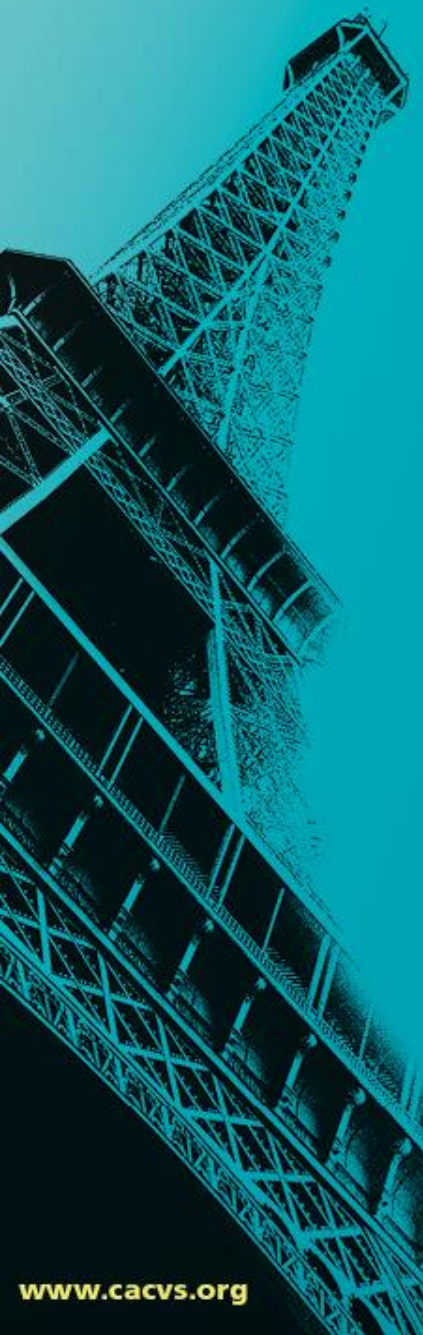
CONTROVERSES ET ACTUALITÉS EN CHIRURGIE VASCULAIRE
CONTROVERSIES & UPDATES IN VASCULAR SURGERY
JANUARY 19-21 2017
MARRIOTT RIVE GAUCHE & CONFERENCE CENTER
PARIS, FRANCE



Infrared thermal imaging for distal ischaemia

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Disclosure

Speaker name:

.....N Inston.....

☐ I have the following potential conflicts of interest to report:

☐ Consulting

☐ Employment in industry

☐ Shareholder in a healthcare company

☐ Owner of a healthcare company

☐ Other(s)

☒ I do not have any potential conflict of interest

Arteriovenous Access Induced Ischaemia

TABLE II - Haemodialysis access-induced distal ischaemia (HAIDI) classification

Grade 1	No clear symptoms but discrete signs of mild ischaemia may be observed (slight cyanosis of nail beds, mild coldness of skin of hand, reduced arterial pulsations at wrist, reduced systolic finger pressures). (only relevant for upper limb access)
Grade 2a	Complains during dialysis sessions or intense use of the hand: *tolerable* pain cramps, paraesthesia, numbness or disturbing coldness in fingers or hand
Grade 2b	Complains during dialysis sessions or use of the hand. *Intolerable* pain, cramps, paraesthesia, numbness or disturbing coldness in fingers or hand
Grade 3	Rest pain or motor dysfunction of fingers or hand Upper limb relevant only
Grade 4a	Limited tissue loss (ulceration, necrosis). Clinically significant hand function (upper limb) is probably maintained if ischaemia is reversed
Grade 4b	Irreversible tissue loss of the hand (upper limb) Impossible to preserve clinically significant hand function. Requires amputation

Classification by Scheltinga et al (23).

Diagnosis is clinical

But not always simple

Clinical symptoms

- Incidence 2-8%

- The clinical presentation
  - Acute (<24 hours)
  - Subacute (<1mo)
  - Chronic (>1mo)

- Clinical symptoms determine management options.

Investigation

- No definitive test
- Angiography and blood flow measurement
  - May not assist diagnosis but may identify the etiology and choice for treatment.
- Digital pressures, BDP, DBPI, transcutaneous oxygen measurement
  - If the differential diagnosis is difficult digital pressure measurements may assist.
  - may be a useful adjunct in monitoring response to treatment.

Adjuncts to diagnosis

TABLE III - The Vascular Access at Charing Cross (VA@CX) Classification of arteriovenous access ischaemic steal (AVAIS)

Stage	Symptoms	Signs	Investigations	Suggested treatment options
Grade 1	Mild symptoms or signs alone	Pale or blueish nail beds, mild coldness of skin of hand, reduced arterial pulsations at wrist	Reduced finger pressures <contralateral side but DBPI >0.4; DUS shows high or normal access flow.	Observation and review
Grade 2a	Symptoms (*tolerable* pain cramps, paraesthesia, numbness or coldness). During dialysis or intense use of the hand:	Pale or blue-ish nail beds, coldness of skin of hand, reduced arterial pulsations at wrist	Reduced finger pressures (DBPI <0.4): DUS shows high or normal access flows. Angiography may demonstrate arterial stenosis proximal to the anastomosis ± collateral and ± run-off disease	If high flow, treat by banding/DRIL/ RUDI and treat underlying arterial disease where possible. If low flow PAI or tie off may be required.
Grade 2b	Symptoms (*intolerable* pain cramps, paraesthesia, numbness or coldness). during dialysis or normal use of the hand	Pale or blue-ish nail beds, coldness of skin of hand, reduced arterial pulsations at wrist	Reduced finger pressures (DBPI <0.4): DUS shows high or normal access flows. Angiography may demonstrate arterial stenosis proximal to the anastomosis ± collateral and ± run-off disease	If high flow, treat by banding /DRIL/ RUDI and treat underlying arterial disease where possible. If low flow, treat any underlying arterial disease and PAI or tie off may be required.
Grade 3	Rest pain or motor dysfunction of fingers or hand.	Pale, white or blue-ish nail beds and skin, coldness of hand, reduced arterial pulsations at wrist	Reduced finger pressures (DBPI <0.4): DUS shows high or normal access flows. Angiography may demonstrate arterial stenosis proximal to the anastomosis ± collateral and ± run off disease	Definitive treatment is required and should be tailored to all causative factors (Tie off/DRIL/PAI/ angioplasty)
Grade 4	Rest pain and or paraesthesia.Loss of sensation (numbness).	Tissue loss (ulceration, necrosis). Motor and sensory loss.	Reduced finger pressures (DBPI <0.4): DUS shows high or normal access flows. Angiography may demonstrate arterial stenosis proximal to the anastomosis ± collateral and ± run off disease	Definitive treatment is required and should be tailored to all causative factors (Tie off/DRIL/PAI/ angioplasty) and debribement/amputation may be required
Grade 5	Irreversible tissue loss of the hand.	Extensive tissue loss	Reduced systolic finger pressures (DBPI <0.4): DUS shows high or normal access flows. Angiography may demonstrate arterial stenosis proximal to the anastomosis ± collateral and ± run off disease. X ray may show bone loss/osteomyelitis	Treatment should be attempted but amputation/debridement of necrotic areas required and abandonment of access may be necessary although underlying arterial disease amenable to treatment should be attempted.

Based on previous classifications and staging schemata by Tordoir et al (6), Scheltinga et al (23).
DBPI = digital:brachial pressure index; DRIL = distal revascularisation interval ligation; PAI = proximalisation of the access inflow; DUS = Doppler ultrasound.

Finger pressures
DBPI >0.4

Finger pressures
DBPI <0.4

Differential diagnosis

- Diabetes
- PVD
- Reynauds and vasculitis
- Arthropathy
- Neuropathy

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EDITORIAL

The DRIL procedure for arteriovenous access ischemic steal: a controversial approach

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ABSTRACT

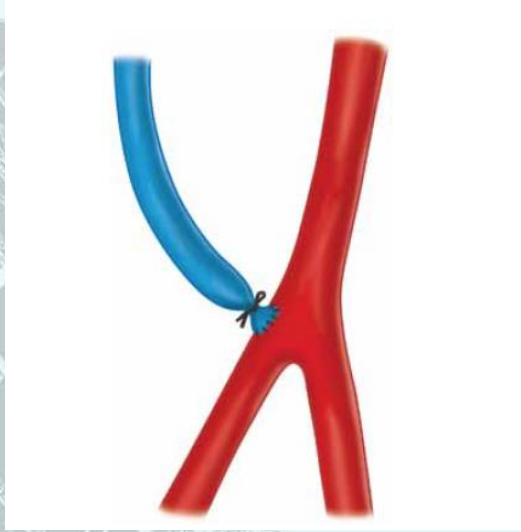
The DRIL procedure first described in 1988 has long been considered the preferred treatment for arteriovenous access ischemic steal (AVAIS). At the time it was a brilliant concept and breakthrough. In the last decade, the DRIL procedure has become less used. With the increasing age of the dialysis population, patients developing AVAIS are more likely to be elderly with advanced peripheral arterial disease, making the distal revascularization anastomosis difficult and risky if not impossible to perform. In addition, the distal ligation of the main artery to the arm is something most surgeons are reluctant to do. The occlusion of the arterial bypass over time is not uncommon with recurrence of hand ischemia. The multistep DRIL procedure requires general anesthesia and the need to harvest the saphenous vein for the bypass, add to the surgical risk in patients with multiple co-morbidities. For these reasons, some surgeons prefer to do only the DR (distal re-vascularization) portion of the procedure omitting the IL (interval ligation). Increasing the bypass distance from the original anastomosis, makes this modification similar to the less invasive proximal arterial inflow (PAI) procedure.

Conclusions: Because of changes in the patient population clinical presentation, most notably forearm atherosclerosis and with new technologies, this editorial addresses the current validity of the DRIL procedure as a safe option in treating AVAIS.

Keywords: AVAIS, Dialysis access steal, DRIL, Hand ischemia

ground. Yet, on another level, it opens up a pathway for much needed conversation about the safe selection between treatment options for AVAIS. The value in redirecting the discus-

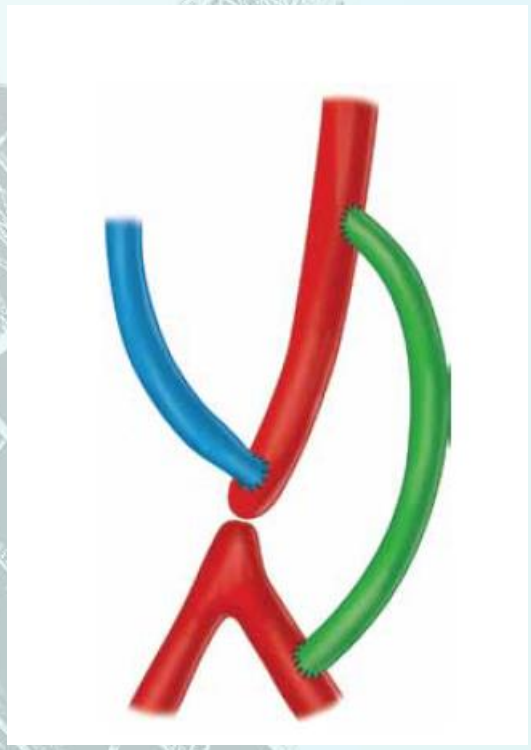
Treatment options



Banding
Directed vs non directed

Study (ref)	Number	Pre-operative classification	Technique	Symptomatic response (%)	Early thrombosis (%)
Wang 2016 (59)	30	Yes (SVS mean = 2.8)	Banding	79.1	4.1
Leake 2014 (53)	37	Yes	Banding	75	11
Wang 2013 (55)	7	No	Banding	100	0
Smith 2013 (54)	6	No	Banding	100	0
Gupta 2011 (46)	21	No	Banding	52.4	19
Shemesh 2010 (56)	7	No	Banding	100	0
Miller 2010 (52)	114	Non standard	Banding	88.6	4.4
Van Hoek 2009 (57)	9	Steal questionnaire	Banding	100	0
Thermann 2007 (58)	15	SVS classification I-III (75% mild steal)	Banding	66.7	0
Schneider 2006 (60)	6	No	Banding	83.3	0
Goel 2006 (61)	16	No	Banding	100	0
Morsy 1998 (62)	6	Yes	Banding	100	66.7
DeCaprio 1997 (63)	11	No	Banding	90.9	81.8

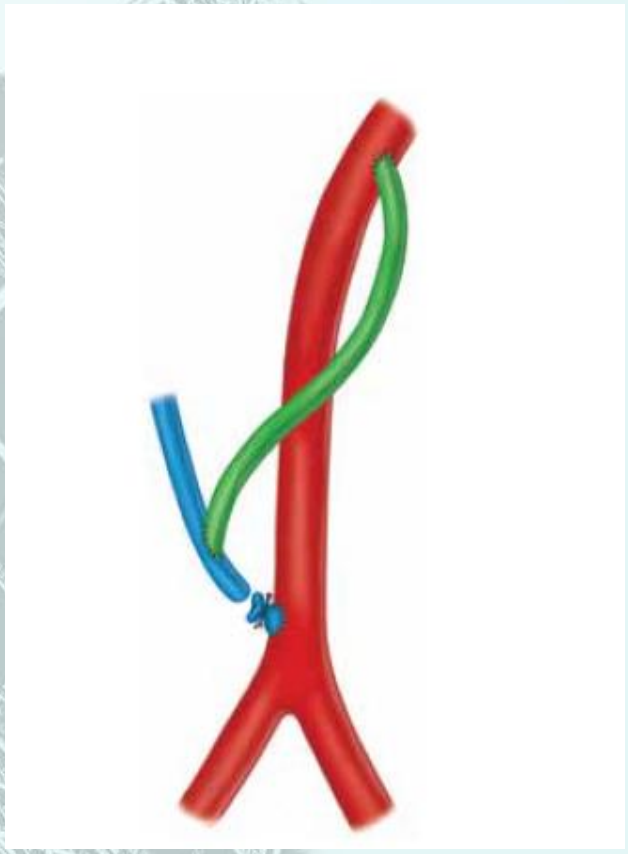
Treatment options



Distal Revascularisation and interval ligation (DRiL)

Leake 2014 (53)	56	Yes	DRIL	98.2	0
Scali 2013 (20)	56	SVS I-III (grade III = 69%)	DRIL	98.2	0
Aimaq 2013 (69)	81	Non-standard (Ischemic rest pain (46.9%), digital ulceration (25.9%), neurological deficits (19.7%), digital gangrene (7.4%)	DRIL	79	0
Anaya-Ayala 2012 (70)	31	Non standard (ischaemic pain [36%], loss of neuro-logic function [21%], both ischaemic pain and loss of neurologic function [12%] tissue loss [21%], pain during haemodialysis in [3%])	DRIL	77.4	0
Gupta 2011 (46)	20	No	DRIL	90	10
Field 2009 (40)	6	Yes (all severe)	DRIL	100	0
Huber 2008 (21)	64	Nonstandard (pain [25%], paraesthesia [34%], motor dysfunction [24%], and tissue loss [17%])	DRIL	78.1	0
Yu 2008 (71)	24	Nonstandard	DRIL	95.8	12.5
Walz 2007 (72)	36	Nonstandard	DRIL	66.7	Ns
Mwipatayi 2006 (73)	12	Nonstandard	DRIL	83.3	0
Sessa 2004 (74)	18	Nonstandard (all severe)	DRIL	100	0
Korzets 2003 (75)	9	Nonstandard	DRIL	88.9	0
Lazarides 2003 (11)	23	No	DRIL	100	0
Knox 2002 (76)	55	Nonstandard	DRIL	85	0
Berman 1997 (35)	21	No	DRIL	100	0
Schanzer 1992 (77)	14	Nonstandard (92% rest pain)	DRIL	100	0

Treatment options



Proximalisation Arterial Inflow (PAI)

Leake 2014 (53)	9	Yes	PAI	100	0
Thermann 2009 (58)	18	DASS classification I-III (75% mild steal)	PAI	94.4	22.2
Zanow 2006 (36)	30	Yes (grade 2 = 13%; 3 = 17%; 4 = 33%)	PAI	100	0

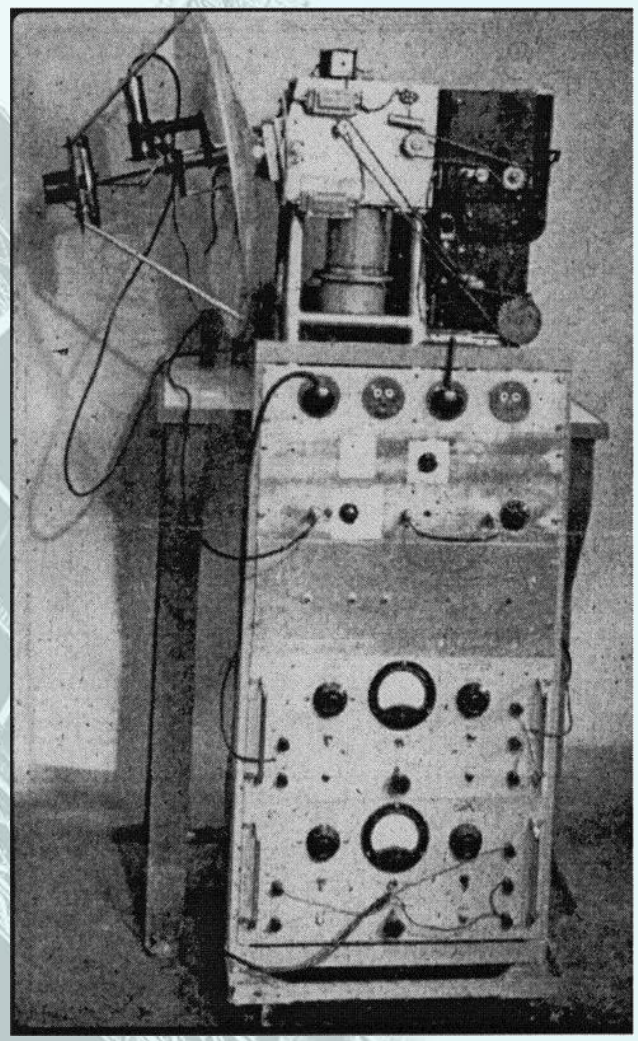
AVAIS

- Diagnosis is poorly defined
- Management is varied and difficult to compare
- Are there any other tools?

Coldness of hand is the main clinical feature

Can we use infrared thermography?

Prototype Pyroscan used in Bath in 1959.



E. F. J. Ring Rheumatology 2004;43:800-802

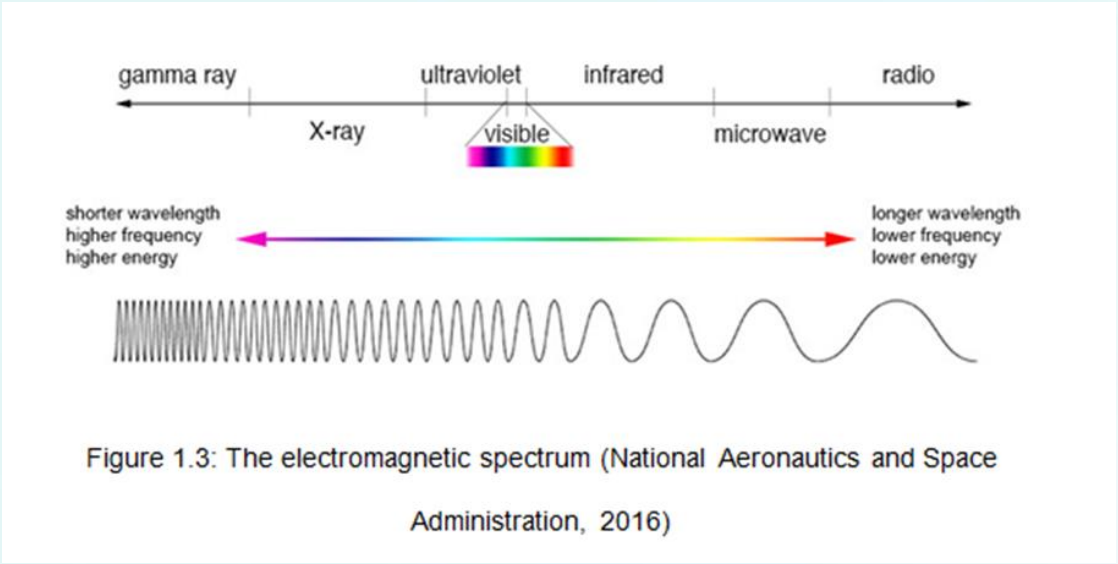


Figure 1.3: The electromagnetic spectrum (National Aeronautics and Space Administration, 2016)

Infrared imaging 2017

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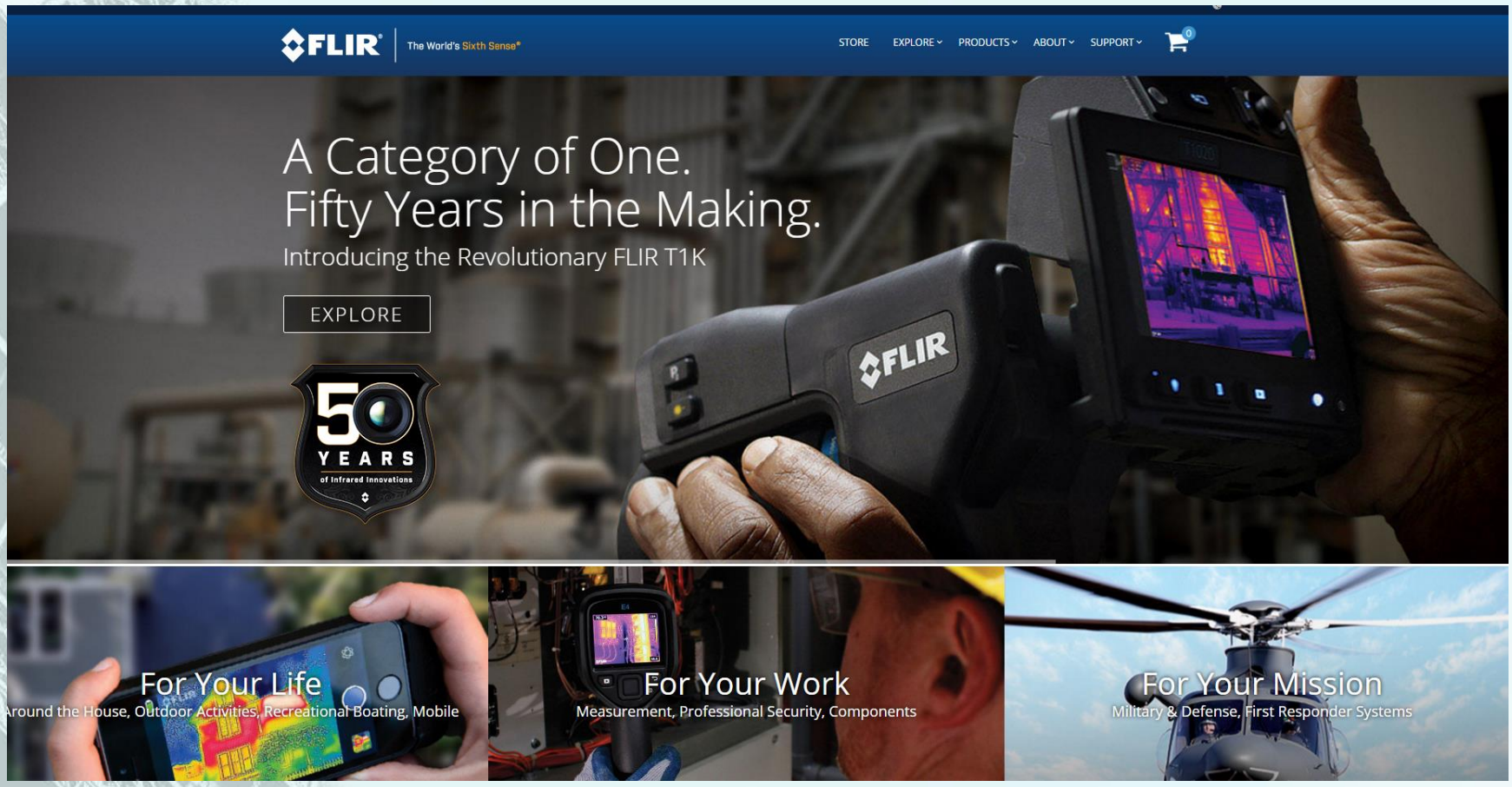
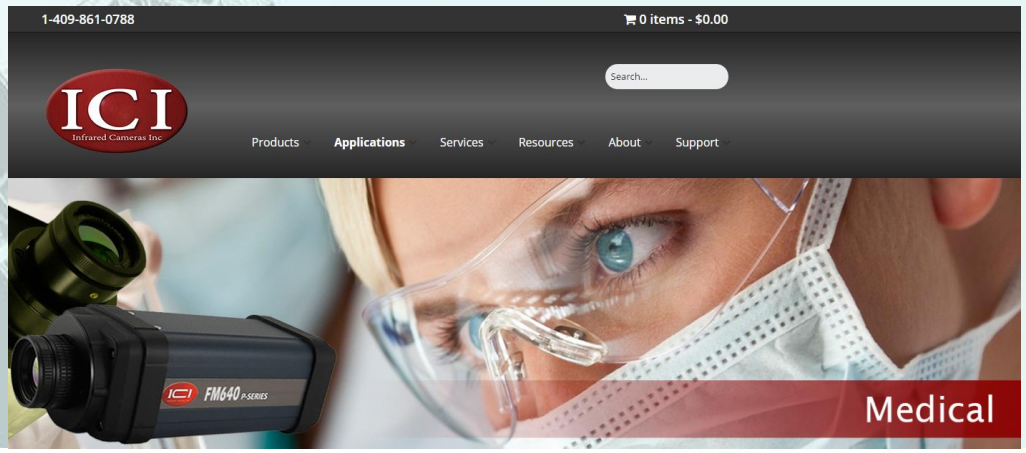
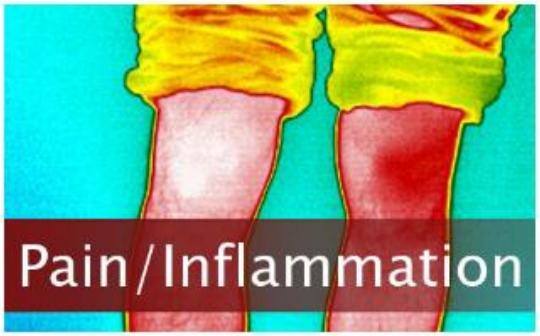
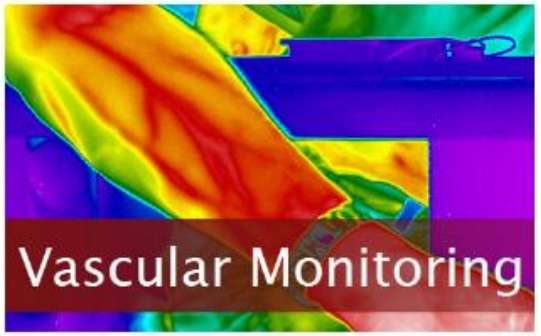


Medical uses







Vascular surgery

- http://www.thermology.com/medical_thermal_imaging_research.html

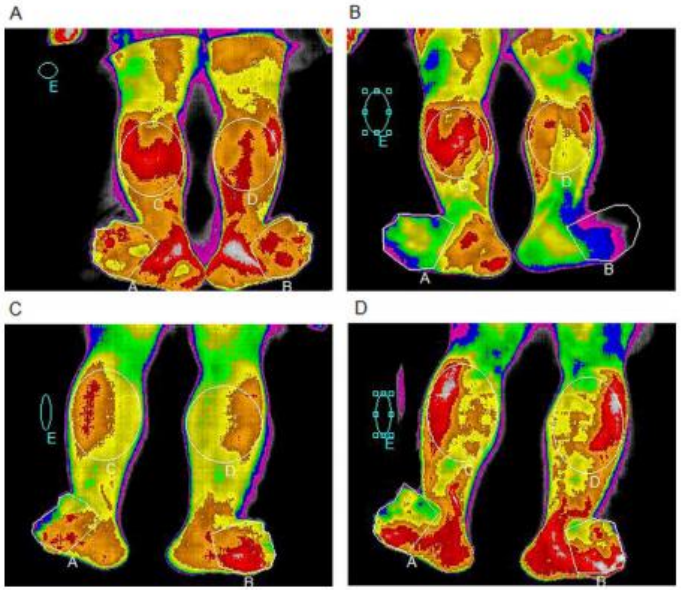
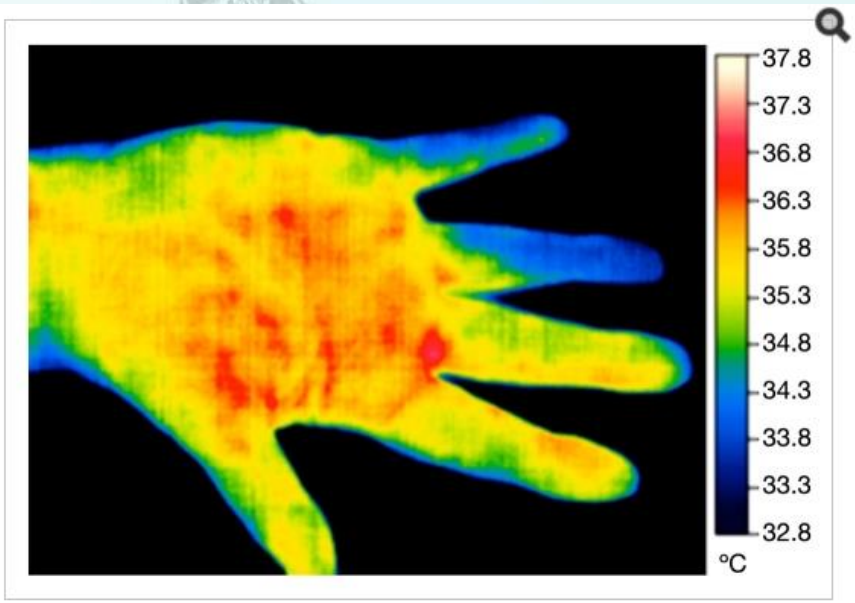


Fig 1. Infrared theromoimages before and after 6-minute walk test in lower extremity peripheral arterial disease (PAD) **(A, B)** and non-PAD patients **(C, D)**.

Diabetic hand



Review

Use of infrared thermography as an endpoint in therapeutic trials of Raynaud's phenomenon and systemic sclerosis

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Key words: medical imaging, Raynaud's, CREST, systemic sclerosis, clinical trials as topic, infrared thermography

ABSTRACT

Objective. *To perform a systematic review evaluating the use of infrared thermography (IRT) as an endpoint in clinical trials of Raynaud's phenomenon (RP).*

Methods. *Articles reporting the use of IRT and Raynaud's phenomenon were identified following systematic searches of PubMed, EMBase, MEDLINE and AMED databases. Articles incorporating IRT as an endpoint in a therapeutic trial were selected for full text analysis. Data extracted from articles included study design, study size, intervention, clinical and thermographic endpoints, and outcomes. Studies were scored on their methodological quality. Data analysis involved a descriptive analysis of the studies, along with a secondary analysis focusing on agreement between clinical and thermographic outcomes in the larger, better-described studies.*

Results. *Thirty-two studies evaluating 654 patients with RP were assessed. Significant heterogeneity between studies precluded any attempt at formal meta-analysis. Most studies were small (median 15.5 patients) and open-label*

continue to evaluate IRT, alongside recommended self-reports, in an attempt to validate objective microvascular assessment tools in therapeutic trials of RP.

Introduction

Raynaud's phenomenon (RP) is characterised by excessive peripheral vascular reactivity to cold exposure and emotional stress leading to intermittent episodes of digital ischaemia (1). Episodes are frequently associated with pain and impaired motor and sensory function. For the majority of patients, RP occurs as an isolated phenomenon (termed primary Raynaud's) however in a minority it can herald the onset of potentially life threatening diseases such as systemic sclerosis (SSc) in which vascular dysfunction can lead to irreversible morphological vascular changes and digital necrosis (1, 2). Treatments are available to reduce the impact of the disorder by altering the balance of vascular resistance in favour of vasodilatation. Objective quantification of peripheral vascular dysfunction in RP is challenging but essential to allow evaluation of

Dorsal view of feet. The left forefoot is inflamed (red) and toes are cold.

Normal Thermography

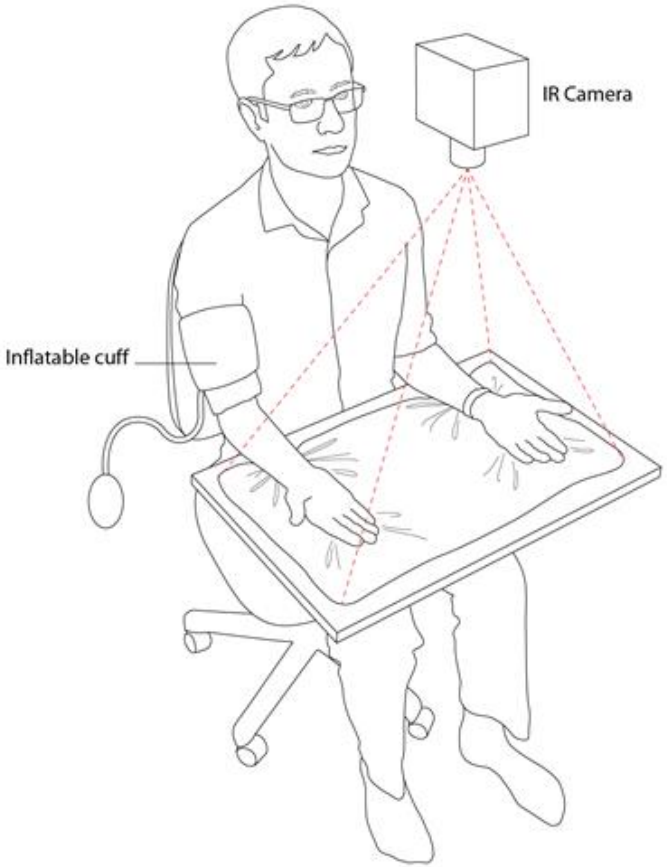


Figure 4.2: Illustration showing the setting for the vascular occlusion test

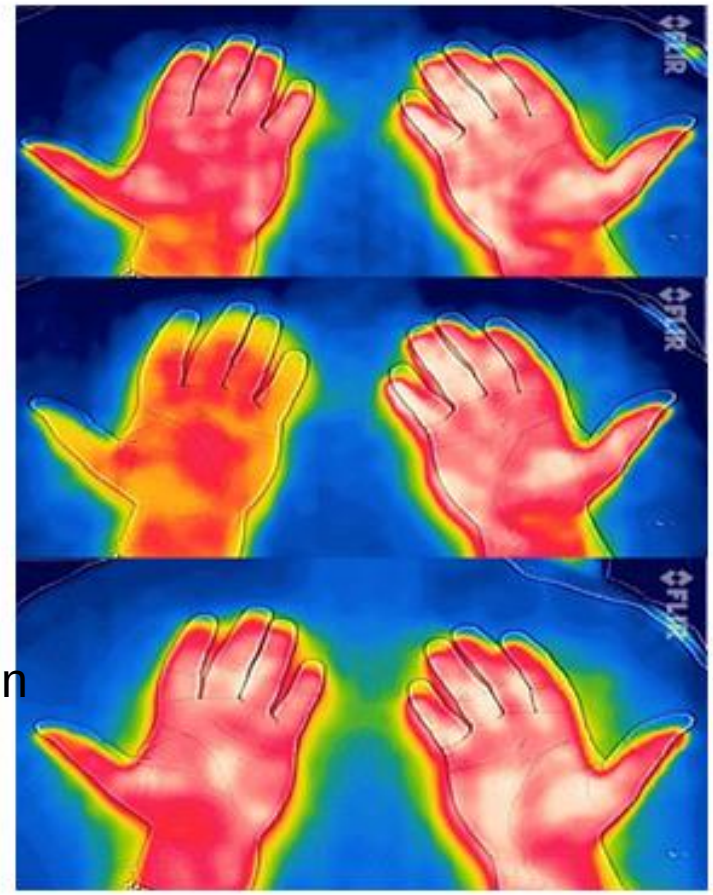
http://www.flir.co.uk/flirone/ios-android/

Normal Thermography

Pre occlusion

Occlusion

Post Occlusion reperfusion



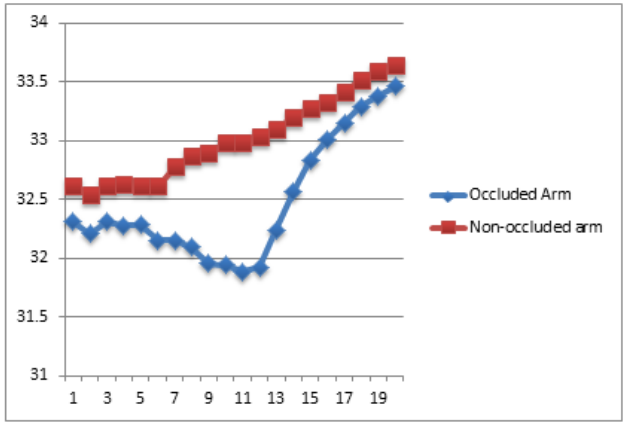


Figure 4.4: Typical thermal changes seen during the three different periods of the vascular occlusion test

Post AV fistula formation

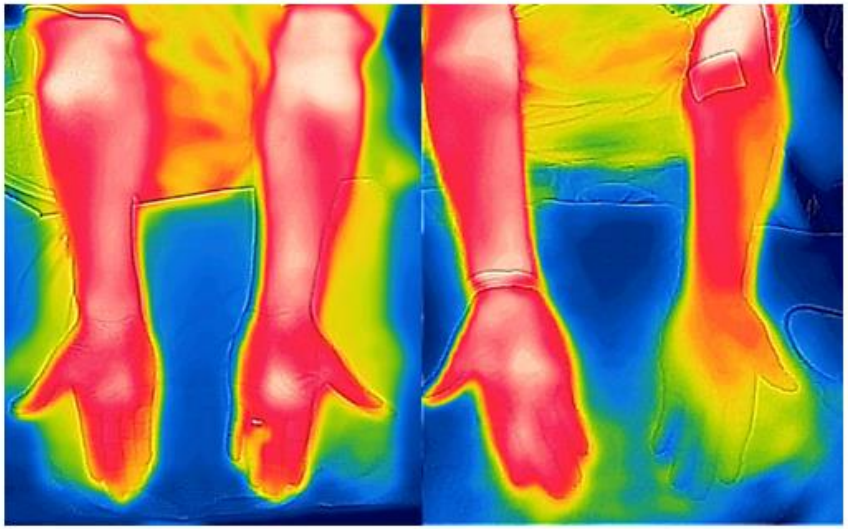


Figure 3 – Infrared thermal imaging before and after creation of a left brachiocephalic fistula, which matured successfully.

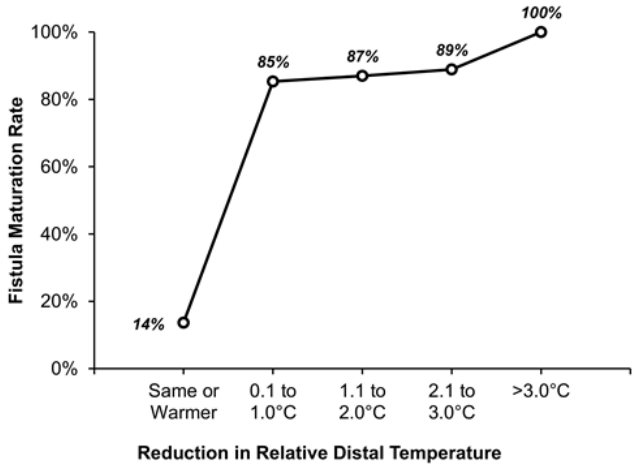


Figure 2 – Fistula maturation rate by change in distal temperature difference

*"**Physiological "** steal occurs in 85% of AV access" Shanzer H*

Immediate reduction in distal temperature is predictive of maturation

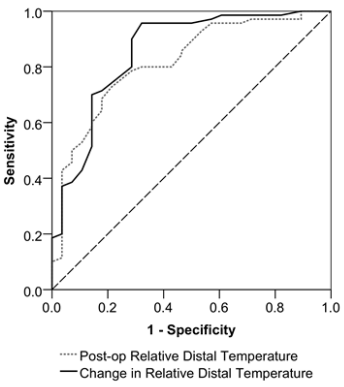


Figure 1 – ROC curve for IRTIVA study

In Ischaemic Steal

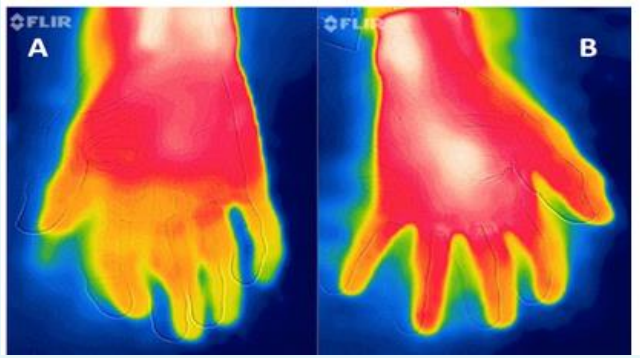
- 76 F ESRD: ANCA positive microscopic polyangitis
- Right BC AVF with no complications.

- 3 weeks following the surgery and the arteriovenous fistula had matured and dilated well.

- BUT:
  - intermittent coldness of the hand and non-specific numbness.
  - She denied any pain.
  - On examination, there was no tissue loss but the radial pulse was absent but returned on compression of the AVF.

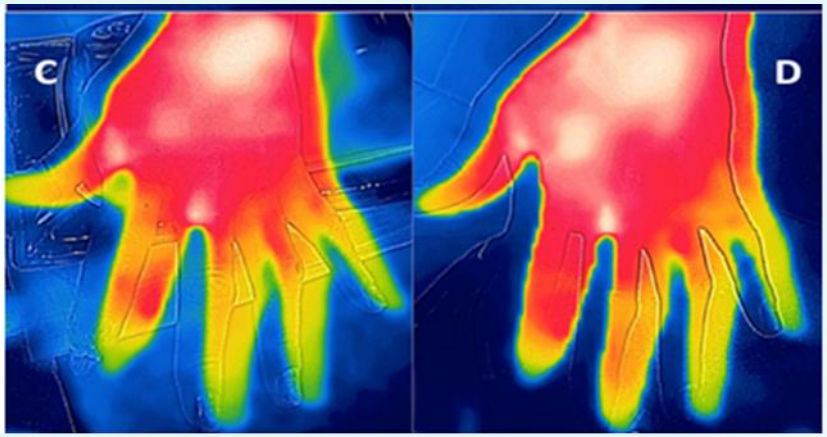
- On assessment with IRTI (fig 1a) skin perfusion was reduced in all digits compared to the other hand
-
- Based on clinical parameters a banding procedure was planned and immediate post-operative IRTI performed which showed improvement in temperature.

- At two weeks follow up she was clinically improved and was asymptomatic. On examination, she had a strong radial pulse and the brachiocephalic fistula was patent and used for dialysis.



A. Thermogram of the affected hand
B. Thermogram of the contralateral hand

- 45 F ESRD secondary to diabetic nephropathy
- Lt BCAVF which was aneurysmal.
- Pain over her left index finger with tissue loss at the tip of her finger.
- Refused treatment as prior line sepsis
- A CT angiogram did not demonstrate significant arterial disease.
- Finger tip necrosis worsened and increased pain including night pain.
- As this was rapidly deteriorating she consented to fistula ligation.
- Pre-operative IRTI demonstrated poor flow in the digits) which improved on ligation
- Symptoms were relived and deterioration halted.
- The necrotic distal phalanx required limited debridement with primary healing.



C. Thermogram of the hand before the ligation procedure
D. Thermogram of the hand after the ligation procedure

- 65M ESRD secondary to diabetic nephropathy

- Progressive painless necrosis of his right index finger.
- Right B/C AVF

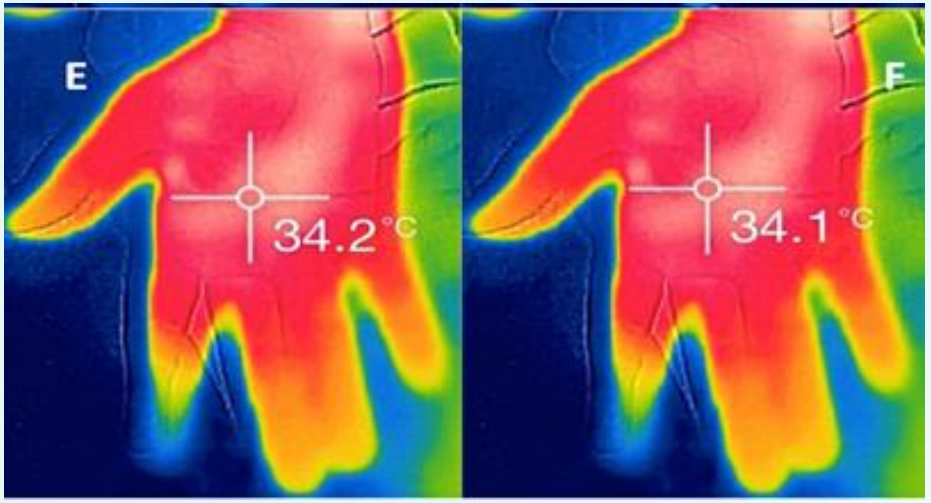
- He had a significant history of comorbidities:
  - peripheral vascular disease with previous bilateral carotid endarterectomies,
  - previous left femoral-popliteal bypass and amputations of two toes,
  - hypertension, diabetes and ischaemic heart disease.

- Weak palpable radial pulse
- Necrotic distal right index finger.

- On compression of the fistula, there was minimal change to the strength of pulse
-
- IRTI demonstrated perfusion in the digits including the affected index finger and no change in temperature following compression of the fistula

- Previous fistulogram and duplex examination heavily calcified vessels aetiology was felt to be microvascular disease rather than HAIDI.

- The patient was referred to the hand surgeon for amputation of the distal phalanx and his fistula was preserved.

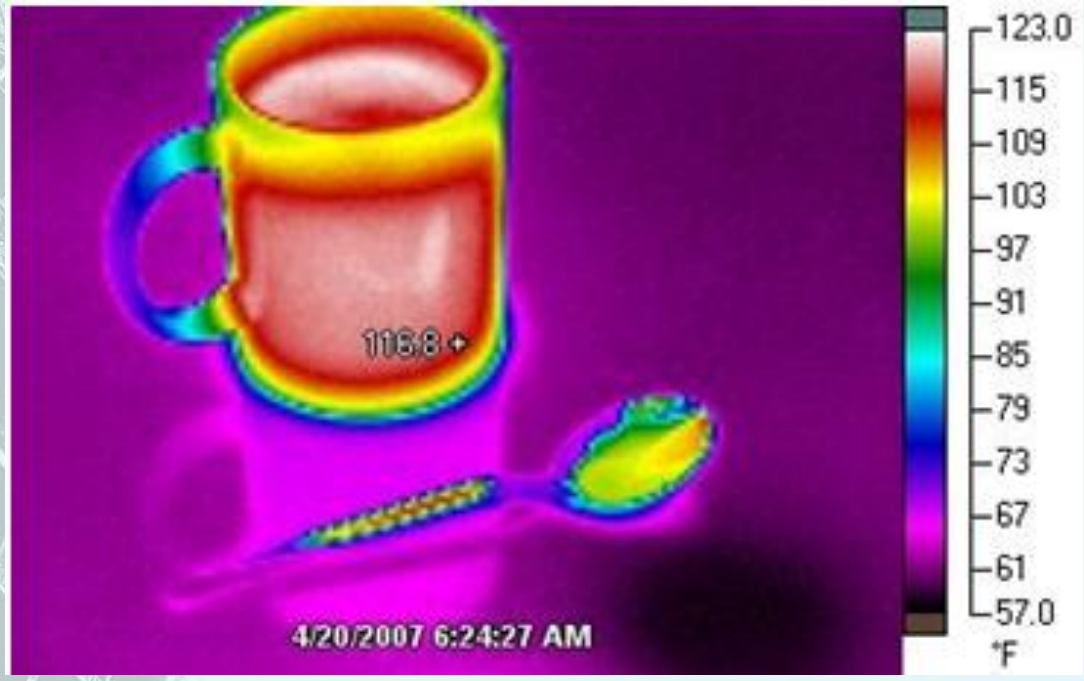


Thermogram of the hand before compression of the fistula
Thermogram of the hand after compression of the fistula

Conclusions

- Infrared thermography is
  - Affordable
  - Available
  - User friendly for near patient study
- May be predictor of AVF outcome
- May be used to aid diagnosis in AVAIS
- Further studies are required:
  - Monitoring AVAIS
  - Predicting and guiding banding procedures
  - Guiding surgical intervention

Thank you



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