Pixel-by-pixel perfusion analysis of Modic changes by DCE-MRI

Haiyan Lv[1], Heather Ting Ma[1], James F. Griffith[2], Alvin F.W. Li[2], Yixiang Wang[2], David K.W. Yeung[2], Anthony Kwok[2], and Ping-Chung Leung[2]

[1]*Department of Electronic and Information Engineering, Harbin Institute of Technology Shenzhen Graduate School, Shenzhen, Guangdong, China, People's Republic of,* [2]*Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong, China, People's Republic of*

Introduction: Modic changes are a common phenomenon on magnetic resonance imaging in spinal degenerative diseases and strongly linked with low back pain. There are three types of Modic changes called type I, II, III classified by different signal change patterns in the MRI images as summarized by Modic et al [1]. Most of current studies on Modic change focus on its histopathologic mechanism, type development and transformation, etc. However, no study showed if blood supply changes in the bone morrow with Modic changes. Dynamic contrast enhanced (DCE) MRI is a good approach to investigate the blood perfusion in living tissues. The purpose of this study is to investigate the perfusion in the bone marrow with Modic changes through DCE-MRI.

Methods: This study comprised 24 elderly male subjects (age 72.8±3.3 years), including 15 patients with Modic changes (type I, II, III) and 9 normal subjects with no degenerative disease throughout the lumbar spine. DCE scan was conducted by a short T1-weighted gradient-echo sequence (2.7/0/95; prepulse inversion time, 400 ms; flip angle, 15°) in the mid-lumbar sagittal plane. A total of 160 dynamic images were obtained with a temporal resolution of 543 ms. A region of interest (ROI) was drawn manually for each Modic change and normal bone marrow area on vertebra, where the signal intensity curves were extracted pixel-by-pixel in the ROI. Brix model was employed to analyze the perfusion curves (Fig.1) [2]. The normalized fitted curves were divided into 3 patterns distinguished by the slope of the end of the curve using 0.0065 as threshold (pattern 1 slope> threshold, pattern 3 slope< -threshold, others pattern 2) (Fig.2). The pixel was colored into red, green and blue corresponding to pattern 1, 2 and 3. Pattern percentage of ROI (color area/ ROI area), and normalized pattern percentage (pattern percentage / all pattern percentage of ROI) were calculated for pattern 1, pattern 2 and pattern 3, respectively. Analysis of variance method (ANOVA) was used to evaluate differences in parameters among groups. A level of 0.05 indicated statistical significance.

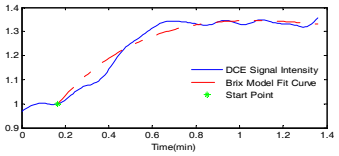

Fig.1. Signal intensity curve and Brix Model fitted curve

Results: The ROI color percentage, normalized pattern1 percentage, normalized pattern 3 percentage showed significant differences ($p<0.01$) among the four groups (Table 1).

Table 1: ANOVA result for pattern percentage analysis

Group	Age (yrs)	ROI Pattern Percentage	Normalized Pattern 1 Percentage	Normalized Pattern 3 Percentage
Normal (n=9)	71.7±4.1	0.431±0.062	0.255±0.076	0.360±0.086
Modic Type I (n=6)	74.2±2.4	0.590±0.151	0.592±0.057	0.163±0.033
Modic Type II (n=6)	72.7±3.5	0.304±0.035	0.393±0.175	0.268±0.137
Modic Type III (n=3)	74.0±1.0	0.539±0.309	0.263±0.135	0.329±0.133
P value (for trend)	=0.512	<0.01	=0.000	<0.01

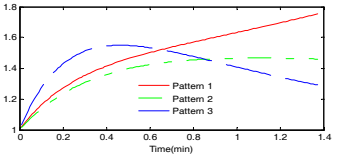

Fig.2. Classification of Patterns. Pattern 1 (red): fast enhancement, followed by a slow enhancement; Pattern 2 (green): fast enhancement, followed by a signal plateau; Pattern 3 (blue): fast enhancement followed by a quick washout.

Each Modic group was compared with normal group by t-test. Modic type I showed higher ROI pattern percentage ($p<0.05$) and normalized pattern1 percentage ($p=0.000$); Modic type II showed a lower ROI pattern percentage ($p=0.000$); while Modic type III showed no significant difference (Fig.3). Normal group had a higher normalized pattern 3 percentage compared with Modic groups ($p<0.01$).

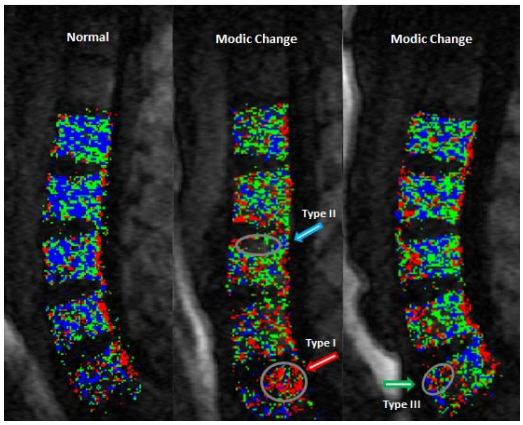

Fig.3. Color mapping image of normal and Modic change subjects in sagittal plane. Modic change type I (red arrow), type II (blue arrow) and type III (green arrow)

Discussion: Current study showed that the blood perfusion varied in different Modic changes. Previous study indicated that Modic change type I may be caused by edema and vascularisation following cumulative trauma and an inflammatory response after microfracture in the endplates. This also causes the perfusion changes that reflected by the higher ROI pattern percentage and pattern 1 percentage observed in current study. Most literatures reported Modic change type II is a fatty marrow. The lower ROI pattern percentage indicates weak perfusion ability in type II region. Since the mechanism of Modic change type III remains unclear yet and no significant difference was observed in this study. More investigation along this direction should be carried out. The higher percentage of pattern 3 indicates that the perfusion ability of normal subjects is stronger than patients with Modic change. This study indicated that the perfusion ability of bone marrow could distinguish Modic change regions with normal regions and the result corresponded with the pathogenetic mechanism of Modic change. Also, color mapping could provide a visualized measurement for pixel-by-pixel perfusion in bone marrow, and possibly to be a measurement for early diagnosis of Modic change.

Acknowledgement: This study is supported by the National Natural Science Foundation of China (81000647) and Basic Research Foundation (Outstanding Young Investigator Track) from Shenzhen Science, Industry, Trade& Information Commission (JC201005260124A).

Reference: 1. Michael T. Modic, *et al*. Radiology 1988; 166: 193-199. 2. Heather T. Ma, *et al*. JMRI 2010; 31: 1169-1175