

Pedal Loop Reconstruction: A Crash Course in 60 minutes

"Pedal-Plantar Anatomy"

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Disclosures

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Osprey Medical
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Gilead

Why is it important to know tibial and pedal anatomy?

- Implications for targeting angiosome guided therapy.
- Understanding anatomic variants which may be congenital and non-pathologic
- Avoiding confusing branches or collaterals with true vessels – which may lead to complications.
- Intact pedal plantar loop allows for the most robust filling of the distal vessels.
- Rates of healing appear to be higher with an intact pedal plantar loop
(Rashid H et al J of Vasc Surgery 57(5):1219-1226, 2013, and Mandl M et al J Cardiovasc. Surg. 50(3):331-7,2009.)

Tibial and Popliteal Anatomy: Implications for the Pedal Circulation

Tibial anatomy → Pedal Anatomy

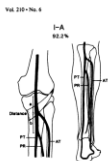
Vast majority of individuals have (at birth) three primary tibial vessels:

- **Anterior tibial artery → anterior circulation**
 - Lateral originating vessel – represents first branch off of P3 segment of popliteal artery.
 - Superiorly passes through tibia's anterior and extensor hallucis longus muscles.
 - Lies in the anterior compartment – therefore perforations have implications for compartment syndrome.
 - At the level of the ankle, crosses under extensor retinaculum and supplies dorsum of the foot at the dorsalis pedis.
- **Posterior tibial artery → posterior circulation**
 - Originates off tibi-peroneal trunk.
 - Lies in the deep posterior compartment.
 - Travels behind the medial malleolus and then divides into medial and lateral plantar vessels.
- **Peroneal artery → communicating branches to the primary tibial vessels, calcaneal perfusion**
 - Originates off tibi-peroneal trunk.
 - Lies in the deep posterior compartment but supplies blood to the lateral compartment.
 - Important source of collaterals when primary tibial vessels are occluded.

Moore & Dalrymple's Anatomic Variations: Textbook of Anatomy

Tibial anatomic variations

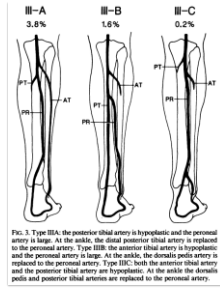
"Normal"



Kim D et al. Ann. Surg. - December 1989

Tibial anatomic variations

Congenitally hypoplastic tibial vessels



Kim D et al. Ann Surg - December 1989

Pedal Anatomy

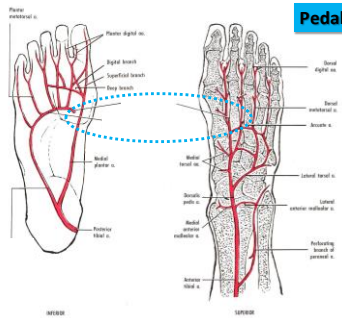
Pedal-Plantar Loop



Deep plantar arch:

- Receives supply from the anterior circulation (dorsalis pedis)
- And the posterior circulation (lateral plantar artery)

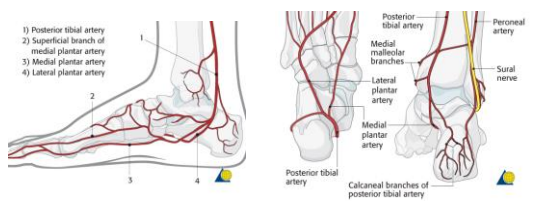
Foot Posterior TIBI Artery. Source: clipart.com/stock-12.embroid.com



Pedal-Plantar Loop

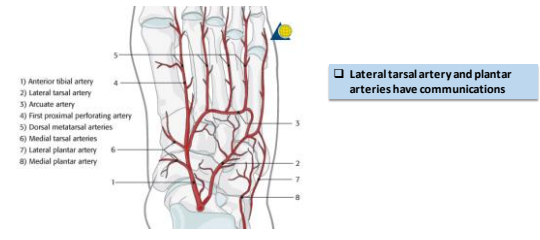
Medial and lateral views of the foot showing the arterial supply. Source: www.medicalsketches.com

Posterior Circulation



Author: Rick Buckley, Andrew Senda, <https://www2.zo.utdallas.edu>

Anterior Circulation

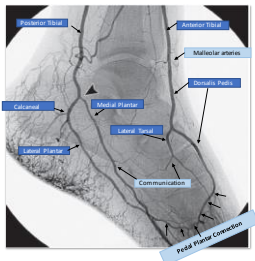


Author: Rick Buckley, Andrew Senda, <https://www2.zo.utdallas.edu>

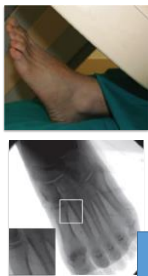
Lateral Oblique View



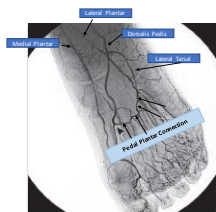
5th Meta-tarsal bone must be separated



Anterior Posterior View



1st Metatarsal space must be visible

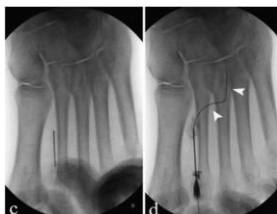
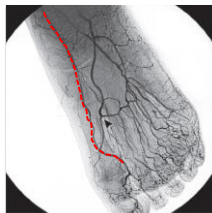


Metatarsal access

Editor's Choice

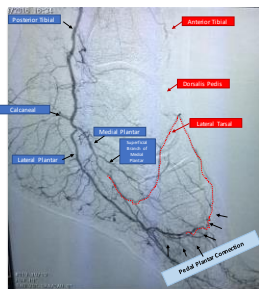
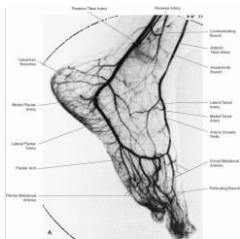
The Clinical Utility of Below-the-Ankle Angioplasty using "Transmetatarsal Artery Access" in Complex Cases of CL

Luis Martinez-Palera,¹ M.D., Dario Bracco,² M.D., and Marco Rossi,³ M.D.



Pedal Anatomy: Occlusions, Collaterals, Variations

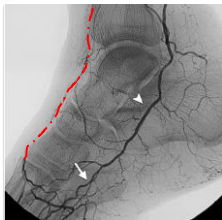
Pedal Plantar Loop: Connections and Collaterals



Pedal Plantar Loop: Connections and Collaterals



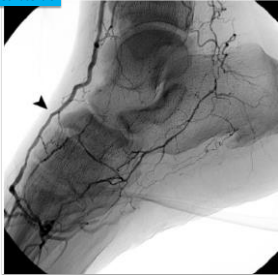
Medial Plantar fills Lateral Tarsal and anterior pedal circulation



Anterior circulation is occluded and the medial plantar provides sole pedal blood flow.

Pedal Plantar Loop: Connections and Collaterals

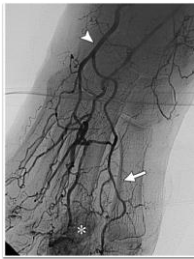
Posterior circulation is occluded but fills from anterior circulation



Pedal Plantar Loop: Anatomic Variation

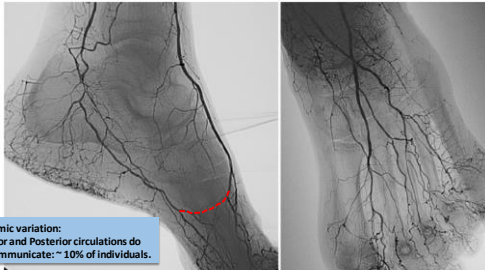
Anatomic variation:

- No dorsalis pedis: Lateral tarsal artery is the dominant anterior vessel: 6-12% individuals.
- The arcuate artery which normally originates from the dorsalis pedis is missing: ~ 30% of individuals.



Pedal Plantar Loop: Anatomic Variation

Anatomic variation: Anterior and Posterior circulations do not communicate: ~ 10% of individuals.



Summary

- Tibial and pedal anatomy in the majority of patients will be reproducible, however variations exist that can impact interpretation of angiograms.
- Identification of primary tibial vessels, perfusion to the wound angiosome, and understanding of collaterals is key to planning interventions.
- Important arteries and landmarks include the first metatarsal space, the medial and lateral plantar course, the lateral tarsal branch off of the dorsalis pedis, and the union of the lateral plantar with the dorsalis pedis to complete the pedal plantar loop

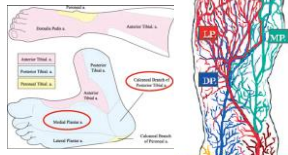
THANK YOU

With Pedal Loop Reconstruction, Any Need For Angiosome Guided Therapy?

John H. Rundback MD FAHA FSVM FSIR
 Medical Director, Interventional Institute
 Holy Name Medical Center, Teaneck, NJ

Angiosomes

- First described by Taylor in 2007
- Not specifically intended to describe pedal arch vessel
- In fact, the pedal arch is the terminal distribution of the named angiosomes
- The extent of name pedal vessels is limited



Alexandrescu J
 Endovasc Ther 2011

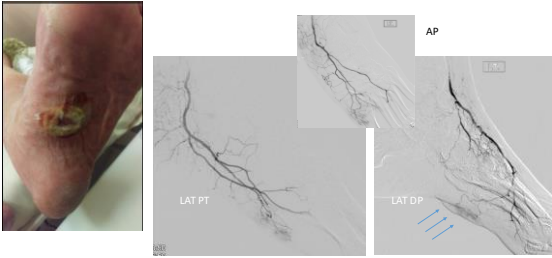


Angiographosomes

- A better term for angiographically mediated revascularization
- Requires distal injections, vasodilator, AP and lateral projections
- Goal is to assess regional and wound specific PERFUSION
- Most pedal wounds are watershed...
- Multivessel contribution including pedal arch branches supply ischemic tissue



Angiographosome



Case 1



- Lateral calcaneal foot ulcer
- Prior posterior tibial intervention
- Normal posterior tibial ABI, normal hallux TBI







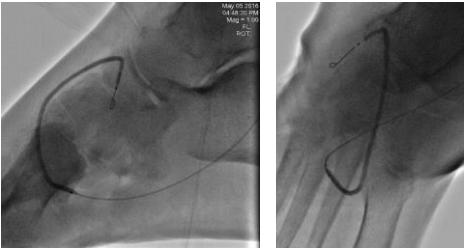


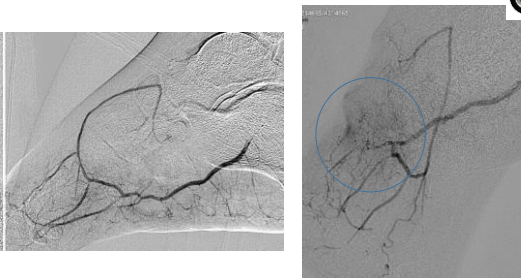


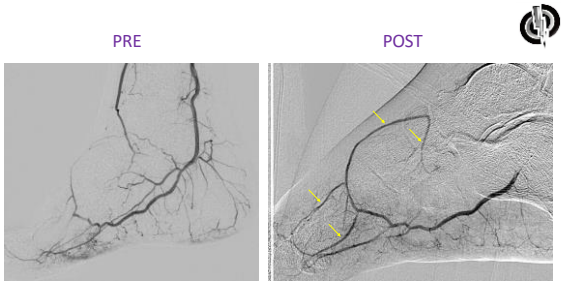












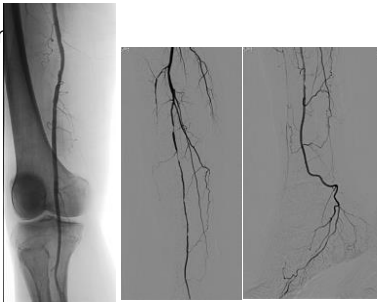


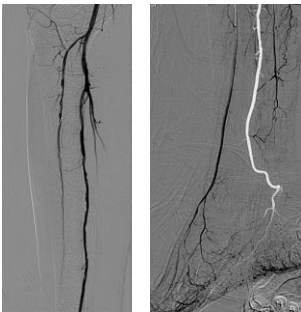
Case 2

- Distal hallux wound in March revascularized peroneal with PT continuation, and AT PTA with sluggish flow.
- Had Distal hallux amp with plantar flap
- Presents with Regional Ischemia, rest pain, cellulitis on dorsum of foot



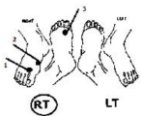
Prior



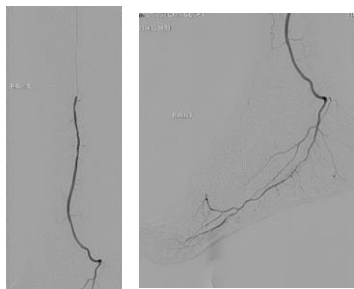


Electrode location	At Rest for 15 minutes	Limb Elevated for 6 minutes	Dangling for 5 minutes
1	0	0	1
2	44	35	44
3	74	69	75

<10mm Hg Critical limb ischemia, insufficient for wound healing
 30-50mm Hg CLI possible, insufficient for wound healing
 >50mm Hg Sufficient perfusion for wound healing





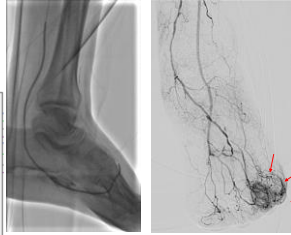
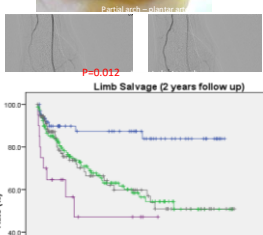








Case 3. Pedal Arch wound supply



Case 4. Wound blush – watershed – multivessel contribution – methylene blue angiography



ANT TIB INJECTION

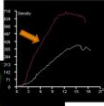
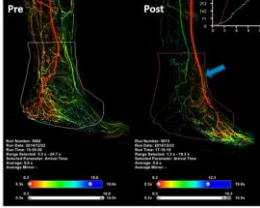


POST TIB INJECTION (PROX TO COLLATS)

Conclusion

- ANGIOGRAPHOSOMES – angiographically mediated revascularization remains relevant for pedal arch interventions
- Wound blush is the main objective measure
- Methylene blue or indocyanine green (Luna systems) can further define patterns of pedal arch perfusion
- Evolving perfusion systems will provide more optimized determination of real time interventional success

2D Perfusion
-time
-AUC
-opacification



Perfusion imaging visualization pre- and post intervention (angioplasty of the anterior tibial artery)

• Image: Clear improvement of the arrival time in the anterior tibial artery (from green to red) [blue arrow], but looks like the heel is hypo perfused.

• In the graphic it shows a much steeper time density curve in the region of interest (whole foot & ankle) [orange arrow]

• Conclusion: Angioplasty of the anterior tibial artery has resulted in improved perfusion of the foot, while this is not clear by only judging the DSA images.

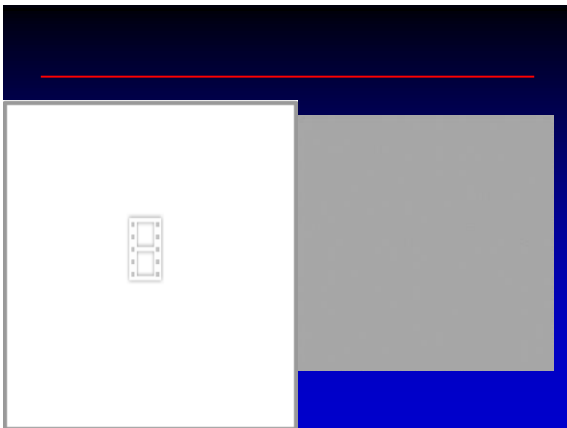


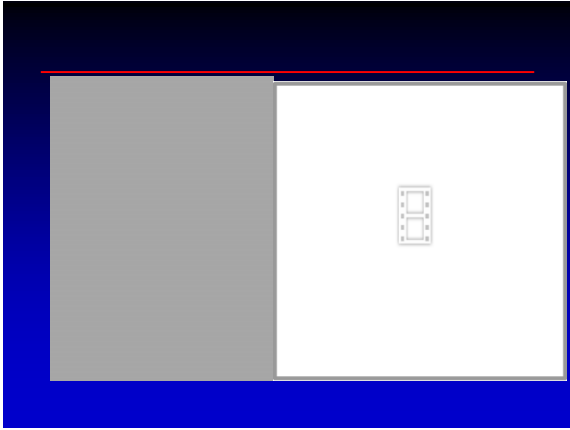
Pedal loop reconstruction: what are the tools?

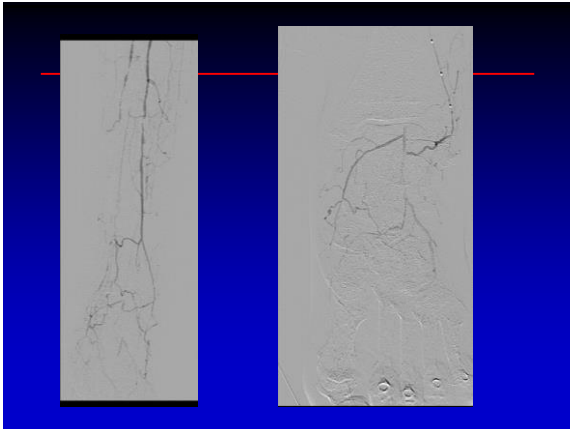
Lawrence A. Garcia, MD
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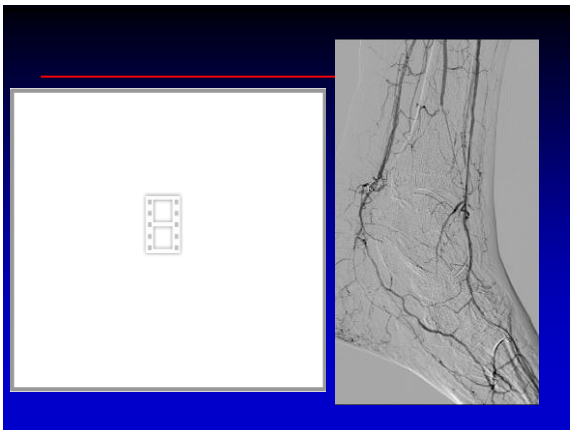
Case PT

- 88 year old female with history HTN, HLP, DM and PVD with L great toe ulceration and chronic pain with infection at site with MRSA
- Non-invasive work-up included ABI/duplex with non-compressible. Pre-occlusive Doppler in all tibial vessels distally with outflow appearing to be PT
- Angiography planned and images taken









What do you need?

- Access tools
- Sheaths
- Wires
- Support catheters
- Balloons
 - Non-DCB
 - DCB
- Stents
 - Balloon expandable
 - SES
 - DES
- Athrectomy

Access tools

- Access and “bear back” your wire and support catheter
- Can use angiocath
 - Simple IV catheter
- Cook systems check-flo 4 Fr
- Larger sheaths have been used (5-6 Fr)

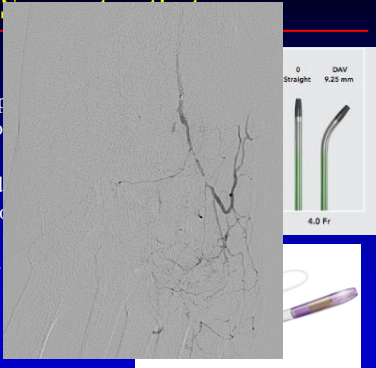


Wires

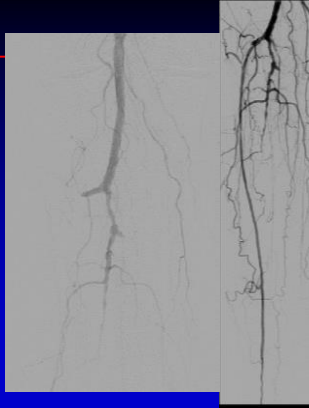
- Depends on your tastes
- 0.035” rarely used in the tibial circulation
- 0.018” useful and supportive
- 0.014” most commonly used

Industry	Name	Support	Tip Wt	Use
Abbott	SpartaCore	Strong	<1.0 gm	WorkHorse
	Command/Winn series	Medium	Up to 10 gm	Crossing
	Connect	Strong	Up to 30 g	Crossing
	SteelCore	Strong	<1.0 gm	WorkHorse
Asahi	Regalia	Low	1.0 gm	Crossing
	Astato 20	Medium	20 gm	Crossing
	GrandSlam	High	<1.0 gm	Position
	Treasure/Astato 30	Medium	12-30gm	Crossing
BSC	V14	High	3 gm	Crossing
	V18	Medium	3-6 gm	Crossing
	Victory 14/18	Medium	12,18,25,30 g	Crossing

- Either for p... increase for... wire
- 0.018" and... systems m... used
- Straight or...



- Balloons
 - POBA
 - DCB?
- Stents
 - DES
 - SES (BMS/DES)
- Atherectomy
 - Directional
 - Orbital
 - Rotational



- To date there are no meaningful data regarding outcomes with atherectomy in the pedal loop
- Definitive LE
 - 78% patency 6 cm LL CLI
- LIBERTY 360
 - To be presented 2016

Primary Patency in Subgroups

Subgroup	Claudicants (n=743)		CLI (n=279)	
	Patency (PSVR ≤ 2.4)	Lesion Length (cm)	Patency (PSVR ≤ 2.4)	Lesion Length (cm)
All (n=1022)	78%	7.5	71%	7.2
By Lesion Length				
< 4 cm (n=318)	81%	2.2	84%	2.3
4-9.9 cm (n=418)	83%	6.5	62%	6.6
≥ 10 cm (n=283)	67%	14.4	65%	15.1
SFA Only By Lesion Length				
< 4 cm (n=184)	78%	2.3	82%	2.3
4-9.9 cm (n=253)	83%	6.5	60%	6.9
≥ 10 cm (n=232)	65%	14.6	63%	15.5

Primary Patency in Subgroups

Subgroup	Claudicants (n=743)		CLI (n=279)	
	Patency (PSVR ≤ 2.4)	Lesion Length (cm)	Patency (PSVR ≤ 2.4)	Lesion Length (cm)
All (n=1022)	78%	7.5	71%	7.2
Lesion type				
Stenoses (n=806)	81%	6.7	73%	5.8
Occlusions (n=211)	64%	11.1	66%	10.3
Lesion Location				
SFA (n=671)	75%	8.1	68%	8.6
Popliteal (n=162)	77%	6.0	68%	5.4
Infrapopliteal (n=189)	90%	5.5	78%	6.0

LIBERTY 360

- Prospective, observational, multi-center clinical study to evaluate acute and long-term clinical, functional and economic outcomes of endovascular device intervention in patients with distal outflow peripheral arterial disease (PAD)
- No inclusion and exclusion
- Independent core laboratory analyses and adjudications
 - Angiographic
 - Duplex Ultrasound
 - Six Minute Walk Test
 - Health Economics
- Includes separate analyses for
 - Claudicants
 - Critical limb ischemia (RB4 and 5)
 - Critical limb ischemia (RB6)

Conclusions

- Pedal loop reconstruction is an attractive intervention for limb salvage and foot preservation
- Devices and selection of method of intervention remain at the discretion of the operator
- Access and contemporary interventional approach allows a myriad of technologies and devices for ultimate revascularization
- Issues that remain
 - Still may be too aggressive to the pedal loop without current long term data seems an important issue
 - Is drug elution/delivery an important part of the intervention?

Pedal Loop Reconstruction Step by Step Case Presentation

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Metro Heart and Vascular

Metro Health Hospital

Disclosures

- Bard Peripheral Vascular - Research, Consultant,
- Cardiovascular Systems, Inc. - Research, Consultant,
- Cook Medical - Research, Consulting
- Covidien – Consulting
- Terumo – Consulting
- Spectranetics – Research, Consulting



Advantage of Retrograde Tibial Access

- Increase success rate of crossing
- Shorten treated segment
- Preserve options of therapy : Surgery, atherectomy
- Utilize hibernating lumen
- Preserve tibial vessels flow

Saab et al

Pedal Loop Reconstruction

Antegrade Approach

- Critical Limb Ischemia patients
- Patients with Short Pedal CTO's
- Requires at Least 5 Fr Sheath
- Adequate Flow through the opposite vessel (PT or AT)

Retrograde Approach

- Usually for longer CTO's
- Requires a Tri-Axial system
- Usually safer
- At least a 6 Fr sheath
- Retrograde crossing under Fluoroscopy with a 0.014 loop technique

Saab et al

Pedal Loop Reconstruction

Wires

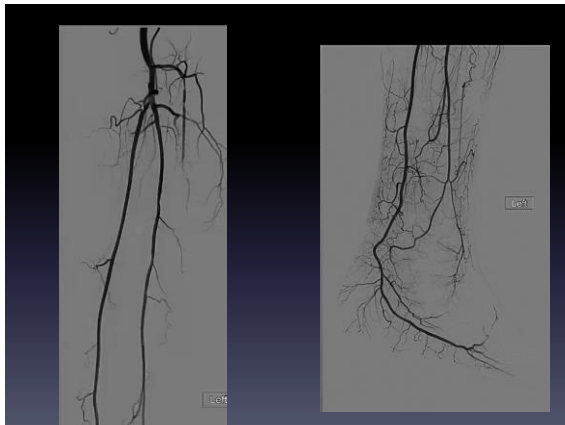
- Journey Wire (BSCN)
- Regalia Wire (Asahi)
- Glide Advantage (0.014) (Terumo)
- Runthrough (Terumo)
- Gladius (Asahi)

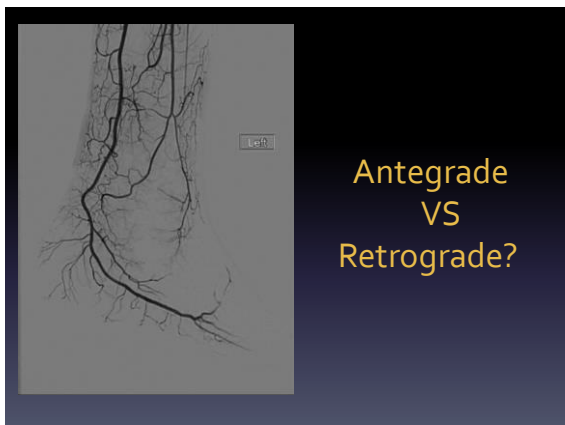
Saab et al

Case Presentation

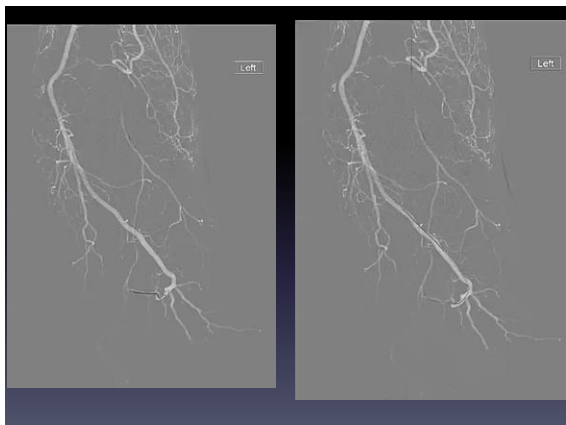
- 69 year old that presented with a non healing wound over the Plantar and dorsal aspect of the great toe
- Risk factors include: HTN, DM, Ischemic cardiomyopathy with an EF of 40%
- Despite 6 months of wound care, no healing
- Non compressible ABI's







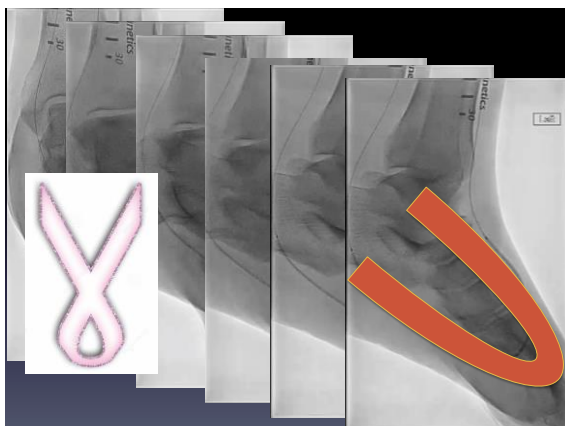


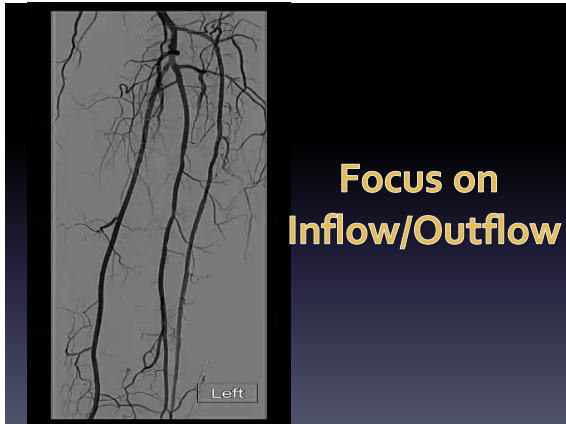


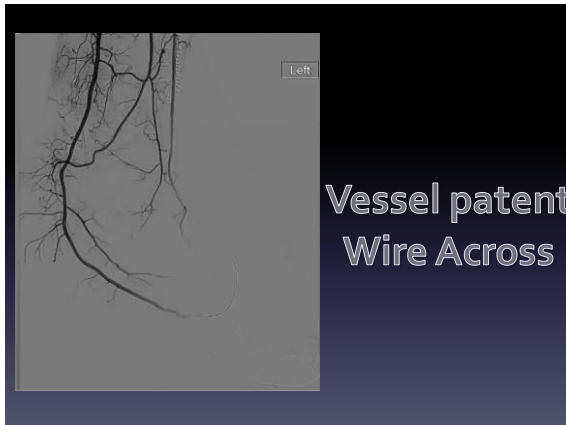




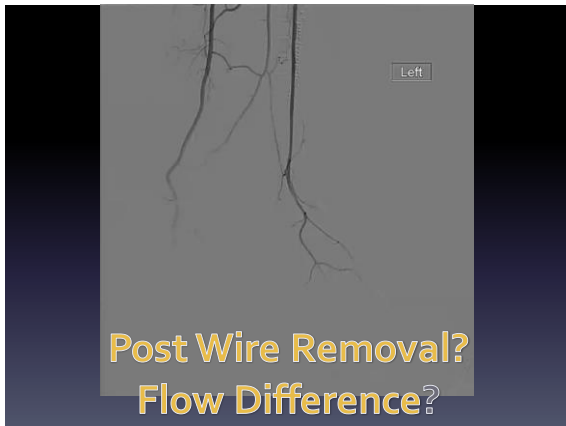


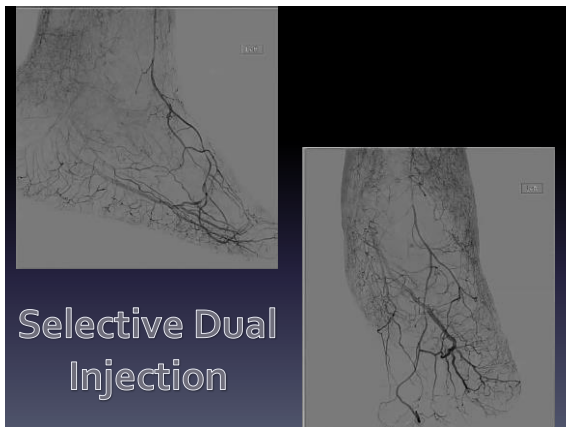


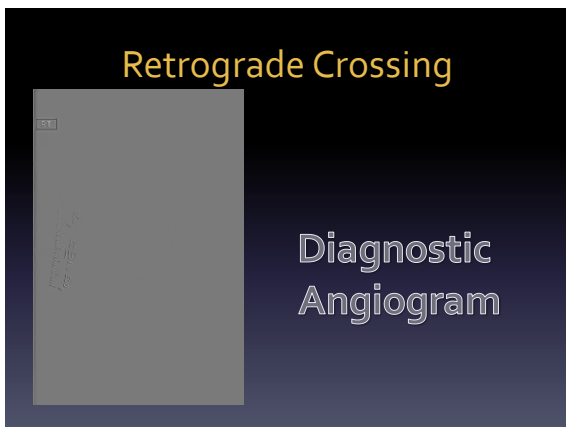


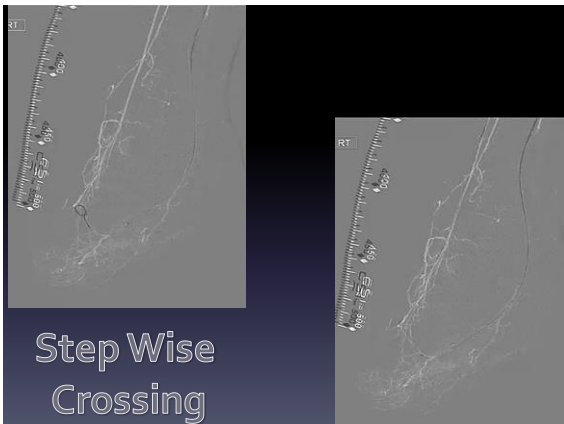




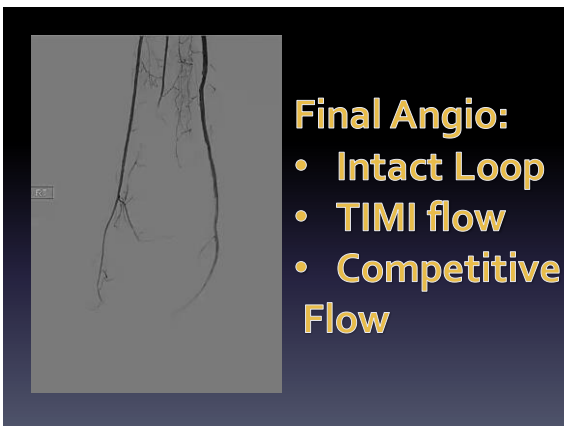




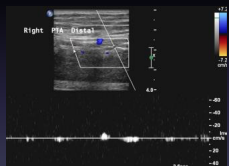


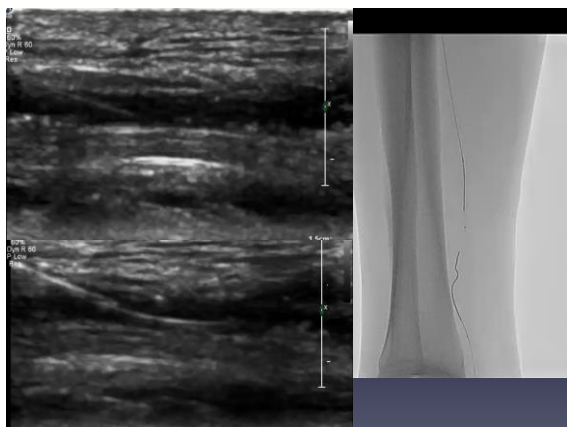


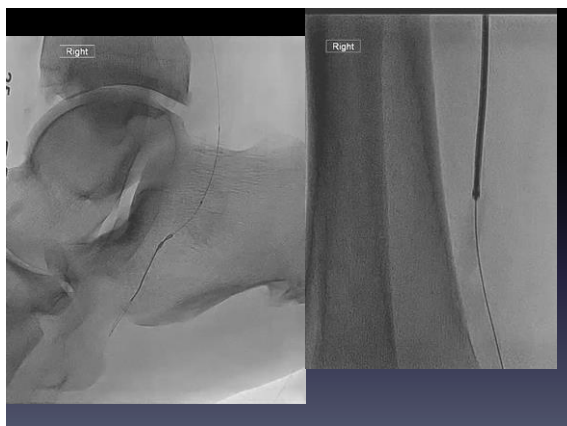


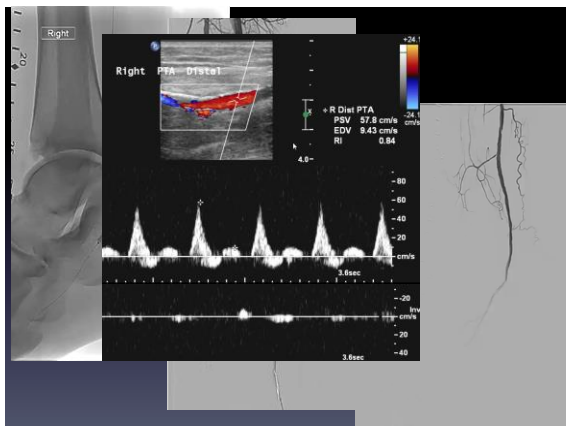


Another Option









Conclusion

- Pedal Loop reconstruction is the next phase in CLI therapy
- Current available plaque modification technology for the pedal loop is expanding.
- Current technologies include Laser atherectomy, Orbital atherectomy and Phoenix atherectomy
- Long term benefits will need to be tracked and documented in trials and registries (PRIME Registry)

AMP
THE CRITICAL LIMB ISCHEMIA MEETING

THANK YOU FOR ATTENDING AMP 2015!
SEE YOU NEXT YEAR

AUGUST 10-13, 2016
HILTON CHICAGO, CHICAGO, IL

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Detailed description: This is a promotional graphic for the AMP (The Critical Limb Ischemia Meeting) held in August 2016. It features the AMP logo, a thank you message for attendees, the meeting dates and location (August 10-13, 2016, Hilton Chicago, Chicago, IL), and contact information for Fadi Saab, including his email addresses and phone number.
