

An Evaluation of the Clinical and Histological Effects of High Dose Radiosurgery on the Rat Dorsal Root Ganglion

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Introduction

Stereotactic radiosurgery (SRS) is a safe and effective technique to create lesions of the brain and trigeminal nerve (TGN) in order to achieve neuromodulation. The lumbar dorsal root ganglion (DRG) contains the body of the sensory neurons responsible for pain sensitivity and can be targeted to treat chronic and debilitating pain in the extremities. Neuromodulation of the DRG might therefore improve chronic peripheral pain. This study was performed to determine the feasibility as well as clinical and histological effects of delivering high dose SRS targeted to the lumbar DRG in a rat model.

Methods

Four Sprague Dawley male rats underwent 80 Gy maximum dose single-fraction SRS to the left L5 and L6 DRG using the Leksell Gamma Knife Icon (Elekta, Atlanta, GA) with onboard cone-beam CT imaging using 4 mm diameter collimators. The right L5 and L6 DRGs served as the controls. The animals were evaluated for motor and sensory deficits every two weeks. Two animals were sacrificed at 3 and two at 6 months after SRS. The lumbar spines were harvested and decalcified. Common histological techniques (Masson trichrome, Prussian blue) were used to assess for fibrosis and demyelination.

Results

No detectable motor or sensory deficits were seen in any animal. Histological changes including fibrosis and loss of myelin were noted to the left L5 and L6 DRGs, but not the right side control DRGs. Fibrotic changes within the vertebral body were also evident on the treated sides of the vertebral bodies.

Conclusions

We were able to detect a demyelinating histopathological response from SRS delivered to the DRG in rats. Since such changes mimic those seen after trigeminal SRS in experimental animals, we hypothesize that radiosurgery may be a potential option in chronic spinal radicular pain amenable to neuromodulation.

Learning Objectives

By the conclusion of this session, participants should be able to 1) determine the feasibility of performing radiosurgery to the dorsal root ganglion in a small animal model 2)determine the clinical effects of delivering 80 Gy radiosurgery to the dorsal root ganglion of a rat 3)describe the histological changes to the rat dorsal root ganglion after 80 Gy radiosurgery.

Figure 1. Stereotactic radiosurgery treatment to the L5 and L6 dorsal root





Animals were anesthetized and place in a stereotactic frame used for Gamma Knife Icon radiosurgery platform (A). A CT scan was obtained for radiosurgery treatment planning, and 80 Gy maximum dose was delivered in a single fraction to the L5 and L6 left DRGs (B). Positioning of the animal at the time of treatment was confirmed by directly comparing onboard cone-beam CT imaging using a 4 mm collimator with the treatment planning CT (B). Notice the location of the L5 and L6 DRGs just rostral to and caudal to the iliac crest.

Figure 2. Histological analysis.



Masson trichrome stain (10X magnification) demonstrating both L5 DRGs within the neural foramen. At 6 months the left DRG exhibits increased collagen deposition (stained in green) compared to the right one (control). B (10X), C and D (40X), Prussian blue staining for myelin demonstrating demyelination of the left DRG evident by diminished stain uptake and a lighter blue

staining. E (Prussian blue) 4X demonstration of radiation changes on the left aspect of the vertebral body (delineated by the line of stars). Arrow: doral root ganglion, *: intrathecal nerve roots, L: left, R: right, VB: vertebral body.

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