

Development of a Variable Geometry Pillow Assisting Neck Extension Movement for Patients with Cervical Disc Herniation

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WE suggest a novel design of an apparatus which is conducive to rehabilitation of cervical spine disorder such as intervertebral disc herniation. Many researchers reported that McKenzie extension has a positive effect on rehabilitation of cervical disc herniation through clinical trials [1-3]. To enlarge this healing effect, an apparatus that helps patients doing McKenzie extension is needed. In this paper, we present a variable geometry pillow which enables a patient to do the cervical extension in supine position by periodically adjusting the height of the pillow. In order to minimize the noise and vibration during the operation, shape memory alloy (SMA) wire is used as an electrically driven actuator instead of the traditional ones such as an electric motor and a hydraulic pump. A coil spring is used to support the patient's head in neutral position before operation. When the SMA wire is heated by electric current, it starts to contract and makes the coil spring compressed. This procedure makes the head lowered by 50mm in 10 seconds, which means the patient's neck is extended. After the extension, the SMA wire is released by cooling as the current is switched off. Finally, the restoring force of the coil spring returns the patient's head to the original position. The variable geometry pillow can provide patients with customized physical treatments by controlling the operational characteristics such as cyclic period, stroke, and speed. To evaluate our device, we compared the magnetic resonance imaging (MRI) data set of a patient in two different postures; when his head is at the neutral position and the lowest position, respectively. In this experiment, we observed slight suction of the nucleus pulposus toward front side of the body at the lowest position, which means an anterior cervical decompression. Since this decompression is conducive to the restoration of the herniated disc, it is expected that this device would be applied to the physiotherapy for the patients after a well-organized clinical trial.

Figure 1. A schematic view of the CAD model of variable geometry pillow and the real prototype manufactured based on the CAD design.

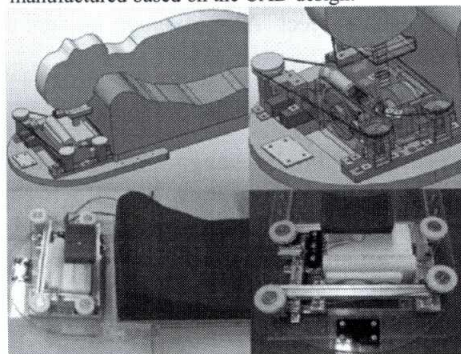


Figure 2. Performance evaluation using MRI scanning and comparison between the images of neutral and extended cervical spine.

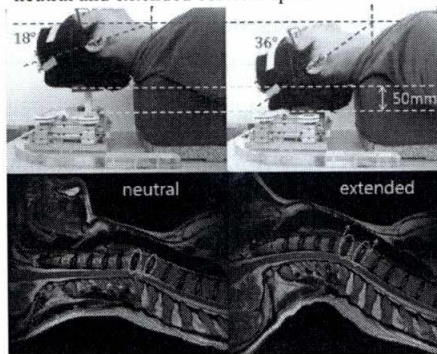
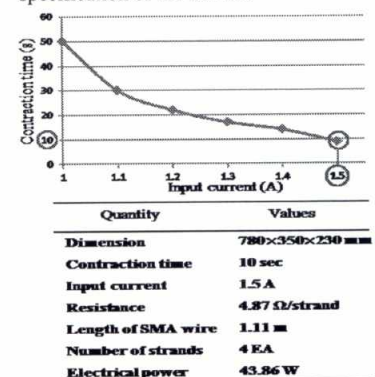


Figure 3. Relationship between input current and contraction time and the specification of the device.



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- [3] Carol P. Dionne, Ronald F. Bybee, Joe Tomaka, "Inter-rater reliability of McKenzie assessment in patients with neck pain", *Physiotherapy*, Vol.92, pp.75-82, 2006.

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DEVELOPMENT OF A VARIABLE GEOMETRY PILLOW ASSISTING NECK EXTENSION MOVEMENT FOR PATIENTS WITH CERVICAL DISC HERNIATION

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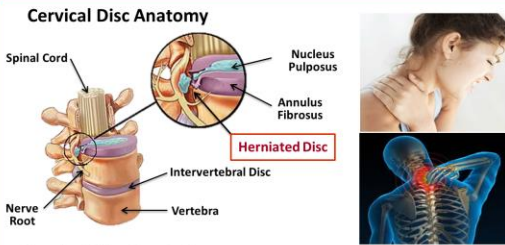
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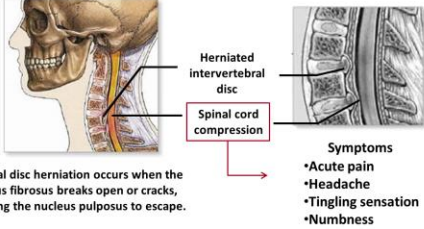
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INTRODUCTION AND OBJECTIVES

Cervical Disc Herniation



Cervical Disc Herniation



Causes for Cervical Disc Herniation



As the body ages, natural biochemical changes cause discs to gradually dry out affecting disc strength and resiliency. And poor posture combined with the habitual use of incorrect body mechanics can place additional stress on the cervical spine.

Current Physical Treatments



INEFFICIENT

TOO EXPENSIVE

UNCONVENIENT

Rehabilitation of Herniated Disc

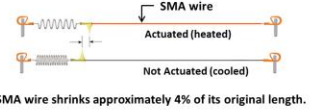
McKenzie method
(MDT = Mechanical Diagnosis and Therapy)

"A comprehensive method of care primarily used in physical therapy"



McKenzie Lumbar/Cervical Extension

Shape Memory Alloy



- Noise Free Actuation
- No Shock / Vibration
- Easy packing & Compact
- Not too fast response

Objectives of Research

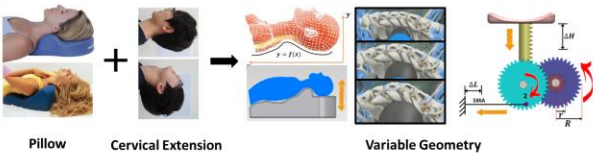
Development of a new apparatus actuated by SMA wire which assists neck extension movement as a physical treatment device for cervical disc herniation.

- Mechanical Design and Manufacturing of A Prototype.
- Biomechanical Analysis and Evaluation of Clinical Effect of The Device.

PROTOTYPE DESIGN AND MANUFACTURING

Conceptual Design

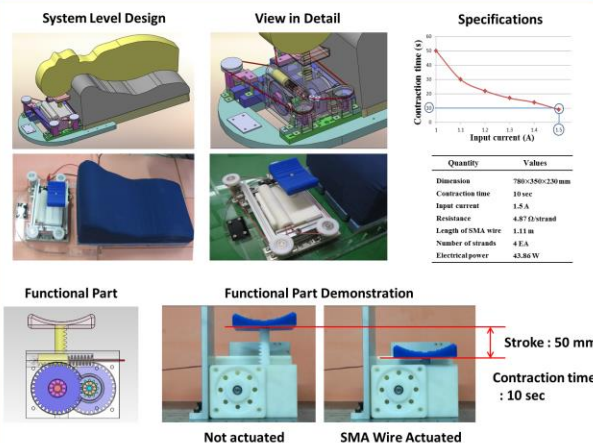
Variable Geometry Pillow : Enables a patient to do the cervical extension in supine position by periodically adjusting the height of the pillow.



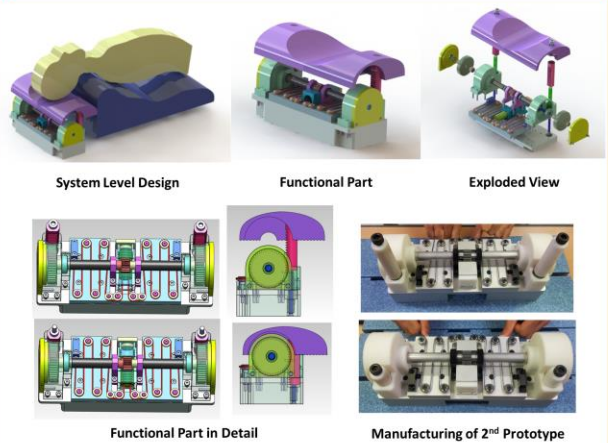
Mechanism of Variable Geometry Pillow

- SMA wire is heated by electric current and starts to contract.
- SMA wire pulls the horizontal rack gear and that makes coil spring compressed.
- The displacement of rack gear is magnified through the compound gear and then transferred to the vertical rack gear.
- Head supporting part moves down allowing the patient's neck to be extended.
- As the SMA wire is released and cooled down, the restoring force of the compressed spring lifts the head up.

First Prototype

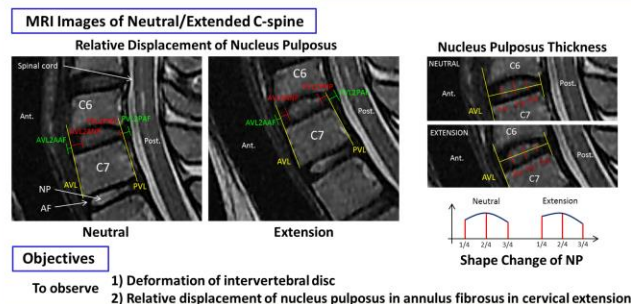


Second Prototype

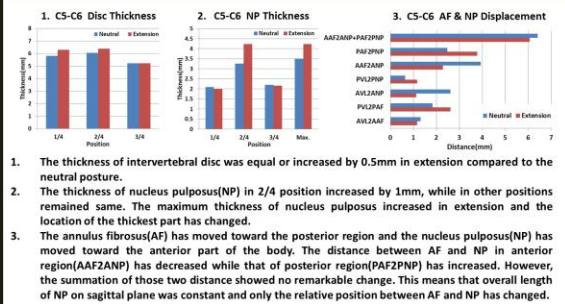


RESULTS, DISCUSSION AND CONCLUSION

Biomechanical Analysis - Method



Biomechanical Analysis – Results and Discussion



Evaluation



Conclusions

- The nucleus pulposus in intervertebral disc moves toward anterior side of the body in cervical extension, which means that the cervical extension is conducive to rehabilitation of herniated disc.
- The Variable Geometry Pillow using SMA wire can allow the patients with herniated disc to do the neck extension exercise without any noise.
- The Variable Geometry Pillow is expected to have an clinical effect of restoring the herniated nucleus pulposus.