Crossing Chronic Total Occlusions

Guiding Principles, Tools and Techniques
CTOs are Prevalent and Frequently Difficult to Cross

- 40% of patients treated for PAD have CTOs\(^1\)
- Nearly 40% of CTOs require adjunctive technology for crossing\(^2\)
- Complications:
  - perforation
  - dissection
  - embolization
  - increased procedure time, radiation and contrast exposure
- Most common reason for open surgical bypass

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Factors Influencing Success

• Lower procedural success associated with:
  ▪ longer occlusions
  ▪ flush ostial occlusions
  ▪ bridging collaterals (esp. near proximal cap)
  ▪ excessive calcification
  ▪ older true “chronic” occlusions

Endovascular Strategies for CTO Crossing Technique
Guidewire Recanalization of CTOs
Assessing the Morphology of the Proximal Segment
CTO Access: Options for Crossing

- Antegrade Approach
- Retrograde Approach
Recanalization of CTOs

3 Phases of Recanalization

• Penetrating proximal occlusion
• Negotiating length of occlusion
• Distal re-entry
Guidewire Recanalization of SFA-Popliteal CTOs
Guidewire Recanalization of SFA-Popliteal CTOs

Starting the process

4 F Support catheter
Guidewire Recanalization of SFA-Popliteal CTOs
Guidewire Recanalization of SFA-Popliteal CTOs

- Completing the process
- End hole injection through support catheter
Proximal and distal caps are usually the most difficult segments to penetrate

- Often require different wires for each segment:
  - CTO wires to penetrate proximal cap and re-enter distal vessel (.014, .018, .035”)
  - Hydrophilic wires in mid-segment (less likely to perforate)
- Occasionally, even CTO wires cannot penetrate caps (esp. proximal)
How do we fail to cross?

Tip fails to enter lesion – Wire tip buckles against lesion

Tip enters the lesion but the wire fails to follow - Wire body curves and buckles

Wire crosses but device fails to cross

Wire enters subintimal space but fails to re-enter true lumen
Tip fails to enter lesion – Wire tip buckles against lesion

**Increase Tip Load**
Heavy tip loads may permit the wire to penetrate further into the lesion

<table>
<thead>
<tr>
<th>Wire</th>
<th>0.014” Tip Load</th>
<th>0.018” Tip Load</th>
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</thead>
<tbody>
<tr>
<td>Journey</td>
<td>1.3g</td>
<td>Pt+ ST</td>
</tr>
<tr>
<td>V-14 LT</td>
<td>3g</td>
<td>4.4g</td>
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<tr>
<td>V-14 ST</td>
<td>6g</td>
<td>V-18 LT</td>
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<tr>
<td>Pt+</td>
<td>7.1g</td>
<td>6.7g</td>
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<tr>
<td>Victory</td>
<td>12g</td>
<td>V-18 ST</td>
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<td></td>
<td>18g</td>
<td>Victory</td>
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<td>25g</td>
<td>12g</td>
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<td>30g</td>
<td>18g</td>
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**Use a Crossing Device**
Mechanically break through the lesion

**Use a Support Catheter**
Provide back up support to the wire tip, focusing the force on the lesion
Tip enters the lesion but the wire fails to follow - Wire body curves and buckles

**Increase Rail Support**
Increased rail support will transmit more push force along the wire

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**Use a Lower-Profile Wire**
Moving from 0.018” to 0.014” may reduce the friction and allow the wire to pass

**Use a Support Catheter**
To provide backup support to the wire body, increasing the push on the wire
Wire crosses but device fails to cross

Increase Rail Support
Increased rail support will transmit more push force along the wire

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Use a lower profile device
Moving to a lower profile device may allow the device to cross

Use a Support Catheter
To provide backup support to the wire body, increasing the push on the wire
Wire enters subintimal space but fails to re-enter true lumen

**Use a Re-entry Device**
To provide direction and to puncture back into the true lumen allowing a wire to re-enter

**Change Support to the Wire Tip**
A change in catheter shape may provide backup support

**Try Different Wire Types**
Smaller wires, stiffer tips, different torque control
Endovascular Strategies for CTO Crossing

Guidewires & Support Catheters
Commonly-Used Guidewires

• Standard Hydrophilic Wires
  – 0.014 PT Graphix™ (Boston Scientific)
  – 0.014 Pilot 150™ (Abbott)
  – 0.014 V-14™ (Boston Scientific)
  – 0.018 V-18™ (Boston Scientific)
  – 0.035 Terumo Glide wire™ (Terumo)
  – 0.014 Journey™ (Boston Scientific)

• 0.014” CTO- Guidewires
  – Miracle™ (Asahi, Abbott)
  – Confienza™ (Asahi, Abbott)
Commonly-Used Support Catheters

- 0.014”, 0.018”, 0.035”
  - Rubicon™ (Boston Scientific)
  - Quick-Cross® (Spectranetics)
  - Seeker® (Bard)
  - Minnie® (Vascular Solutions)
  - Trailblazer™ (Covidien)
- CXI® (Cook) - 0.018”, 0.035”
- NaviCross™ (Terumo) – 0.035”
Endovascular Strategies for CTO Crossing

Intraluminal Crossing
Intraluminal Crossing

• Device uses axial force to advance through a fibro-calcific CTO
• Designed to track the guidewire through the true lumen
Intraluminal CTO Crossing Devices

TruePath™ CTO Device (Boston Scientific)

Frontrunner® CTO Catheter (Cordis)

Enteer™ CTO Catheter (Covidien)

Crosser™ CTO Catheter (Bard)

Wildcat Catheter (Avinger)
Intraluminal Crossing: Relative Device Sizes
Endovascular Strategies for CTO Crossing

Subintimal Crossing and Re-entry
Wire enters subintimal space but fails to re-enter true lumen

Use a Re-entry Device
To provide direction and to puncture back into the true lumen allowing a wire to re-enter

Change Support to the Wire Tip
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Try Different Wire Types
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Subintimal Crossing

• Traverse the occluded region by creating a new channel between the intimal and medial layers of vessel wall
• Re-entry into the true lumen occurs distal to the occluded region
• Also known as PIER (percutaneous intentional extraluminal recanalization)
Subintimal Crossing

Advantages

• Isolate the occluding atheromatous lesion
• Create a smooth neo-lumen
• Reduced crossing time

Disadvantages

• 10%-20% failure rate due to failure to re-enter the distal true lumen\(^1\) (especially in small BTK vessels)
• May be associated with propagation of subintimal dissection or vessel perforation due to manipulation of the guidewire

Subintimal Crossing

Lesions typically NOT suited for subintimal crossing:

- heavily calcified lesions
- small caliber vessels
- lesions with diffuse disease in the distal target (difficult re-entry)
Re-entry Devices to Enter True Lumen

Outback® LTD® Re-entry Catheter (Cordis)

OffRoad™ Re-entry Catheter System (Boston Scientific)

Pioneer Catheter (Medtronic)

Outback LTD is a registered name of Cordis. OffRoad is a trademark of Boston Scientific. OffRoad™ is an investigational device and not available for sale in the US.
OffRoad™ Re-entry Catheter System Components

- Positioning Balloon Catheter
  - over-the-wire
  - tipless shape and flexible neck for natural movement into the true lumen
- Microcatheter Lancet
  - single-lumen hypotube catheter with a lancet tip
  - advanced coaxially in the inner lumen of the Positioning Balloon Catheter
OffRoad™ Re-Entry Catheter System

<table>
<thead>
<tr>
<th>OffRoad™ System Components</th>
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<tbody>
<tr>
<td>Nominal balloon diameter</td>
<td>5.4 mm</td>
</tr>
<tr>
<td>Nominal inflation pressure</td>
<td>2 atm</td>
</tr>
<tr>
<td>Radiopaque marker</td>
<td>Within balloon body</td>
</tr>
<tr>
<td>Guide sheath diameter</td>
<td>6F</td>
</tr>
<tr>
<td>Recommended guidewire</td>
<td>≤0.035 in (balloon)</td>
</tr>
<tr>
<td></td>
<td>≤0.014 in (lancet)</td>
</tr>
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Guidewire Recanalization of CTOs

Lesion Complexity vs Predicted Success

- Long occlusion (entire SFA to distal popliteal)
- flush occlusions
- ostial, excessive calcium
- bridging collaterals, > 20 cms

- 10-15 cms, mid-distal SFA
- proximal – mid popliteal
- moderate calcium

- 5-10 cms
- Non ostial
- ISR

Low Predicted Success

High Predicted Success
Guidewire Recanalization of CTOs

Predicted Procedural Time

Focal occlusion

- 5-10 mins
- .014-.035 wire
- 4 Fr catheter

10-15 mins

- Different catheters
- Wire redirection
- FrontRunner, Crosser, TruePath
- Excimer laser

Long, complex

- 20-30 mins
- Re-entry device
Guidewire Recanalization of CTOs

Summary and Recommendations

• Base the decision to recanalize on the clinical objective and the safety and effectiveness of ultimate endovascular therapy.

• Complex CTOs can be recanalized with high predicted success (85-90%).

• Use a “step” approach for recanalization (low profile wires and catheters → stiffer, larger profile).
Guidewire Recanalization of CTOs
Summary and Recommendations

• Successful recanalization of CTO is the most important component of the total procedural success.

• Begin with shorter, “uncomplicated” CTOs and progress to longer, more complex CTOs.

• Currently available equipment is adequate for recanalizing most CTOs.
Conclusions

- CTOs are prevalent and offer unique and complex technical challenges.

- Integrating specialty guidewires and support catheters is highly effective in crossing even very difficult CTOs.

- Previously unapproachable CTOs can be successfully crossed by using newer crossing technologies and strategies.