Recanalization of Superficial Femoral Artery Occlusion —
The Subintimal Approach

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ABSTRACT
The technique of subintimal angioplasty or percutaneous intentional extraluminal angioplasty for recanalization of femoropopliteal occlusions in critical limb ischaemia is described in detail. Various indications and contraindications are outlined. The technique is easy to learn and offers a high success rate, combined with a low rate of complications.

Key Words: Femoral arteries, Limb ischaemia, Subintimal angioplasty

INTRODUCTION
Subintimal angioplasty (SA) or percutaneous intentional extraluminal recanalization is a technique that has gained minimal recognition despite its advantages. The technique is inexpensive and can be performed using simple conventional guidewires and catheters. SA does not require extensive operator experience and therefore most departments can potentially provide this service. It offers a cheap alternative to reconstructive surgery as it has a high success rate and low complication rate. The technique is applicable mainly to the femoral popliteal segment,\textsuperscript{1-6} but is being used increasingly in tibial and iliac arteries.\textsuperscript{6-9} The atheroma and occluding material are displaced eccentrically following extraluminal angioplasty, creating a new channel that is smooth and disease free. This creates a more favourable situation for laminar flow, reducing the risk of intimal hyperplasia and recurrence of disease.\textsuperscript{10}

CONTRAINDICATIONS AND INDICATIONS
There are a number of specific contraindications and indications to guide the selection of patients considered for SA.\textsuperscript{2,3,10}

Contraindications:
\begin{itemize}
\item Very short lesions (less than 3 cm).
\item Recent occlusions (less than 3 months old).
\item Narrowed vessels with extensive disease (less than 4 mm in diameter).
\end{itemize}
These lesions are generally treated with intraluminal angioplasty but if dissection occurs during an attempted intraluminal approach, then subintimal recanalization is undertaken.

Indications:
\begin{itemize}
\item Long standing occlusion.
\item Hard occlusion.
\item Long occlusion.
\item Diffuse and tandem disease.
\item Failed intraluminal approach.
\item Presence of a large proximal collateral.
\end{itemize}
Occlusion that has been present for a long time is ideally suited to the subintimal approach. Long, hard occlusions and occlusions in diffusely diseased vessels make it more difficult to maintain the intraluminal position of the wire and, therefore, dissection is likely to result. Subintimal angioplasty is attempted when the intraluminal approach fails, because it is unlikely that a subsequent intraluminal attempt will be successful. Large collaterals that develop at the origin of an occlusion, do not offer a suitable entry point for the guidewire, preventing an intraluminal approach. Using the subintimal approach, dissection can be initiated in the main vessel wall, above and opposite to the origin of the collateral.
PREPROCEDURE PREPARATION

Informed consent is obtained from the patient. Blood investigations including renal function tests and clotting profiles are completed. Prophylactic antibiotics are not required but premedication with oral aspirin (300 mg) is usually given the night before the procedure.

TECHNIQUE

The procedure commences with an antegrade puncture of the common femoral artery (Figure 1). With the sub-intimal approach, a very small stump (less than 5 mm) is all that is required.10,11 When there is a reasonable length of the superficial femoral artery (SFA) available proximally, the puncture can be made selectively into the SFA itself. The puncture site should be made so that there is sufficient length of the common femoral artery to be able to manoeuvre the guidewire and catheter in the direction of the SFA.

Once the puncture is successful, a 6-French arterial sheath is introduced (Figure 1). I prefer to use an arterial sheath at the beginning of the procedure because it facilitates both catheter and guidewire exchange, and subsequent angiograms.

The arterial sheath is positioned with the distal end just proximal to the SFA occlusion. If the SFA occlusion is near the origin, the arterial sheath is positioned in the common femoral artery. In cases where there is only a short SFA stump, there may only be 2 to 3 cm of the arterial sheath within the arterial lumen. Puncturing the common femoral artery more superiorly in the groin can be attempted but must not be made beyond the groin where bleeding cannot be controlled by pressure.

When the arterial sheath is in place, a selective angiogram is performed through the arterial sheath, to define the anatomy of the SFA occlusion (Figure 2). The site and length of occlusion can be marked with a radio-opaque tape or ruler, as seen in Figure 2. Oblique views may be required if the SFA stump is projecting over the profunda femoris artery. This assists the operator in cannulation of the SFA stump.

Heparin (70 units/kg) and vasodilators (nitroglycerine 100 mcg) are injected intra-arterially before crossing the lesion. Nitroglycerine is used to assist dilation of the distal vessels, and reduces the possibility of spasm during the procedure.

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Figure 1. Ten cm occlusion of the superficial femoral artery. An antegrade puncture of the common femoral artery is performed and a 6-French arterial sheath introduced with the tip positioned in the superficial femoral artery.

Figure 2. A preprocedure selective angiogram is performed through the arterial sheath. The length and site of occlusion is determined using a radio-opaque ruler.
Various types of guidewire can be used to enter the occlusion. I commonly use a tapered-tip J-Terumo wire (1.5 mm J, 180 cm long, 0.035 inch diameter). A straight, floppy guidewire (3 cm floppy, 180 cm long, 0.035 inch diameter) can also be used. The tip of the wire is directed towards the arterial wall, away from any large collateral. Sometimes this may require the use of a preshaped catheter (Cobra-shape). Supporting the Terumo guidewire (Terumo Corporation, Tokyo, Japan) on a dilating catheter, such as a 5-French Van Andel dilating catheter, can facilitate creation of the subintimal plane. Forward advancement of the guidewire/catheter combination into the occlusion invariably creates a dissection because this is the path of least resistance.

Entry into the subintimal space can be confirmed by injecting a small amount of dilute contrast medium. Once in the subintimal space, the guidewire moves freely, usually encountering little resistance. The angled Terumo guidewire is pushed down the occluded vessel until it forms a large loop configuration (Figure 3). This loop configuration acts like a dissecting device, similar to a surgeon’s ring stripper. The large U-shaped loop in the guidewire serves two functions. The loop helps to dissect along the subintimal plane and also enables re-entry into the true arterial lumen distally. The resistance to forward pressure is suddenly decreased once the true lumen has been entered.

If the U-shaped loop guidewire encounters resistance during advancement, the guidewire is retracted and advanced in a different direction. An alternative is to advance the dilating catheter over the guidewire, with the J-wire protruding from it. This combination gives added support to complete the dissection, but the loop position must be regained as soon as possible.

Sometimes the procedure results in a dissection that needs to be extended further than the end of the occlusion, in order to achieve re-entry. This is usually of no consequence to the patient, unless a major collateral has been compromised without achieving re-entry. In order to avoid this possibility, the major collateral that is feeding the artery beyond the occlusion should be avoided.

The dilating Van Andel catheter is advanced along the guidewire until the distal end reaches the true lumen. Re-entry into the true lumen is critical to the success of the procedure and can be confirmed by injecting contrast through the dilating catheter (Figure 4). A 20% failure of re-entry rate, however, can be expected with this procedure.

Once the lesion has been crossed, the Terumo guidewire is exchanged with an extra-stiff guidewire (Amplatz, Cook, Bloomington, USA). The new lumen is dilated with a 5-French balloon catheter (5 mm/4 cm balloon). The dilation is performed from the distal end of the occlusion to the proximal part, with a short 30 second to 60 second inflation time. During dilation, the patient may experience some pain. This is usually more profound in cases of severe calcification. Residual stenosis of more than 30% is repeatedly balloon dilated with higher pressures and longer periods of dilation (up to 3 mins), until a satisfactory result is achieved (Figure 5).

At the conclusion of the procedure, a further dose of a vasodilator (nitroglycerine 100 mcg) is given. This facilitates peripheral vasodilatation and reduces peripheral resistance, as well as enhancing flow through the recanalized segment. Aspirin, if not contraindicated, is prescribed for patients who have had a successful recanalization (150 mg daily for 3 months). Oral anticoagulants are usually not required.
Figure 4. The dilating catheter is advanced along the guidewire until the distal end reaches the true lumen. Re-entry into the true lumen is confirmed by injecting iodinated contrast.

Figure 5. A postprocedure angiogram is performed through the arterial sheath with the extra-stiff guidewire in place. The typical spiral appearance of the subintimal neo-lumen can be seen.

The technical success rate for this procedure has been reported at 80%, independent of occlusion length. Actuarial haemodynamic patencies for technically successful procedures at 12 and 36 months were 71% and 58% respectively, while symptomatic patencies were 73% and 61%. Factors influencing long term patency included smoking, number of calf run-off vessels, and occlusion length. Smoking appears to be a major risk factor for re-occlusion.

COMPLICATIONS
Complications occur in 3 to 5% of patients. Major complications include retroperitoneal or scrotal haematomas, and limb loss, when important collaterals are compromised. Minor complications reported include groin haematomas, distal emboli, and vessel perforation.

POSTPROCEDURAL CARE
Patients routinely receive oral aspirin (150 mg daily for 3 months) unless contraindicated. Subcutaneous heparin (5000 U 6-hourly for 1 day) may be considered in patients following recanalization of a long femoropopliteal occlusion, or a particularly difficult procedure. Stringent monitoring of pulse and blood pressure is required if there is a high puncture site because the risk of retroperitoneal haemorrhage is increased.

CONCLUSIONS
Percutaneous subintimal angioplasty offers an attractive alternative to reconstructive surgery in femoropopliteal occlusions. The technique has a high success rate, low complication rate, is inexpensive, and does not require extensive operator experience. Peripheral vascular disease of the lower limbs is extremely common in Hong Kong and consequently, major departments should consider this technique as part of their vascular interventional services.

REFERENCES
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