Introduction: Structural changes within the intervertebral discs are thought to be a major source of back pain. There has been extensive research into the epidemiology, anatomy, biomechanics, biochemistry and neuromechanisms of degenerative disc disease. To date, however, a full study into the significance of pathological changes in disc structure has been restricted by the imaging techniques available. Magnetic resonance imaging is limited in resolution; discography is only capable of showing defects of the annulus which communicate directly with the nucleus. Histology requires postmortem material and often results in distortion of tissue dimensions.

Ultrasound imaging is a flexible, non-invasive technique which can be used to provide high resolution images of soft tissues. So far little work has been done to evaluate the potential applications of ultrasound in the imaging of intervertebral discs. Initial in vivo studies, however, have indicated that ultrasound imaging is capable of producing images of the disc containing a high degree of structural information (1).

The objective of this study was firstly to determine the reliability of assessing disc degeneration using ultrasound. The ultrasound images and the photographic images were assessed blind by two separate observers. A third independent observer was used to confirm the match, both in location and appearance, of real structural defects identifiable on the sectioned discs. Circumferential fissures were especially well highlighted, appearing as hyperechoic areas with hyperechoic margins.

Method: 13 nonchondrodystrophic dogs, of varying breed, were studied (average age 5 years 8 months). Following euthanasia the lumbosacral disc and adjacent vertebrae were removed from each dog. Radiographs were then performed to rule out the presence of osteophytes. Muscle tissue from around the disc and vertebrae was dissected away and the segments were placed in frozen storage at -20°C.

Prior to imaging each segment was defrosted at 4°C for 12 hours. All imaging was performed in a water bath at room temperature, using a 7.5MHz linear array transducer in conjunction with an Acoustic Imaging 5200 imaging system (Acoustic Imaging Technologies Corporation, Phoenix, Arizona, U.S.A). Ultrasound images were taken in a transverse plane, through the centre of each disc and a single machine operator performed all ultrasound imaging.

A visual scale (3) with 4 levels was used to assess the discs following transsection. The visual grading scale is a long established method of rating the degree of pathological change within a disc, based on visual changes to disc structure. A scale on which to grade the ultrasound images on 4 levels was designed, based on the structural coherence of lamella echoes in the annulus and uniformity and lack of echogenic foci in the nucleus. The images of the disc were split into 3 sections, the anterior annulus fibrosus, the nucleus pulposus and posterior annulus fibrosus, and each of these sections was graded independently. The ultrasound images and the photographic images were assessed blindly by two separate observers. A third independent observer was used to confirm the appropriate grade in borderline cases. The results obtained under the two different grading systems were then compared using Cronbach’s alpha test to determine the reliability of assessing disc degeneration using ultrasound.

Results:

<table>
<thead>
<tr>
<th>Region of Disc</th>
<th>Number of Matched Grades</th>
<th>Number of Unmatched Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAF</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>NP</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>PAF</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1. Table indicating the number of samples in which the ultrasound grade and visual grade were matched.

When Cronbach’s alpha test was applied to the results for the anterior annulus fibrosus an alpha value of 0.92 was obtained. Grades for the nucleus pulposus produced an alpha value of 0.82, while those for the posterior annulus fibrosus gave an alpha value of 0.88. In cases where the grade given to the ultrasound image did not match those given in visual assessment the disparity was never greater than 1 grade.

The ultrasound images of 4 pathological discs demonstrated echo patterns that matched, both in location and appearance, real structural defects identifiable on the sectioned discs. Circumferential fissures were especially well highlighted, appearing as hypechoic areas with hyperechoic margins.

Discussion: Cronbach’s alpha is a measure of internal consistency, the value of which indicates the reliability of our scale at determining the degree of disc degeneration. An alpha above 0.80 is considered very good, showing a high degree of reliability. The results of this study were above 0.8 in all three areas of the disc. This is an extremely significant finding. Currently the only imaging techniques known to reveal clinically useful information about the disc are magnetic resonance imaging and computed tomography / discography. Both techniques are costly and time-consuming. The results of this study indicate that ultrasound, a far cheaper and more accessible form of imaging, offers the potential to determine levels of pathology based on changes in disc structure in a non-invasive way.

On of the most promising aspects of the results of this study is the way in which significant structural defects appear to correlate specifically with certain echo patterns seen on the ultrasound images. In many cases it appears possible to define the exact size, shape and position of a defect based on the ultrasound image (figure 1). Further work is now required to determine the sensitivity of ultrasound imaging in the identification of defects associated with symptomatic discs and to investigate the application of this technique in vivo.

References: