

1 **Introduction**

2 Giant Cell Arteritis (GCA) is a major area of clinical risk, due to a combination of the
3 seriousness of the condition, challenges in its diagnosis and the associated morbidity of its
4 treatment. Admissions for investigation of suspected GCA currently shows an upward
5 trend [1]; hence a reliable, noninvasive test is required. Temporal artery biopsy (TAB) is
6 specific, but surgically invasive. Using ultrasound to identify temporal artery oedema (“the
7 halo sign”), stenosis and occlusion has gained popularity. A meta-analysis reported the
8 sensitivity and specificity for unilateral halo sign as 68% and 91%, respectively.[2]
9 Ultrasound is cheaper, non-invasive, permits longitudinal scanning for disease activity and
10 can be quicker to organise than TAB, but requires experience.[2,3] Magnetic resonance
11 imaging and angiography [4] has also been used to image the superficial temporal artery
12 but access and high expense has limited its widespread use.

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14 Optical Coherence Tomography (OCT) is a noninvasive interferometric optical imaging
15 modality [5]. Dermal OCT devices are capable of imaging tissues in vivo, including distinct
16 skin layers up to 2mm in depth, and the acquisition time is short. [6] Dermal OCT uses
17 longer infrared wavelengths (1300nm) compared to that conventionally used in ophthalmic
18 OCT (800 nm). Both dermatological and ophthalmic OCT machines have demonstrated
19 the ability to image arterial microvascular structures [7,8]. To the authors’ knowledge OCT
20 has not yet been used in GCA or health to image the superficial temporal artery (STA).

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26 **Materials and methods**

27 We used a commercially available dermatological multi-beam, Fourier-domain, swept
28 source OCT device (InVivoSight; Michelson Diagnostics, Kent, UK) with a wavelength of
29 1305nm (HSL- 2000; Santec Corp, Komaki, Japan), an axial optical resolution of 10 μ m
30 and lateral optical resolution of 7.5 μ m. The aim was to test the hypothesis that the STA
31 could be imaged using dermal OCT. We scanned eight individuals, all over the age of 50
32 years: five had a clinical diagnosis of GCA (TAB positive n=3; TAB negative n=2) and
33 three were healthy controls, with no prior history of GCA symptoms or ophthalmic history
34 (other than cataracts). Three cases are presented here to illustrate the preliminary imaging
35 findings. Ethical approval was obtained and informed consent was taken.

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37 **Results**

38 In this proof of concept case series eight individuals were scanned. In all eight (1) the STA
39 could be localized by palpation to align the OCT tracer beam, (2) the STA could be
40 identified on OCT 'free-run' mode and (3) the STA could then be captured, in part, on
41 'multi-scan' mode to obtain the desired 6.0 x 6.0mm grid of high-resolution stack of images
42 with 0.1mm separation between slices and 2.0mm slice depth.

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44 A specific limitation of the technology was found with depth of penetration at around 2mm,
45 therefore in some cases only the more proximal wall of the artery and lumen were
46 captured. A hyperreflective band that probably corresponds to elastin within the external
47 elastic lamina and possibly including the internal elastic lamina, distinguished artery from
48 vein. (figures1, 2A, 3). Signal drop out is seen on the images as linear artifact from skin
49 hairs. Where the whole circumference of the artery was captured in the image, a ratio of
50 band thickness (BT) to arterial lumen diameter (ALD) could be calculated (BT:ALD ratio)
51 using the device software.

52 The following 3 cases were chosen to demonstrate the capability of the device: Case 1
53 and 3 illustrate the ability to calculate the BT:ALD ratio and Case 2 shows the presence
54 and absence of the hyperreflective band.

55 **Case 1**

56 A 69 year old caucasian female presented with bilateral arteritic anterior ischemic optic
57 neuropathies. TAB was positive. Figure 1 images are from the contralateral side to TAB
58 site 9 months after diagnosis. The white arrows demonstrate a hyperreflective band
59 isolating the vessel lumen, corresponding to the thicker connective tissue wall of an artery
60 rather than vein. BT=22 μ m, ALD=240 μ m; BT:ALD ratio 0.092.

61 **Case 2**

62 A 68 old caucasian male diagnosed with unilateral arteritic anterior ischemic optic
63 neuropathy. TAB was positive. Images in figure 2 are taken 4 weeks post-diagnosis and
64 ongoing corticosteroid treatment. Figure 2A demonstrates the artery distal to TAB site;
65 figure 2B observes a vessel without the hyperreflective band likely to be a vein.

66 **Case 3**

67 A 72 year old systemically well caucasian male, was reviewed for cataracts (control). The
68 arrow demonstrates the hyperreflective band of the artery in figure 3. BT=21 μ m,
69 ALD=213 μ m; BT:ALD ratio 0.099.

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71 **Discussion**

72 We have demonstrated that transdermal OCT can identify the STA. The preliminary
73 images presented here need further validation. We found specific limitations of the
74 technology such as the depth of penetration; in some cases only the proximal vessel wall
75 and lumen were captured. Also artifact from overlying hairs masked image data that may
76 in future investigations be problematic. We did not attempt to scan the parietal branch of
77 the STA and given its position beyond the hairline may not be possible due to hair follicle

78 artifact. Current developments in the technology include enhanced depth imaging which
79 may see image data increased by 50% greater depth. No coupling agent was used and it
80 is probable in future investigations that this may reduce artifact.

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82 Potentially transdermal OCT has a number of advantages over TAB as it is quick and
83 noninvasive; and could be performed serially over time. OCT allows image acquisition by
84 a novice, permits detailed retrospective analysis of all images, with extremely high
85 resolution enabling assessment and measurement of structural changes down to a few
86 microns. The axial resolution of OCT images achieved here is less than 20 μm , up to 10
87 times higher than conventional ultrasound and magnetic resonance imaging.

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89 As a significant number of patients with large vessel GCA do not have demonstrable
90 temporal artery abnormalities this could limit the development of dermal OCT for GCA as
91 here we have only demonstrated imaging of the STA. Additionally current expense of the
92 platform may hinder widespread clinical access for cranial GCA.

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94 These cases provide a proof of concept that transdermal OCT can image parts of the STA.
95 A large scale validation study of this imaging modality is required to provide evidence that
96 this technique is meaningful in the diagnosis of GCA.

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103 **What was known before**

104 The diagnosis of GCA is an area of major challenge to rheumatologists, internal physicians
105 and ophthalmologists.

106 Imaging techniques for the STA that are currently being used both for diagnosis and
107 monitoring in GCA include ultrasound and magnetic resonance imaging/magnetic
108 resonance angiography.

109 Histopathology from a temporal artery biopsy is still considered the definitive investigation
110 for diagnosis of GCA.

111 **What this study adds**

112 This is the first report that the superficial temporal artery can be identified and imaged, in
113 part, non-invasively using a commercially-available dermal OCT instrument.

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115 **References**

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139 **Titles and legends to figures**

140 **Figure Legend**

141 Figure 1A, 1B and 1C are dermal OCT images from case 1. The white arrows highlights
142 the hyper-reflective band seen. Areas of loss of signal, relate to hair follicle artifact. (TAB
143 positive)

144 Figure 2 are dermal OCT images from Case 2. 2A demonstrates the STA distal to the
145 TAB site; 2B observes a vessel without the hyperreflective band likely to be a vein. (TAB
146 positive)

147 Figure 3 is a dermal OCT image from case 3, where the hyper-reflective band is identified
148 by the white arrow. (Control case)