

The value of BOLD-MRI in early diagnosis of osteonecrosis of the femoral Head in patients with steroid treatment

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Target audience: Researchers and clinicians with an interest in osteonecrosis and BOLD-fMRI.

Purpose: Patients who require long-term steroid use are at high risk for occurrence of osteonecrosis. Early diagnosis of this complication is essential as the prognosis is affected by the stage of the disease. However, there is no consensus on whether screening of bone necrosis should be performed for long-term glucocorticoid. Magnetic resonance imaging (MRI) is more sensitive than plain film for diagnosing early-stage bone necrosis [1]. Traditionally functional magnetic resonance imaging (fMRI) using blood oxygenation level-dependent (BOLD) contrast has appeared to measure vascular oxygenation change due to neuron activity. This study attempted to compare BOLD-MRI with conventional MRI sequence on determining the onset of osteonecrosis of the femoral head following steroid-related osteonecrosis.

Methods: In the present study, there are 20 subjects' hip joint scanned using 3T MRI scanner (Achieva Intera; Philips Medical Systems, Best, the Netherlands). We use the conventional MRI (T2WI/TSE, SPAIR/PDW in coronal view, and SPAIR/T2WI, 3D/WATS in axial view) and BOLD-MRI sequence (TR=15ms, 8echos, TE=9.21/18.42/27.63/36.84/46.05/55.26/64.47/73.68ms, FA=30°, matrix size=312x429, FOV=250x429mm, slice thickness=2.5 mm) to compare the hip joint between the 10 patients with osteonecrosis of the femoral head as above and the hip joint of 10 healthy controls. With the section cross the fovea of femoral head, we set six ROIs on the section (Fig. 1) and then analyzed morphological performance on routine MRI sequences between normal control group and patient group with femur avascular necrosis. R2* image performance in each district of head of femur in normal group and the difference of R2* value between normal group and patient group were analyzed. Moreover, R2* value change in the suspicious uninjured side of patients with unilateral disease, R2* value change in a patient in different time, and the difference between R2* image and routine sequences in the lesion area in a patient were also explored.

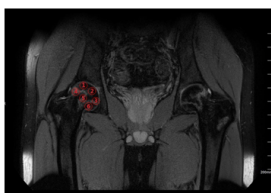


Fig. 1: Six regions of interest (ROIs) in the femoral head

| ROIs | control group | osteonecrosis group | F value | P value |
|--------|---------------|---------------------|---------|---------|
| zone 1 | 22.36±2.69 | 17.83±3.46 | 1.690 | 0.000* |
| zone 2 | 16.02±1.93 | 15.93±3.42 | 3.273 | 0.921 |
| zone 3 | 18.89±1.75 | 16.80±2.83 | 4.407 | 0.014* |
| zone 4 | 23.54±2.63 | 21.32±6.35 | 9.201 | 0.162 |
| zone 5 | 17.67±2.82 | 16.82±5.13 | 6.271 | 0.530 |
| zone 6 | 20.96±2.30 | 19.34±4.34 | 4.932 | 0.156 |

*: indicate significant difference

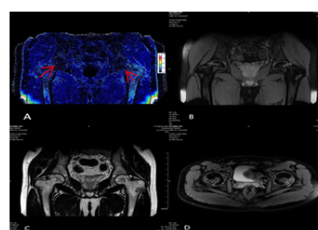
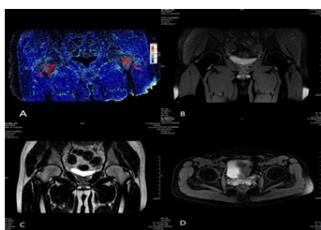


Fig. 2: Reduced R2* in bilateral femoral heads without abnormal MRI findings Fig. 3: Reduced R2* in bilateral femoral heads with abnormal MRI findings.

Result: ① In control group the value of R2* in zone 4 and zone 6 was the highest, next was zone 1 to zone 3, and zone 2, while the zone 5 was the lowest (Table 1).

② In osteonecrosis group, zone 4 and zone 6 were not always involved in lesion, except for zone 1 and zone 3. ③ In affected femoral head, The R2* merely descended over times for zone 1 and zone 3, instead of zone 2, zone 4, zone 5 and zone 6 (Fig. 2, 3). ④ For one month followed up, the R2* of the affected region on BOLD was larger than that the one in conventional sequences for the same patient.

Discussion: The necrosis area of femoral head was confined to the zone 1~3, which accompanied by the thromboembolism. Unlike previous studies using BOLD-MRI to detect abnormality in fat, kidney and so on [2], both oxyhaemoglobin and deoxyhemoglobin decreased in the lesion and therefore the R2* value in osteonecrosis zone reduced. Because of ligamentum capitis femoris, the oxyhaemoglobin concentration of zone 2 and 5 was higher than the other areas, leading to the significant difference between the value in zone 1 and 3.

Conclusion: BOLD-fMRI could potentially detect the necrosis of femoral head in early stage. This phenomenon indicated that R2* could screen osteonecrosis of the femoral head earlier and more sensitive than conventional sequences.

Reference: [1] Poignard A, Flouzat-Lachaniette CH, Amzallag J, et al. The natural progression of symptomatic humeral head osteonecrosis in adults with sickle cell disease[J]. J Bone Joint Surg Am 2012, 94(2): 156-62. [2] Głowiczki ML, Lerman LO and Textor SC. Blood oxygen level-dependent (BOLD) MRI in renovascular hypertension[J]. Curr Hypertens Rep 2011, 13(5):370-377.