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TI VIBE inversion MRI – An alternative to CT for imaging of hip pain

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ABSTRACT

Introduction: MR and CT are excellent complimentary diagnostic modalities for evaluation of hip pain which are often used together along with radiographs. However, CT involves radiation, which is a concern particularly in younger patients. T1VIBE is a 3D gradient echo MR sequence with high intrinsic contrast between the bone and soft tissues with multiplanar capabilities.
Aim: We performed a study to assess if TIVIBE can be used to complement MR for evaluation of hip pain in young adults and to see if measurements and angles can be calculated using T1VIBE inversion images with similar accuracy to CT scan.
Material and methods: A retrospective review of 50 patients aged less than 40 years, who had MR (including TIVIBE) and CT of pelvis was performed. Post surgical patients were excluded. Some important measurements such as Centre edge angle, Tonnis' angle, anterior acetabular sector angle, posterior acetabular sector angle and acetabular version were independently measured by two readers on T1 VIBE inversion and CT images separately and measurements were compared. One reader performed the measurements again to assess for intra-observer error.
Results: There was a female predominance (37 F, 13M) with an average age of 27.6 years (range of 17–39). There was no significant difference in the measurements between CT and TI VIBE inversion and there was good intra and interobservor reliability.
Conclusion: TI VIBE inversion sequence can be used as an alternative to CT with added advantage of alleviating the radiation exposure.

1. Background

Hip pain in young patients can be due to femoro-acetabular impingement and hip dysplasia.[1] Following radiographs, MRI is commonly requested by the orthopaedic surgeon to assess the soft tissues and articular surfaces. MRI aids the surgeon's decision upon operative management. T1VIBE is a 3D gradient echo MR sequence with high intrinsic contrast between the bone and soft tissues with multiplanar capabilities.[2]

Prior to operative management, the surgeon will often request CT to allow the calculation of the various measurements and angles used in pre-operative planning.[3] CT is considered to be the most accurate modality for this as it allows for 3D reformatting and has good bony definition.[4] Measurements performed include centre edge angle (CE), Tonni's angle, anterior acetabular sector angle (AASA), Posterior acetabular sector angle (PASA) and Acetabular version.[5]

In this study we aim to compare the measurements taken on T1 VIBE inversion sequences with those of CT to determine whether this single sequence could negate the need for subsequent CT in these patients. There is currently no such article described in the literature using 3D T1VIBE for measuring various angles around hip instead of a routine pre-operative CT.

2. Aim

To assess if T1VIBE inversion can be used as a part of a routine MRI protocol for evaluation of hip pain in young adults and to see if measurements and angles can be calculated using T1VIBE images with similar accuracy compared to high resolution CT scan.

3. Material and Methods

Institutional review board approval at our hospital was obtained. A retrospective search of the electronic database at a tertiary orthopaedic hospital was performed for patients under 40 who had both MR (including TI VIBE) and CT of pelvis between Jan

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2020 and Sept 2020. Post surgical patients were excluded. A total of 50 patients were identified.

All the MR scans were obtained with Siemens Skyra 3T and CT with Siemens Somatom Definition AS (64 slice). Imaging protocols were performed using a 3T MR scanner (Magnetom Trio with TIM system, Siemens Healthcare Company) with an 18-cm eight-channel receiver knee coil. In addition to the routine hip joint-specific imaging protocol, fat-suppressed 3D VIBE is performed in each patient. The parameters for fat-suppressed 3D VIBE were TR/TE, 6.9/2.6; flip angle, 10^0; two acquisition averages; and total imaging time, 3 min 23 s. Fat-suppressed 3D VIBE is obtained with strictly identical slab position and equal isotropic image resolution (FOV, 400 × 250 mm; matrix, 480 × 150; slice thickness, 0.8 mm; and voxel size, 0.8 × 0.8 × 0.8 mm).

Two readers independently measured the CE angle, Tonni's angle, AASA, PASA and Acetabular version. These were measured on both CT and MRI by a Fellowship trained Consultant MSK Radiologist with more than 8 years experience and an MSK Radiology Fellow with five years experience post Radiology speciality training(Figs. 1–3). One of the readers performed the measurements again on CT and MRI after an interval of 2 weeks to allow assessment for intra-observer error.

4. Results

Out of the cohort of these 50 patients, patients were aged between 17 and 39 yrs with 3:1 female to male predominance. Unpaired *t*-test was performed and p value greater than 0.05 for all the angles measured for both the readers, and hence statistically insignificant (Fig. 4, Table 1). The kappa value was 0.9 demonstrating that there was good intra-observer reliability for all angles calculated in the study.

5. Discussion

T1VIBE MRI has been mainly used for abdominal, breast and brain scanning, but recent work has also focused on its potential use in orthopaedics.[6,7] The use of VIBE MRI in the musculoskeletal setting is beginning to expand. The potential to use of T1 VIBE inversion MRI instead of CT in the assessment of CE angle, Tonni's angle, AASA, PASA and Acetabular version required for young patients with hip pain has many advantages. These include the lack of exposure to ionising radiation and the decreased time and cost compared to arranging a separate CT. The average CTDI for a CT pelvis in our study group was calculated to be 10.7 mGy.

VIBE sequences are characterised by lower signal characteristics of fluid compared to standard T_1 weighted images. VIBE sequences have high intrinsic tissue contrast between cortical bone and fatty marrow. High resolution volumetric imaging of bone can be generated by VIBE MRI. The acquired images can then be windowed and inverted to resemble CT. By adding a T1 VIBE sequence to our standard protocol, we are attempting to negate the requirements for a CT and its radiation exposure.[2] Incorporation of T1 VIBE sequence into all our routine hip MRI protocol helps to delineate osseous anatomy better which is useful for measurements and also for diagnosing other bone pathologies similar to CT. The additional T1 VIBE sequence takes only about 3 min and 43 s to complete in our scanner.

Previous workers have used this concept of T1 VIBE inversion as a CT equivalent. A study by Ang et al. used this sequence to assess pars stress fractures of the lumbar spine, they concluded that 3D T_1 VIBE had a sensitivity and specificity of 96.7% and 92% for diagnosis of incomplete pars and 100% in diagnosing complete pars fractures and this was comparable to CT.[8]

Stillwater et al. compared the osseous reformats of 3D-T1 VIBE vs 3D-CT in patients with glenohumeral instability. Their results

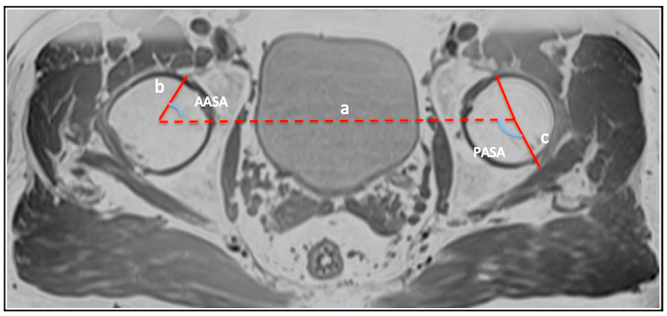

Fig. 2. Measurement to AASA and PASA on T1VIBE inversion. AASA is the angle between line a (line formed by joining the centre of both femoral heads) and b (line between the anterolateral edge of the acetabulum and centre of femoral head). PASA is angle between line a and c (line formed by joining the centre of femoral head and posterolateral edge of the acetabulum).

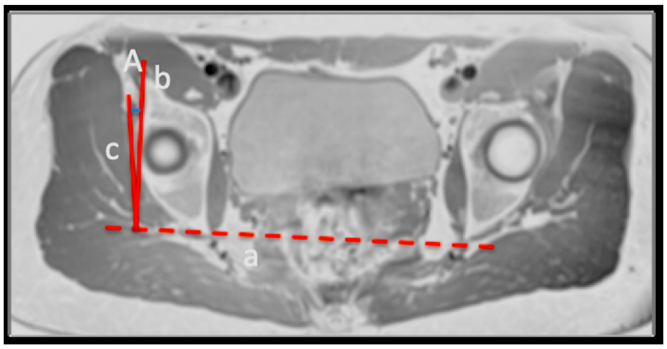

Fig. 3. Measurement of acetabular version (A) on T1VIBE inversion which is angle between b (line perpendicular to a (trans ischial line) and c (line formed by joining the anterolateral and posterolateral edge of the acetabulum at the most superior axial slice.

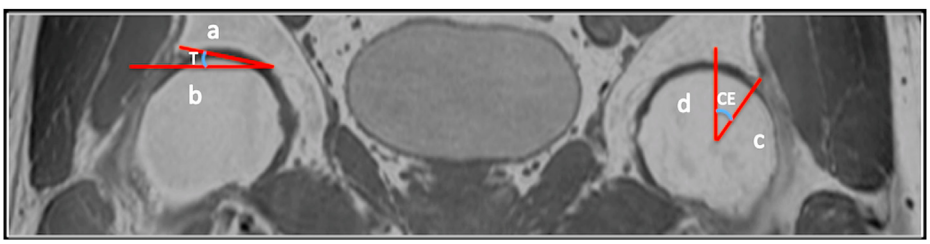

Fig. 1. Measurement of Tonni's angle (T) and Centre edge angle (ce) on T1VIBE inversion. Tonni's angle is between a (line joining the medial edge of sourcil and outer edge of the acetabulum) and b (horizontal line parallel to trans ischial line. Centre edge angle is angle between c (line from centre of femoral head to the outer edge of the acetabulum) and d (line from centre of the of femoral head and perpendicular to the trans ischial line).

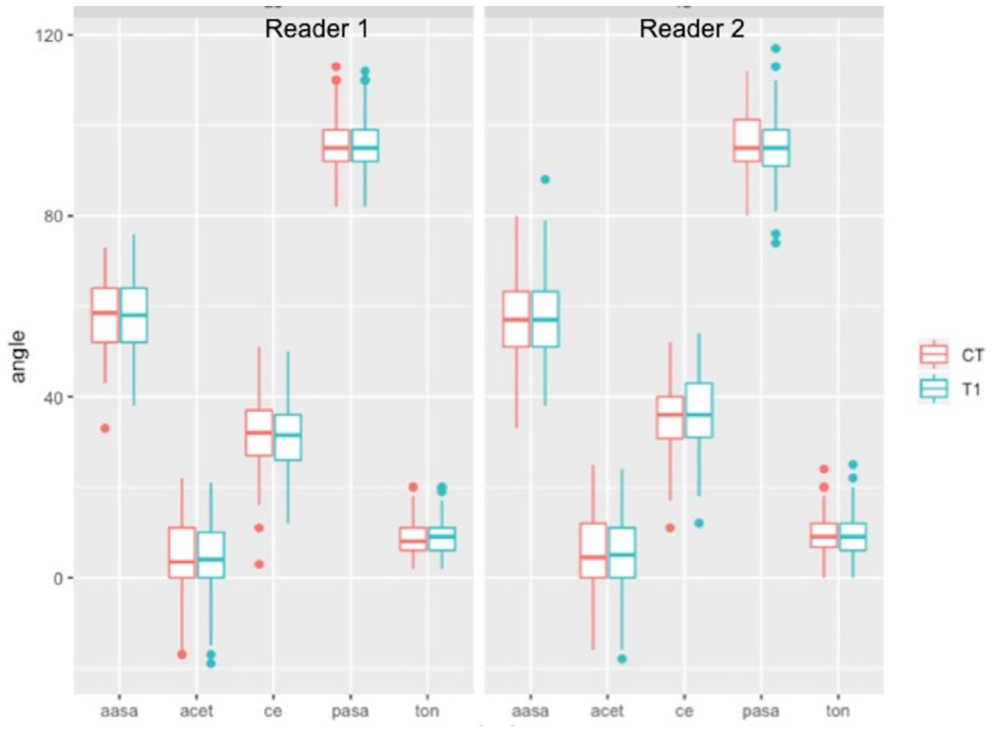

Fig. 4. Box plot showing reading of both readers for aasa, acetabular version (acet), ce (centre edge angle), pasa, ton (Tonni's angle) measured on CT and T1VIBE inversion (T1).

Table 1
The P value for various angles measured between the two readers.

Angles measured	Reader 1	Reader 2
	p value	p value
CE angle	0.3	0.4
Tonni's angle	0.9	0.6
AASA	0.7	0.8
PASA	0.2	0.8
Acetabular version	0.7	0.7

suggested that 3D-MRI performed similar to CT with no statistical significance between measured parameters of humeral height, glenoid height and glenoid width.[9]

This is the first study to implement T1VIBE inversion in hip angle measurements for pre-operative use. When we compared the diagnostic efficacy of these two different modalities, our study found that sensitivity and specificity of these two modalities showed good inter-observer and intra-observer correlation. We also found substantial agreement (Kappa correlation coefficient 0.9) between these two readers for measuring the angles around the hip joint. Therefore fat suppressed 3D T1VIBE inversion can be a good alternative to CT for measuring the angles around the hip.[10] This reduces the need for further CT examination (which requires ionising radiation) and this sequence does not add a significant amount of time to the routine scan of the hip during the assessment of hip pain.

The use of radial T1VIBE sequence can produce radially oriented streaks or mild blurring due to respiratory motion and under-sampling.[11] However in our study, we encountered minimal if any noticeable artefacts, without appreciable image quality degradation.

This clinically significant concept is more efficient than another CT which also avoids unnecessary radiation exposure.[2] In the future T1VIBE MRI could change the diagnostic and follow up imaging strategies.

6. Conclusion

This paper demonstrates a good correlation between measurements taken on T1 VIBE inversion and on CT in the assessment of young adults with hip pain. In future, T1 VIBE will play a more significant role in assessing hip measurement for pre-operative purposes. The use of an additional T1 VIBE inversion sequence at the time of routine MRI for the assessment of hip pain has shown to have similar correlation to CT. We therefore recommend its use as it reduces radiation burden and the need for an additional CT examination.

Financial disclosures

No financial disclosures.

Declaration of competing interest

No conflicts of interest.

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