

Visualization of accessory root of Trigeminal Nerve using HFMRI: potential for preoperative planning

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INTRODUCTION Trigeminal neuralgia (TN) is a disorder characterized by intermittent episodes of acute lancinating facial pain in the somatosensory distribution of the Trigeminal Nerve produced by exposure to non-painful and often routine stimuli [1]. The exact pathophysiological mechanism in TN remains unknown although it is widely thought that it is a result of abnormal pulsatile vascular compression of the sensory root of the Trigeminal Nerve at the Nerve Root Entry Zone or REZ by adjacent vascular loops. However, similar degrees of proximity of the sensory root of the Trigeminal Nerve and vascular loops can also be found in normal individuals. It is unknown however, if inter-individual variations in the precise location of the REZ (which has been known to vary in length between individuals) or aberrant presence of sensory fibers in the adjacent motor rootlets or accessory rootlets of the Trigeminal nerve can account for these apparently contradictory phenomena. Currently, it is difficult to precisely localize the REZ or identify all the accessory rootlets of the Trigeminal Nerve with conventional MRI imaging, although this may have a significant impact on therapeutic decisions, especially when surgery is considered. Here we explore the feasibility of identifying the REZ and accessory rootlets of the Trigeminal Nerve at 7 Tesla.

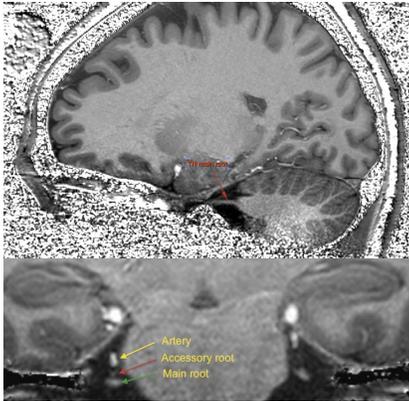


Fig. 1A (top) and 1.B (Bottom)

METHODS Healthy volunteers who signed an informed consent were imaged on a 7T scanner (Siemens Germany) with a 32-Rx channel coil (Nova Medical, MA). Two dielectric pads (15 cm x 10cm x 1 cm) filled 40% aqueous suspension of CaTiO₃ were positioned on each side of the head to improve transmit B1 profiles [2]. Flip angle maps were obtained with AFI [3] to adjust RF voltage. 3D volumes were acquired at isotropic 0.6mm resolution with the following contrasts: **a) T1w-MPRAGE:** TR/TE/TI= 3100/3.5/1500 ms, FA=6°, GRAPPA=2 **b) Proton Density weighted-3D Gradient Echo (PDwGE):** same as a) without inversion, TR=2160 ms and FA=4°, GRAPPA=2 **c) T2w-GE:** TR/TE= 4910/16ms, FA=5°, GRAPPA=3. After identify the trigeminal nerves on T1wMPRAGE images, high resolution multi-slice T2w-TSE images were collected in oblique coronal/axial views (0.25x0.25x0.8 mm³, TR/TE= 6000/56 ms) positioned perpendicularly to the main root of both trigeminal nerves, with 32 contiguous slices encompassing the REZ and the main root of the trigeminal nerve, up to the trigeminal ganglion. As previously described [4], the 32 slices were scanned in two separate runs (16 odd- and 16 even-numbered slices) with three averages each. Lower resolution, 32 contiguous slices T2-TSE were then acquired in a single run and used as reference to co-register the odd- and even-numbered stacks of slices with SPM (<http://www.fil.ion.ucl.ac.uk/spm>). The T1wMPRAGE volume was divided by PDwGE (T1w/PDw) to eliminate receive sensitivity profile and T2* contrast [5]. T1wMPRAGE was also divided by T2w-GE (T1w/T2w) to enhance T2* weight in T1w images, thereby increasing sensitivity to myelo-architectural features as previously shown in the cortex at 7T.

RESULTS

All data shown here are from a single, 59y.o.subject. As seen in Fig. 1A in a sagittal view of a T1w/PDw ratio, the trigeminal nerve path can clearly be followed between brain stem and

trigeminal ganglion. On a coronal oblique view (Fig. 1B) one can identify an accessory root of the trigeminal nerve between the main root of the nerve

and an artery. These structural components are even better individualized at higher in-plane spatial resolution on the T2w-TSE data set. Shown Figs. 2A&B, oblique coronal views at two positions posterior to the trigeminal ganglion unveil sharp details of the main and accessory roots of the nerve, as well as of surrounding vessels (veins are dark, arteries are bright). Fiber bundles can be individualized inside the main root. Further exploring another data set, i.e. the T1w/T2w ratio volume shown in Fig. 3A, a change in contrast is observed when traveling along the path of the main root of the trigeminal nerve; given the known sensitivity of such images to myelin-related contrast in the cortex, we hypothesize that the position of this contrast change may potentially correspond to the transitional zone from central to peripheral myelin (see discussion).

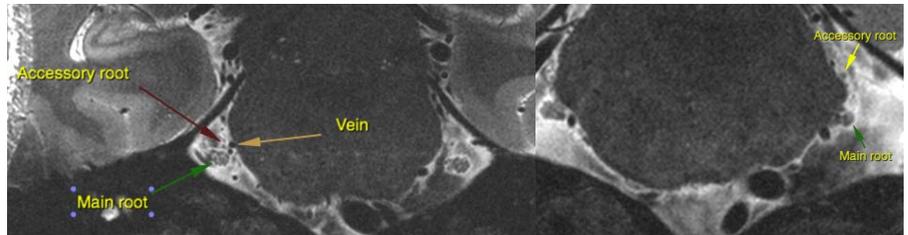


Fig. 2A (left) and 2B (right)

DISCUSSION In our study, we found that there was a variation of the signal intensity of the sensory root of the Trigeminal Nerve along its length, with a short central segment of the nerve root near the junction of the nerve with the ventral surface of the Pons showing higher signal intensity on the T1/T2* images when compared to the longer more peripheral segment of the nerve (Note the color scale of the image Figure 2a has been inverted for the purposes of display). We speculate that the difference is signal intensity between these two segments is caused by the differences in their myelination with the higher iron content of oligodendrocytes resulting in higher T1/T2* signal intensity in the short central segment. If this finding can be confirmed on future studies and can be correlated with histology, the junction between these two zones of the Trigeminal nerve on this imaging sequence may represent the REZ. We also found that we could accurately identify the accessory and motor rootlets of the trigeminal Nerve as well as adjacent small vasculature with a high degree of accuracy using high resolution T1 and T2 images. Further, by comparing the signal intensity of these small vessels on the T1 and T2 weighted images, it was also possible to accurately identify them as arteries (bright on T1 and dark on T2) or veins (dark on both). Therefore high resolution imaging of the Trigeminal Nerve at 7 Tesla has the potential to further our understanding of the pathophysiology of this disorder and ultimately provide new therapeutic guidelines and directions.

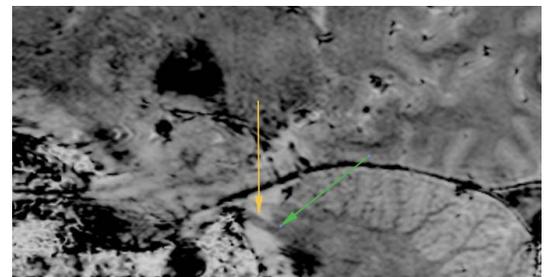


Fig. 3

REFERENCES: [1] Merskey, H et al. 1994, ISASP Press [2] Haines et al. JMR 2010 [3] Yarnykh, V. et al MRM [4] Henry T. et al, Radiology 2011 [5] Van de Moortele et al. NeuroImage 2009 **Acknowledgment:** NIH P41 EB015894, S10 RR26783, P30 NS076408, KECK Foundation