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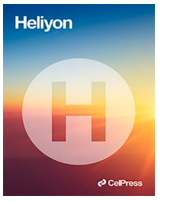

Prone extension views in cervical MRI: A case-driven Novel approach

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ABSTRACT

The cervical spinal canal has a wide range of motion and specific biomechanics involved with different pathologies that may cause dynamic cord compressions. This study has introduced new protocol for acquiring an extension view of cervical MRI to assess dynamic cervical spinal canal compromise. We posit that dynamic MRI comprising extension view in prone position could be a practical option when deciding the best approach in treating challenging patients.

1. Introduction

The cervical spinal canal has a wide range of motion and specific biomechanics that are influenced by different pathologies that secondarily affect cervical spinal cord function [1]. Cervical spondylosis and cervical disc herniation are the most common pathologies developing cervical myelopathy or nerve root impingement and radiculopathy [1].

There are many imaging techniques with various accuracy to evaluate cervical spinal canal and spinal cord. Myelography and computed tomography (CT)-myelography are less used imaging; however, they are recommended for conditions such as contraindication of MRI. Since the late 1980s magnetic resonance imaging (MRI), an efficient modality, has become the gold standard of care in patients with cervical complaints [2,3].

Conventional MRI is a static method in which the patient is lying in supine position [3], and this technique could help determine traumatic and continuous cervical canal compromise while the dynamic pathologies may not be visualized [4].

Researchers introduced a new method called dynamic cervical MRI acquired via flexion and extension positions to cover drawbacks of the conventional method. They obtained this imaging in two additional views in a recumbent patient, including flexion and extension neck positions representing dynamic cervical canal stenosis [5,6].

There are many studies comparing different approaches to cervical spinal canal compromise. Authors frequently discuss advantages and disadvantages of anterior versus posterior interventions [7]. The goal of these studies was to improve patient outcome with a less invasive approach; however, at times this method may not resolve patient deficit(s) resulting in a second or third surgery [8]. We

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suggest that good quality imaging depicting the exact point of the pathology can help in deciding the best approach and better patient outcome. Some authors have supported dynamic cervical MRI in supine position. Even though these imaging are good, taking the extension imaging in supine position will be restricted due to the gantry limitation [8,9].

The present study introduces a new protocol for acquiring the extension view of cervical MRI in patients who have cervical spinal cord root manifestations related to dynamic cervical spinal canal compromise.

2. Methods

After signing both the informed consent form and consent to publish form by the patient, he underwent this procedure. Cervical extension MRI is performed with a 1.5 T superconducting system (Avanto; Siemens, Erlangen, Germany) using a 4-element design with 4 integrated preamplifiers Neck Coil. During the procedure the patient is placed in a prone position with maximum active neck extension. Figs. 1 and 2 depicted patient preparation for taking cervical flexion (see Fig. 1) and extension (see Fig. 2) MRI respectively.

Similar to conventional MRI, protocol includes sagittal T1-weighted images (repetition time (TR) 500 ms, echo time (TE) 10 ms, Matrix 320 × 224, Field of View (FOV) 260 mm, and number of excites (NEX) 3) and Fast spin echo sagittal T2-weighted images (TR 3400 ms, TE 91 ms, Matrix 320 × 224, FOV 260 mm, and NEX 2) with a slice's thickness of 3.0 mm and a slice's space of 0.3 mm). Additional axial 2D MEDIC (Multi Echo Data Image Combination) T2-weighted images (TR 800 ms, TE 17 ms, Matrix 256 × 204, FOV 180 mm, and NEX 2) are taken with a 3.0 mm slice's thickness and a 0.3 mm slice's space and these images are disc-angled. This protocol has the same time as cervical MRI in supine position being approximately 8–10 minute in duration.

2.1. Illustrative case

We present a 37-year-old previously healthy boxer man who complained of left-hand weakness and unilateral decreased grasp forces of the hand that started from three years ago. His family history was unremarkable. He had no pain or sensory symptoms. Six months later, his condition did not improve, and he underwent left ulnar nerve release by an orthopedic surgeon with the impression of ulnar entrapment syndrome.

His weakness diminished within the first month after the operation but developed neck pain radiating to the left C5 dermatome and had a conventional cervical MRI. This imaging revealed an anterior located intramedullary hypersignal lesion on T2-weighted sequences posterior to the C5–C6 disc space without noticeable cord compression which was suspect to demyelinating lesion. Examinations including repeated cervical MRI ruled out demyelinating process. In the previous MRI, non-enhancing intramedullary bright object was visible yet.

Three years later he came to our clinic with persistent neck and left arm pain along with decreased sensation in the left side of the body, decreased left-hand dexterity, and prolonged constipation and urinary retention. On examination, all cranial nerves were intact. Muscle reflexes were 3^{+} throughout the left upper and lower extremities. Strength examination revealed 4/5 in the left hand and 5/5 throughout the rest of the extremities. Upper motor neuron signs revealed positive left-sided Hoffman's sign accompanied by left Babinski sign. Sensory examination was intact. On inspection of the cervical spine, spinal curvature was normal. Spurling test was negative, no muscle atrophy was seen, and cervical facet tenderness was not found. His Japanese Orthopedic Association (JOA) score, Nurick grade, and neck disability index (NDI) were 15, grade II, and 50 %, respectively.

After finding no cervical spondylolisthesis by dynamic neck X-ray, we used the new protocol, and the patient underwent dynamic cervical MRI including flexion view of the cervical spine in supine position concomitant with extension view in the prone position by active motions.

These sequences revealed folded yellow ligament posteriorly compressing the cervical spinal cord following neck extension. The pathology showed posterior compression on the spinal cord identified by the new protocol which confirmed our decision to operate on the patient via posterior laminectomy (Fig. 3, A-D). Left arm pain disappeared immediately postop, and on one-year follow-up visit, the patient was totally pain free in both neck and arm. In addition, his left hand found complete strength, sphincteric problems improved, and had some complaints of mild sensory discomfort in left side of the body.

Fig. 1. Patient preparation for taking cervical flexion MRI.

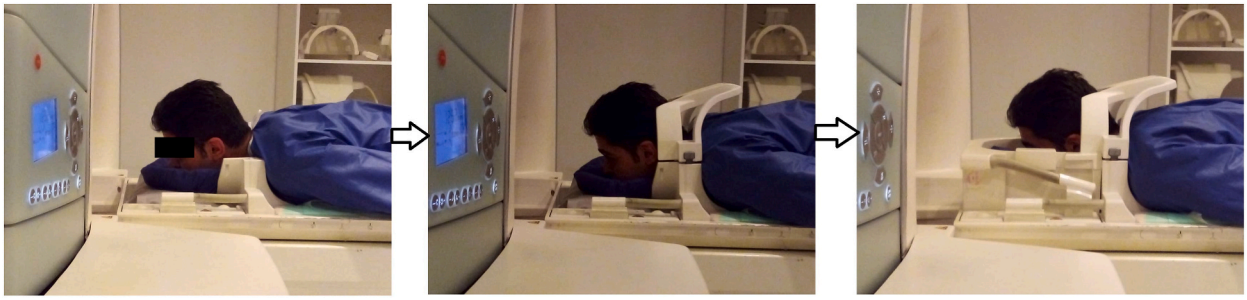

Fig. 2. Patient preparation for taking cervical extension MRI.

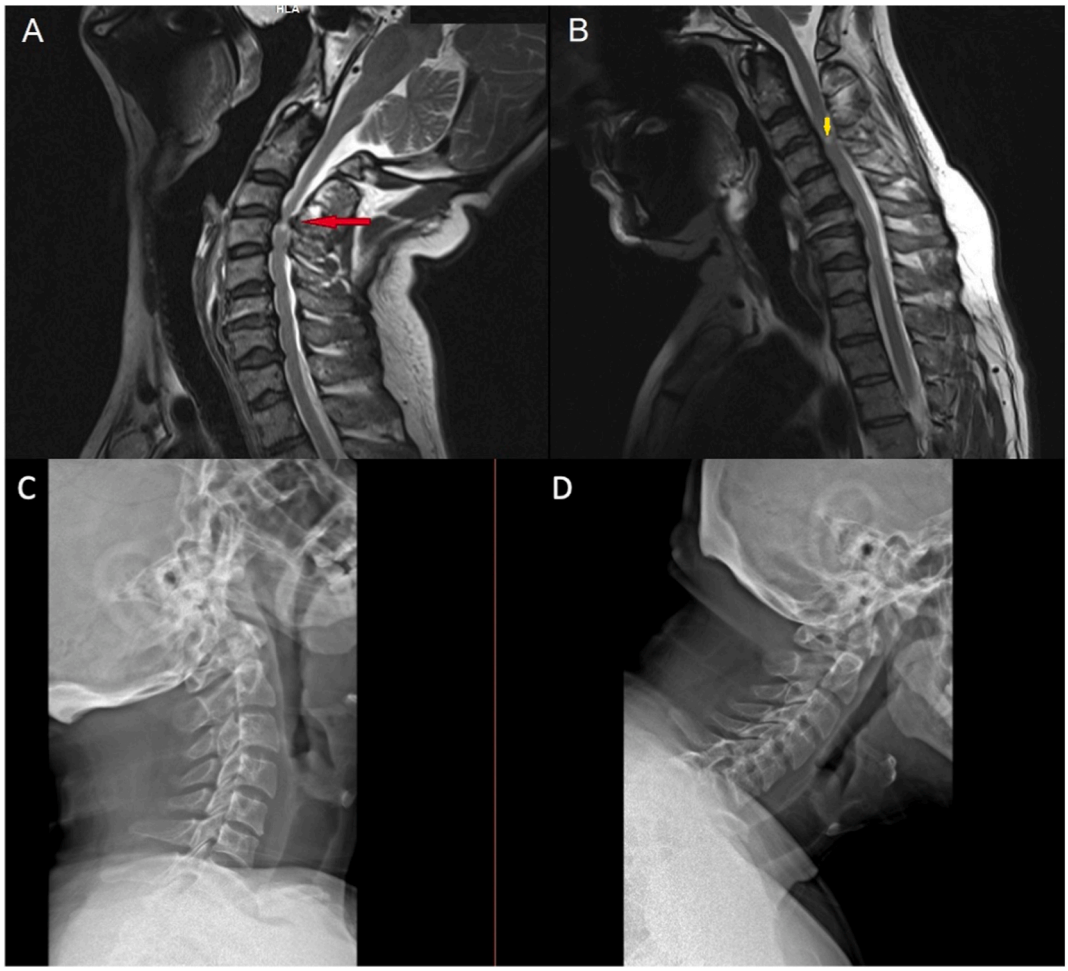

Fig. 3. The extension (A) and flexion (B) cervical MRI in our patient which shows a bright object in cervical cord parallel to the C3-4-disc space (white arrow) and posterior cord compression in that level by folded ligamentum flavum (red arrow). Also, there is no spondylolisthesis in the extension (C) and flexion (D) cervical x-ray.

3. Discussion

The cervical spine differs from the other parts of the spine biomechanically [10]. It has higher range of motion than other areas and enables a wide-degree neck movements [10]. In addition to these unique biomechanics, the spinal cord in this region contains more essential neural elements supplying various organs compared to the remaining spinal cord. Hence, compression on this segment, whether due to the trauma or other pathologies like discopathy or degeneration, can result in devastating consequences [11].

Previous research suggests that there are three different mechanisms compressing the spinal cord or cervical root compression.

Continuous compression, traumatic compression, and dynamic compression are thought to be causes of cervical symptoms [1,12]. Apart from traumatic cases, cervical spine degeneration is more common among the other lesions [12]. The Ligamentum flavum is one of the spinal canal components playing an essential role in different spine positions. This ligament, which can become pathologic over time, accounts for some dynamic cord root compressions in which cervical motion aggravates its compression because of the probability of ligament folding resulting in more canal narrowing [13]. In these patients, cervical discectomy via the anterior approach without removing the pathologic element directly may not resolve the symptoms and impose additional surgery on the patient [14]. Therefore, to reach an optimal outcome, it is necessary to address the true pathology before decision-making.

Recently, some studies have suggested that dynamic cervical MRI is a safe tool used to define pathologies thoroughly [5,15]. They revealed that dynamic MRI could provide more information about the cervical spine and serve as a guide to the best approach [6]. Zeitoun et al. reported the extension MRI is a useful method to indicate pathologies hidden in neutral or flexion MRI [4]. Furthermore, they suggested that the flexion MRI revealed intramedullary hypersignal lesions more clearly, a finding that is associated with poor prognosis [4,16]. Gotkine et al. found that dynamic MRI has an essential role, especially in patients with distal weakness in upper extremities (similar to our patient's symptoms) [17,18]. In these studies, dynamic MRI has been taken when the patient has been placed in a supine position, with neck flexion and extension views [4,6,17,19].

According to the clinical manifestations of our patient, we decided to use dynamic cervical MRI. Neck flexion was done with the patient lying in the supine position, but the new protocol of extension MRI was implemented. For this view, the patient was placed in the prone position, then neck extension with active movements was done. To the best of our knowledge, this is the first study introducing cervical MRI use in a prone position. This new method has three advantages. First, it enables the patient to perform maximum neck extension, while it is limited in the supine position due to the chin-gantry proximity. Second, the spinal cord moves forward in a prone position that shows probable anterior compressions along with posterior points. Third, the volume of the intramedullary hyperintense spots may be estimated better.

Although this protocol could be helpful in challenging cases, there are some limitations that should be considered in practice. First, we must use the results of this study cautiously because this is based on the only one case. Accordingly, the authors suggest conducting a larger-scale study to find the advantages and disadvantages of this protocol better. Additionally, we emphasize that this type of MRI should be taken with active cervical extension without any manipulation by the operator. Moreover, this protocol should be used cautiously in patients with moderate to severe myelopathy. In addition, this method may not be tolerated well with populations such as the elderly, claustrophobic or patients with severe pulmonary disease. Finally, this protocol is not indicated in patients with cervical spondylolisthesis. Because of the potential risks related to this protocol, our patients will be referred to the only center in which the operators have been fully trained and will take the MRI by confirming the expert radiologist (E.R.).

4. Conclusion

Dynamic cervical cord compression is a process presenting with symptoms similar to the other cervical cord pathologies without significant findings on conventional MRI. In such patients, dynamic MRI comprising extension in prone position could be a practical option helping to clarify true pathology and decision-making for the best approach to treatment. Recommendations for future research would be a comparison larger-scale study of MRI findings between neck extension in prone position and neck extension in supine position which could provide valuable data.

Data availability statement

Data has associated with my study been deposited into an available repository that will be available when it is requested via 00989124870553 or email; ahmadpourrashidi89@gmail.com.

CRediT authorship contribution statement

Ahmad Pour-Rashidi: Data curation, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Jalil Arabkheradmand:** Conceptualization, Resources, Writing - original draft, Writing - review & editing. **Elham Rahimian:** Methodology, Resources, Writing - original draft, Writing - review & editing. **Judith Aarabi:** Writing - original draft, Writing - review & editing. **Mahshid Fallahpour:** Data curation, Validation, Visualization, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Abbreviation

JOA Score: Japanese Orthopedic Association Score
NDI: Neck Disability Index
MEDIC: Multi Echo Data Image Combination
FOV: Field of View