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Short communication

Stretch along the craniocaudal axis improves shape recoverability of the spinal cord

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ABSTRACT

The spinal cord is physiologically stretched along the craniocaudal axis, and is subjected to tensile stress. The purpose of this study was to examine the effect of the tensile stress on morphological plasticity of the spinal cord under compression and decompression condition. The C1–T2 spinal column was excised from 4 rabbits. The laminae and lateral masses were removed. After excision of surrounding structures, a small rod was placed on the spinal cord. The rod was connected with a pan of the scale balance. Varying the weight between 0 and 20 g on the other scalepan, the indentation of the rod was measured. Then, the spinal cord was cut transversely to remove longitudinal tensile stress. The samples were measured again with the same protocol at point 10 mm caudal to each pre-measured point on the spinal cord. The shape recovery rate was calculated. The length of the spinal cord decreased by 9.7% after the separation. The maximum indentation was 2.1 mm (mean) at 20 g, and did not differ between the separated and un-separated cords. The recovery rate was not significantly different between the separated and un-separated cords until 3 g. At the load under 3 g, the recovery rate after the separation was significantly lower than that before the separation. The tensile stress along the craniocaudal axis in the spinal cord did not affect the spinal cord deformation in response to the compression, but it did affect the shape recoverability after the decompression.

1. Introduction

The spinal cord is physiologically stretched along the craniocaudal axis, and is subjected to tensile stress. Breig and el-Nadi (1966) reported that the spinal canal decreases in length when the spine is extended and increases in length when the spine is flexed in human cadavers. The spinal cord adapts to these changes of length by elongating and shortening itself. Tensile stress in the spinal cord is produced by the stretching of the spinal cord.

Clinically, the excess increase or decrease of the tensile stress in the spinal cord induces various pathological conditions. Tethered cord syndrome, especially tight filum terminale, is caused by the pulling of the spinal cord at the base of the spinal canal. The spinal cord is stretched and should present the increase of the tensile stress with growth, leading to progressive spinal cord damage. On the other hand, the decrease of the tensile stress in the spinal cord causes the bending of the spinal cord. It may induce neurologic deterioration as in spinal shortening by vertebral column resection (O'Shaughnessy et al., 2008).

Cervical myelopathy is a well-known spinal cord compression syndrome. It is caused by narrowing of the spinal canal due to degenerative changes in the cervical spine. The spinal cord is deformed according to compression as observed on CT myelograms and axial MR images. The cross-sectional area of the spinal cord decreases in response to compression and increases after decompressive surgery (Ozawa et al., 2004). Biomechanical analysis of the spinal cord is important to clarify the morphological plasticity of the spinal cord. Although various mechanical factors regulating the morphology of the spinal cord have been studied, the influence of physiological tensile stress in the spinal cord has not been studied from the viewpoint of the morphological plasticity. The purpose of this study was to investigate the effect of the tensile stress on the morphology of the spinal cord under compression and decompression in rabbits.

2. Materials and Methods

2.1. Experiments

Animal experiments and treatments were conducted in accordance with the guide for animal experimentation at Tohoku University. Four Japanese rabbits

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