follows: most metals are electropositive and, therefore, thrombogenic because blood elements are negatively charged, while electronegatively charged metals are thromboresistant. Schatz states that a metal stent should have low surface potential among other characteristics. In this respect, carbonated stents may have advantages, because carbons are dielectric in electric potential.

Akaba and his associates\textsuperscript{27} reported on the biocompatibility of carbonated grafts in animal experiments, stating that pathological examination of carbonated grafts demonstrated satisfactory biocompatibility.

Carbon is used as an inert material in the form of diamond-like carbon (DLC) in the field of orthopedic and cardiac implants or vascular grafts\textsuperscript{28-31}.

DLC consists of carbon and hydrogen. Biocompatibility of DLC was the subject of basic investigations by several researchers, and DLC was recognized as a biocompatible, as well as blood-compatible material.

Hasebe and his associates\textsuperscript{32-33} reported the
results of hydrophobicity of fluorine-incorporated diamond-like carbon films. Hotta and Hasebe 34) studied DLC coating on polymers for biomedical applications. Kapfer and his associates 35) studied the effect of carbon-impregnated (C) and standard (S) ePTFE in the treatment of occlusive lesions of crural arteries in a randomized multicenter study. Their total sample comprised 265 patients (C group=130 patients, S group=135 patients), of which they subsequently analyzed 241. They reported that the primary patency rates were 33% (C) and 30% (S) at 36 months, and secondary patency rates were 43% (C) and 38% (S). The limb salvage rates were 67% (C) and 58% (S).

However, in the six-to-18-month period the primary patency rates of C-group and S-group were 50% and 38% respectively, a seemingly significant difference. Kapfer and his associates stated that coating medical heart valves with carbon was standard, and the results of carbon coating were encouraging in terms of biocompatibility, hemocompatibility and decreased thrombogenicity evaluated in vitro, in animal trials and in non-randomized clinical settings. They also stated that the apparent advantages in the carbon group in their study in the period from six to 18 months was noteworthy and might be of clinical importance for individual patients, but seemed to be a temporary effect.

In their series, bypass infection occurred in 4.9%. The 30-day mortality rate was 3.4%. They treated occlusive crural arteries, including critical limb ischemia. These lesions are considered to be severe lesions and difficult to treat.

As mentioned above, the patency rate of Carbon-impregnated e-PTFE (C) seemed to be better than that of Standard-ePTFE (S) at 18 months. This phenomenon seemed to be valuable to analyze. First of all, due to the severity of crural artery disease, the disease itself may advance and result in restenosis or reocclusion as time goes on until 36 months.

Another point is how long the carbon impregnated in the graft can be expected to last. If carbon is washed out or detached from the graft gradually, the inert (anti-thrombotic) effect of carbon cannot be expected to be maintained.

In cases of laser-irradiated intima of an artery with a thin layer of carbon, it would be assumed that carbonated tissues would remain at the arterial intima until smooth endothelialization takes place. Our clinical results seem to support this assumption.

In an earlier report Airoldi 36) and his associates reported in 2004 that the 6-month follow-up showed similar rates of binary restenosis (31.8% in the carbon-coated stents group versus 35.9% in the stainless-steel stents group; p = 0.448) and carbon coating did not provide significant improvement over 55 stents with similar design.

Ando and his associates 37) reported in 2016 that DLC-coated coronary stents suggested low rates of target vessel failure and angiographic binary restenosis (n = 99, target volume failure in DLC-coated stents versus bare-metal stents were 11.2% and 19.6% respectively at 9 months), and small in-stent late loss in DLC-coated stents.

Differences among techniques of PTLA:

There are a variety of lasers used for PTLA, including Argon, Nd:YAG, Ho:YAG, Eximer and Dye Laser, with researchers attempting to identify the merits of each.

As to technique, some have used the laser itself, while others used it indirectly (i.e., in indirect technique, a metal tip is heated by laser and the heat used to dissolve atheromatous plaque/thrombi).

We investigated the direct effects of irradiation with Argon and Nd:YAG on arterial walls, and finally decided to use Nd:YAG laser (wave length 1640 nm) itself directly in our clinical practice because the holes created by the Nd:YAG laser were larger than those created by Argon laser.

Pros and Cons of PTLA:

As described above, there are various techniques of PTLA, and this leads to differences in the degree of atheromatous changes or amount of thrombi in the stenotic or occluded arteries. It is difficult to judge fairly the difference of results or superiority of one technique or specific series because of the large variety in the degree of sclerotic changes, lesion length, differences in techniques and patient selection.

However, some reports reflecting good results (pro) and fair or poor results (con) can be tabulated (Table 1).

In techniques using hot tip, follow-up results were fair to poor in most institutions. Okada and his associates 38) seem to be the only successful group in the practice with hot tip. The reason for their success seems to be due to good control of the temperature of the metallic tip by a thermistor attached to the tip of the laser catheter.

We also paid much attention to the temperature of the arterial wall irradiated by laser to avoid lateral damage by overheating. That research indicated that the temperature far from the center of heating by the laser dropped rapidly as described before (Fig. 8A). Therefore, we could apply laser irradiation to an
Table 1. Pros and Cons for Laser Angioplasty

**A and B**: Reports for Pros. **C**: Reports for Cons.

### Pros for Laser Angioplasty (A)

<table>
<thead>
<tr>
<th>Researchers (Authors)</th>
<th>Theme</th>
<th>Journal or Meeting (year)</th>
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<tbody>
<tr>
<td>Gerrity, RG et al</td>
<td>Smooth healing (endothelialization) of wound that was irradiated with laser.</td>
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<td>Ginsburg, R</td>
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<td>1984, Clin Cardiol 7:54-</td>
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<td>Sanborn, TA</td>
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<td>1984, JACC 5:934-</td>
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### Pros for Laser Angioplasty (B)

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<tr>
<th>Researchers (Authors)</th>
<th>Theme</th>
<th>Journal or Meeting (year)</th>
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<tbody>
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<td>Lammer, J</td>
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<td>1988, Radiology 168:734-</td>
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<td>Safian, RD</td>
<td>ELCA more effective than PTCA</td>
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<td>Berger, PB</td>
<td>Excimer for ELCA.</td>
<td>1993, Cathet Cardiovasc Diag.</td>
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<td>Litvack, F</td>
<td>ELCA in 3000 pts.</td>
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### Cons for Laser Angioplasty (C)

<table>
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<tr>
<th>Researchers (Authors)</th>
<th>Theme</th>
<th>Journal or Meeting (year)</th>
</tr>
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<tbody>
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<td>Nd:YAG laser. Metallic tip. In OR. Tech success 82%. Long-term patency 22.5% (6 mos). 13.5% (12 mos) High rate of restenosis. 20 lesions (36%) less than 5cm 19 lesions (34%) 5-14cm 17 lesions (30%) longer than 15cm</td>
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<td>Huppert, PE</td>
<td>Pulsed laser vs PTA</td>
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The contents were reported by Takekawa at ISIM 90, Stockholm, Sweden, June, 1990.
occluding lesion, although we also added additional cooling to the arterial wall by flushing with normal saline during the treatment.

Conclusion

Percutaneous transluminal laser angioplasty offers a less invasive technique to treat occlusive arterial diseases compared with some others, including surgical revascularization and the use of stents. PTLA can also deliver long-term patency, as demonstrated in cases introduced that revealed 8-year and 30-year patency.

We reviewed several effects of laser irradiation to cut or vaporize vascular tissue: carbonization of the irradiated arterial wall, the welding effect of the laser and the larger size of holes or craters in atheromatous arterial walls when compared with normal wall. These effects seem to have contributed to smooth endothelialization of the irradiated arterial wall.

The good results we obtained can be attributed to the combined effects of laser irradiation, thrombolysis and aspiration of thrombi.

The author would like to propose PTLA as an option for the treatment of peripheral occlusive arterial diseases where indicated by need and the patient’s condition, although care must be taken to prevent or reduce possible complications.

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[Acknowledgements]
Collaborators: Hiraku Yodono, M.D., Taisuke Sasaki, M.D., Koji Tarusawa, M.D., Tamaki Kimura, M.D., Naoko Nishi, M.D., Kouichi Shibutani, M.D., Hiroyuki Miura, M.D. Hiroshi Noda, M.D., Masaki Takahashi, M.D., Junji Tanaka, M.D, Satoshi Komai, M.D. (from the Departments of Radiology, Hiroaki University Hospital and Dokkyo University Koshigaya Hospital).
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