Disc prolapse: evidence of reversal with repeated extension


**Aim:** To create *in vitro* disc prolapse and then investigate whether extension or combined extension and side flexion could reverse the position of the displaced nucleus.

**Methods:** The C3-C6 segments of 18 porcine cervical spines were prepared, with a radio-opaque mixture injected into the C3-C4 nucleus of the intervertebral disc of each segment. The segments were placed in a servo hydraulic dynamic testing machine and subjected to repeated axial compression and flexion, or combined flexion and side flexion to create a prolapse. Radiographs were taken at regular intervals to monitor the displacement of the nucleus. Specimens that prolapsed were immediately put through a reversal test, which consisted of axial compression and extension, or combined extension and side flexion.

**Results:** After failure testing, two specimens had endplate fractures, five did not fail, and 11 had prolapsed. Reversal of the position of the nucleus occurred in five of the 11 prolapsed discs, but did not occur in six specimens. Disc height loss was less in the specimens that showed reversal.

**Conclusion:** This study showed that in a number of porcine cervical spines, a displaced portion of nucleus could be repositioned back towards the centre of the disc in response to specific loading of repetitive movement.

**The authors make two important observations from this study. The first is that not all the prolapsed discs could be reversed. This matches clinical observations that not all patients with suspected disc lesions are able to centralise their symptoms using repeated end range movements. Earlier work by Donelson et al (1997) has shown that the hydrostatic mechanism of the disc must be intact for this to occur, and indeed the integrity of the annulus can be predicted by this type of mechanical assessment.**

**The second observation is the significant loss of disc height in the discs that did not respond. The authors hypothesise that loss of disc height prevented enough range of extension to occur before the facets stopped the movement, with less compressive force able to be exerted. Once again a clinical observation is that complete end range movement is often necessary to achieve total centralisation of patient’s symptoms. Furthermore, it is not uncommon for alternative loading (eg combined positions) or force progression strategies (eg mobilisation) to be required to facilitate end range to achieve centralisation.**

Porcine cervical spines are anatomically and functionally similar to human lumbar spines so their use in this experiment is justified. It is also important to remember that previous studies looking at this disc model have limited or contradictory data to support this model in the symptomatic or degenerative cases of cervical or thoracic discs (Kolber and Hanney 2009).

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**REFERENCES**


Commentary

This basic science experiment has demonstrated *in vitro* that the position of the nucleus pulposus of the intervertebral disc can be influenced by directional load. This has been demonstrated in previous *in vitro* studies (Gill et al 1987, Krag et al 1987, Seroussi et al 1989, Shah et al 1978), which have demonstrated posterior migration of the nucleus with flexion motion and anterior migration with extension. However, this is the first study to deliberately create a prolapse and then test for reversibility.

The rationale for this study is the clinical phenomenon of centralisation (McKenzie and May 2003), which describes the abolition of peripheral pain from a distal to proximal location in response to repeated end range movement testing of the spine. A conceptual model of internal disc displacement has been used to explain this clinical observation (McKenzie and May 2003) and a system of mechanical assessment has been designed around this. Clinically, many patients with suspected discogenic pain report worsening of systems with flexion biased postures, and a reduction of symptoms with extension movements, or a combination of extension and lateral movement (Donelson et al 1991, Donelson et al 1997). This animal study attempts to add plausibility to McKenzie’s model.
Proprioception of the wrist joint: A review of current concepts and possible implications on the rehabilitation of the wrist


**Background:** Over the past two decades the notion that ligaments are mere static stabilisers of a joint has been questioned. The differing types and distribution of mechanoreceptors in ligaments implies a variable functionality of their sensory role in the regulation of muscle activity around a joint and contribution to dynamic joint stability. With the majority of studies based around the knee, ankle and shoulder, it has only been over the past five years that research has focused on the proprioceptive sensory influence of wrist ligaments. In order to adequately rehabilitate wrist injuries an understanding of these influences is essential.

**Aim:** The main aims of this review were to (i) Summarise the scientific evidence on wrist joint proprioception, and (ii) Relate this evidence to wrist proprioceptive rehabilitation.

**Study Design:** Narrative review. Information regarding the proprioception of the wrist joint is summarised under the broad headings of joint mechanoreceptors, proprioceptive reflexes and pathways, and proprioception senses and therapeutic applications.

**Conclusion:** Research on the sensorimotor function and neuromuscular control of the wrist joint is still in its infancy. Further basic science studies of proprioceptive reflexes and the effect of neuromuscular actions on wrist stability are required, as is clinical research into proprioceptive rehabilitation of the wrist joint and the development of neuromuscular rehabilitation programmes.

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**Commentary**

Elisabeth Hagert draws on what has been identified about the wrist joint, along with the knowledge gained from studies about the knee, ankle and shoulder joints, to present proprioceptive therapeutic concepts that can be incorporated into clinical rehabilitation of the wrist.

Evidence of wrist proprioceptive reflexes was demonstrated in a recently published article (Hagert, 2009). By electrically stimulating the scapholunate ligament (SL) during wrist flexion-extension and radioulnar deviation, the immediate reflex response was consistently observed in the antagonist muscle for each position (joint protection), followed by coactivation (global stability). An interesting observation in this study was the consistent reflex inhibition of the extensor carpi ulnaris (ECU) during ulnar deviation, differing greatly from co-contractions that were seen in the other wrist positions. Correlating this finding with studies performed on the role of muscles on carpal stability, Hagert (2010) postulates why ECU was inhibited during this motion. Contraction of ECU has been found to increase the pronation tendency of the distal row of the carpus, which results in widening of the scapholunate interval and tension of the SL.

Obscured by the historical vision of carpal kinematics of the wrist moving through sagittal and coronal planes, exercises of this joint have primarily focused on rehabilitation in the orthogonal moments of flexion-extension and radioulnar deviation. In fact, the most common plane of wrist rotation in activities of daily living, aligning with minimal muscle force and normal carpal kinematics, is that of an oblique motion from radial extension to ulnar deviation (the dart-throwing motion (DTM)). It is suggested therefore that any training should follow this arc. This is particularly pertinent in patients with a SL injury whereby using the DTM, the activity of the stabilising flexor carpi ulnaris (FCU) and extensor carpi radialis longus is enhanced, whilst the activity of the potentially harmful ECU is demoted.

Based primarily on injuries to the knee or shoulder joints, the types of exercise and movements in proprioceptive training include isokinetic, isometric, eccentric, co-activation and unconscious reactive muscle activation. Some examples are provided as they apply to the wrist:

1. **Isometric activation of pronator quadratus** in supination and neutral wrist position can serve to stabilise the distal radioulnar joint (both pre- and postoperatively). Isometric exercise of the FCU will act to compress the pisiform against the volar aspect of the triquetrum, thus contributing to stability in the presence of an ulnar midcarpal instability pattern. However, with instability of the SL, isometric exercise can either be beneficial or detrimental depending on the degree of ligament injury. If the SL is intact, flexor carpi radialis (FCR) is thought to be an important dynamic stabiliser of the scaphoid, possibly due to its compression action at the scaphotrapezial-trapezoid joint. In a complete lesion however, cadaver studies of FCR have revealed a significant increase in its moment arm and subsequent increase in the load distributed through the radial carpus, thus enhancing the scaphoid displacement.

2. **Designed to strengthen the muscle while it is lengthening, and commonly used to relieve pain and build tendon strength in tendonopathies, a secondary benefit of eccentric exercise in rehabilitation of the wrist has been suggested to lie in the coactivation of the antagonist muscles (Leger and Milner 2001).**

3. **Akin to the balance plate exercises used in ankle instabilities, which have been shown to improve proprioception and co-activation around the ankle joint, Hagert (2010) suggests slow and controlled motion of a ball on a table.**

4. **A recent study on subjects with no wrist dysfunction, using a Powerbar® gyroscope demonstrated a significant increase in muscle endurance, which was sustained for an extended period after not using the device (Balan and Garcia-Elias 2008). Because this device generates random, multidirectional forces, the muscles are forced to react in an unpredictable manner and the resultant unconscious reactive muscle activation would likely stimulate more efficient neuromuscular control about the wrist. The authors suggest that this device may be beneficial in those patients with hyperalgesy acquired as a result of poor neuromuscular control. They warn however that this device should be used with caution as the muscular control that is required to counteract the centrifugal forces is likely an eccentric exercise, thus predisposing the patient to a possible increase in pain and damage to the neuromuscular structures.**

Hagert (2010) also proposes the use of visual influences, cutaneous influences and the conscious awareness of limb movement and position to complement the aforementioned techniques. Shown to enhance motor memory and motor control after hand injury (Altichiero and Hu 2006, Rosen and Lundborg 2005), mirror therapy creates an illusion of
REFERENCES


