3D Free-Breathing and Motion-Insensitive Post-Contrast Brain and Spine MRI at 3T in Pediatric Patients using a Golden Angle Radial Acquisition

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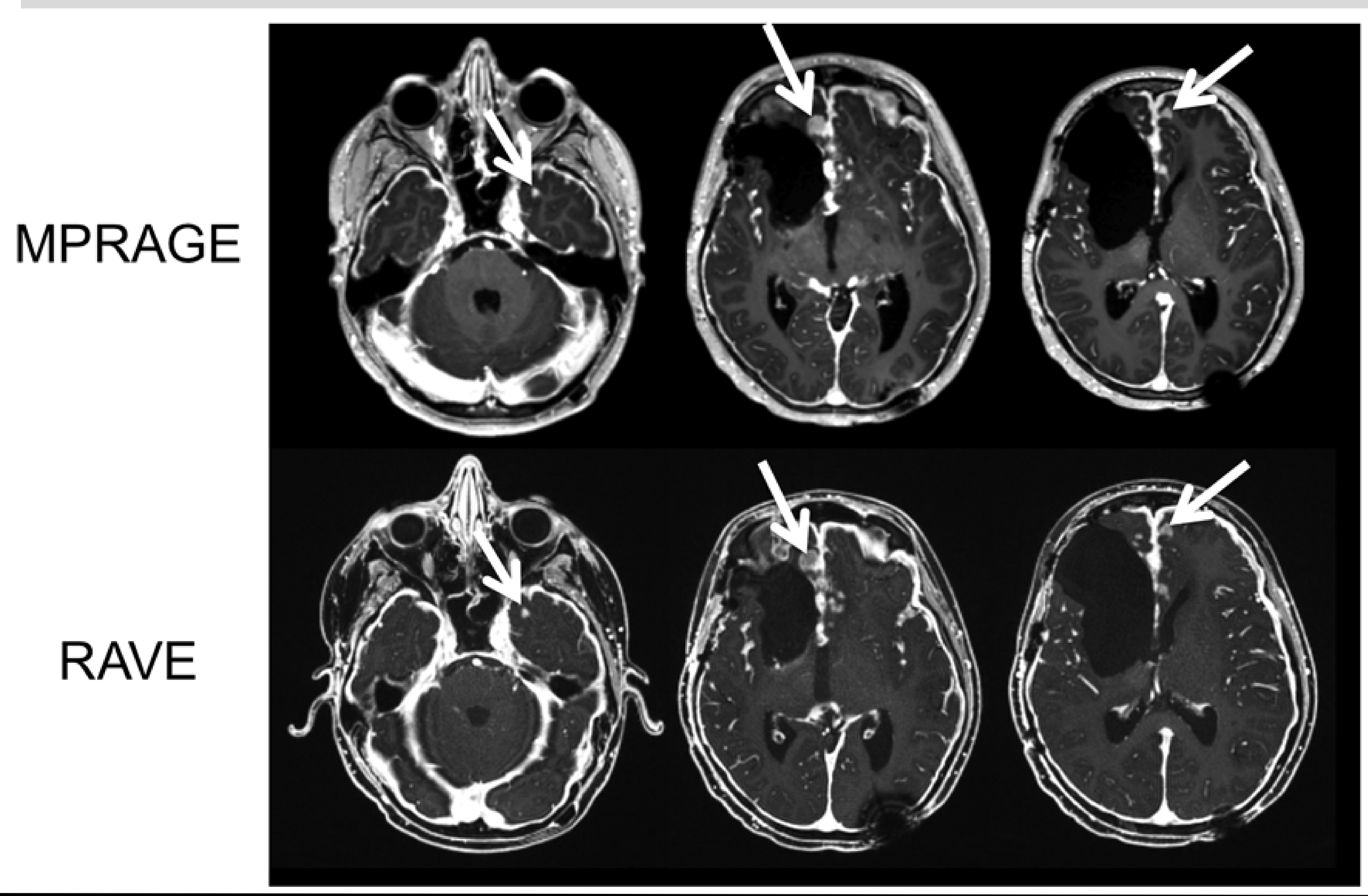
INTRODUCTION

Free-breathing MRI scans are attractive and of high-value in pediatric imaging, as they reduce the need for breath-holds in children. The scans can remove the need for patients to strictly follow technologist instructions on breath-holding, and are helpful when patients can not comprehend or do not speak the communication language. **Free-breathing MRI scans that are less sensitive to involuntary physiological motion (i.e., respiratory, gastrointenstinal, flow) are also of high clinical value** as they can remove the need for prospective signal gating.

Since September 2017, we have been evaluating **a free-breathing 3D non-Cartesian radial T1w "stack of stars" gradient echo acquisition called 3D RAVE-Radial Volumetric Encoding (i.e., Siemens StarVIBE) in post-Gd-contrast brain and spine MRI.** The RAVE sequence is now **routinely** integrated into our neural protocols. In this work, we demonstrate the benefits of RAVE MRI on a **Siemens 3T Prisma platform.**

METHODS - BRAIN

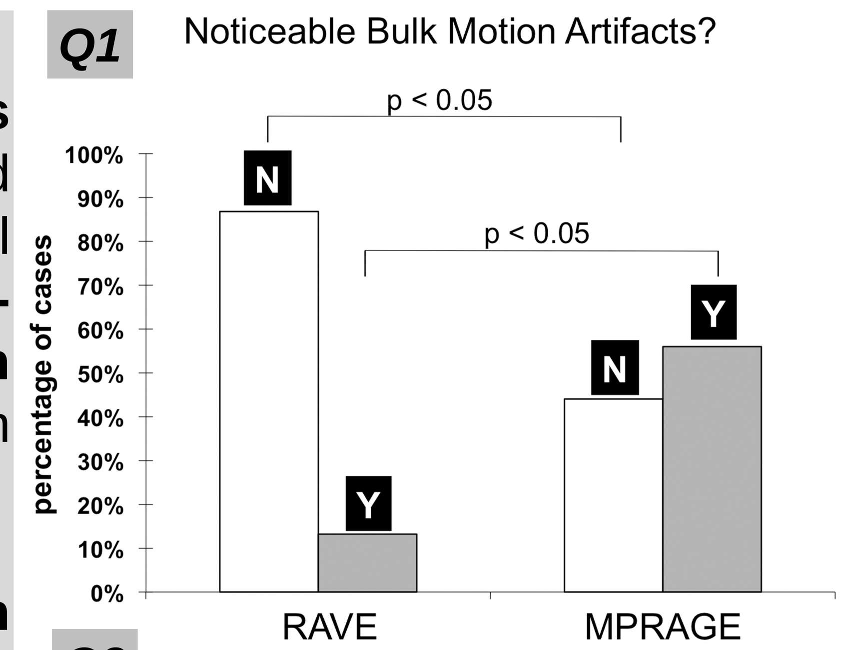
We evaluated RAVE in **54 patients** (mean age: 12 years) referred for brain MRI exams with contrast. Upon injection of standard dose Gd contrast media, data from a RAVE acquisition and a conventional 3D MPRAGE were implemented (MPRAGE always first). The two scans were matched in 1 mm native isotropic spatial resolution and whole-brain volume coverage. On average, the MPRAGE acquisition took 5-6 minutes to complete, where as the RAVE scan is ~25-30% faster at 400 spokes/slice. Two radiologists independently compared the data using 3 questions: ***(Q1)*** Is there bulk motion in MPRAGE (Y/N)? In RAVE (Y/N)? ***(Q2)*** What is the overall preference for image quality and lesion conspicuity (if any)? RAVE preferred, equal, MPRAGE preferred. ***(Q3)*** Would the same diagnosis have been made if RAVE was acquired in lieu of MPRAGE (Y/N)?



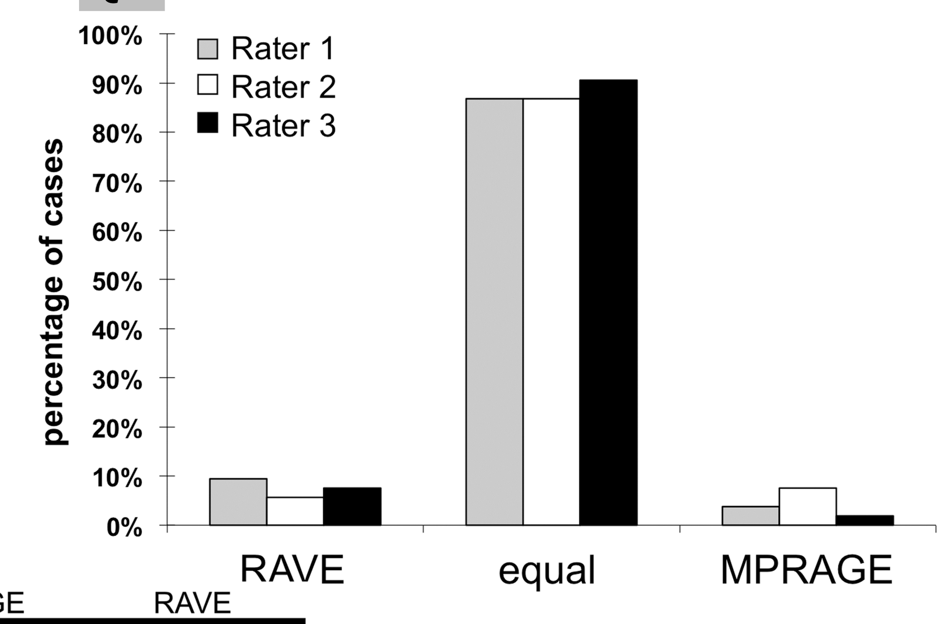
Exemplary images from a 13y male with multiple metastatic nodules (arrows), all of which are clearly seen with equal conspicuity in MPRAGE and RAVE scans.

In all cases, radiologists were able to make the same diagnosis with MPRAGE or RAVE.

Q1 Noticeable Bulk Motion Artifacts?

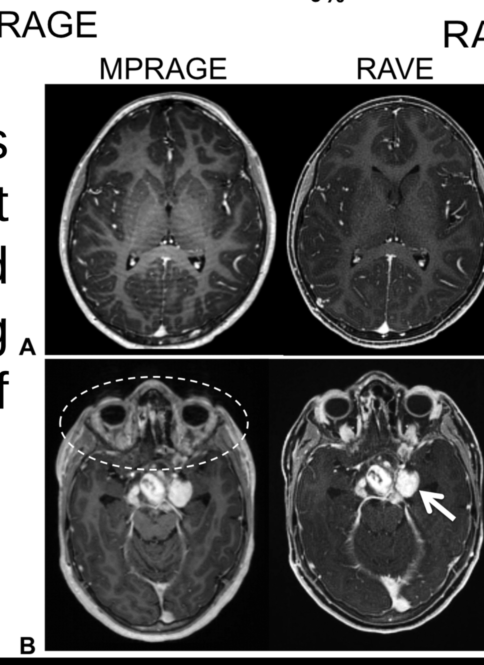


Q2 Preference?

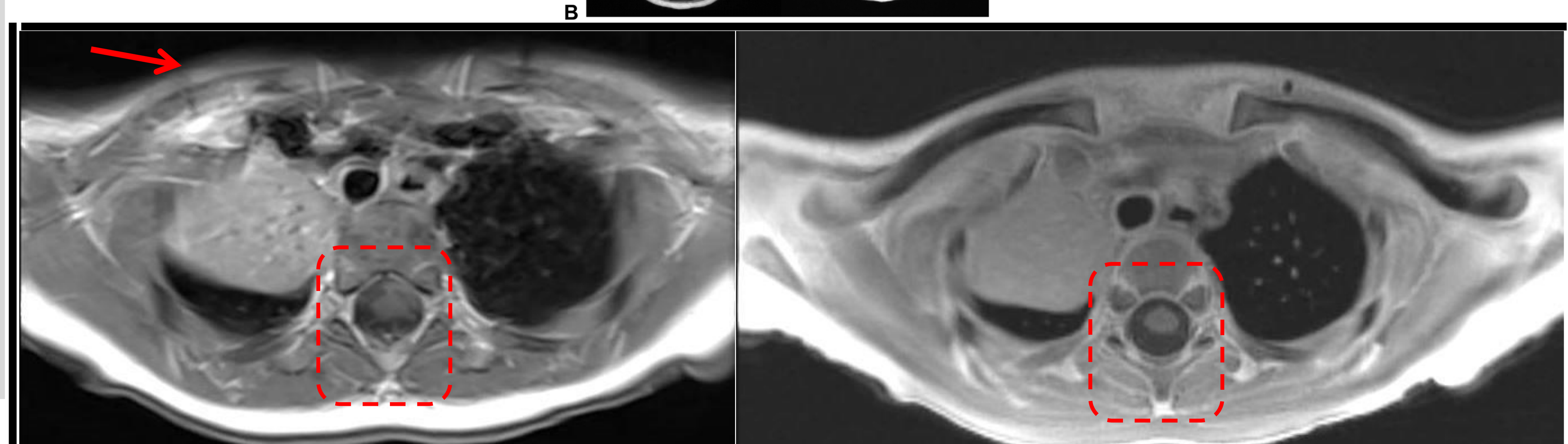


Q3

For *Q3*, both radiologists felt that in all cases that the same diagnosis would have been reached using only RAVE in place of MPRAGE.

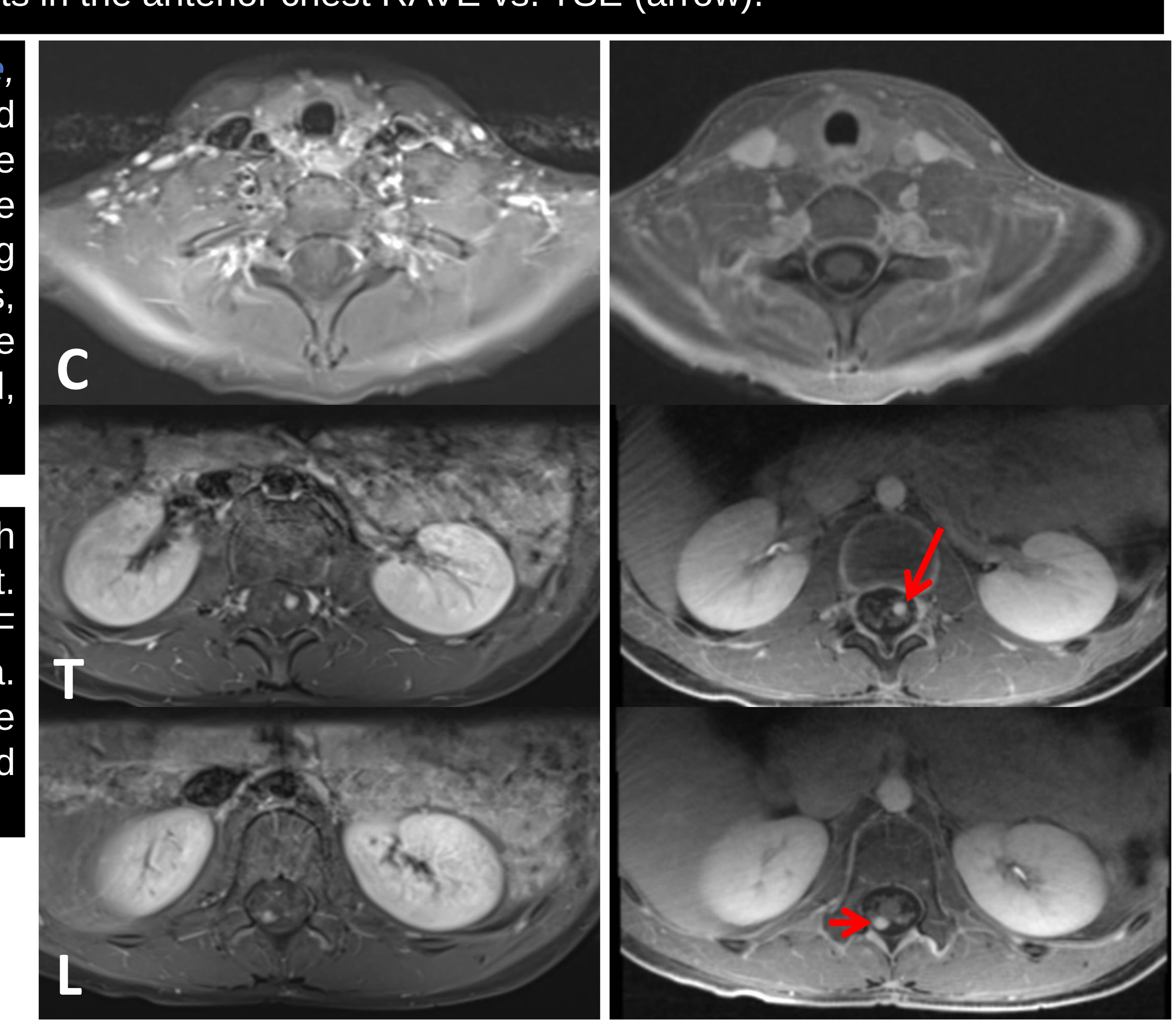


(A) a *12y boy* and **(B)** a *13y girl* with a solid and cystic suprasellar mass (arrow). In the MPRAGE scans, note significant ringing artifacts due to head motion in **(A)** as well as blurring effects due to eye motion (dashed oval) in **(B)**. Corresponding RAVE scans do not exhibit any noticeable motion artifacts, whilst maintaining lesion conspicuity of the suprasellar mass.



Exemplary data in a *3y male*, with TSE data on the left, and RAVE data on the right. Note improved clarity of the spinal cord and CSF with RAVE (dashed region). Scans were free-breathing. Note also the lack of motion corrupted artifacts in the anterior chest RAVE vs. TSE (arrow).

Exemplary data in a *10y female*, with TSE data on the left, and RAVE data on the right. In the lower spine, there are multiple enhancing nodules (arrows) along the cauda equina nerve roots, indicative of schwannomas. Note improved clarity of the spinal cord, CSF and nerve roots with RAVE.



QR codes show axial fly-through movies in a *14y female* patient. Note greater spinal cord-CSF signal contrast in the RAVE data. Nerve roots and individual nerve bundles are also better visualized with RAVE.

TSE RAVE

METHODS - SPINE

We compared RAVE to conventional T1w FSE/TSE in **32 patients** to date (mean age: 12.2 years). Patients were scheduled for routine exams of their spine with contrast for clinical indications. **All scans were acquired free-breathing.**

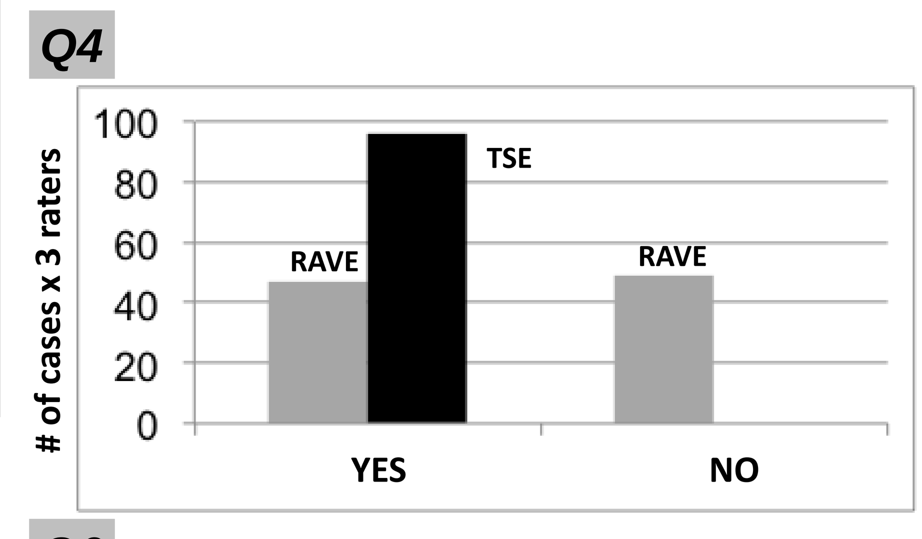
Typical imaging parameters for axial TSE were: 0.6mm in-plane resolution, 5mm slices with 5-6mm gap, TR/TE 610/9.1ms, no parallel imaging, two signal averages, bandwidth 270Hz/pixel, 150 refocusing angle, echo train length 3, and anterior suppression slabs over the chest and abdomen. The RAVE spoiled gradient echo sequence used 0.7mm in-plane resolution, 3mm contiguous slices, TR/TE 4.5/2.1ms, 600-700 radial spokes per slice, 10% slice oversampling, no parallel imaging, no suppression slabs, frequency-selective fat suppression, bandwidth 490Hz/pixel.

Spine results were reviewed by 3 attending neural radiologists. The following 3 questions were asked:

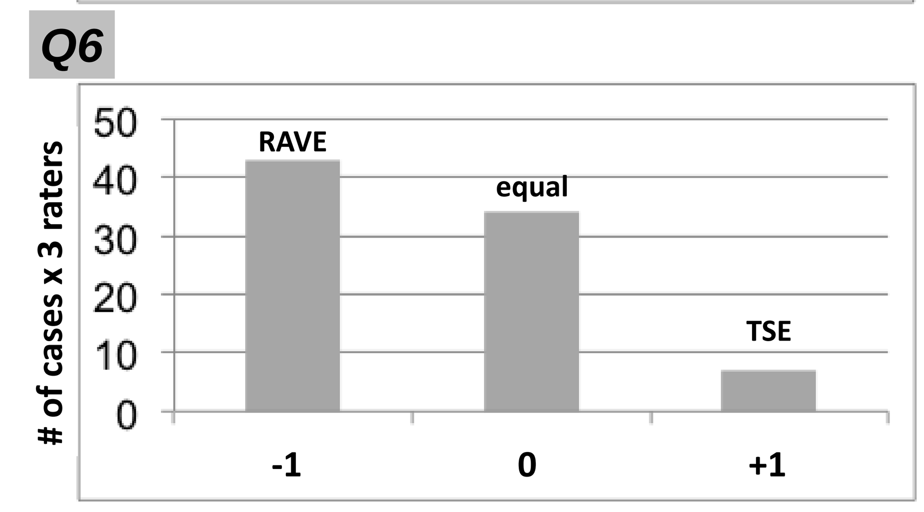
- ***Q4:*** **Is there significant physiological motion in RAVE (Y/N)? In TSE (Y/N)?**
- ***Q5:*** **Using a 4-point scale, can you visualize and characterize dorsal and ventral nerve roots at C5/C6, T5/T6, and L3/cauda equina levels for RAVE and TSE?**
  - *1: clearly visible*
  - *2: partially visible - high confidence*
  - *3: partially visible - low confidence*
  - *4: barely visible*
- ***Q6:*** **If pathology was present, which was preferred?**
  -1: RAVE, 0: equal, +1: TSE

SCAN QR CODES FOR MOVIES

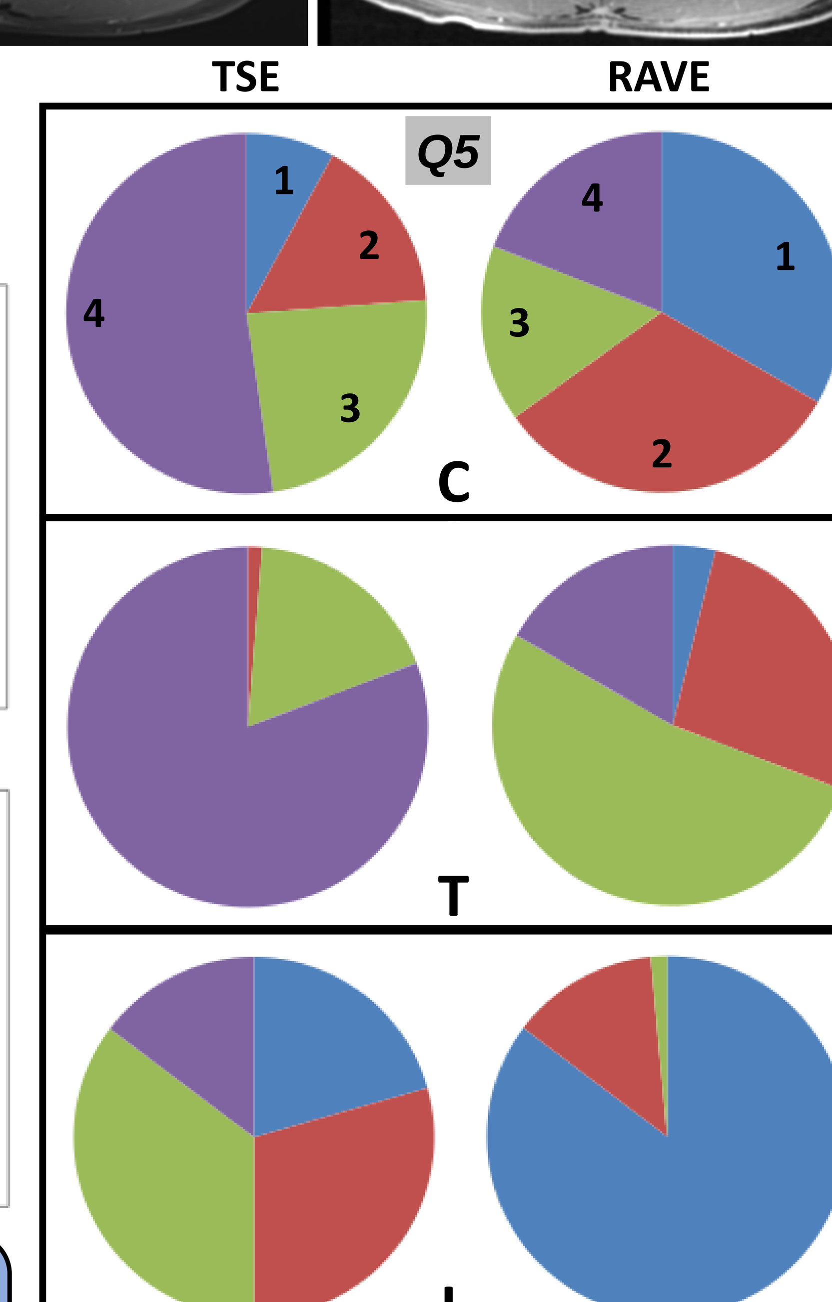
Q4



Q6



Q5



"TAKE HOME MESSAGE"

In the spine where physiological motion and CSF pulsation can frequently hamper diagnostic image quality, RAVE is superior in visualizing nerve roots and extramedullary metastases than than traditional 2D multi-slice fast-spin-echo (FSE/TSE) acquisitions. In the brain, our preliminary experience has demonstrated that the radial fat-suppressed T1-weighted 3D gradient-echo pulse sequence can yield diagnostically useful images with strong immunity to bulk motion. **RAVE has provided our neuroradiology practice with a more confident "first-time-right" protocol with the potential to reduce the need for repeat scans.**

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