# 3D Volume Selective TSE for carotid artery wall imaging with navigator detection of swallowing

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**Aim**

Improvement of 3D volume selective TSE carotid artery wall imaging by the addition of navigators to reduce artefacts caused by swallowing.

**Introduction**

As atherosclerosis and arterial wall imaging becomes increasingly common in a clinical setting,[1,2,3] it is important to optimise the techniques used. In 3D volume selective TSE[4] scans of carotid artery, blurred images have been observed when scanning patients and have been attributed to swallowing/throat motion during the scan. Artefacts may be caused by motion of the vessel, surrounding tissue or by the change in blood flow patterns caused by the increase in heart rate on swallowing. Similar effects have been observed in other carotid imaging MR techniques.[5] Detection and removal of this motion is needed to improve 3D scans. Typical scans are acquired during free breathing, meaning that swallowing is more likely to occur than during a short breathhold scan. During a 3D acquisition a single, badly timed swallow may affect the whole slab image quality.

**Methods**

Images were acquired on a Siemens Magnetom Sonata 1.5T scanner. 3D volume selective TSE scans of carotid artery were acquired in 6 healthy volunteers. The FOV used was 120 x 24 mm and imaging matrix size was 256x52 giving a true pixel size of 0.47 mm x 0.47 mm (which was reconstructed to higher resolution). A total of 18 2mm thick slices were acquired, with the central slices located around the bifurcation. An echo train length of 11 echoes per cardiac cycle was used to fit the scan within the desired acquisition window (65 ms) to avoid motion blurring of the vessel wall due to pulsatility. For $T_1$ weighting, TE was 11ms.

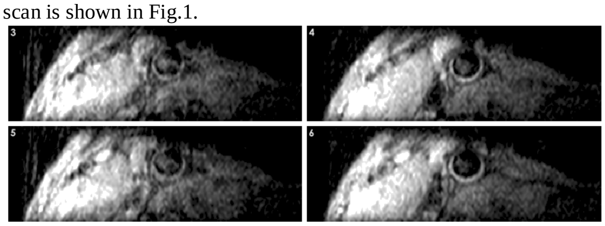
A cross-pair navigator placed on back of the tongue was used to detect swallowing. The navigator was acquired in all scans, either with just monitoring or with an accept/reject algorithm. Prospective navigator gating with a ±2mm acceptance window was used. Two swallowing patterns were tested, for one navigator and one non–navigator acquisition, subjects were asked to swallow half way through the scan (k-space centre) to represent a worst case single swallow and, for the others, subjects swallowed regularly, as often as physically possible. This was around every 10-20 seconds during a 2 minute scan. Signal intensity in the lumen (i.e quality of blood suppression) was quantified and the images were ranked by 4 observers in terms of the clarity of the vessel wall. For this, eleven slices in the common carotid and start of the bifurcation were graded on a scale of 0-5 and this was taken as an average image quality for each 3D scan.

**Results and Discussion**

In general, higher signal intensity is recorded in the lumen as well as increased blurring and ghosting on scans without navigator control. Table 1 shows the comparison of intra-luminal signals where the difference is likely either to be an effect of a decrease in double inversion/blood suppression efficiency due to heart rate changes at the point of swallowing, or due to increased motional blurring/ghosting of tissue into the lumen. There was one exception, where no significant difference was observed, however this subject had poorer overall SNR due to coil positioning, The blurring and ghosting in the $k_z$ (slice) and $k_y$(phase-encode) directions causes a reduction in image quality throughout the 3D slab. A comparison of two slices from a typical scan is shown in Fig.1.

Table 1. Lumen signal intensity

| Subject | No navigator | Navigator | %Difference |
|---|---|---|---|
| 1 | 53.36 | 36.71 | 45.4 |
| 2 | 20.86 | 21.83 | -4.4 |
| 3 | 73.79 | 59.58 | 23.9 |
| 4 | 71.20 | 45.90 | 55.1 |
| 5 | 36.29 | 27.19 | 33.4 |
| 6 | 34.82 | 29.53 | 17.9 |




No navigator Navigator control

Figure 1. Comparison of image quality in the common carotid.

Results of statistical analysis of image quality, in terms of clarity of vessel wall inner and outer boundaries show a significant difference between navigated and non-navigated scans by 4 independent observers. The difference in mean score between navigator and non navigator images was on average greater than 0.6 (on a scoring scale of 0-5) and p values for all observers were less than 0.01.

Apart from one pair, all navigator images were scored higher than the non-navigator scan on the same subject with the same swallowing pattern. The one exception is likely to result from a poor choice of navigator window, as several lines were wrongly accepted during the swallowing motion as an alternative edge in the navigator trace came in to the acceptance window.

In general, the central swallow scans were scored higher than the random swallow scans. Heart rate was seen to increase on swallowing and often lasted for one or two cardiac cycles after the navigator returned to the normal accept position. The effect of the increased heart rate after a swallow is likely to have an effect on double inversion, blood suppression efficiency and therefore the increased amount of heart rate changes with repeated swallowing will have more effect on a scan, even if the navigator rejects scans during the swallowing motion. A further improvement to this technique might be to use additional arrhythmia rejection that will also reject the additional short cycles that follow the swallow or to incorporate a more intelligent algorithm that will calculate the required double inversion time, which will be automatically adjusted during the scan.

**Conclusions**

Clarity of vessel wall delineation and the apparent efficiency of blood suppression are reduced by swallowing during acquisition. The image quality can be improved using a navigator accept/reject method. Even with the subjects swallowing as often as possible, the acceptance rate of the navigator sequence was >70%, therefore it is possible that this technique could be applied as a standard ‘safety net’ feature to help in the case of swallowing without affecting the image acquisition, or increasing the scan time, significantly. This would help significantly in scans of the order of a few minutes long where a single movement during the scan can affect image quality.

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