Benha International Journal of Physical Therapy

Online ISSN: 3009-7266 Home page: https://bijpt.journals.ekb.eg/

Original research

Effects of Mulligan Mobilization Technique on Pain, Cervical Range of Motion, Proprioception, and Disability in Cervical Spondylosis.

Mohamed A. Elkomy[1]*, Enas F. Youssef[2], Mazen S. Abulsaad[3], Ahmed O. Abdelnaeem[4]

[1]Demonstrator of physical therapy for orthopedic, Faculty of Physical Therapy, Horus University, New Damietta, Egypt.
[2]Professor and Chairperson of the Department of Physical Therapy for Musculoskeletal Disorder and Its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt.
[3]Professor of Orthopaedic Surgery, Faculty of Medicine, Mansoura University, Mansoura, Egypt - Horus University, New Damietta, Egypt.
[4]Lecturer at the Department of Physical Therapy for Musculoskeletal Disorders and Its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

***Correspondence to:**
Mohamed Elkomy, Demonstrator of physical therapy for orthopedic, Faculty of Physical Therapy, Horus University, New Damietta, Egypt.

Email:
melkomy@horus.edu.eg

Telephone:
01016029044

Article history:
Submitted: 02-04-2025
Revised: 17-04-2025
Accepted: 24-04-2025

Abstract

Background: Cervical spondylosis (CS) is a frequent aging-associated disorder (95%), impacting cervical spine joints and discs. Among various physical therapy interventions, the Mulligan Mobilization Technique (MMT) applies sustained passive accessory glides with active movement. **Purpose:** The primary aim of this study was to evaluate the effects of MMT combined with conventional physical therapy exercises on pain, cervical Range of Motion (ROM), proprioception, and functional disability in chronic CS patients. The secondary aim was to examine the interrelationships among these clinical outcomes. **Methods:** Twenty chronic CS patients (15 females, 5 males; ages 40-60 years) received a 4-week intervention combining MMT with conventional physical therapy exercises (ROM, isometric, and deep neck flexor exercises) three times per week. Outcome measures were recorded at baseline and post-intervention; these measures included the Visual Analogue Scale (VAS) for assessing pain, the Cervical Range of Motion (CROM) device to measure ROM and proprioception, and the Arabic version of the Neck Disability Index (NDI) to evaluate disability level. **Results:** Significant improvements were observed post-intervention across all outcome measures. Correlation analysis revealed strong negative correlations between neck pain intensity, NDI, and all cervical ROM. Additionally, the NDI showed strong positive correlations with target head position (THP) and neutral head position (NHP) (left rotation), along with moderate positive correlations with NHP (right rotation) and NHP. **Conclusion:** MMT effectively reduces pain and disability while enhancing cervical ROM and proprioception in chronic CS patients. The significant interrelationships among these outcomes emphasize the need for a multimodal rehabilitation approach.

Key Words: Cervical Spondylosis, Mulligan Mobilization, Mobilization with Movement, SNAGs.

INTRODUCTION:

Cervical spondylosis (CS) represents a highly prevalent aging-associated condition (95%), that affects the cervical intervertebral discs and facet joints [1]. By age 60, nearly all individuals experience some degree of degeneration, characterized by disc breakdown and enlarged facet joints. While aging is the primary cause, injuries can accelerate this process in younger populations [2]. CS typically

involves the middle and lower cervical vertebrae (C5-C6 and C6-C7), but may also affect higher levels [3]. Neck pain is the most prominent symptom [4]. CS can affect all cervical components, including the spinal cord, blood vessels, and nerve roots [2]. Such involvement can lead to changes in proprioception (accurate sensory feedback) and restricted neck mobility, which contribute to overall functional disability [5].

Conventional physical therapy offers some benefits that have been used for many years and have effectively improved functional activities in chronic CS patients. These techniques include strength training, high-intensity laser therapy [6], heat therapy, traction [7], Massage Therapy [8], kinesio tape [9]; however, manual therapy techniques such as the Mulligan Mobilization Technique (MMT) have become integral to clinical practice [10].

Mulligan mobilization technique involves sustaining a passive joint glide during the patient's active performance of a problematic movement, thereby restoring joint biomechanics through sustained natural apophyseal glides (SNAGs) [11]. Previous studies done by [12] and [13] showed that MMT was an effective modality for treating mechanical neck pain and chronic neck pain respectively.

Although extensive literature has demonstrated the clinical benefits of MMT in reducing pain and improving mobility, there remains a paucity of data on both its direct impact on pain, range of motion (ROM), disability, and proprioception, and on the interrelationships among these outcomes [14]. Therefore, this study was designed with dual aims: (1) to evaluate the treatment outcomes of MMT in chronic CS patients and (2) to investigate the correlations among these clinical measures to provide insight into the mechanisms by which MMT may enhance overall function.

METHODS

Study Design:

A single-group, pre-post-intervention. Approval was obtained from the Institutional Review Board of the Faculty of Physical Therapy at Cairo University (R.T.REC/012/005271), and all participants signed informed consent forms.

Sample size determination:

Using G*Power software (version 3.1.9.2), the sample size was determined based on data from the Shoulder Pain and Disability Index (SPADI) [15]. The analysis revealed that at least 18 participants were necessary to detect an effect size of 0.96 with 80% power at a significance level of 0.05. To account for an anticipated dropout rate of approximately 10%, the sample size was increased to 20 participants.

Participants:

Twenty patients with chronic CS participated in the study (15 females and 5 males). Referred by orthopedic surgeons with chronic CS diagnosis. Their ages ranged from 40 to 60 years according to the flowchart Figure (1). All patients received MMT in addition to a conventional physical therapy program consisting of ROM exercises, isometric exercises, and deep neck flexor strengthening exercises.

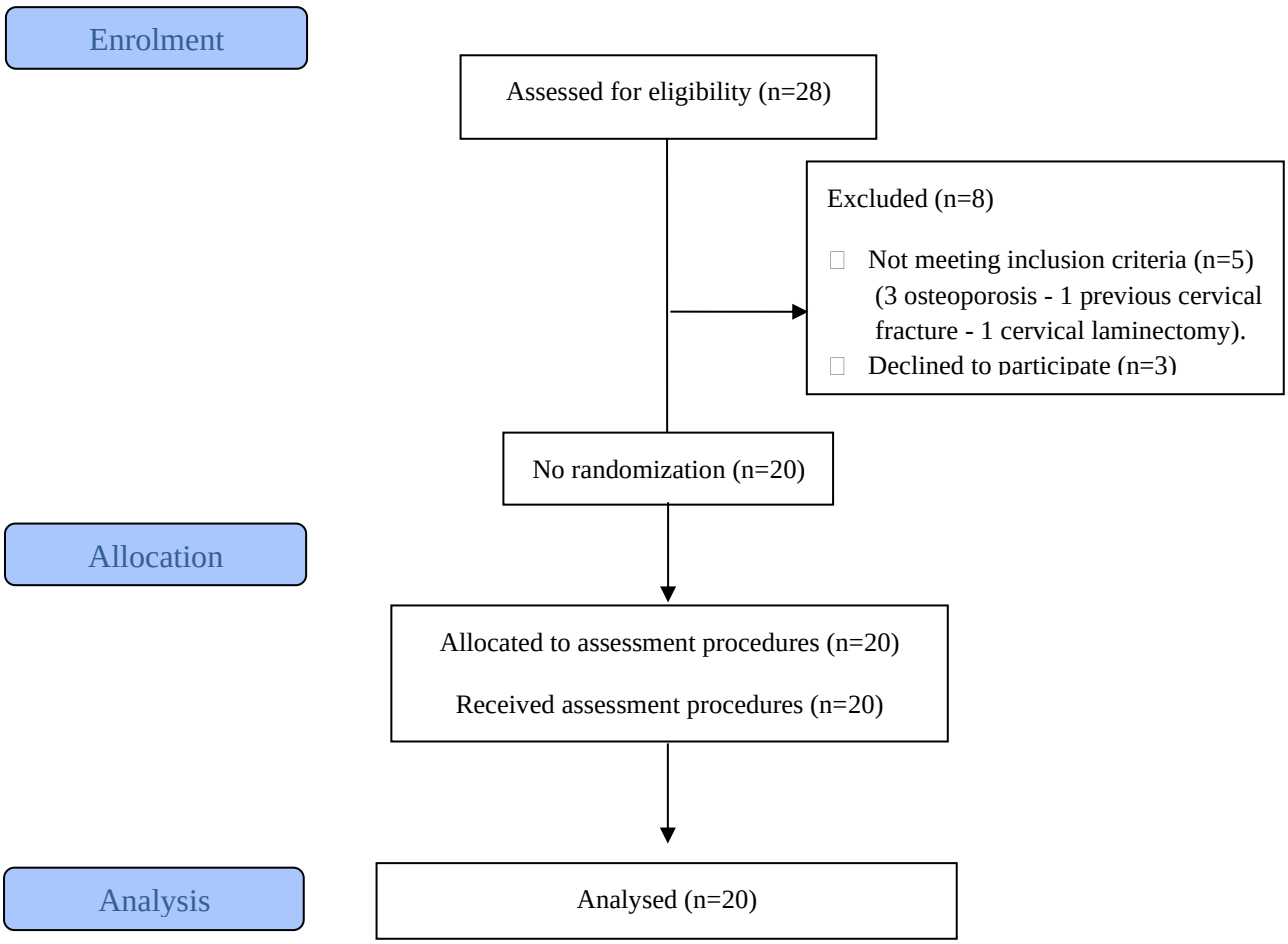

Figure (1): Flowchart Description.

Eligibility criteria

Inclusion criteria:

The participants were chosen based on the following criteria:

- Both genders, aged 40–60 years.
- Assessed and referred by orthopedic surgeons with clinically stable chronic CS [16].
- Presence of cervical-region mechanical neck pain [17].
- Neck pain persisting for over 3 months, accompanied by upper trapezius tenderness, limited cervical ROM, and muscular spasm [18,19]. Visual Analogue Scale (VAS) scores indicated moderate pain (45–74 mm), and disability levels measured by Neck Disability Index (NDI) ranged from 30–48% [17].
- Free from any pathological conditions that might influence the results [18].

Exclusion criteria:

Participants were excluded if they had:

- Systemic diseases (e.g., rheumatoid arthritis, metabolic diseases, inflammatory arthritis, tumors, infections, or osteoporosis) [20].
- A History of trauma or accidental injuries to the cervical spine [19].
- Cervical myelopathy, vertebrobasilar artery insufficiency [19], or any other neurological disorders [20].

Assessment procedures:

1- Cervical Range of Motion device (CROM) Device:

A. Cervical ROM: The participant was positioned in a seated posture, with the CROM device secured on his/her head [21]. Instructions were provided to move the head through flexion, extension, rotation, and lateral flexion until encountering movement restriction or pain onset. Concurrent angular measurements were obtained via the inclinometer. All movements underwent triple assessment, with mean values determined for analysis.

B. Proprioception: To assess proprioception, the patient's eyes were covered with a blindfold, and the CROM device was secured on the participant's head.

- **Neutral head position (NHP):** Participants were requested to execute complete neck rotation toward the left or right and then return to what he/she considered the starting (neutral) position in a controlled manner [22]. The relocation accuracy was evaluated using a CROM device once the reference position was reached.
- **Target Head Position (THP):** The head was passively rotated to a predetermined point at half of the total ROM, where it remained for 3 seconds [23]. After resetting to neutral, participants were asked to relocate to the same target angle. CROM readings were used to determine the relocation accuracy in degrees.

No feedback regarding repositioning performance was provided during testing.

2- The Arabic Version of Neck Disability Index (NDI):

This self-administered questionnaire comprised 10 items addressing pain and functional limitations related to neck pain's impact on daily tasks. Each item utilizes a 6-point scale ranging from 0 to 5, with cumulative greater scores reflecting higher disability [24].

3- Visual Analogue Scale (VAS):

The current neck pain intensity was quantified using the VAS. Participants marked their pain intensity along a continuous 10-centimeter line anchored by "no pain" (0) at one end and "worst imaginable pain" (10) at the other end [25].

Therapeutic procedures:

A. Mulligan Mobilization Techniques:

Mulligan Mobilization utilizes a specific technique called Sustained Natural Apophyseal Glides (SNAGs) to improve joint mobility **Figure (2).**

- **Practitioner Action:** A gentle, painless backward-to-forward glide was applied to the facets (bony projections) on either the spinous process or the cervical lamina/articular pillar. This glide was maintained throughout the movement [26].
- **Participant Action:** During the sustained glide, the patient consciously guided his/her neck through the motion that had earlier elicited pain. If the movement was pain-free, the participant could gently push further into the range of movement.

Progression: If clinically relevant improvements in pain and motion were observed, self-SNAGs were taught to the participant **Figure (2).**

A. SNAGs for Cervical Extension B. Self-SNAGs Figure (2): Mulligan Techniques.

B. Conventional physical therapy program:

1. Deep neck flexor strengthening exercises:

The participant assumed a supine position with neutral cervical alignment and was asked to execute a head nodding motion for achieving cervical flattening. The exercise involved holding the position for 10 seconds, with 10 total repetitions.

2. Cervical Isometric Exercise:

The practitioner applies resistance while the patient exerts force without movement:

In cervical flexion, the practitioner places their palms on the patient's forehead, and the patient pushes forward against resistance, in cervical extension, the practitioner's palm is positioned behind the head, and the patient pushes backward while resistance is applied, during Right and left Side bending, the practitioner's palm is positioned on the corresponding side of the head, and the patient pushes toward the hand without tilting the head, and Right and left Rotation, the practitioner's palm is positioned on the corresponding side of the face, and the patient exerts rotational force without turning the head.

3. Cervical active range of motion (AROM):

The participant slowly lowered their chin toward the chest during cervical flexion until a

gentle stretch was felt at the back of the neck. For cervical extension, they tilted their head back to look toward the ceiling. In right and left side bending, the participant tilted their head toward the right or left shoulder without lifting the shoulder. During right and left rotation, they slowly turned their head toward the right or left, aiming to align the chin with the shoulder. Each exercise was maintained for 5 seconds, followed by a return to the initial position, with 5–10 repetitions.

Statistical analysis:

SPSS for Windows version 26 (SPSS, Inc., Chicago, IL) was employed for all statistical procedures. Initial data screening included evaluation of normality assumptions, variance homogeneity, and identification of potential outliers. Normal distribution was confirmed for all study variables through Shapiro-Wilk testing ($p > 0.05$). Consequently, parametric statistics were applied. (MANOVA) test was used to measure periods with 2 levels (pre-treatment vs. post-treatment), with the main dependent variables were the main variable outcomes (pain, disability, cervical ROM, NHP, and THP). Quantitative variables are presented as means accompanied by standard deviations (X ± SD). To determine relationships between the measured parameters, Pearson's correlation coefficients were calculated, with $p < 0.05$ considered statistically significant.

RESULTS

A total of 20 patients with chronic CS (15 females and 5 males) participated in this study. The demographic characteristics of the sample are presented in **Table 1**.

Table 1. Demographic data for patients of cervical spondylosis

Quantitative variables		Mean ±SD
Age (year)		50.46 ±6.19
Weight (kg)		80.80 ±9.09
Height (cm)		169.65 ±8.17
BMI (kg/m2)		27.99 ±1.97
Qualitative variable		Number (%)
Gender	Males	5 (25.00%)
	Females	15 (75.00%)

Quantitative variables data (age, weight, height, and BMI) are reported as mean ±standard deviation. Qualitative variable data (gender) are reported as frequency (percentage)

The statistical analysis demonstrated significant post-treatment improvements ($P<0.05$) across various outcome measures. VAS and NDI exhibited a significant reduction following treatment ($P=0.0001$). Cervical range of motion showed significant increases in flexion, extension, right and left rotation, as well as right and left side bending ($P=0.0001$) Additionally, a significant decrease in right and left rotation was observed in the neutral head position post-treatment ($P=0.0001$). Furthermore, the target head position assessment indicated significant reductions in extension, right side bending, and left side bending compared to pre-treatment ($P=0.0001$).

Table 2: Pre- and post-treatment comparisons for all study variables:

Variables	Pre-treatment	Post-treatment	MD	P-value
	Mean ±SD	Mean ±SD		
Pain intensity (VAS/scores)	60.45 ± 8.33	11.80 ± 4.22	48.65	0.0001*
Flexion	43.10 ± 5.88	74.10 ± 3.76	31.00	0.0001*
Extension	31.05 ± 5.11	60.95 ± 4.24	29.90	0.0001*
Right rotation	45.55 ± 4.61	73.85 ± 2.90	28.30	0.0001*
Left rotation	46.10 ± 5.68	73.05 ± 3.22	26.95	0.0001*
Right side-bending	24.05 ± 2.70	43.50 ± 1.35	19.35	0.0001*
Left side-bending	23.90 ± 3.11	43.75 ± 1.33	19.85	0.0001*
Neck disability index (NDI/scores)	40.25 ± 4.81	10.20 ± 5.05	30.05	0.0001*
Right rotation	3.57 ± 1.35	1.22 ± 0.80	2.35	0.0001*
Left rotation	3.65 ± 1.20	1.77 ± 0.54	1.88	0.0001*
Extension	8.20 ± 1.43	2.60 ± 0.71	5.60	0.0001*
Right side-bending	6.45 ± 1.29	1.80 ± 0.80	4.65	0.0001*
Left side-bending	6.02 ± 1.43	1.65 ± 0.70	4.37	0.0001*

Data are expressed as mean ± standard deviation and compared statistically by MANOVA test. MD: Mean difference; P-value: probability value; *: Significant at $P \leq 0.05$.

Correlation between different study variables:

There were significant strong negative correlations between neck pain intensity (VAS) and all cervical range of motion (ROM), as well as between the Neck Disability Index (NDI) and all cervical ROM. Conversely, pain intensity showed significant strong positive correlations with the NDI, the NHP (left rotation), and all THP variables, along with a significant moderate positive correlation with the NHP (right rotation). Similarly, the NDI demonstrated significant strong positive correlations with all THP parameters and significant moderate positive correlations with all NHP variables as illustrated in **Table (3), and (4).**

Table 3: Pearson correlation among neck pain intensity, disability index, and other variables.

Variables	Pain intensity (VAS/scores)		Neck disability index (NDI/scores)	
	r-value	P-value	r-value	P-value
Flexion	-0.914	0.000***	-0.910	0.000***
Extension	-0.905	0.000***	-0.907	0.000***
Right rotation	-0.943	0.000***	-0.897	0.000***
Left rotation	-0.924	0.000***	-0.889	0.000***
Right side-bending	-0.936	0.000***	-0.914	0.000***
Left side-bending	-0.944	0.000***	-0.907	0.000***
Neck disability index (NDI/scores)	0.909	0.000***	-	-
Right rotation	0.679	0.000***	0.668	0.000***
Left rotation	0.713	0.000***	0.695	0.000***
Extension	0.882	0.000***	0.849	0.000***
Right side-bending	0.901	0.000***	0.881	0.000***
Left side-bending	0.905	0.000***	0.853	0.000***

r-value: Pearson correlation coefficient; P-value: probability value; ***: Significant at P < 0.001.

Table 4: Pearson correlation between cervical ROM and different study variables.

Variables		NHP		THP		
		Right rotation	Left rotation	Extension	Right side-bending	Left side-bending
Flexion	r	-0.648	-0.743	-0.887	-0.903	-0.889
	P	0.000***	0.000***	0.000**	0.000***	0.000***
Extension	r	-0.662	-0.703	-0.882	-0.883	-0.848
	P	0.000***	0.000***	0.000**	0.000***	0.000***
Right rotation	r	-0.616	-0.706	-0.948	-0.854	-0.861
	P	0.000***	0.000***	0.000**	0.000***	0.000***
Left rotation	r	-0.588	-0.714	-0.914	-0.877	-0.830
	P	0.000***	0.000***	0.000**	0.000***	0.000***
Right side-bending	r	-0.641	-0.717	-0.950	-0.883	-0.859
	p	0.000***	0.000***	0.000**	0.000***	0.000***
Left side-bending	r	-0.630	-0.695	-0.905	-0.882	-0.871
	P	0.000***	0.000***	0.000**	0.000***	0.000***

r-value: Pearson correlation coefficient; P-value: probability value; ***: Significant at P < 0.001.

DISCUSSION:

This study evaluated the impact of MMT alongside conventional physical therapy on pain, cervical ROM, disability, and proprioception in chronic CS patients while also investigating the interrelationships among these outcomes. The CROM device has demonstrated high validity in all directions [27], and moderate to good intra-rater and inter-rater reliability, with ICC values ranging from 0.84 to 0.96 and 0.73 to 0.94 [28], in addition to the Arabic version of the NDI has established validity and reliability for neck pain assessment, with interclass correlation ranging between 0.50 – 0.98 [29], also, the VAS has demonstrated good validity and both intra-rater and inter-rater reliability [30,31]. The findings demonstrated significant improvements in all measured parameters: pain was reduced, ROM

increased, disability scores decreased, and proprioceptive accuracy improved. Notably, correlation analysis revealed strong negative correlations between neck pain intensity (VAS) and all cervical range of motion (ROM), as well as between the Neck Disability Index (NDI) and all cervical ROM, and strong positive correlations with the NDI, the NHP (left rotation), and all THP variables, in addition to moderate positive correlation with the NHP (right rotation). Similarly, the NDI demonstrated significant strong positive correlations with all THP parameters and significant moderate positive correlations with all NHP variables. These findings suggest that pain diminution directly correlates with improved mobility and functional performance.

Regarding pain reduction, this study's findings align with [32] and [33], who observed that MMT leads to significant pain reduction in patients with cervical radiculopathy compared with alternative techniques such as Maitland mobilization. In support, [34] and [35] also demonstrated a reduction in neck pain following the application of Mulligan SNAGs.

The reduction in pain associated with MMT may be attributed to the gliding mobilization inherent in MMT, which likely triggers a sympathoexcitatory effect by stimulating afferent nerve endings and inhibiting nociception at the spinal cord level. Moreover, the accessory glide component may mechanically separate facet surfaces or reduce adhesions, which may further contribute to the analgesic effect [13]. Furthermore, mechanisms like the gate control theory and the activation of descending pain-inhibitory systems during full-range guided movement using SNAG may also contribute to reduced pain and disability [36].

The observed negative correlation between pain and Cervical ROM; as pain decreased, ROM increased. This finding is consistent with [37], and [38] who showed that MMT, when combined with stabilization exercises effectively enhances cervical mobility. However, alternative manual therapies such as Maitland mobilization have also produced similar improvements, suggesting that factors beyond MMT may contribute to ROM gains. For instance**,** [39] and [40] reported early range changes and moderate correlations between disability and pain in neck pain populations, implying that pain reduction is intrinsically linked to improved movement.

In terms of cervical proprioception, this study indicated that NDI positively correlated with proprioceptive measures, indicating that improved function is associated with better proprioceptive control. These results corroborate the findings of [41] and [42], who observed enhanced sensorimotor control through MMT application in subjects suffering from mechanical neck pain. Furthermore, [43] noted a strong relationship between cervical joint position error and functional balance, supporting the idea that better proprioception may reduce disability. The improvement in proprioception may be explained by the stimulation of mechanoreceptors and increased sensitivity of muscle spindles via gamma motor neurons during SNAG application, as noted by [44] and [45]. Nevertheless, some studies argue that the improvements in ROM and proprioception might not be solely attributable to MMT, as comparable effects have been reported with other manual therapies (e.g., Mulligan vs. Spinal Manipulation therapy [46]. Neural mobilization [47]. Moreover, the long-term sustainability of these benefits remains uncertain, emphasizing the need for future randomized controlled trials with extended follow-up periods [46,48,49].

Clinically, these findings advocate for a multimodal rehabilitation strategy in CS. Integrating MMT with conventional physical therapy appears to produce interdependent improvements across pain, mobility, and functional capacity, supporting a comprehensive approach that targets both symptom relief and underlying biomechanical dysfunctions.

Despite these promising outcomes, several limitations should be acknowledged. Firstly, the study’s lack of a control group makes it difficult to isolate the effects attributable solely to MMT. Secondly, the relatively small sample size may have reduced our ability to detect more subtle relationships among variables. Additionally, we did not include an assessment of neck trigger points pain threshold, nor did we evaluate the strength of the affected neck muscles, which might have provided further insights into the functional outcomes. Moreover, although the

CROM device is widely employed to assess cervical proprioception, it does not represent the gold standard; more advanced, software-assisted measurement systems may offer greater precision. Finally, the lack of long-term follow-up prevents us from determining the durability of the treatment effects and assessing the recurrence rate. Future studies should employ larger, controlled trials with comprehensive outcome measures and extended follow-up periods to validate and expand upon these findings.

CONCLUSION:

Mulligan mobilization technique (MMT) combined with conventional physical therapy results in significant reductions in pain and disability, alongside improvements in cervical ROM and proprioception in chronic CS patients. The observed correlations underscore the interdependent nature of these clinical outcomes, advocating for a comprehensive, multimodal approach to rehabilitation.

Highlights:

- Cervical spondylosis is an age-related, chronic degenerative condition of the cervical spine with a prevalence rate of 3.3 participants per 1000 people in the general population.
- Although degenerative CS can affect any component of the cervical spine, such as bone quality and joint structures, the most clinically significant changes occur in the intervertebral disks and facet joints.
- The pathogenesis of CS of the cervical spine manifests as secondary compression of neural and vascular structures
- The Mulligan mobilization Technique treatment approach, which combines passive accessory glides (i.e., mobilizations) with active movement, is indicated to increase ROM, decrease pain, and enhance muscle function when treating musculoskeletal pain and/or dysfunction.
- Mulligan is one of the mobilization techniques that can be applied in the case of neck pain.
- Being an important treatment tool used by most manual physical therapists, MMTs include several methods, such as sustained natural epiphyseal glides (SNAGs) and natural epiphyseal glides that target the spine.
- Mulligan mobilization Technique has a beneficial effect on biomechanical factors, especially in reducing pain and enhancing ROM, however, a further explanation should be discussed for their neurophysiological effects.

Scientific Responsibility Statement:

The authors confirm that they contributed to this study by collecting, analyzing, and interpreting data, as well as writing, preparing, and approving the final article draft.

Human Rights Statement:

Every procedure used in this study conformed to the Declaration of Helsinki (1964) and its subsequent modifications, as well as similar ethical norms, and the guidelines of the organizational and/or national research committee.

Funding:

This research was not funded by any external source.

Clinical Implication:

Physical therapists should consider incorporating MMT into rehabilitation programs for chronic CS patients, as it reduces pain and disability while enhancing cervical ROM and proprioception.

REFERENCES

1. Kelly JC, Groarke PJ, Butler JS, Poynton AR, O'Byrne JM. The Natural History and Clinical Syndromes of Degenerative Cervical Spondylosis. Adv Orthop. 2012; 2012:1–5.
2. Kuo DT, Tadi P. Cervical Spondylosis. PubMed. Treasure Island (FL): StatPearls Publishing; 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK551557/
3. Binder AI. Cervical spondylosis and neck pain. BMJ. 2007 Mar 8;334(7592):527–31. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1819511/
4. Takagi I, Eliyas JK, Stadlan N. Cervical Spondylosis: An Update on Pathophysiology, Clinical Manifestation, and Management Strategies. Disease-a-Month. 2011 Oct;57(10):583–91.

5. Page P, Frank CC, Lardner R, Human Kinetics. Assessment and treatment of muscle imbalance: the Janda approach. Champaign, Il; Windsor, On; Leeds: Human Kinetics, Druk; 2014.
6. Venosa M, Romanini E, Padua R, Cerciello S. Comparison of high-intensity laser therapy and combination of ultrasound treatment and transcutaneous nerve stimulation in patients with cervical spondylosis: a randomized controlled trial. Lasers in Medical Science [Internet]. 2018 Nov 15;34(5):947–53. Available from: https://link.springer.com/article/10.1007/s10103-018-2682-7
7. Haładaj R, Pingot M, Topol M. The Effectiveness of Cervical Spondylosis Therapy with Saunders Traction Device and High-Intensity Laser Therapy: A Randomized Controlled Trial. Medical Science Monitor. 2017 Jan 20; 23:335–42.
8. Rostron, RMT S. The The Effects of Massage Therapy on a Patient with Migraines and Cervical Spondylosis: a Case Report. International Journal of Therapeutic Massage & Bodywork: Research, Education, & Practice. 2021 Jul 6;14(3):15–21.
9. Xiong J, Zhang Z, Zhang Z, Ma Y, Li Z, Chen Y, et al. Short-term effects of Kinesio taping combined with cervical muscles multi-angle isometric training in patients with cervical spondylosis. 2023 Jan 18;24(1).
10. Mulligan BR. Manual therapy: NAGS, SNAGS, MWMS etc. Wellington, N.Z.: Plane View Services Ltd; 2018.
11. Hing W, Hall T, Mulligan B. The Mulligan Concept of Manual Therapy. Elsevier Health Sciences; 2019.
12. Cevik R, Pala OO. Effects of upper thoracic Mulligan mobilization on pain, range of motion and function in patients with mechanical neck pain: A randomized placebo-controlled trial. Gunaydin G, editor. PLOS ONE. 2024 Oct 28;19(10):e0311206.
13. Copurgensli C, Gur G, Tunay VB. A comparison of the effects of Mulligan's mobilization and Kinesio taping on pain, range of motion, muscle strength, and neck disability in patients with Cervical Spondylosis: A randomized controlled study. Journal of Back and Musculoskeletal Rehabilitation. 2016 Dec 20;30(1):51–62. Available from: https://content.iospress.com/articles/journal-of-back-and-musculoskeletal rehabilitation/bmr713
14. Ozlu O, Sahin M. The effect of mulligan mobilization technique application in addition to conventional physiotherapy on pain and joint range of motion in people with neck pain. Journal of Bodywork and Movement Therapies. 2024 Jul 1; 39:225–30. Available from: https://www.sciencedirect.com/science/article/abs/pii/S1360859224000664#:~:text=Conclusions
15. Khalil R, Tanveer F, Asif Hanif, Ahmad A. Comparison of mulligan technique versus muscle energy technique in patients with adhesive capsulitis. Journal of the Pakistan Medical Association. 2022 Apr 1;72(2).
16. Pragassame S. A, Kurup V. K. M, V. S. A Study on the Effectiveness of Manual Mulligan Traction Compared to Intermittent Electrical Traction in Patients with Cervical Spondylosis. Asian Journal of Pharmaceutical Research and Health Care. 2019 Mar 4;11(1):01–9.
17. Kashyap R, Iqbal A, Alghadir AH. Controlled intervention to compare the efficacies of manual pressure release and the muscle energy technique for treating mechanical neck pain due to upper trapezius trigger points. Journal of Pain Research. 2018 Dec;Volume 11:3151–60.
18. Mohamed EE, Elrazik R kotb A. Sustained Natural Apophyseal Glides versus Positional Release Therapy in the Treatment of Chronic Mechanical Neck Dysfunction. International Journal of Human Movement and Sports Sciences. 2020 Dec;8(6):384–94.
19. Buyukturan O, Buyukturan B, Sas S, Karartı C, Ceylan İ. The Effect of Mulligan Mobilization Technique in Older Adults with Neck Pain: A Randomized Controlled, Double-Blind Study. Pain Research and Management. 2018; 2018:1–7.
20. Samar Mohammed Alansari, Youssef EF. Maitland mobilization versus mulligan mobilization in sub-acute and chronic non-

specific neck pain. International journal of applied research. 2019 Jan 1;5(9):147–53.
21. Alahmari K, Reddy RS, Silvian P, Ahmad I, Nagaraj V, Mahtab M. Intra- and inter-rater reliability of neutral head position and target head position tests in patients with and without neck pain. Brazilian Journal of Physical Therapy. 2017 Jul;21(4):259–67.
22. Reddy R, Alahmari K, Silvian P. Test-retest reliability of assessing cervical proprioception using cervical range of motion device. Saudi Journal of Sports Medicine. 2016;16(2):118.
23. Reddy RS, Tedla JS, Dixit S, Abohashrh M. Cervical proprioception and its relationship with neck pain intensity in subjects with cervical spondylosis. BMC Musculoskeletal Disorders. 2019 Oct 15;20(1).
24. Young IA, Dunning J, Butts R, Mourad F, Cleland JA. Reliability, construct validity, and responsiveness of the neck disability index and numeric pain rating scale in patients with mechanical neck pain without upper extremity symptoms. Physiotherapy Theory and Practice. 2018 Jun 1;35(12):1328–35.
25. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF. Arthritis Care & Research. 2011 Nov;63(S11): S240–52. Available from: https://pubmed.ncbi.nlm.nih.gov/22588748/
26. Delgado DA, Lambert BS, Boutris N, McCulloch PC, Robbins AB, Moreno MR, et al. Validation of Digital Visual Analog Scale Pain Scoring with a Traditional Paper-based Visual Analog Scale in Adults. JAAOS: Global Research and Reviews. 2018 Mar;2(3): e088. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6132313/
27. Audette I, Dumas JP, Côté JN, De Serres SJ. Validity and Between-Day Reliability of the Cervical Range of Motion (CROM) Device. Journal of Orthopaedic & Sports Physical Therapy. 2010 May;40(5):318–23.
28. Gugliotti M, Tau J, Gallo K, Sagliocca N, Horan M, Sussman N, et al. Between-week reliability of the cervical range of motion (CROM) device for upper cervical rotation. Journal of Manual & Manipulative Therapy. 2020 Aug 18;29(3):176–80.
29. Elbeltagy AM, Sayed WHE, Allah SSR. Validity and Reliability of the Arabic Version of the Copenhagen Neck Functional Disability Scale in Neck Pain Patients. Asian Spine Journal. 2018 Oct 31;12(5):817–22.
30. Naz S, Jamali N, Iftikhar A, Nawaz H, Iqbal T, Ghafoor F. Compare the effectiveness of Mulligan (NAGS & SNAGS) and McKenzie (self-stretching) on improving the pain and functional ability in patients with chronic neck pain. Pak J Health Sci. 2023;47–52.
31. Abe H, Koyanagi S, Kusumoto Y, Himuro N. Intra-rater and inter-rater reliability, minimal detectable change, and construct validity of the Edinburgh Visual Gait Score in children with cerebral palsy. Gait & Posture. 2022 May; 94:119–23.
32. Niaz M, Zafar A, Sadi U, Adil HB, Akhtar SK. Effectiveness of Maitland and Mulligan Mobilization in Cervical Radiculopathy Patients. Pakistan BioMedical Journal. 2022 Mar 3;5(1).
33. Zoya Mehmood, Umama Ijaz, Iqra Imtiaz, Asmar Fatima, Muhammad Junaid Akram, Naveed Ahmed, et al. Effects of cervical traction mobilization with mulligan's SNAGS on Pain, cardiovascular and respiratory outcomes among young adults with cervical pain. The Professional Medical Journal. 2022 Sep 30;29(10):1459–64.
34. Said SM, Ali OI, Elazm SNA, Abdelraoof NA. Mulligan Self Mobilization Versus Mulligan Snags on Cervical Position Sense. International Journal of Physiotherapy. 2017 Apr 1;4(2).
35. Abdallah GA, Mohamed RA, Sharaf MA. Effect of Snags Mulligan Technique Versus Low-Level Laser Therapy on Patients with Unilateral Cervical Radiculopathy. International Journal of Physiotherapy and Research. 2017 Aug 11;5(4):2240–8.

36. Tank KD, Choks P, Makwana P. To Study the Effect of Muscle Energy Technique versus Mulligan Snags on Pain, Range of Motion and Functional Disability for Individuals with Mechanical Neck Pain". – A Comparative Study. International Journal of Physiotherapy and Research. 2018 Feb 11;6(1):2582–7.
37. Kocaman H, Yildiz NT, Canli M, Alkan H. Comparison of the effects of Mulligan mobilization technique combined with cervical stabilization exercises with the effects of cervical stabilization exercises alone in chronic neck pain: A randomized controlled study. Karya J Health Sci. 2023;4(3):22734. Available from: https://www.researchgate.net/publication/376179511
38. Aggarwal A, Gomes R, Palekar TJ. Mulligan Versus Conventional Neurodynamic Mobilization in Patients with Cervical Radiculopathy - A Randomized Controlled Trial. International Journal of Physiotherapy. 2021 Apr 1;8(2).
39. Lee, H., Nicholson, L. L., & Adams, R. D. (2004). Cervical Range of Motion Associations with Subclinical Neck Pain. Spine, 29(1), 33–40. https://doi.org/10.1097/01.brs.0000103944.10408.
40. Chiu, T. T., Lam, T.-H., & Hedley, A. J. (2005). Correlation among physical impairments, pain, disability, and patient satisfaction in patients with chronic neck pain. Archives of Physical Medicine and Rehabilitation, 86(3), 534–540. https://doi.org/10.1016/j.apmr.2004.02.030
41. Saleh A., Abdel-AalN., Ibrahim O. Mobilization with Movement versus Thoracic Manipulation on Neck Proprioception in Mechanical Neck Pain: A Randomized Controlled Study. Journal of Pharmaceutical Nagative Results 2023; 14(03); 3972-80
42. Said SM, Ali OI, Elazm SNA, Abdelraoof NA. Mulligan Self Mobilization Versus Mulligan Snags on Cervical Position Sense. International Journal of Physiotherapy. 2017 Apr 1;4(2).
43. Raizah A, Reddy RS, Alshahrani MS, Gautam AP, Alkhamis BA, Kakaraparthi VN, et al. Mediating effect of chronic pain on the relationship between cervical proprioception and functional balance in elderly individuals with chronic neck pain: A mediation analysis study. J Clin Med. 2023;12(9):3140. https://doi.org/10.3390/jcm12093140
44. Nagai T, Clark NC, Abt JP, Sell TC, Heebner NR, Smalley BW, et al. The effect of target position on the accuracy of cervical-spine-rotation active joint-position sense. J Sport Rehabil. 2016;25(1):58–63.
45. Tachii R, Siddhartha S, Arfath U. Short-term effect of sustained natural apophyseal glides on cervical joint position sense, pain and neck disability in patients with chronic neck pain. Int J Ther Rehabil Res. 2015;4(5):244–50.
46. Nambi G, Alghadier M, Ebrahim EE, Vellaiyan A, Tedla JS, Reddy RS, et al. Comparative effects of Mulligan's mobilization, spinal manipulation, and conventional massage therapy in cervicogenic headache: A prospective, randomized, controlled trial. Healthcare. 2022;11(1):107.
47. Kachhadiya RG, Jani P, Vaidya SB. A Review on Advanced Physiotherapy Treatment for Cervical Spondylosis. International Journal of Health Sciences and Research. 2023 Mar 6;13(3):126–39.
48. Bishop MD, Torres-Cueco R, Gay CW, Lluch-Girbés E, Beneciuk JM, Bialosky JE. What Effect Can Manual Therapy Have on a patient's Pain experience? Pain Management. 2015 Nov;5(6):455–64.
49. Rubinstein SM, de Zoete A, van Middelkoop M, Assendelft WJJ, de Boer MR, van Tulder MW. Benefits and harms of spinal manipulative therapy for the treatment of chronic low back pain: systematic review and meta-analysis of randomized controlled trials. BMJ. 2019 Mar 13;364(1689): l689. Available from: https://www.bmj.com/content/364/bmj.l689