Orbit Fat Suppression at Canon Vantage Galan 3T Scanner

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In general, both subcutaneous and visceral fat mainly contain saturated fatty acids (or aliphatic fat) which resonate at +3.5 ppm from water signal as a center frequency (f0). Thus, standard fat-suppression (FatSat) imaging by applying a fat suppression pulse like chemical-shift selective (CHESS) and spectral adiabatic inversion recovery (SPAIR) works well in most fat suppression in bone, subcutaneous, and visceral regions. However, the fat content of the orbit is unique, containing a higher proportion of unsaturated or olefinic fat, as compared to other fatty tissues. Therefore, adequate olefinic fat suppression is required for high quality orbital imaging to better delineate both inflammatory and neoplastic processes. Unfortunately, olefinic fat resonates only -0.5 ppm from the water f0, as shown in Figure 1. This close proximity to water resonance results in incomplete fat-suppression by chemical-shift selective methods.

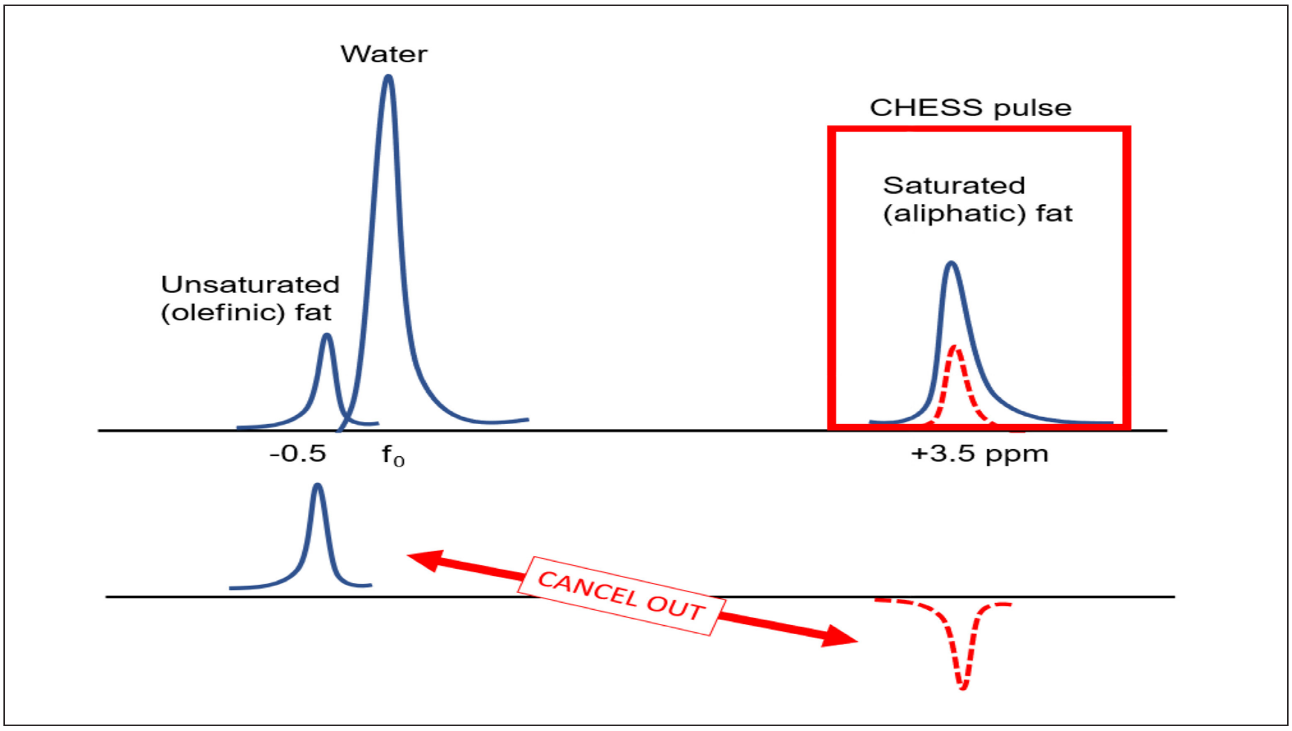

Figure 1 Frequency of aliphatic and olefinic fatty signals, corresponding to water as a center frequency. Once the CHESS pulse is applied, due to the impairment of T1, the residual signal is remained (red-dotted line). Then water-fat opposed phase (WFOP) method cancels out with olefinic fat.

To suppress both aliphatic and olefinic fat signals, our approach utilizes a combination of CHESS and water-fat opposed phase (WFOP). As shown in Figure 1, the first 90-degree CHESS pulse unmasks the presence of residual aliphatic fat signal due to the impaired T1 recovery. Subsequently, we applied WFOP by shifting the chemical shift of opposed phase by shifting a $\delta T/2$ (at 3T in-phase is 2.2 ms and thus $\delta T/2=1.1$ ms) to collecting echoes in the readout. As a result, we cancel out the residual aliphatic fat with the olefinic fat.

Figure 2 shows T1 images with and without CHESS fat suppression.

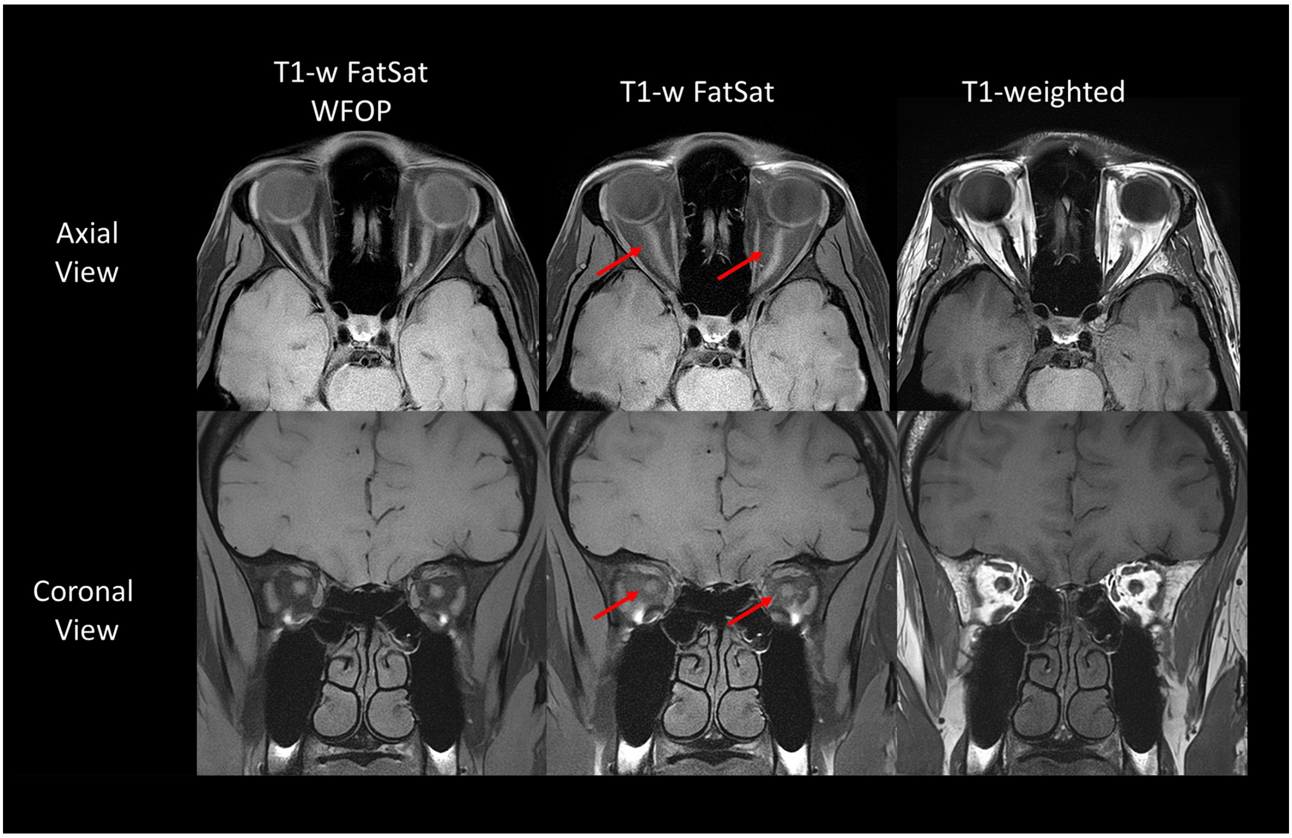

Figure 2 T1-weighted image with FatSat and WFOP (first column), with FatSat (second column), and without FatSat (third column). Orbit with only fat suppression (FatSat) does not eliminate all fat signals in the orbits (red arrows).

Note that CHESS fat suppression does not provide complete fat suppression due to the presence of olefinic fat signals. Figure 3 shows complete orbit fat suppression in both axial and coronal images by the addition of WFOP. The patient has a very subtle optic neuritis.

In conclusion, this tailored technique has helped us to achieve complete fat suppression in the orbit utilizing a combination of CHESS and WFOP technique without added scan time. This affords improved clinical diagnostic yield of orbital MRI, particularly in detailing infection, inflammatory and neoplastic processes of the extraocular muscles, lacrimal glands and the optic nerves.

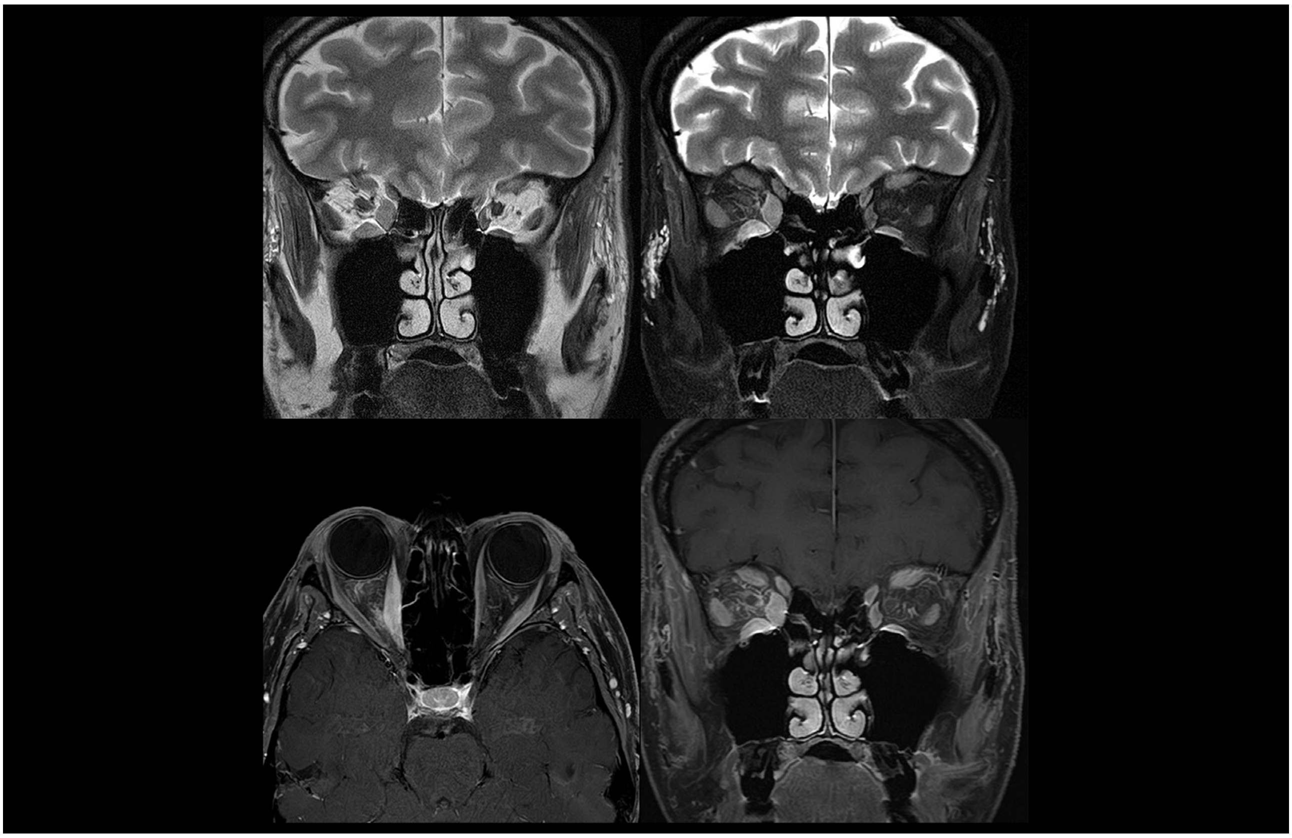

Figure 3 FatSat combined with WFOP allows all fat signals suppressed in the orbits. Axial and Coronal T1 with Gadolinium administration. Top left: Coronal T2; Top right: Coronal T2 with FatSat; Bottom left: Axial T1 with FatSat, WFOP, and Gadolinium administration; Bottom right: Coronal T1 with FatSat, WFOP, and Gadolinium administration.

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