Primary Stenting in Femoropopliteal Occlusive Disease
– What Is the Appropriate Role? –

Wai-ki Yiu, MD, PhD; Michael S. Conte, MD

Endovascular treatment of femoropopliteal occlusive disease is challenging and often limited by its unique anatomic, hemodynamic and biomechanical constraints. Despite technical improvement, percutaneous transluminal angioplasty alone is not adequate to provide satisfactory long-term patency. Several randomized controlled trials have shown that primary nitinol stenting can provide a better short-term radiological patency in intermediate lesion, but the results were often limited by intrinsic stent complications, particularly in-stent restenosis. Solutions to long lesions have been more elusive. To date, many novel technologies have been developed with a goal of improving stent design for this specific environment. Interwoven stents are made to provide a higher radial strength and kink resistance. Covered stents are designed to prevent the ingrowth of intimal hyperplasia, which is the main cause of restenosis in bare metal stent. Drug-eluting stents have shown improved patency in clinical trials. Bioabsorbable stents, combining biological agents and mechanical scaffold, provide temporary vascular support while reducing implant-related vascular inflammation in the long term. New developments in balloon angioplasty, such as drug elution, provide a challenge to stenting in this arena. Although these technologies look promising, a uniform reporting system and large-scale comparative studies with longer follow-up are needed to evaluate their clinical effectiveness in the future. (Circ J 2015; 79: 704–711)

Key Words: Bioabsorbable stent; Drug-eluting stent; Femoropopliteal occlusive disease; Interwoven stent; Primary nitinol stent

Percutaneous transluminal angioplasty (PTA) is often challenged by the intrinsic biomechanic and hemodynamic properties of the superficial femoral artery (SFA). The patency in the SFA was only 65–77% at 1 year to 42–55% at 5 years. Stenting, once used as a bailout option, has evolved from “not indicated” in the TransAtlantic Inter-Society Consensus (TASC) to “preferred choice” in conditions such as stenoses/occlusions up to 10 cm in TASC II. With the intrinsic super-elastic and high radial force properties, the invention of the nitinol stent theoretically imparted greater resistance to the high mechanical forces exerted on these vessels, and has altered endovascular treatment strategies in femoropopliteal disease.

Currently most trials using self-expanding nitinol stents involved claudicant patients with relatively short lesions (<10 cm) and varying study definitions and endpoints. As a result, evidence supporting routine use of bare metal stent (BMS) in the femoropopliteal artery remains inconclusive, particularly in the setting of long occlusions, calcified lesions, and small caliber vessels. In recent years, newly designed nitinol stents, covered stents and drug-eluting stents (DES) have been developed. This article reviews the current evidence regarding these novel techniques for the revascularization of the femoropopliteal artery.

Bare Nitinol Self-Expanding Stents

Among the published studies on the use of BMS in femoropopliteal artery, there are five randomized controlled trials to date: Absolute trial; Femoral Artery Stenting Trial (FAST); Astron trial; Randomized Study Comparing the Edwards Self-Expanding Lifesent versus Angioplasty Alone In LEsions INvolving The SFA and/or Proximal Popliteal Artery (RESILIENT) trial; and the SUPER trial (Table). In the Absolute trial, the investigators randomized 104 patients with femoropopliteal artery disease (>80% Rutherford-Becker class 3) to 6-mm-diameter Dynalink/Absolute stent (Abbott Vascular, Redwood city, CA, USA; n=51) or PTA with bailout stenting (n=53). The mean lesion length was 101±75 mm in the stent group and 92±64 mm in the PTA group. Occlusion was found in one-third of patients. Predilation of vessel was performed only when the lesions were too tight to pass the deployment device. Restenosis, defined as >50% stenosis on duplex ultrasound, was 37% in the stent group and 63% in the PTA group at 1 year (P=0.01). This advantage was maintained for up to 2 years, when the restenosis rate was 45.7% in the stent group and 69.2% in the PTA group. The walking distance and ankle-brachial index (ABI) also remained improved in the stent group. Stent fracture was...
Interwoven Nitinol Stent

Despite technology evolution, stent compression and fracture are still major complications after stent placement. Scheinert et al reported an overall 37.2% stent fracture rate that increased with the stented length and had led to in-stent restenosis (ISR) and re-occlusion in two-thirds of cases. Davaine et al reported a 17.8% stent fracture rate and the fracture was positively associated with the distal placement and the diameter of the stent, indicating that the ability to withstand bending stress and flexibility in the axial direction are crucial in stent design. With the same stent but shorter stented length, the fracture rate was only 3.1% at 1 year and 4.1% at 3 years in the RESILIENT trial.

The invention of an interwoven nitinol stent (Supera; Abbott Laboratories, Abbott Park, IL, USA) may solve the stent fracture problem. It is made of six closed-end interwoven nitinol wires to improve the kink resistance and provide a very high radial strength. In contrast to conventional stent placement, predilation of the vessel by a balloon catheter of the same diameter as the reference vessel and 1:1 matching of the stent diameter with the reference vessel diameter are needed to reduce the outward force onto the vessel wall and hence minimize the possibility of neointimal formation. To date, there has been no stent fracture reported. Scheinert et al reported 2-year single center results in 107 patients with predominately SFA occlusive disease and a mean stented segment of 111±50 mm. The primary patency rate was 84.7% at 1 year and 76.1% at 2 years. Mean ABI increased from 0.68 to 0.87 and the mean Rutherford-Becker class decreased from 3.3 to 2.0. Chan et al reported another single-arm study in which the primary patency rate was 78.6% at 1 year in 78 patients with femoropopliteal artery disease. Mean ABI increased from 0.58 to 0.87. Unlike other studies in which the majority of patients presented with Rutherford class 3 or above, 15% of patients in that study had mild-moderate claudication only. In a study of 80 patients with mean lesion length 143±98 mm, George et al noted clinically driven target lesion revascularization of 85% at 1 year, and mean ABI increased from 0.60 to 0.83 after stenting. Supera stents have also shown acceptably good results when placed in popliteal artery, although data are limited. León et al reported a primary patency rate on duplex scan of 79.2% at 1 year in 34 patients with solely popliteal artery occlusive disease. Six of 39 stents were occluded but none led to limb ischemia. In the Leipzig Supera Popliteal Artery Stent Registry, Scheinert et al reported a 1-year patency rate of 87.7%, and the mean ABI increased from 0.58 at baseline to 0.97 in 101 patients. Four patients had in-stent occlusion, of whom one died of the complication of acute limb ischemia.

Currently all the studies related to Supera stent are short term, non-randomized and single centered (Table). There are several ongoing clinical studies worldwide, such as the STRONG (Supera Treatment Registry Observing Neointimal Growth) registry, which evaluates long-term outcome of Supera stent in femoropopliteal disease. The Popliteal Artery Trial of Patients Undergoing Treatment With Balloon Angioplasty vs. the Adaptive SUPERA VERITAS Peripheral Stent System (PARADIGM) trial compares the outcomes of balloon angioplasty and Supera stent in patients with atherosclerotic popliteal artery. The RAndomized trial of Legflow Paclitaxel Eluting Balloon (LPEB) with stent placement vs. standard PTA with stent placement for the treatment of intermediate (>5 cm and ≤15 cm) and long (>15 cm) lesions of the SFA (RAPID) trial is a multicenter randomized controlled trial comparing paclitaxel-coated balloon with Supera stenting or uncoated
polytetrafluoroethylene, aims to reduce ISR and distal embolization by preventing the ingrowth of neointimal tissue into the stent and covering the ulcerated segments of vessels. Since the introduction of Hemobahn® (W.L. Gore & Associates, AZ, USA) in Europe in 1996, followed by the Food and Drug Administration (FDA) approval of the use of Viabahn® for balloon with Supera stenting in patients with atherosclerotic SFA disease.22

### Covered Stents

Covered stents, combining a self-expanding stent with expanded polytetrafluoroethylene, aims to reduce ISR and distal embolization by preventing the ingrowth of neointimal tissue into the stent and covering the ulcerated segments of vessels. Since the introduction of Hemobahn® (W.L. Gore & Associates, AZ, USA) in Europe in 1996, followed by the Food and Drug Administration (FDA) approval of the use of Viabahn® for...

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<th>Reference</th>
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<th>Occlusion (%)</th>
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<td>Absolute</td>
<td>Dynalink vs. PTA</td>
<td>51/53</td>
<td>Stent: 88%/12%, Control: 87%/13%</td>
<td>Stent: 37%, Control: 32%</td>
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<td>FAST</td>
<td>Bard Luminexx 3 vs. PTA</td>
<td>123/121</td>
<td>Stent: 97.5%/2.5%, Control: 96.5%/3.5%</td>
<td>Stent: 36.6%, Control: 24.8%</td>
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<td>ASTRON</td>
<td>Astron vs. PTA</td>
<td>34/39</td>
<td>Stent: 91%/9%, Control: 87%/3%</td>
<td>Stent: 38%, Control: 39%</td>
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<td>RESILIENT</td>
<td>Lifestent vs. PTA</td>
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<td>Stent: 100%/0, Control: 100%/0</td>
<td>Stent: 17%, Control: 18.5%</td>
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<td>SUPER</td>
<td>SMART vs. PTA</td>
<td>74/76</td>
<td>Stent: 85.1%/14.9%, Control: 78.9%/21.1%</td>
<td>Stent: 95.9%, Control: 90.8%</td>
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### Interwoven Stent

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<th>Trials</th>
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<tr>
<td>15</td>
<td>Scheinert et al</td>
<td>Supera</td>
<td>107</td>
<td>Stent: 93.1%/16.8%, Control: 82%/19%</td>
<td>30.8%</td>
</tr>
<tr>
<td>16</td>
<td>Chan et al</td>
<td>Supera</td>
<td>78</td>
<td>58%/42%</td>
<td>29.3%</td>
</tr>
<tr>
<td>17</td>
<td>SAKE</td>
<td>Supera</td>
<td>80</td>
<td>68%/31%</td>
<td>39%</td>
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### Covered Stent

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<th>Trials</th>
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<th>No. patients (Device/Control)</th>
<th>Rutherford Classification (≤3/≥4)</th>
<th>Occlusion (%)</th>
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<td>VIBRANT</td>
<td>Viabahn endoprosthesis vs. bare metal stent</td>
<td>Viabahn: 72, Control: 76</td>
<td>Viabahn: 2.7, Control: 2.8</td>
<td>Viabahn: 61.1%, Control: 56.6%</td>
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<tr>
<td>26</td>
<td>McQuade et al</td>
<td>Viabahn endoprosthesis vs. surgical bypass</td>
<td>Viabahn: 40, Control: 46</td>
<td>Viabahn: 41%/9%, Control: 31/19%</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>VIASTAR</td>
<td>Viabahn with PROPATEN bioactive surface vs. nitinol stent</td>
<td>Viabahn: 72, Control: 69</td>
<td>86%/14%</td>
<td>Viabahn: 79%, Control: 70%</td>
</tr>
<tr>
<td>28</td>
<td>VIPER</td>
<td>Viabahn endoprosthesis with heparin bioactive surface</td>
<td>113</td>
<td>88%/12%</td>
<td>56%</td>
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</table>

### Drug-eluting Stent

<table>
<thead>
<tr>
<th>Reference</th>
<th>Trials</th>
<th>Devices</th>
<th>No. patients (Device/Control)</th>
<th>Rutherford Classification (≤3/≥4)</th>
<th>Occlusion (%)</th>
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<tr>
<td>29</td>
<td>SIROCCO</td>
<td>SMART with Sirolimus vs. BMS</td>
<td>47/46</td>
<td>Stent: 43%/57%, Control: 57%/43%</td>
<td>Stent: 69%, Control: 57%</td>
</tr>
<tr>
<td>32</td>
<td>Zilver PTX</td>
<td>Zilver PTX vs. PTA</td>
<td>238/241</td>
<td>Stent: 90.2%/8.9%, Control: 90.7%/8.5%</td>
<td>Stent: 29.6%, Control: 24.7%</td>
</tr>
<tr>
<td>35</td>
<td>STRIDES</td>
<td>Dynalink and everolimus</td>
<td>104</td>
<td>83%/17.4%</td>
<td>45%</td>
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</table>

### Bioabsorbable stent

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<thead>
<tr>
<th>Reference</th>
<th>Trials</th>
<th>Devices</th>
<th>No. patients (Device/Control)</th>
<th>Rutherford Classification (≤3/≥4)</th>
<th>Occlusion (%)</th>
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</thead>
<tbody>
<tr>
<td>43</td>
<td>GAIA</td>
<td>Igaki-Tamai stent</td>
<td>30</td>
<td>NA</td>
<td>10%</td>
</tr>
</tbody>
</table>

1Rutherford classification ≤2/≥3; 2restenosis at 24 months; 3mean Rutherford category; 4mean stenosis at the narrowest site. NA, not available; PTA, percutaneous transluminal angioplasty; TASC, TransAtlantic Inter-Society Consensus.

(Table continued the next page.)
symptomatic femoral occlusive disease in 2005, several improvements in the stent design have been made. Contoured proximal edge, heparin bioactive surface and the introduction of 5-mm-diameter stent graft all aim to reduce the risk of edge stenosis and stent thrombosis. In one of the early single-arm single-center studies, the primary patency rate, as determined on ultrasound, was 76% at 1 year and 55% at 4 years. The edge restenosis was 13.6% and the Rutherford-Becker classification improved from 3.4 to 0.68. There was no significant difference between the types of lesion and length of lesion. Primary patency rate, however, was increased to 83% if 5-mm-diameter stent graft was excluded. The authors therefore suggested that the Viabahn was not suitable in situations where the landing zone was smaller than 4.5 mm in diameter.

<table>
<thead>
<tr>
<th>Reference</th>
<th>TASC II classification</th>
<th>Lesion length (mm)</th>
<th>Stent fracture (%)</th>
<th>Primary endpoint</th>
<th>Results (Device/Control)</th>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>NA</td>
<td>Stent: 101.0±75.0, Control: 92.0±64.0</td>
<td>2</td>
<td>6-month binary restenosis</td>
<td>Stent: 24%, Control: 43% (P=0.05)</td>
</tr>
<tr>
<td>7</td>
<td>NA</td>
<td>Stent: 45.2±27.9, Control: 44.5±28</td>
<td>12</td>
<td>12-month binary stenosis</td>
<td>Stent: 31.7%, Control: 38.6% (P=0.377)</td>
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<tr>
<td>8</td>
<td>NA</td>
<td>Stent: 82.0, Control: 65.0</td>
<td>NA</td>
<td>6-month binary restenosis</td>
<td>Stent: 21.9%, Control: 55.6% (P=0.005)</td>
</tr>
<tr>
<td>9</td>
<td>NA</td>
<td>Stent: 70.5±44.3, Control: 64.4±40.7</td>
<td>3.1</td>
<td>12-month target lesion revascularization</td>
<td>Stent: 87.3%, Control: 45.1% (P=0.0001)</td>
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<tr>
<td>11</td>
<td>NA</td>
<td>Stent: 123.0±54.3, Control: 116.8±52.2</td>
<td>NA</td>
<td>12-month binary stenosis</td>
<td>Stent: 47.2%, Control: 43.5% (P=0.84)</td>
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</tbody>
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Interwoven stent

<table>
<thead>
<tr>
<th>Reference</th>
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<th>Lesion length (mm)</th>
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</tr>
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<tbody>
<tr>
<td>15</td>
<td>NA</td>
<td>90.2</td>
<td>0</td>
<td>stent patency</td>
<td>6 months: 93.1%</td>
</tr>
<tr>
<td>16</td>
<td>A=27%, B=49%, C=23%</td>
<td>126</td>
<td>0</td>
<td>6-month &amp; 12-month primary patency</td>
<td>6 months: 83.5%, 12 months: 76.6%</td>
</tr>
<tr>
<td>17</td>
<td>NA</td>
<td>143</td>
<td>0</td>
<td>primary patency</td>
<td>6 months: 96.9%, 12 months: 85.8%</td>
</tr>
</tbody>
</table>

Covered stent

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<thead>
<tr>
<th>Reference</th>
<th>TASC II classification</th>
<th>Lesion length (mm)</th>
<th>Stent fracture (%)</th>
<th>Primary endpoint</th>
<th>Results (Device/Control)</th>
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</thead>
<tbody>
<tr>
<td>23</td>
<td>NA</td>
<td>Viabahn: 180, Control: 180</td>
<td>Viabahn: 2.6%, Control: 50%</td>
<td>3-year primary patency</td>
<td>Viabahn: 24.2%, Control: 25.9% (P=0.392)</td>
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<tr>
<td>25</td>
<td>NA</td>
<td>Viabahn: 70±40, Control: 70±40</td>
<td>NA</td>
<td>1-year primary patency</td>
<td>Viabahn: 65%, Control: 40% (P=0.0003)</td>
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<td>26</td>
<td>A=16% (stent); 20% (bypass), B=54% (stent); 58% (control), C=10% (stent); 12% (control), D=20% (stent); 10% (control)</td>
<td>Viabahn: 256</td>
<td>NA</td>
<td>12-month primary patency</td>
<td>Viabahn: 72%, Control: 76% (P=0.807)</td>
</tr>
<tr>
<td>27</td>
<td>A=0% (stent and control), B=26% (stent); 42% (control), C=57% (stent); 52% (control), D=47% (stent); 32% (control)</td>
<td>Viabahn: 189.8±63, Control: 173.2±66</td>
<td>NA</td>
<td>12-month primary patency</td>
<td>Viabahn: 70.9%, Control: 55.1% (P=0.11)</td>
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<tr>
<td>28</td>
<td>A=14%, B=25%, C=29%, D=31%</td>
<td>190</td>
<td>NA</td>
<td>12-month primary patency</td>
<td>73%</td>
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Drug-eluting stent

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<th>Stent fracture (%)</th>
<th>Primary endpoint</th>
<th>Results (Device/Control)</th>
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<tr>
<td>29</td>
<td>NA</td>
<td>Stent: 85.0±44, Control: 81.0±52.0</td>
<td>Device: 36.0%, Control: 20.0%</td>
<td>In-stent stenosis</td>
<td>Stent: 22.9%, Control: 21.1% (P=0.05)</td>
</tr>
<tr>
<td>32</td>
<td>NA</td>
<td>Stent: 66.4±38.9, Control: 63.1±40.7</td>
<td>0.9</td>
<td>12-month primary patency</td>
<td>Stent: 83.1%, Control: 32.8% (P&lt;0.001)</td>
</tr>
<tr>
<td>35</td>
<td>A=42%, B=45%, C=13%, D=0%</td>
<td>90±43</td>
<td>0</td>
<td>6-month in-stent binary restenosis</td>
<td>14%</td>
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Bioabsorbable stent

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<tr>
<th>Reference</th>
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<tr>
<td>43</td>
<td>NA</td>
<td>59±36</td>
<td>NA</td>
<td>1-, 6-, 9-, 12-month primary patency</td>
<td>1-month: 6.9%, 6-month: 39.3%, 9-month: 60.7%, 12-month: 67.9%</td>
</tr>
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</table>
The results subsequently led to the FDA approval for use of Viabahn endoprostheses in the USA. That study involved 197 patients (PTA alone, n=100; PTA followed by stenting, n=97) with mean lesion length 7.4 cm. The 1-year primary patency rate on duplex scan was 65% in the stent graft group compared with 40% in the PTA group (P=0.0003). The patency rate of the stent-graft was independent of the lesion length, which remained at 68–56% when the lesion length increased from <3 cm to >12 cm, while the patency rate for PTA dropped from 66% to 17%. The clinical success rate was also higher in the stent graft group (84% vs. 69%, P=0.025). Although that study was terminated in 2000, the data did show the potential benefit of the use of Viabahn in long segment lesion.

To compare the efficacy of the Viabahn endoprostheses with open surgical bypass, McQuade et al showed that the primary and the secondary patency rates for the stent graft group were not significantly different to those of the open surgical bypass group (primary patency rate: 72% at 1 year and 59% at 4 years in stent graft group vs. 76% at 1 year and 58% at 4 years in the bypass group, P=0.807) in 86 patients with a mean lesion length of 25.6 cm. Only 63% of patients in the bypass group, however, were compliant with the recommended antiplatelet regimen.²⁶

The Viabahn Versus Bare Nitinol Stent in the Treatment of Long Lesion (≥8 cm) Superficial Femoral Artery Occlusive Disease (VIABAHN) trial was the first multicenter trial to show similar primary and secondary patency rates for covered stent and bare nitinol stents (24.2% vs. 25.9%, P=0.392; 89.3% vs. 79.5%, P=0.304) in a group of 148 patients with mean lesion length 18±8 cm.²³ The overall patency rate, however, was much lower than prior reports and the stent fracture rate of bare nitinol stent was particularly high (50% vs. 2.6%). The somewhat disappointing equivalency of the patency rates in both groups may imply hidden reasons for the results.

With the improvement of the stent graft design, the Viabahn Endoprostheses With PROPATEN Bioactive Surface (VIA) versus Bare Nitinol Stent in the Treatment of Long Lesions in Superficial Femoral Artery Occlusive Disease (VIASTAR) trial compared heparin-bonded covered stents with BMS in 141 patients with femoropopliteal occlusive disease (Viabahn group, n=72; BMS group, n=69). The mean lesion length was 19±6.3 cm in the VIA group vs. 17.3±6.6 cm in the BMS group. In per-protocol analysis, the 2-year primary patency rate was significantly higher in the VIA group compared with the BMS (78.1% vs. 53.5%, P=0.009). The difference was even higher in patients with lesion length >20 cm (73.3% vs. 33.3%, P=0.004). The primary patency rate, however, was not statistically significant when analyzed on intention-to-treat protocol. Also, the benefit of the patency rate difference was not reflected on the clinically driven target lesion revascularization. Occlusion occurred in 6 patients in the VIA group, of whom 1 patient had acute limb ischemia.²⁷

The potential benefit of heparin-bonded Viabahn covered stents was also supported by the Viabahn Endoprostheses with Heparin Bioactive Surface in the Treatment of Superficial Femoral Artery Obstructive Disease (VIPER) trial. That study evaluated the efficacy of heparin-bonded covered stent graft in 113 patients with mean lesion length 19 cm and TASC D lesions in one-third of lesions. The 1-year primary and secondary patency rates were 73% and 92%, respectively. The primary patency rate was not affected by the lesion length and device diameter but by the oversized stent graft at the proximal landing zone.²⁸

Overall, the efficacy of covered stent is at least similar to that of the conventional endovascular technique (Table). The risk of acute limb ischemia appears higher than with BMS but may be reduced by appropriate patient selection, minimizing collateral coverage, and anti-thrombotic medications. It remains unclear if the potential advantages of covered stents outweigh the risks for patients with long segment disease, where it competes primarily with open bypass surgery.

**Drug Elution**

Drug-eluting stents were first developed for coronary artery disease, in order to deliver anti-proliferative drugs to the vessel wall, and reduce restenosis. The first human study for femoropopliteal occlusive disease was published in the Sirolimus Coated Cordis SMART Nitinol Self-expandable Stent for the treatment of Obstructive Superficial Femoral Artery Disease (SIROCCO) trial by Duda et al in 2002. This double-blind, randomized controlled trial randomized 36 patients with mean lesion length 85±57 mm to either a polymer-based sirolimus-eluting self-expanding nitinol SMART stent (n=18) or a bare metal SMART stent (n=18). The sirolimus was combined with elastic copolymer in a 30:70 drug-copolymer weight ratio and coated onto the stent at 5 μm thickness. The amount of drug used was 90 μg/cm² with a total of 1.2 mg of sirolimus given per stent. The binary restenosis on angiography in the DES group was lower (22.6%) compared with the BMS (30.9%), but no significant difference was observed due to the high fracture stent rate (27%) and the low sample size.²⁹ In the 24-month follow-up study for all 93 patients in the SIROCCO I and SIROCCO II trials, no significant reduction in stenosis was achieved in the DES group. The ISR rate on duplex scan was similar in both the DES and BMS groups (DES vs. BMS: 4.8% vs. 4.5% at 6 months; 22.9% vs. 21.1% at 24 months, P>0.05).³⁰

Currently, a paclitaxel-eluting stent (Zilver PTX, Cook Medical, Bloomington, IN, USA) is the only FDA-approved DES for femoral occlusive disease in the USA. Paclitaxel is a lipophilic and highly protein-bound agent with good penetra-
Primary Stenting in Femoropopliteal Occlusive Disease

In a prospective multicenter global registry, a total of 479 patients were randomized either to PTA (n=238) or paclitaxel-eluting stent groups (n=236). The majority of patients belonged to Rutherford class 2 and class 3 with mean lesion length 53.2±40.3 mm in the PTA group and 54.3±40.8 mm in the DES group. The 12-month primary patency rate on ultrasound was 32.8% in the PTA group vs. 83.1% in the stent group (P<0.001; Figure 2). This patency advantage, however, was not reflected in the walking score or ABI. The stent fracture rate of 0.9% was exceptionally low compared with most of the studies published. That study differed from the SIROCCO study in several ways. First, paclitaxel was loaded without combination of polymer at a dose density of 3 μg/mm² for a maximum of 880 μg on the largest stent. Second, the control arm was PTA alone whereas uncoated BMS was used in the SIROCCO study. Third, the lesion treated was relatively shorter than those in the SIROCCO study, which may not reflect the clinical reality. Last, this is the largest prospective randomized trial demonstrating biological effects of anti-proliferative agent in femoropopliteal occlusive disease to date. Recent data suggest that these improvements in patency may be maintained in the longer term (paclitaxel stent vs. PTA: 68.7% vs. 22.8% at 3 years, P<0.01). A randomized controlled trial comparing self-expanding BMS (Misago RX, Terumo, Tokyo, Japan) and paclitaxel-eluting stent is currently underway. The trial is expected to be finished in another 2 years.

The Superficial Femoral Artery Treatment with Drug-Eluting Stents (STRIDES) trial was the first clinical trial involving 104 patients with nitinol self-expanding everolimus-eluting stents for peripheral arterial disease. The drug-delivery system included the Dynalink nitinol self-expanding stent (Abbott Laboratories, Abbott Park, IL, USA), everolimus as anti-proliferative drug and an ethylene vinyl acetate copolymer. This Dynalink-E stent has a much higher total drug load of 225 μg/cm² stent surface area and a longer elution profile with approximately 80% of drug being slowly released over the first 90 days. The majority (87%) of patients had TASC A and B lesions. The mean lesion length was 9.0±4.3 cm. The primary patency rate was 94±2.3% at 6 months and 68±4.6% at 12 months. No stent fracture was detected after 12 months. Despite the different study population, this result seemed to differ little from the historical results with bare metal Dynalink/Absolute stent alone (Table). Another study comparing bypass surgery and Zilver PTX for femoropopliteal TASC C and D lesions is currently underway and the result is pending.

Despite the ongoing improvement in DES design, its role may be challenged by the introduction of drug-eluting balloons (DEB). Understanding that ISR is more difficult to treat and the vascular architecture may be permanently changed by the implantation of stent, DEB can provide a homogenous drug delivery without foreign body reaction. The Lutonix Paclitaxel-Coated Balloon for the Prevention of Femoropopliteal Restenosis (LEVANT) I study showed that the late lumen loss was 58% lower for the DEB group than the standard balloon group at 6 months (P=0.016), same as the target lesion revascularization. The LEVANT II study also showed a better primary patency in the DEB group at 12 months when defined as freedom from both restenosis and target lesion revascularization (65.2% vs. 52.6%, P=0.015). The primary safety end-point rate, defined as freedom from perioperative death and 12-month index limb amputation, index limb re-intervention and index limb-related death, was not inferior to the control angioplasty (83.9% vs. 79%, P=0.005). These studies led to the first FDA-approved DEB catheter for femoropopliteal occlusive disease. Recent data suggest that these improvements in patency may be maintained in the longer term (paclitaxel stent vs. PTA: 68.7% vs. 22.8% at 3 years, P<0.01).

A randomized controlled trial comparing self-expanding BMS (Misago RX, Terumo, Tokyo, Japan) and paclitaxel-eluting stent is currently underway. The trial is expected to be finished in another 2 years.

Similar binary restenosis rates and clinically driven target lesion revascularization between DEB (IN.PACT Adramal and IN.PACT Pacific, Metronic Vascular, Roncadelle, Italy) and DES (Zilver PTX, Cook Medical) was also demonstrated by Zeller et al, in that both performed similarly in long femoro-
popliteal lesions. Despite limited data, it appears that DEB offer a new potential treatment option in femoropopliteal occlusive disease. Most studies published, however, have provided only 6–12-month results in selected patients. Unpredictable drug absorption into vessel walls, potential systemic toxicity and the lack of immediate prevention of elastic recoil may be the drawback of DEB as compared with DES.

Bioabsorbable Stents

Bioabsorbable stents offer the attractive potential of temporary scaffolding to improve the success of PTA and drug delivery, while avoiding a permanent implant and its attendant sequelae. With the success of non-drug eluting Igaki-Tamai Stent (Kyoto Medical Planning, Kyoto, Japan) in coronary artery, there are currently two lengths available for use in SFA: 36 and 78 mm in a 7-Fr delivery system. The initial experience in the Belgian REMEDY registry showed that the 6-month primary patency and target lesion revascularization were 70.2% and 17.9%, respectively, in a group of 100 patients with TASC HA and B lesions and mean lesion length 35 mm. The Evaluation of the Biodegradable Peripheral Igaki-Tamai Stent in the Treatment of De Novo Lesions in the Superficial Femoral Artery (GAIA) study was a prospective multicenter non-randomized trial on symptomatic de novo SFA lesions with a mean length 5.9 cm. It found that the binary restenosis rate was 39.3% and 67.9% at 6 and 12 months, respectively. The target vessel revascularization rates were 25% at 6 months and 57.1% at 12 months. Despite the relatively high re-intervention rate, most patients had improvement in functional outcome. The preliminary PERSEUS trial also reported similar results; the angiographic-based restenosis was 30% at 6 months and the primary assisted patency rate was 91% at 9 months in 45 patients with de novo SFA lesion <6 cm.

The Stanza stent is another bioabsorbable self-expanding stent being developed for SFA. It is composed of polylactic-co-glycolic-acid fibers with an elastomer, which enables the scaffold to maintain adequate radial strength while providing flexibility in vessels. The preliminary result of the STANCE trial, a prospective, single-arm, multicenter trial targeting patients with symptomatic SFA with lesions up to 100 mm, was first presented in the Charing Cross meeting in 2012 and showed a 100% technical success rate.

Drug-eluting bioabsorbable vascular scaffold is currently being evaluated in the ESPRIT I trial. As reported in the Vascular Interventional Advances Conference 2013, there was no restenosis at 6 months in a group of 34 patients with mean lesion length 35.5 mm.

Conclusions

Advancement of endovascular intervention from simple PTA through modern stent and balloon designs has allowed for better lesion-crossing capabilities, yet clinical outcomes have lagged well behind technical success. While the role of BMS seems promising in intermediate lesions, the presence of calcified occlusive vessels, particularly in areas with high mechanical stress, remains a major obstacle in clinical practice. DES appears promising but more data are needed on their efficacy vis-à-vis newer bare metal devices, and cost is a consideration. Currently, the outcomes of interwoven nitinol stents appear promising in single-arm studies. The results of covered stents in longer lesions seem favorable, but there are concerns about the impact of failure, particularly in claudicant patients. The innovative drug-eluting platform of the bioabsorbable stents is still in an early phase of development. The questions of whether this technology can eliminate future ISR and what length of stent is needed to support the vessels before it is resorbed, remain to be answered. DEB are now available and may lead to a new paradigm in the endovascular treatment of femoropopliteal disease. The overall trend for the future seems to favor moving away from long-term implants. Uniform reporting systems and adequate large-scale randomized controlled trials with long-term outcomes are needed to provide evidence to vascular specialists on the optimum selection of revascularization strategies for femoropopliteal occlusive disease.

Disclosures

Conflict of Interest: None.

References

16. Chan YC, Cheng SW, Ting AC, Cheung GC. Primary stenting of femoropopliteal atherosclerotic lesions using new helical interwoven


30. 제안된 주제는 femoropopliteal occlusive disease입니다. 이 질환은 대퇴 동맥과胭血管의 혈류가 가려지는 질환이며, 이를 치료하기 위해 다양한 방법들이 사용되고 있습니다. 이 연구는 최근의 연구 결과를 기반으로, 다양한 치료법들의 성과를 비교하고자 합니다. 이는 특히, bioabsorbable stent 및 paclitaxel-eluting stent 등의 새로운 치료법들이 대퇴동맥 질환에 대한 효과를 평가하는 데 사용될 수 있습니다.


