ABSTRACT

Chronic back pain is a benign, frequent, costly and complex condition which is the second leading cause of Burden of Disease in Australia. Lack of standard therapeutic treatment options for herniated disc and back pain, in general, is a consequence of the limited knowledge in understanding disc failure, although it is commonly believed that certain motions can cause disc herniation in the lumbar region of the vertebral column. A precise perusal of the literature reveals that analyzing the progression of three-dimensional internal maximum shear strains (MSS) in different regions of the disc, during repetitive combined loading can bring insight to understanding the disc failure mechanism. The current multimodal study is designed to investigate disc damage that results from combined motions under repetitive loading using internal tissue displacements and strains supported by magnetic resonance imaging (MRI) assessment.

Eight human lumbar discs underwent pre-test MRI and then were loaded under combined 13 degrees of forward flexion, 2 degrees of right axial rotation and 1.7 MPa compression up to 20,000 cycles or failure at the frequency of 1Hz which is supposed to remodel the heavy lifting in physical work, realistically. Calibration and endplate beads together with circumferential markers were used to identify the periphery of the disc and a wire grid inserted into the mid-transverse plane followed by stereo-radiography technique; then digitizing is performed in neutral position followed by 1, 500, 1,000, 5,000, 10,000, 15,000, 20,000 cycles. A sequence of Matlab codes was used to reconstruct the markers and wires to measure the tissue displacement progression, average MSS and largest principle strain in 9 anatomical regions. Complementary post-test MRI-based grading system is used to score the initiation and progression of the tears and fractures in order to correlate the level of damage to MSS findings in the same nine regions of the disc.

The association between two sets of scores from MRI and MSS analyses obtained in this study could potentially serve for a better understanding of the biomechanical behaviour of the herniated disc and for investigation of the biomechanical aetiology of disc abnormalities (Spearman correlation factor= 0.5966; $P<0.001$). The high MSS values are located where annular tears fractures and disc bulge are present in MRI image. Additionally, posterolateral region is the common site of failure resulted by combined axial rotation, flexion and compression which validates the findings from computational studies using the same protocol of loading (right posterolateral region experiencing the largest MSS=62%). Finally, comparing the result obtained from alternative methods would be valuable in terms of developing the current surgical methods and procedures, improving the rehabilitation strategies, heavy lifting guidelines and therapeutic implant designs, as well as prevention of the segmental instability and back pain.