CASE REPORT

A Case Report: Adverse Outcomes Following Cervical Spine Manipulation – A New Chronic Neck Patient?

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ABSTRACT

Introduction: Cervical cord injury from spinal manipulation is not rare. Safety protocols and predictors have been emphasized to prevent adverse events. In October 2012, the International Federation of Orthopaedic Manipulative Physical Therapists approved a framework for safer cervical spine assessment, focusing on the risk of Cervical Arterial and Neurological Dysfunction. This case study investigated whether cervical spine manipulation in an asymptomatic neck could cause soft tissue lesions.

Clinical and radiological follow up: To explore this potential cause of the patient's neurological symptoms in this single case, a Computer Tomography and Magnetic Resonance Imaging scan were requested. The supervising clinician emphasized the importance of positioning the patient's head and neck according to her specific clinical findings before performing the radiological scans of the cervical spine.

Case Report Findings: Significant radiological findings, including C1 anomalies and soft tissue lesions were revealed. Imaging identified C1 Spina Bifida, absence of the Rectus Capitus Minor muscle, C1-2 hyper-rotation with borderline Atlas-axis facet subluxation, lesions to the Anterior Longitudinal Ligament and central Alar/Cruciate ligament complex, as well as unphysiological contact between the spinal cord and ligament structures at the C0-1-2 level.

Discussion: This Case Report highlights the importance of thorough clinical assessment and individualized imaging before cervical spine manipulation. Undetected structural anomalies and soft tissue vulnerabilities can increase the risk of adverse effects. Standard radiological protocols may lack sensitivity to functional biomechanics, highlighting the need for a more precise diagnostic approach. Adhering to established clinical guidelines can enhance patient safety and treatment outcomes

Conclusion: These Clinical and Radiological findings underscore the importance of integrating comprehensive clinical assessment with individualized pre-manipulative imaging to enhance patient safety in cervical spine manipulation. Identifying pre-existing structural vulnerabilities through advanced imaging can help reduce risks associated with manipulative techniques. Furthermore, aligning radiological findings with clinical evaluation ensures a more precise diagnosis, reducing the likelihood of overlooked lesions and subsequent complications.

Keywords: Cervical spine manipulation, C1 instability, Adverse Results after Cervical spine manipulation, Cervical spine imaging, Pre-manipulative assessment and imaging, Cervical Arterial and Neurological Dysfunction after cervical spine manipulation.

Introduction

Cervical cord injury caused by spinal manipulation is not a rare condition[2,3]. Safety protocols and predictors of cervical spine manipulation has been emphasized to prevent adverse events[4-8]. In October 2012, the International Federation of Orthopedic Manipulative Physical Therapists developed and approved a framework for a safer clinical assessment of the cervical spine. This framework focused on evaluating the potential for Cervical Arterial and Neurological Dysfunction. Cervical spine injuries with Cervical Arterial and Neurological Dysfunction can be a serious condition, and it needs to be considered ahead of all cervical treatment[9,10].

Individual adapted pre-manipulative Cervical spine Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) protocols to prevent adverse events after cervical spine manipulation are regularly not in use. New clinical decision rules for cervical CT to detect cervical spine injury in patients with head or neck trauma could improve the health outcome for the patients[11]. Clinical and radiological findings with adapted cervical protocols suggest that the combined use of MRI together with cervical spine CT could clarify the morphological and biomechanical cervical spine status in the blunt trauma patient[12]. Turner et al. focused on the medical clearance status prior to cervical manipulation in potential at risk patients that would drastically reduce morbidity and mortality[13].

This Case Report illustrates a healthy female (NN), born in 1981. In July 2020, NN experienced a fall where she hit the low lumbar spine and the sacro-iliaca (SI) joint. The initial complaints were solely located to the lumbar spine/ SI joint right side. NN sought consultation with a therapist three days later. During the initial session, she reported pain and functional deficit in the lower spine/SI area only, and reported no pain or dysfunction in the thoracic or cervical spine/head regions. NN received nevertheless manipulations techniques for both the lumbar, thoracic and cervical spine. For the cervical spine, NN was treated in both prone and supine positions. No imaging was done prior to the manipulation.

NN underwent a total of five treatment sessions. Initially, there were no symptoms in the head or neck area. After the first cervical manipulation treatment, NN reported severe onset of symptoms in the neck/ head, arms and feet, together with breathing problems. Despite four additional therapist follow-up sessions, NN's cervical/ head and extremities symptoms worsened after each session. Eventually, NN declined further treatment. These five treatment sessions occurred over a span of 20 days in 2020.

Status January 2024: NN experienced that the deep neurological burning pain to both legs and arms had become chronic. The pain in the neck and the dizziness had worsened over the years from 2020 to 2024. Rotation of the head and neck aggravated the symptoms, especially rotation to the right side. With rotation right, NN experienced a strong pulsation left side in the upper cervical spine, which lead to a pressure like pain in the head with blurry vision[1].

NN had been through MRI scan of the cervical spine, with head and neck in neutral position, 3 times from 2020 to 2023, all with normal findings. A CT scanning in 2023 showed a spina bifida C1.

EXAMPLE OF CERVICAL MANIPULATION TECHNIQUE IN THIS CASE REPORT.

The patient was laid down on a bench, prone position. NN was told to relax and exhale her respiration. The therapist did a straight downward thrust on the cervical spine (Figure 1,2).

The thrust was performed straight downwards. Figure 3 illustrates the direction of the prone cervical thrust on NN's spine. The red arrow indicates the thrust direction. NN's report does not contain secure information about level of treatment.

A clinical and radiological follow up after the adverse cervical spine manipulation revealed a spina bifida C1. Figure 4 shows a broader C1 left-side bow-end than the right-side bow-end. With the neck in slight extension, the left-side bow-end of C1 is already inside the foramen magnum.

Figure 1-2: *The therapist locates the cervical segment for manipulation (left picture). The upper-hand make the straight downward thrust on the cervical segment (right picture).*

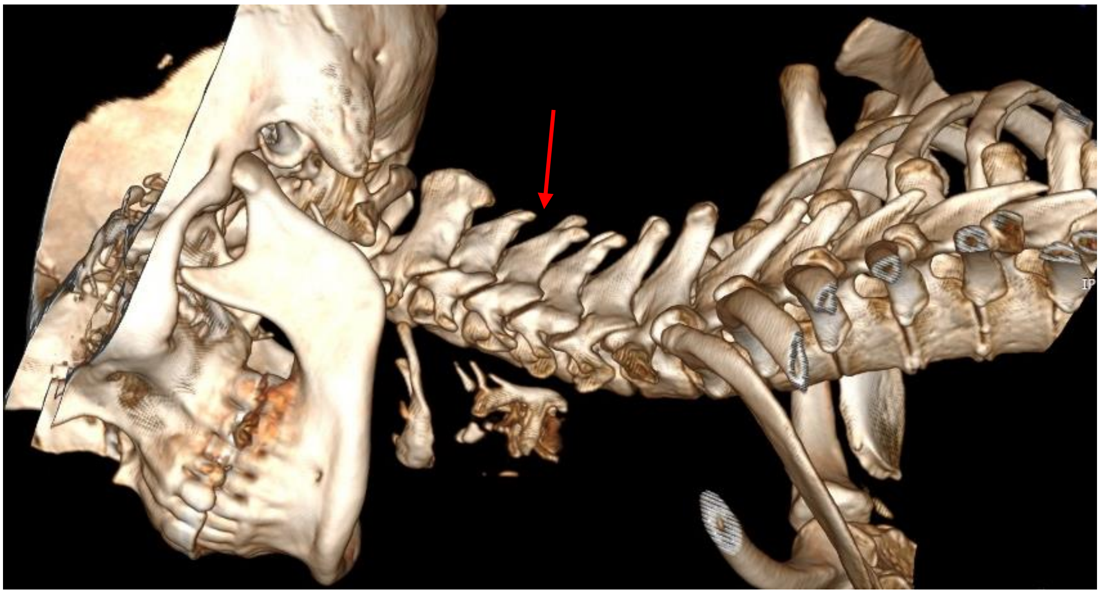

Figure 3. This is NN's cervical spine in neutral prone position (CT). The red arrow indicates the downward thrust.

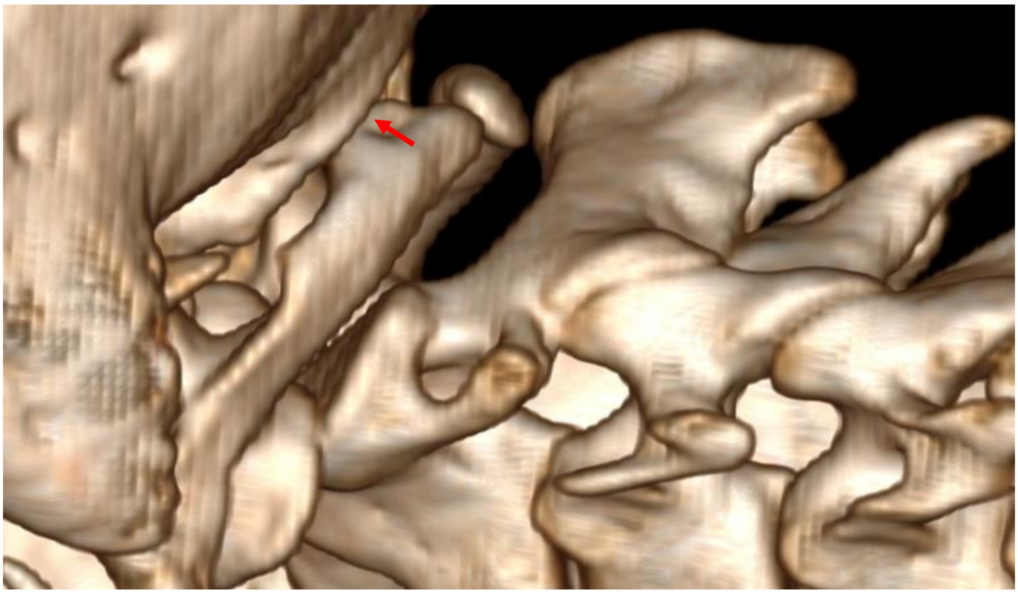

Figure 4. CT, 3D, lateral view C0-1-2, left side. Neutral head and neck position.
The CT demonstrates the spina bifida C1. An undiagnosed, and thereby an overlooked anomaly, at the moment of cervical spine manipulations. The red arrow shows the left-side bow-end inside foramen magnum.

The MRI illustrated no-existing M. Rectus Capitis Minor (RCmin). This small, but vital muscle, normally goes from the lower part of the skull to an intact C1 bow. In this case there are no normal RCmin muscle. On the MRI we located some loose connective tissue without the supporting muscular collagen fibers. See Figure 5.

To emphasize this muscular finding, we have included an MRI image of the same muscle under normal clinical conditions with normal MRI findings. Figure 6 shows a normal Rectus Capitis Minor muscle in a control Case.

Figures 5 and 6: *MRI, 3T, coronal T2-weighted images.*
Figure 5: *Left picture - An abnormal M. Rectus Capitis Minor indicated by the red arrow.*
Figure 6: *Right picture - A normal M. Rectus Capitis Minor indicated by the green arrow.*

The aim of this case report is to describe a patient who developed severe symptoms following cervical spine manipulation and to explore the potential relationship between the intervention and the observed clinical findings. By presenting imaging results and discussing possible mechanisms, we seek to contribute to the ongoing debate on the safety and risks associated with cervical spinal manipulation. This report aims to raise awareness among clinicians about the importance of thorough assessment, early recognition of adverse events, and careful patient selection when considering manual therapy techniques.

Clinical and Radiological follow up

The Supervising Clinician, with thoroughly insights in the patient's history of trauma with clinical findings, gave the exact positioning of the patient on the CT and MRI table. The Clinician participated together with a Senior Radiographer with extended competence in MSK imaging. The Senior Radiographer, together with the Supervising Clinician collaborated in optimizing the imaging protocol tailored to the specific needs of the patient. NN was placed on the CT table with the head and neck both in neutral, and in levels of right/ left rotation; correlated specifically to the C1-2 rotation with facets rest coverage[14] with the skull/ C1 position in the sagittal plane regarding to level of flexion-neutral-extension.

CT PROTOCOL

The CT scans were obtained from above the base of the skull to T1/T2. The CT images were generated on a Toshiba (Canon Healthcare Aquilion Prism) CT scanner; typical parameters were 100 kVp and 50 mAs with a 0.5-sec scan rotation time. Bone, soft tissue and CT image filter convolutions (FC) were used, and the patients were scanned without gantry angulation. The scans were a helical acquisition of 0.5mm x 80 slices with a pitch of 0.8 and reconstructed as 0.5 mm axial slices every 0.25mm. Table 1.

3D Volumetric CT scans were reviewed using RadiAntViewer software using both 3D and cross-sectional imaging techniques. The ionizing radiation dose for the CT assessment is between 1,9-2,5 mS.

Imaging Protocol Summarized

- **Volumetric CT Protocol**
- **Parameters- Dedicated Volumetric CT Cervical Spine**
- **Anatomic coverage** Above foramen magnum to T2
- **Collimation** (mm)* 0.5; **Rotation time** (sec) 0.4
- **Exposure factors** 100 kV 50 MAs Automatic modulation
- **Table Pitch** 0.8
- **Imaging and reconstruction planes** Axial mm (0.5/0.25); coronal and sagittal mm (2.0); three-dimensional volume mm (0.50).

MRI PROTOCOL

This study outlines a standardized protocol for magnetic resonance imaging (MRI) of the cervical spine using the 3T Siemens Skyra scanner (NUMARIS/4, Version Syngo MR E11). Utilizing a 20-channel Head and Neck coil, the protocol focuses on evaluating ligament integrity, particularly the atlas C1, through a combination of neutral and tilted head positions. Details of imaging sequences and positioning techniques are described to facilitate reproducibility and enhance diagnostic accuracy.

MRI is the imaging modality of choice for evaluating the cervical spine, offering high-resolution visualization of soft tissue structures, including intervertebral discs, ligaments, and neural elements. This study documents a structured approach to cervical spine MRI, particularly emphasizing the assessment of the C0-C1-C2 ligaments. The MRI was conducted on a 3T Siemens Skyra system using the NUMARIS/4 software and syngo MR E11 version. A 20-channel Head and Neck coil was employed to ensure optimal image quality. The patient was positioned head-first supine on the table, with extra pads for immobilization during tilted head sequences.

In the initial neutral position, sequences were acquired to establish baseline anatomy and pathology. Following this, the patient's head was tilted to the right/ left, enabling focused evaluation of the C0-C1-C2 ligaments under strain. This was achieved through transverse and sagittal T2w TSE sequences. Subsequently, the head was tilted to the left, with the same sequences repeated. Padding was utilized to maintain stability and reduce motion artefacts. The MRI sequences are shown in Table 2.

Imaging Protocol Summarized

The following sequences were performed:

1. **Neutral Head Position:**
    a. Localizer
    b. Sagittal T2-weighted (T2w) Turbo Spin Echo (TSE)
    c. Transverse T2w TSE
    d. Coronal T2w TSE
    e. Transverse T2 Short-Tau Inversion Recovery (STIR) TSE
2. **Head Tilted Right:**
    a. Localizer Right (Loc rt)
    b. Transverse T2w TSE (Tra T2w TSE rt)
    c. Sagittal T2w TSE (Sag T2w TSE rt)
3. **Head Tilted Left:**
    a. Localizer Left (Loc lt)
    b. Transverse T2w TSE (Tra T2w TSE lt)
    c. Sagittal T2w TSE (Sag T2w TSE lt)

Case Report Findings

With neutral head and neck position we locate the left bow-end inside the foramen magnum. Figure 7. Clinically the hyper extension C0-1-2 together with over-rotation C1-2, close to subluxation, has earlier been demonstrated for this Case[1,14].

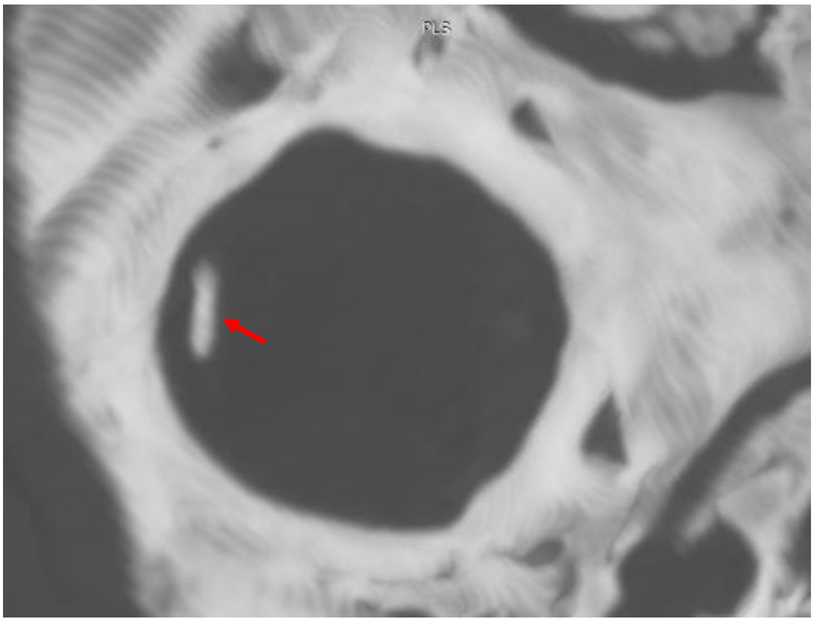

Figure 7: *CT, axial section at a level just inside the foramen magnum. Neutral head and neck position.*
Findings: *The left-side bow-end of C1 is 2,5 mm up in the foramen magnum indicated by the red arrow.*

The MRI results indicated a cross-sectional lesion to the Anterior Longitudinal Ligament illustrated in Figure 8 and 9. To emphasize these ligament findings, we have included an MRI image of the same ligament under normal clinical conditions with normal MRI findings in Figure 10.

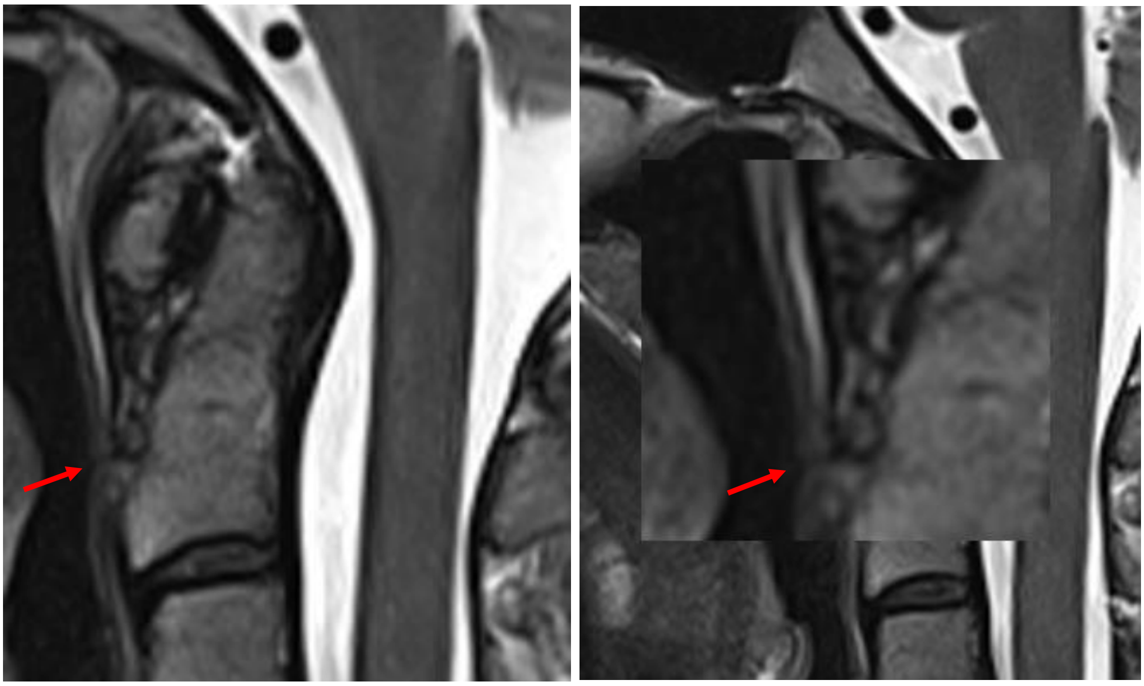

Figure 8 and 9. *3T MRI, T2-weighted sagittal TSE at the level of the upper part of the dens axis-atlas. The right picture with enlargement of the pathological findings.*
Findings: *Both pictures indicate an injury (dis-continuity in the collagen fibers) to the Anterior Longitudinal ligament indicated by red arrows.*

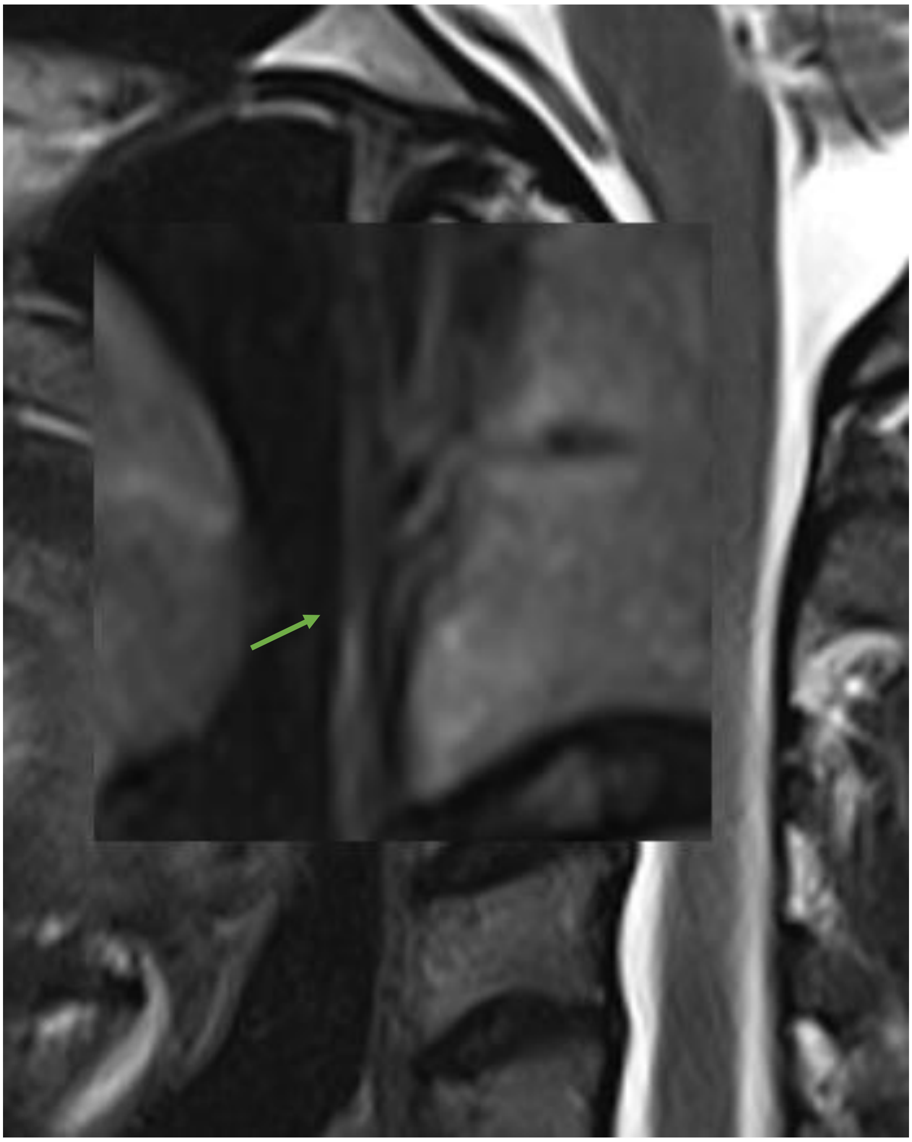

Figure 10. 3T MRI, T2-weighted sagittal TSE at the level of the upper part of the dens axis-atlas. This picture shows the same enlarged section of the Anterior Longitudinal ligament as shown in figure 9.
***Findings:** This figure show a normal, uninjured ligament (normal continuity of the collagen fibers), indicated by the green arrow.*

Rotation of the cervical spine

We positioned the cervical spine in a rotated position, and the ligaments that control the rotation of the C1-2 segment placed under tension. The ligaments on the opposite side of the direction of rotation were put under the highest level of tension.

In this Case Report the MRI findings indicated a lesion in the central part of the alar/ cruciatum ligament complex. See Figures 11-12. The lesion area is hyperintense, where the STIR sequence confirms the fat infiltration. The non-injured part of the ligament complex shows healthy, intact black collagen fibres.

Combining one third rotation of the cervical spine together with extension of the upper cervical spine we put the neck in the clinically tested most unstable position. The MRI findings indicate unphysiological cord contact between ligament structures and the cord when combining rotation one third to the left in combination with C0-1-2 extension. We did not have the same findings with motion vice versa. See Figures 13-14.

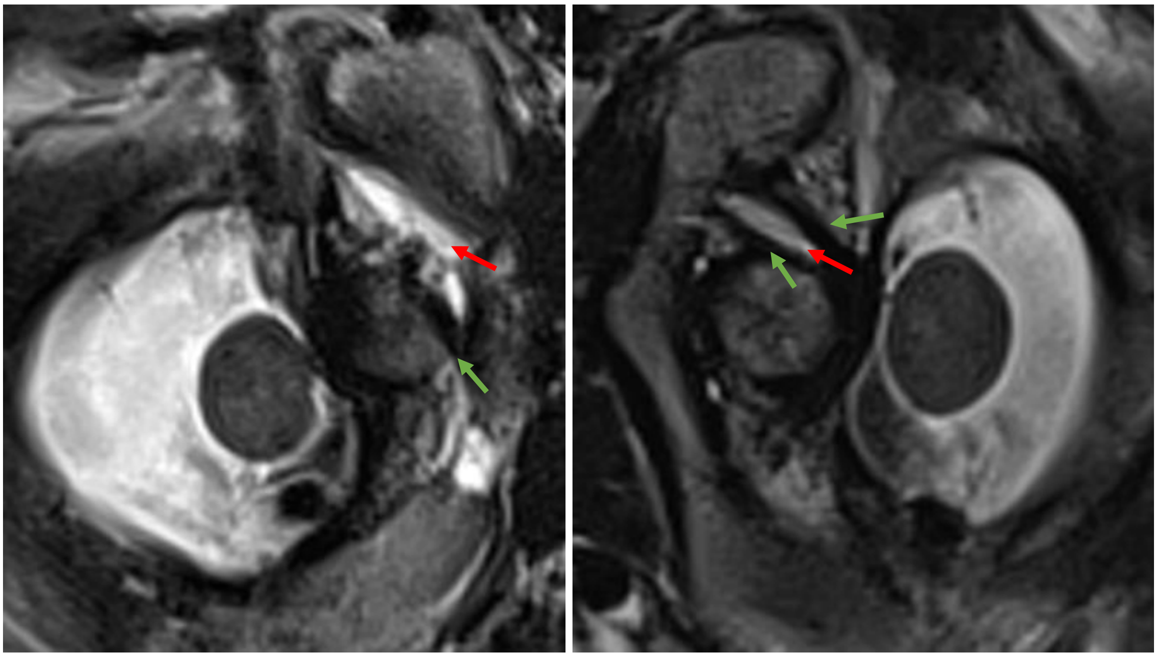

Figure 11-12. *3T MRI, T2-weighted axial TSE at the level of the upper part of the dens axis-atlas.*
The left figure shows C1-2 rotation to the left (mirrored), the right figure shows C1-2 rotation to the right (mirrored). We focus on the ligament complex of the alar- cruciatum. With rotation to the left (left figure) we straighten mostly the right side of the ligament complex – and vice versa.
Findings: *Inside the stretched part of the ligament complex, a central white elliptical area of tissue, identified as fat tissue, is observed (red arrows). In contrast, the intact lateral parts of the ligament complex show black collagen fibres, as indicated by the green arrows.*
The findings are more comprehensive on the left side picture indicated by red arrows.

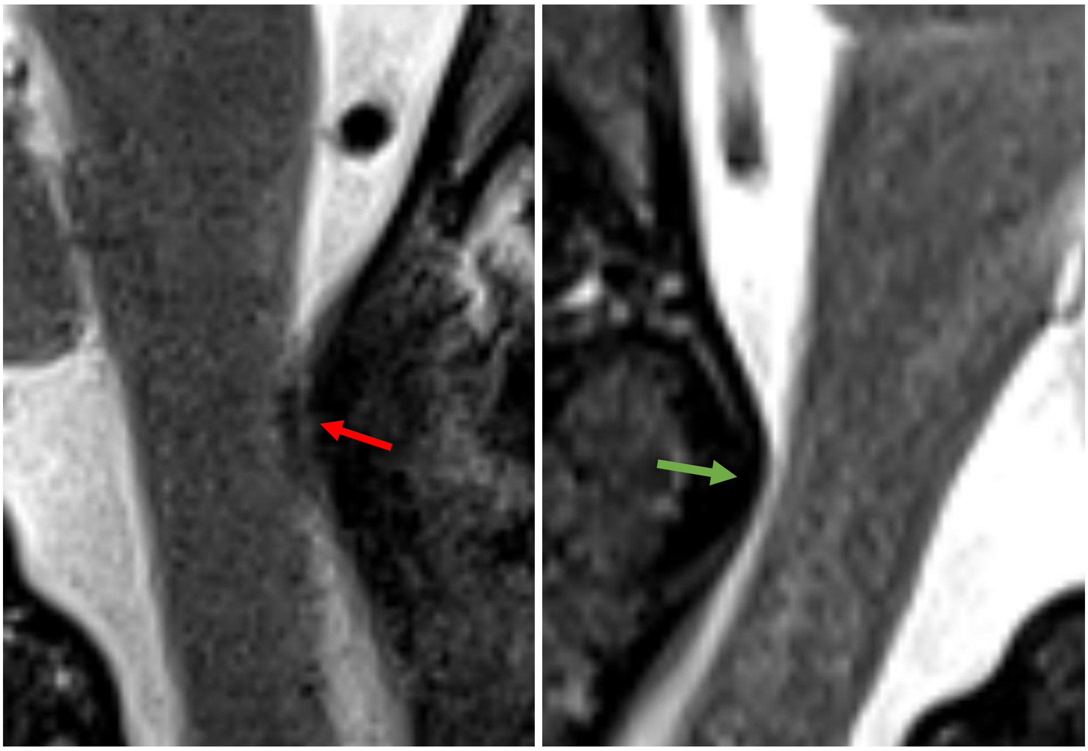

Figure 13-14. *3T MRI, T2-weighted sagittal TSE.*
The left figure: On third left C0-1-2 rotation- craniovertebral extension.
The right picture: On third right C0-1-2 rotation- craniovertebral extension.
Findings: *The left picture show a possible unphysiological contact area between ligament structures and the cord indicated by the red arrow. We do not have the same findings on the right picture indicated by the green arrow.*

Due to the provocation of long-track neurological symptoms on both sides after the MRI, caused by combined one-third cervical rotation and upper cervical spine extension, we decided not to proceed with the axial MRI in the same positions. We followed up with an axial view, with neutral head and neck positions regarding to rotation, but combined with and without head/neck extension.

The MRI with axial view, showed solid unphysiological contact between the cord and the ligament complex with extended head and neck position. See Figures 15-16.

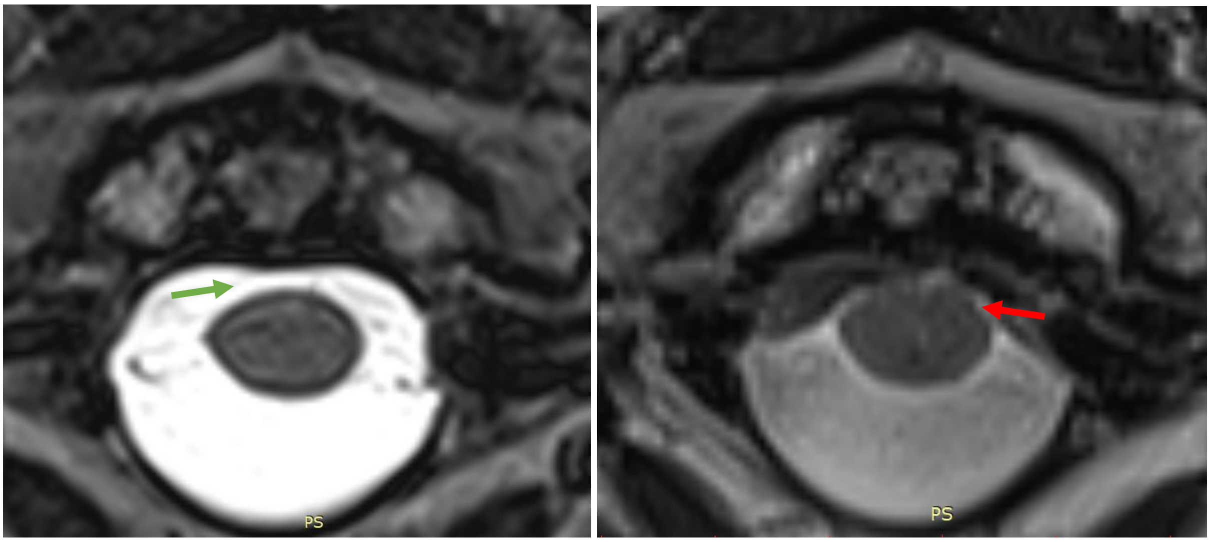

Figure 15-16. *3T MRI, T2-weighted axial TSE at the level of the upper part of the dens axis-atlas.*
The left picture shows neutral head and neck positions, <u>with no</u> rotation or extension. The right picture shows <u>no</u> rotation, but <u>with</u> extended head-neck position.
Findings: *The left picture shows no contact between the cord and the ligament complex indicated by the green arrow.*
The right picture shows solid contact between the cord and the ligament complex indicated by the red arrow.

Not all MRI planned sequences were carried out due to rise in the neurological long tract symptoms. A summary of all radiological findings is given in Table 3.

Table 3: Summary of CT and MRI Cervical findings in this Case Report:

Finding	Imaging Modality
Spina Bifida	CT
Absence of the Rectus Capitus minor muscle. Loose connective tissue as replacement tissue	MRI
C1-2 hyper-rotation	CT
Atlas-axis facets rest-coverage R/L on the border to subluxation	CT
Lesion to the Anterior Longitudinal Ligament	MRI
Lesions to the Alare/ Cruciate ligament complex, central part	MRI
Unphysiological contact the cord- ligament complex- level C0-1-2, in provoked position, Sagittal view	MRI
Unphysiological contact the cord - ligament complex- level C0-1-2, in another provoked position, Axial view	MRI

Discussion

This Case Report shows the very serious imbalance between performing cervical spine manipulation techniques and simultaneously controlling the manipulative impact on the cervical morphology, biomechanics, vascular, and neurological system. The report lacks detailed documentation of clinical findings and a clear rationale for performing cervical manipulation. There are no documented findings that would justify the use of this treatment technique on her asymptomatic neck.

The post-treatment CT and MRI adapted protocols have uncovered serious anomalies and soft tissue injuries. One of the findings, Spina Bifida C1, is a congenital anomaly. The absence of the muscle Rectus Capitis Minor, which has been replaced by loose fibrotic tissue, is also likely a consequence of this bony anomaly. Additionally, radiological imaging has revealed rotational instability at the C1-C2 segment in both right and left rotation, on the border of facets luxations[14].

The clinically and radiologically uncovered soft tissue findings and lesions; including the lesion to the Anterior Longitudial Ligament, the central part of the Alar/ Cruciate ligament complex (right/left), and the pathological contact between the cord and the ligament structures in the upper cervical spine – follow the same biomechanical injury pattern. All of the illustrated soft tissue lesions lie in the same plane as the downward cervical segmental thrust. This thrust hit unphysiologically several different soft tissue structures, and exposed them all for a load that exceeded their limit of failure. This emphasizes the urgent revised radiological approach for this group of patients. The lack of coherence between the clinical biomechanical findings and the radiological findings is clear in this Case Report. The patient underwent three cervical MRI scans with minimal reported abnormalities

Radiological interpretation of soft tissues and joint that affect the biomechanics have to cope with the term ‘Normality’. Historically, 'normality' has been determined by comparing an isolated anatomical structure to age- and gender-matched controls. However, this approach fails to account for the essential principle of biomechanics: one structure is multifunctional, and one function is controlled by multiple structures. Radiological statements on a single patient structure, evaluated against the average gender and age evaluated finding of the same single structure, often out of the patient context, is a mis-understood approach to useful biomechanical information that gain the assessment and treatment follow up[15-17].

Our experience with the The American Academy of Orthopedic Manual Physical Therapists (AAOMPT) Clinical Guidelines for Manipulations highlights their benefits for both treatment safety and patient health outcomes. Mintken et al. (2008) developed a standardized framework for manipulation terminology[15], which provides a structured approach to segmental manipulation. This model enhances safety by ensuring precise execution of manipulative techniques (Table 4).

Table 4: Clinical Guidelines for Manipulations

Parameter	Description
Rate of force application	Describe the rate at which the force was applied.
Location in range of available movement	Describe whether motion was intended to occur only at the beginning of the available range of movement, towards the middle of the available range of movement, or at the end point of the available range of movement.
Direction of force	Describe the direction in which the therapist imparts the force.
Target of force	Describe the location to which the therapist intended to apply the force.
Relative structural movement	Describe which structure or region was intended to remain stable and which structure or region was intended to move, with the moving structure or region being named first and the stable segment named second, separated by the word "on."
Patient position	Describe the position of the patient, for example, supine, prone, recumbent. This would include any pre-manipulative positioning of a region of the body, such as being positioned in rotation or side bending.

In addition to Mintken's model[15], The American Academy of Orthopedic Manual Physical Therapists Guidelines (2012) offer a broader framework for clinical assessment of the cervical spine, focusing on indications, contraindications, and technical execution of manipulative techniques[9]. These guidelines emphasize the importance of evaluating each anatomical structure under stress during a manipulation. A failure to adhere to these safety protocols can prolong soft tissue damage or even create new lesions. Had these principles been strictly followed in this case, it is likely that the adverse reaction could have been avoided.

The Kaale/ McArthur Concept focuses on the strong correlation between thorough clinical testing and the radiological follow up[1,14]. The primary focus of clinical testing is to match findings with the patient's reported symptoms and functional impairments.

The Kaale/McArthur Concept can provide a stronger foundation for making qualified decisions about the most appropriate course of action. By integrating thorough clinical testing with radiological follow-up, this method helps identify biomechanical dysfunctions and potential risk factors. Additionally, it can uncover red flags that may necessitate further referral and medical evaluation, ensuring that patients receive the most accurate diagnosis and appropriate treatment pathway. This comprehensive approach enhances patient safety and helps avoid unnecessary or potentially harmful interventions.

In cases with Red Flags, further medical evaluation is necessary. However, when Red Flags are absent, the therapist must determine an effective and safe treatment strategy. If this strategy includes manipulations, it is crucial to apply the six safety principles outlined in the AAOMPT guidelines[15]. To ensure treatment safety and prevent further tissue damage, detailed anatomical knowledge is required. Before performing a thrust, each affected structure must be evaluated individually to confirm its ability to withstand mechanical stress. Failure to follow these protocols may not only prolong tissue damage but also create new injuries.

Had these safety measures been followed in this case, the likelihood of an adverse reaction would have been significantly reduced.

The therapist must evaluate the risks and benefits of performing a pre-manipulative cervical spine CT. Through a precise clinical pre-assessment, the therapist selects only the necessary cervical spine positions for imaging. This targeted CT approach keeps the radiation dose below 2.4 mSv. In cases where the patient undergoes multiple medical follow-ups involving CT scans, this dose must be considered as part of their total radiation exposure.

Conclusion

This Case Report highlights the significant value of a thorough clinical assessment combined with individualized pre-manipulative CT and MRI scanning before performing Cervical Spine Manipulation. Assessing the bone and soft tissue status in advance can help reduce the risk of creating a new chronic neck patient or exacerbating existing soft tissue lesions. Radiological interpretation should be closely aligned with individual clinical findings, as standard imaging protocols often lack the specificity and sensitivity needed to accurately detect bony and/or soft tissue lesions, potentially leading to false-negative results.

Conflict of Interest:

None

Acknowledgements:

None

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