3D ultra-short TE imaging of the spine for vertebral segmentation

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TARGET AUDIENCE

MRI researchers in ultra-short TE and spine imaging; researchers who study the functioning, development and diseases of the spine

PURPOSE

The ability to segment and reconstruct 3D vertebral models from spine images can be important for functional, developmental and diagnostic assessment of the spinal column. For instance, such models can facilitate 3D quantification of scoliotic deformity [1] and functional evaluation of motion segment [2]. Since cortical bone has T2* in sub-milliseconds while tendons and ligaments have T2* under 10ms [3], these structures usually appear dark in conventional MRI. As a result, cortical bone may not be separable from its neighboring connective tissues, hindering its segmentation. In recent years, ultra-short TE (UTE) sequences[3] with minimum TE in tens of micro-seconds provide higher signal for the short T2* connective tissues, potentially distinguishing them from the cortical bone. Our objective is to evaluate the use of UTE imaging for improved visualization and segmentation of vertebrae in the spine.

METHODS

The study was conducted on a Siemens TRIO 3T system using a spine MATRIX coil. Two normal subjects (age 22 and 24; weight 162 and 135 lbs) were imaged. Both subjects were instructed not to move during MRI scan, and one subject was also instructed to breathe quietly. A Siemens work-in-progress 3D UTE sequence with radial sampling was used with TR=8.0ms, TE=0.07ms, flip angle=8^0, FOV=24cm, receive bandwidth=801Hz/pixel, and imaging time=10 min 40 sec. With number of radial views=80000, the Nyquist equivalent matrix size was 115 and image resolution was 2.0x2.0x2.0 mm^3. Images were also acquired with 3D CISS, which has been used for bone imaging [4], using TR=4.76ms, TE=2.38ms, flip angle=38^0, resolution=1.0x1.0x1.0 mm^3, receive bandwidth =930Hz/pixel and imaging time=5 min 13 sec. The UTE and CISS were compared with respect to the ease of bone segmentation.

RESULTS

Outlines of the vertebrae from L1 to L5 could always be discerned from the surrounding soft tissues using UTE. However, for CISS the cortical bone, ligament and articular capsule appear to have similar signal intensities, making vertebrae segmentation challenging.

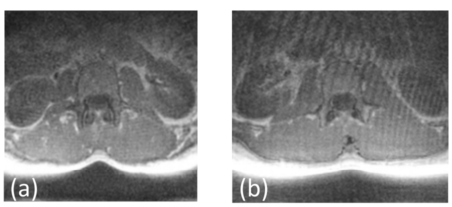

Fig. 1: Images obtained (a) with and (b) without explicit instruction to breathe quietly. It reveals that (b) shows significantly more artifacts than (a).

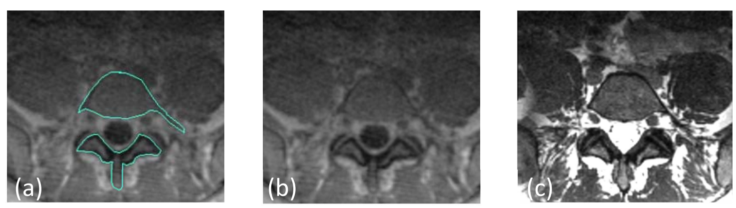

Fig. 2: (a) Segmented vertebra from UTE, (b) UTE, (c) CISS. UTE distinguishes posterior elements of the vertebra from other tissues better than CISS.

DISCUSSION

We have optimized the image quality of UTE spine imaging that enables more effective segmentation of the vertebrae than conventional sequences such as CISS. The technique provides the needed 3D acquisition with isotropic resolution for image segmentation in an acceptable imaging time. Breathing quietly appears to significantly reduce image artifacts caused by respiratory motions. Though the use respiratory gating (which is not supported by the UTE sequence in this study) may further reduce the associated motion artifacts, it could substantially increase scan time, which is especially undesirable for pediatric scoliotic patients.

CONCLUSION

With the improved ability for bone visualization and segmentation, 3D UTE of the spinal column is potentially useful for the studies of scoliotic deformities in a 3D manner, and for the evaluation of bone diseases such as osteophyte formation.

REFERENCES

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