Introduction

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

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

Materials and methods

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

Results

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

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

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

Case 1

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

Case 2

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

Case 3

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

Discussion

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

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

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

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

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

What was known before

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

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

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

What this study adds

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

References

1 Mollan SP, Begaj I, Mackie S, O'Sullivan EP, Denniston AK. Increase in admissions related to giant cell arteritis and polymyalgia rheumatica in the UK, 2002-13, without a decrease in associated sight loss: potential implications for service provision. *Rheumatology (Oxford)*. 2015;**54**:375-377.

2 Arida A, Kyprianou M, Kanakis M, Sfikakis PP. The diagnostic value of ultrasonography-derived edema of the temporal artery wall in giant cell arteritis: a second meta-analysis. *BMC Musculoskelet Disord.* 2010;**11**:44.

3 Czihal M, Zanker S, Rademacher A, Tatò F, Kuhlencordt PJ, Schulze-Koops H, *et al.* Sonographic and clinical pattern of extracranial and cranial giant cell arteritis. Scand J Rheumatol. 2012;**41**:231-236.

4 Rhéaume M, Rebello R, Pagnoux C, Carette S, Clements-Baker M, Cohen-Hallaleh V, *et al*. Accuracy of High Resolution MRI of Scalp Arteries for the Diagnosis of Giant Cell Arteritis: Results of a Prospective Study. *Arthritis Rheumatol.* 2014;**66**:S390–S391.

5 Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W *et al*. Optical coherence tomography. *Science* 1991; **254**:1178-81.

6 Sattler E, Kästle R, Welzel J. Optical coherence tomography in dermatology. *J Biomed Opt* 2013;**18**:061224. doi: 10.1117/1.JBO.18.6.061224.

7 Yonetsu T, Bouma BE, Kato K, Fujimoto JG, Jang IK. Optical coherence tomography– 15 years in cardiology. *Circ J* 2013;**77**:1933-1940.

8 Ouyang Y, Shao Q, Scharf D, Heussen FM. An easy method to differentiate retinal arteries from veins by spectral domain optical coherence tomography: retrospective, observational case series *BMC Ophthalmology* 2014; **14**:66 doi:10.1186/1471-2415-14-66.

Titles and legends to figures

Figure Legend

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

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

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