Quantitative and qualitative characterization of vascularization and hemodynamics in head and neck tumors with a 3D magnetic resonance - time-resolved echo-shared angiographic technique (TREAT)

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Purpose
To characterize and quantify the vascularization and hemodynamic properties of head and neck tumors (HNT) with a dynamic 3D time-resolved echo-shared angiographic technique (TREAT) during the administration of a regular contrast agent (CA) bolus.

Material and Methods
Sixteen patients with HNT referred for morphological assessment of the tumor extent with magnetic resonance imaging (MRI) underwent 3D-TREAT during the regular CA administration on a 1.5T MR-scanner (Magnetom SONATA, Siemens). Using integrated parallel imaging techniques (GRAPPA [1]) with an acceleration factor of 2, 20 3D-data sets with high spatial resolution of 2.1x1.3x3mm³ were acquired. The sequence parameters of the TREAT were: TR – 2.29 msec /TE – 0.95 msec /FA – 25° /FOV – 360x360 mm /Matrix – 256x179 /iPAT – GRAPPA Factor 2 /BW – 810 Hz/Pixel / Number of TREAT Segments - 3. TREAT updates the central k-space parts more often than the k-space periphery. View-sharing techniques are used to fill in the missing k-space parts [2]. A spiral-radial k-space reordering was used. Together with parallel imaging techniques a temporal resolution of one entire 3D-data set every 2.3 seconds was achieved. The first frame with complete k-space acquisition was used as a subtraction mask. T1 weighted (w) pre- and post-contrast gradient-echo-sequences (GE) were also obtained. The quality of tumor delineation, vascularization type (arterial, intermediate, venous), enhancement pattern and secondary effects (shunting, vessel occlusion, collaterals and flow asymmetry) were evaluated in consensus by two radiologists. Quantitative assessment included measurements of signal-intensity-over-time (SIT) curves, time-to-peak enhancement within the carotid arteries and the tumor (TPC, TPT) and the difference between both (deltaTP). TREAT was compared to catheter-based digital subtraction angiography (DSA) in 6 patients.

Results
Tumor delineation with TREAT was very good or good in 13/16 patients and better with TREAT than with DSA in 3/6 cases. Figure 1 presents an example of a hypervascularized glomus tumor. For hypervascularized and hypovascularized tumors distinct SIT curves could found (Figure 2). CNR was statistically significantly different for glomus tumors versus hypo-vascularized malignant tumors with TREAT ($p=0.0001$) but not on T1w GE images. Semi-quantitative assessment of tumor vascularization on dynamic TREAT shows good correlation to quantitative SIT-curves. TREAT identified additional secondary findings, like vessel occlusion, flow asymmetry and collateral formation in 11/16 patients which were not seen with regular T1w GE images.

Conclusion
Dynamic TREAT during the administration of a regular CA bolus permits the characterization of tumor vascularity and holds promise for a supplementary diagnostic tool in the differential diagnosis of HNT. TREAT imaging offers additional information to the standard T1w GE imaging without requiring additional contrast agent or scan time.
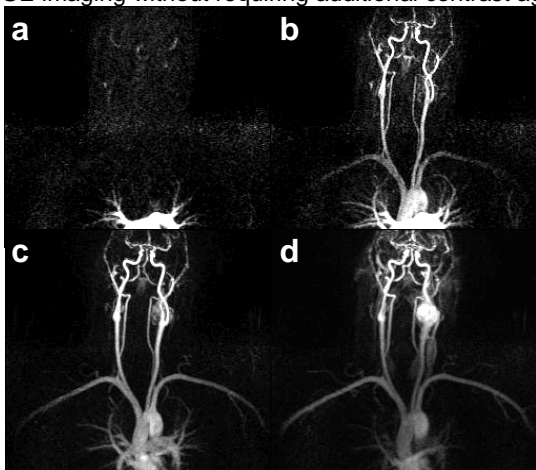

Figure 1 Exemplary images taken from the TREAT sequence showing a hypervascularized glomus tumor of the left carotid bifurcation.
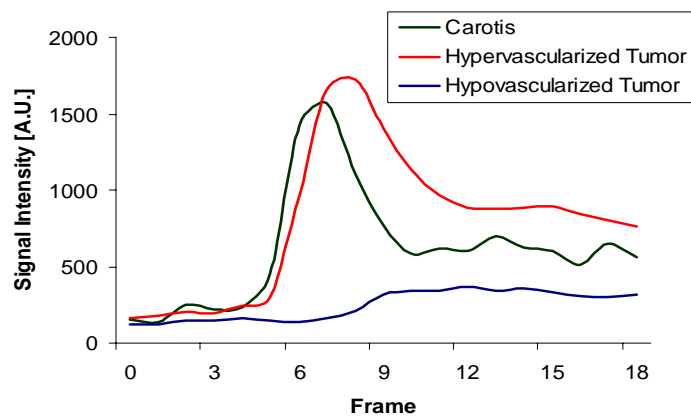
Figure 2 Signal intensity versus time curves for the carotid arteries (green), a hypervascularized tumor (red) and a hypovascularized tumor (blue). As seen above hypervascularized tumors exhibit a peak 1-2 frames after the carotid arteries. Hypovascularized tumors in contrast show rather a plateau than a distinct peak which occurs 4-5 frames after the carotid artery peak.

References
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2. Korosec, F.R., et al., Time-resolved contrast-enhanced 3D MR angiography. Magn Reson Med, 1996. 36(3): p. 345-51.