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# Using Biomechanical Principles In Collar Selection For Patients Complaining Cervical Disc Prolapse

**Usama M Rashad , Hoda M Zakaria and Walaa M Ragab**

**Department of neuromuscular disorders and its surgery, Faculty of Physical Therapy, Cairo University, Egypt**

**Abstract : Objective :** Using cervical collar in management of cervical disc prolapsed has a controversial and different outcomes. So, proper selection of collar is very important for obtaining best results. **Design:** One hundred subjects suffered from cervical disc prolapse; complaining neck pain and brachialgia; were participated in this study. They were classified into five equal groups; group one had no collar, group two applied soft collar, group three applied hard collar (one piece), group four applied Philadelphia collar and group five applied two pieces variable length collar (Adjusted according to length of patient's neck to be put in a slight flexion). Visual analogue scale was applied for all patients to measure the degree of brachialgia. Electronic Goniometer or Cervical range of motion (CROM) was used also to determine painless range of motion (ROM) of neck extension. Assessment was performed before and after treatment (Twelve sessions; three times per week). **Results:** Results revealed a significant improvement in patients applied both Philadelphia and variable length collar in both VAS and ROM with more evidence for variable length collar. **Conclusion:** Variable length collar is the best choice for patients complaining cervical disc prolapsed with brachialgia.

**Key word :** *Soft collar ; one and two pieces hard collar ;Philadelphia collar ;Cervical disc*.

## Introduction

Cervical radiculopathy or brachialgia is a common disorder. It develops when a nerve in the neck region becomes irritated. This type of neck problem frequently causes neck pain, pain down the arm, and sometimes a loss of feeling or decreasing strength in the arm. Cervical radiculopathy can cause also clumsy or uncoordinated hands. Treatment strategies to decrease the irritation around the affected nerve are very important [1,2].

Epidemiological data on cervical radiculopathy are light. There is an annual age-adjusted incidence. Male is more predominance than female. Peak incidence is more in the fourth and fifth decade. The common cause of the radiculopathy is usually a herniated disc and Spondylarthrosis . Spondylarthrosis as a cause of cervical radiculopathy tends to occur more in higher age, whereas disc herniation is more common in younger patients. Pain is often severe and terrible during the first weeks to months. Treatment to accelerate the improvement of pain and function would be highly valuable [3].

The most common level of root compression is C7 (reported percentages 46.3–69%), followed by C6 (19– 17.6%); compression of roots C5 (2–6.6%) and C8 (10– 6.2%) are less frequent. One possible explanation

is that intervertebral foramina are largest in the upper cervical region and progressively decrease in size in the middle and lower cervical areas, with an exception of the C7-Th1 foramen. Thus, the middle and lower cervical regions are most susceptible for mobility and stress. The C5-C6 interspace is generally considered to have the largest range of motion in the cervical spine, hence the potential reason for the high incidence of cervical spondylosis (arthritis) at this segment [4]**.**

Bulging of the intervertebral disc can result in nerve root impingement, causing pain in areas of the body enervated by the impinged nerve. Degeneration of the nucleus combined with the annular degeneration may cause disc herniation into the spinal canal causing radiation and neck pain due to nerve pinching [4]**.** Range of cervical motion is tested in patients who complain of neck pain and radicular symptoms. Impairment in the range of motion and limitation of function are often found. This is most commonly seen in extension, since the foramina tend to narrow significantly when the spine is extended. The location, duration and quality of pain are all important considerations in assessing cervical spine patients also. Questionnaires and visual analog scores are helpful for quantifying debility and how much the symptoms are affecting the activities of daily living [5]**.**

Irritation of the cervical nerve roots occurs as a result of some mechanical derangement in or about the intervertebral foramina and the most common cause is ruptured or protruding intervertebral discs and swelling of capsular structures from inflammatory and allergic reactions as a result of disc herniation .Rupture or protrusion of one or more intervertebral discs may occur at the time of the injury, or much later as a result of some very trivial injury inasmuch as the relaxation of the ligamentous and capsular support makes the discs more vulnerable to rupture. Ruptured discs may or may not cause immediate nerve root irritation, depending upon the location of the protrusion or herniation[6]**.**

Understanding of the onset and nature of the pain is required. A cervical radiculopathy may be acute or insidious in onset. Axial neck pain and reduced cervical range of movement are commonly associated cervical disc brachialgia. Certain cervical movements may relieve or exacerbate the pain. Extension and lateral bending to the side of the pain causes or intensifies the pain. This is due to foraminal compression. The more distal roots cause radiation down the arm. C5 typically radiates into the shoulder, with C6 differentiating itself by radiating to the lateral elbow and into the thumb. C7 causes more posterior arm pain and into the middle finger when classic, with C8 involving the little finger. Scapula pain might be a feature that often confuses the situation, and is often due to C7 root irritation[7]**.**

Intervertebral disk make up 20-30% of the height of the column and thickness varies from 3mm in cervical region, 5mm in thoracic region to 9 mm in the lumbar region. Ratio between the vertebral body height and the disk height will read out the mobility between the vertebra . Highest ratio in cervical region allows for motion .Lowest ratio in thoracic region limits motion .Hydration of the disc will also decrease with compressive loading - this loss of hydration decreases its mechanical function [8]**.** This explain the aim of our study to focus on collar to decrease load or compression load on the disc by collar . Intervebral Foramina is exit for nerve root. The size is dictated by the disc heights and the pedicle shape. The foramina loses space with osteophytic formation, hypertrophy of ligaments and loss of disc height with herniation and lateral stenosis. This foramina is Decreased by 20% with extension and increases 24% with flexion this explain why in our study we focus to choose extension for assessment not flextion[9]**.**

Range of motion (ROM) evaluation has been widely used to quantify musculoskeletal deficits, besides serving as a basis for evaluating the efficacy of therapeutic interventions. The cervical range of motion device (CROM) is an instrument designed specifically for measuring cervical ROM. There is an intertester and intratester reliability by measuring with CROM [10]**.** Visual analogue scale (VAS) is a common using method to assess pain. It is 10-cm line, oriented vertically or horizontally. It is formed of one end representing zero “no pain” and the other end representing ten “pain as bad as it can be”. The patient is asked to mark on the line corresponding to the current pain intensity[11]**.**

The amount of irritation of the nerve, and hence the symptoms and clinical findings, are not dependent upon the extent of the derangement .In all instances the symptoms are aggravated by certain motions and positions of the neck. reading, driving a car, or any occupation which necessitates holding the neck in flexion, hyperextension, rotation or lateral bending for any length of time increases the symptoms. Patients who are seen

immediately following an injury to the neck should have the benefit of some type of collar immobilization for about three weeks[12]**.**

Axial Compression is one type of neck segmental loading that should be decreased by applying probe collar . It caused by gravity, ground reaction forces, muscle contraction and ligaments reaction to tensile forces. Intradiscal loads can range from 294N to 3332N depending upon position. anterior segment has the most load but the posterior part can load from 0-30% depending upon segments position. The bending is another type of segmental loading of the neck. Bending should be preventing by collar because it is a combination of compression, shear and tensile forces on the segment from translation. Bending into flexion will be resisted by posterior annulus, posterior longitudinal ligament and the facet capsule and anterior compressive forces on the anterior structures causing disc displacement. Extension on other hand , causes posterior compressive forces in anterior segment and there is a tensile load in facet capsule and anterior longitudinal ligament . Torsion on other hand, is caused by axial rotation and coupled motions[12]**.**

Mobility is the amount and direct of motion in a segment is determined by the Vertebral body and disc size. During Flexion of the neck the Superior vertebra will tilt anteriorly and forward gliding will occur that Widening the intervertebral foramina 24% and Central canal is widened but in extension The Superior vertebra will tilt and glide posteriorly and the intervertebral foramina narrowed up to 20%. The central canal is also narrowed. That explains why extension is more indicated for improvement in cervical disc[12]**.**

Collar is commonly described for cervical disc. Little evidence exists on the mechanisms of collars and their types on pain relief. The collar probably reduces foraminal root compression and associated root inflammation by immobilizing the neck. This might explain the larger reduction of arm pain compared with neck pain and neck disability[13]**.** There are many types of collar in the field but the best one for cervical disc and brachialgia is not clear . This is the main purpose of this study which is to compare the effect of different types of cervical collar on neck pain and brachialgia and range of motion (ROM) based on biomechanical principles. This study will help the physiotherapy to choose the best collar suitable for the patients that has an effect on pain and ROM.

## 2.Subjects and Methods:

### 2.1.Design of the study:

Control randomized design where the group one was considered as a control group as it received physiotherapy program and no collar and the other groups received physiotherapy program and variable types of collars.

### 2.2.Sample of the study:

This study was conducted on one hundred patients. The patients were suffering from neck pain and brachialgia due to C5-6 disc prolapsed; postero – lateral herniation. The diagnosis was confirmed by magnetic resonance image (MRI). This study was applied to study the effect of different types of collar on neck pain and brachialgia .

The selected patients were assigned randomizing into five equal groups; Group one had no collar, Group two applied soft collar, Group three applied hard collar (one piece), Group four applied Philadelphia collar and Group five applied two pieces variable length collar (Adjusted according to length of patient's neck to be put in a slight lateral flexion).Age ranged from 28 to 55 years. Sixty five patients were males, while forty six were females. Duration of illness was from two weeks to two months. All groups were matched in age, sex and duration of illness. Written informed consent was obtained from each patient. Each subject was informed of the protocol and risks for this study and was allowed to ask questions or exit the study at any time.

Any patients with cervical myelopathy, verigo, cervical headache, diabetic neuropathy, carpal tunnel syndrome (CTS), shoulder impingement syndrome, cervical rib and vascular problems in the affected arm were excluded from participation in this study.

**2.3.Instrumentations:**

The data was collected through the visual analogue scale (VAS) and neck electronic goniometer or Cervical range of motion (CROM). The data was collected two times before and after one month (Twelve sessions; three times per week) of applying treatment of the study.

**2.3.1.Visual analogue scale (VAS):**

VAS is a clinical evaluation method to determine the pain intensity. It is a ten centimeters tape with two perpendicular ends (the first end (zero) means no pain and the second end (ten) means the worst pain) to evaluate the intensity of pain. The reliability of the VAS for measurement of pain is moderate to good [14]. Patients determined the level of pain on this scale by Using a ruler, the score was determined by measuring the distance (mm) on the 10-cm line between the "no pain" anchor and the patient's mark, providing a range of scores from 0–100 **(Fig. 1).**

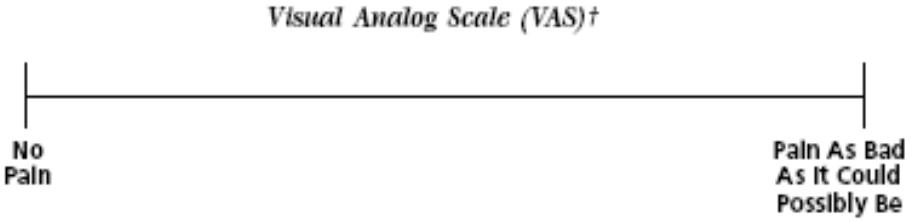


**Figure 1: Visual Analogue Scale (quoted from Boonstra et al., [14])**

**2.3.2. Cervical range of motion (CROM) :**

The cervical range of motion device (CROM) is an instrument designed specifically for measuring cervical ROM. The intertester and intratester reliability are moderately high when subjects are tested with the CROM**.** It can measure accurately and quickly the range of sagittal, coronal and horizontal movements which are performed by the head and neck[15]**.**

The CROM in this study was aligned on the Nose Bridge and ears and was fastened to the head by a Velcro strap. Three dial angle meters; The sagittal plane meter, lateral flextion meter and rotation meter are founded in CROM to take most of the measurements. The sagittal plane meter was used in this study to measure neck extension movement **(Fig.2).**


**Figure 2: The cervical range of motion (CROM) and sagital plane meter reading**

All the patients ROM of neck erextension were measured from sitting position, with thoracic & lumbar spine well supported by the back of the chair and the frame of CROM was set on the patient's head. The patient was asked to stay in a neutral position while the therapist took the first reading from the sagittal plane meter. The patient was asked to perform a maximally active movement of extension while the therapist took the second reading from the sagittal plane meter with the patient in the new position. The beginning value was subtracted from the end value to obtain the range of motion for neck extension.

### 2.4.Procedure:

All subjects were applied physiotherapy program consisted on ultrasound(5 minutes , 1MH, continuous mode, 1.5 watt/$cm^2$) on neck, hot pack on neck, TENS (20 minutes, subthreshold stimulus) on neck and affected arm (4 electrodes on shoulder , elbow and wrist), cervical traction(10 minutes , contralateral to the affected side from sitting position by 10% of body weight) and neck exercises (contralateral side bending and isometric resisted head on neck flexion exercises).Muscle relaxant (Dantrolene) once per day (before sleep) preceded traction. Collar was added to the experimental groups (two, three, four and five) during upright positions and removed during recumbancy. This program of physiotherapy and wearing collar applied for one month (Twelve sessions of physiotherapy; three times per week), with daily use of muscle relaxant. VAS and range of motion (CROM) tests were applied before and at the end of the program.

### 2.5.Statistical analysis [16]:

1. The arithmetic mean as an average description of central tendency for the observations.
2. The stander deviation as a mean of dispersion of results.
3. One-way analysis of variance (abbreviated one-way ANOVA) is a technique used to compare means of more than two independent samples (using the F distribution). This technique can be used only for numerical data . It was used in this study to detect the significant difference between the improvement groups (one, four and five) for the results of CROM and VAS analysis.
4. The paired T TEST is a technique used to compare means of two dependent samples. This technique can be used only for numerical data . It was used in this study to detect the significant changes within each group (pretest –posttest) for the results of CROM and VAS analysis.
5. SPSS for Windows Version 18 was used for all statistical analyses .All statistical procedures were two-tailed with significance set at $\alpha$ level$< 0.05$ .

## 3.Results:

## 3.1.Results within each group:

### 3.1.1.Visual Analogue Scale (VAS) ,(Fig.3):

There was no significant changes in group one(G1) and two(G2) regarding brachialgia at the end of treatment program, ($t=1.31$, $p>0.05$) for each group**.** While in group 3 there was a significant increase in brachialgia at the end of treatment program, ($t= 2.13$, $p < 0.05$)**.** From other hand, there was a significant decrease in brachialgia in group four(G4) and a highly significant decrease in brachialgia in group five(G5) at the end of treatment program, ($t= 2.13$, $p < 0.05$) and ($t= 4.14$, $p < 0.01$) respectively**.**

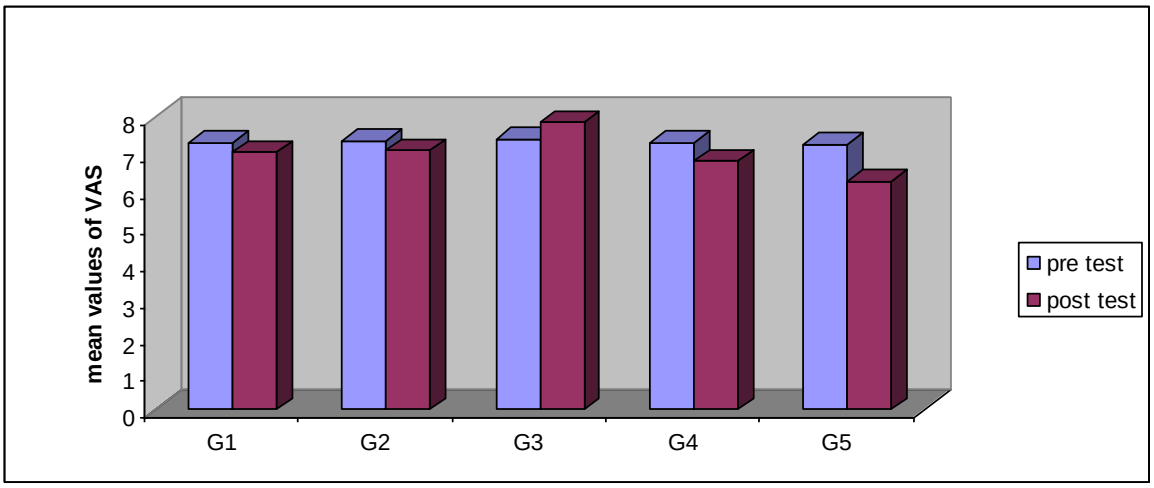


**Figure 3: Changes in the mean values of VAS within each group before and after treatment**

### 3.1.2.Range of motion (CROM), (Fig.4):

There was a statistically significant improvement or increase in G1 in active painless ROM of neck extension at the end of treatment program, (t= 2.38, p<0.05). While in G2 there was no significant changes in active painless ROM of neck extension at the end of treatment program, (t= 1.23, p>0.05)**.** Regarding G3, there was a highly significant decrease in painless active ROM of neck extension at the end of treatment program, (t= 4.09, p < 0.01). on the other hand, there was a significant increase in painless active ROM of neck extension in G4 and a highly significant increase in active painless ROM of neck extensors at the end of treatment program in G5, (t= 2.43, p < 0.05) and (t= 7.09, p < 0.01) respectively**.**

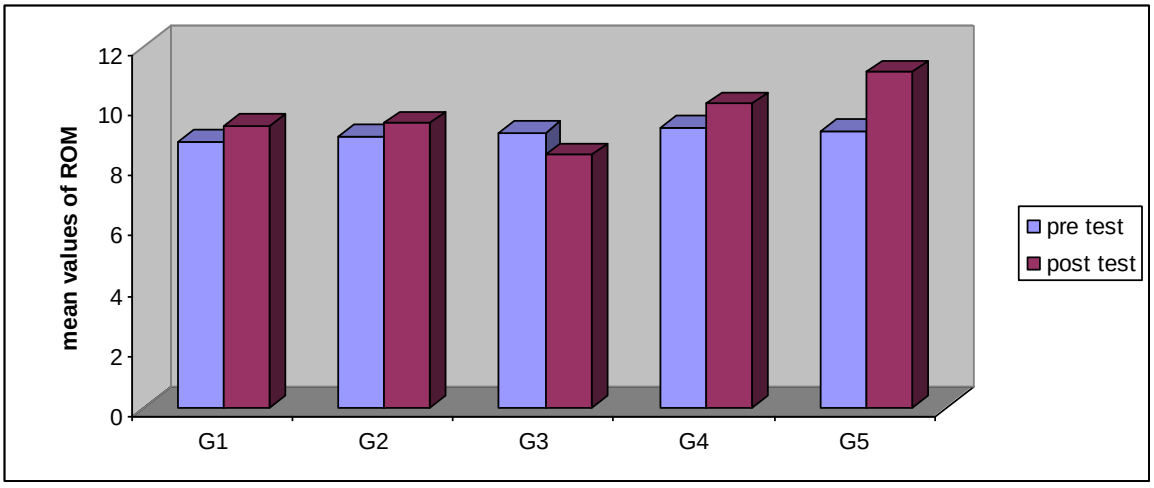


**Figure 4: Changes in the mean values of ROM of neck extension within each group before and after treatment**

### 3.2.1.Comparison among results of groups one ,four and five:

These groups showed improvement after treatment. By comparing degree of improvement (post-pre) among these groups (using one –way analysis of variance ANOVA).

There was no significant difference among improvement in VAS between those groups (F=2.93, P>0.05) **, (Fig. 5).** While in ROM, there was a significant difference between those groups, with the best improvement in G5 (F=8.14, P<0.05) **,(Fig. 6).**

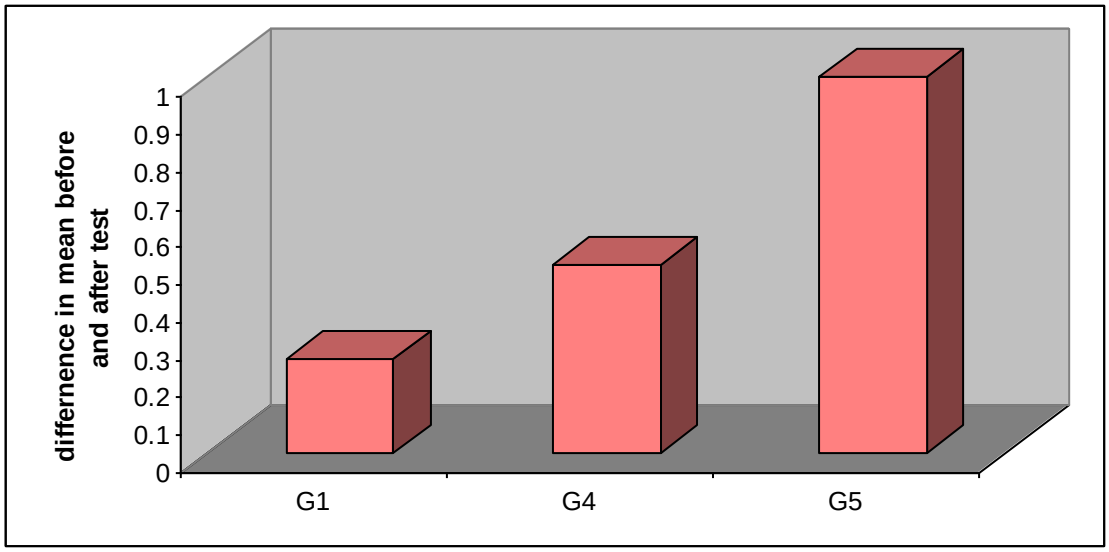


**Figure 5: Difference in the mean values of VAS between the improvement groups of the study**

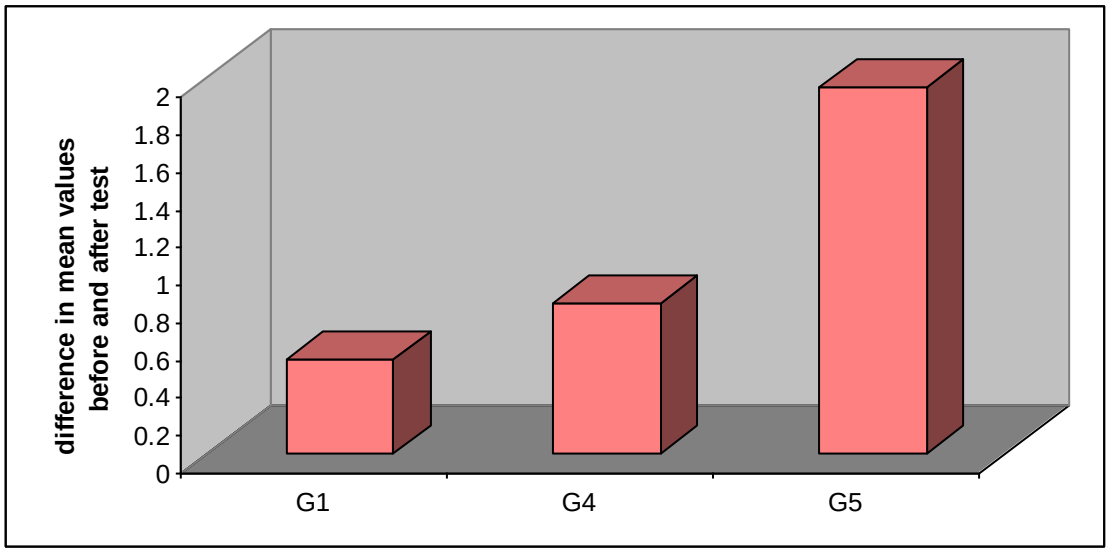


**Figure 6: Difference in the mean values of ROM of neck extension between the improvement groups of the study**

## 4.Discussion:

Neck pain and brachialgia is one of the most prevalent and costly or even disable problems as a result of cervical disc prolapse. Although cervical collars are a seemingly benign intervention for this condition, adverse effects or even no response might occur due to inappropriate choice of the suitable collar for the patient because of different types of collar in the field of physiotherapy or even in neurology. The effect of common using types of collars presenting in the field of physiotherapy was the target of this study because of few studies had discussed the cervical collars for the management of patients with radicular pain. This will help to decrease the intervention of surgery for cervical disc. The current study measured the effect of phyladifia ,soft, one piece hard collar and two piece adjusted hard collar and no collar using on ROM of neck extension and brachialgia.

Neck forward and backward, and moving to left and right, places many kinds of pressure on the vertebrae and disc. The disc responds to the pressure from the vertebrae by acting as a shock absorber. In herniated disc the tear in the annulus portion of the intervertebral disc is that part of the nucleus pulposus squeezes out of the center of the disc so it can press against the spinal nerves. Pressure against the nerve root

from a herniated disc can cause pain, numbness, and weakness along the nerve. There is also evidence that the chemicals released from the ruptured disc may irritate the nerve root, leading to some of the symptoms of a herniated disc especially pain.

That leads the physiotherapist to be sure that there is no load on the disc from the neck weight or motion so no pressure on the nerve so less inflammation of the nerve and no brachialgia and increase ROM and that should be the rule of any collar prescribed for cervical disc herniation. A cervical collar is often used to provide support and limit motion while an injured neck (disc herniation) is healing. It also helps to keep the normal alignment and keeps the head in a comfortable gravity-aligned position, this means a normal cervical lordosis. The head is held high on the shoulders and the ears are directly over each shoulder. Cervical collars can be soft (made of foam) or hard (made of metal or plastic).

The first result of the current study found that group one who had no collar in treatment showed no significant improvement in brachialgia although the neck extention ROM improved. The ultrasound, traction and muscle relaxant for muscle relaxation might help to increase ROM but because of no collar was used the nerve was putting on loading from head movement and position that might contribute to brachialgia did not decrease in this group.

The result of soft cervical collar in this study had no significant effect on brachialgia or ROM. This might attribute to soft cervical collar has the least restrictive ROM, allowing the closest to normal range of motion because of its component that makes it not rigid, So the compression on the nerve from irritated disc did not decrease and the load on the disc remained still.

These results is agreed with **Logan and Holt** [17] and also with the conclusion of **Whitcroft et al.,** [18] who concluded that the soft cervical collar did not adequately immobilize the cervical spine or put the neck on the desired biomechanical alignment that suitable to increase the intervertebral foramen space so decreasing the pressure on nerve root and soft collar as no collar have no effect on management of decreasing load on disc to decrease radiculopathy. .

Hard collar ( one piece) had in this study showed significant increase in brachialgia and significant decrease in neck extension and so it indicated that one piece hard collar not recommended to be used in cervical radiculopathy due to disc herniation. This might be attributed to although hard collar is made of metal that could carry the weight of neck and so decreasing the load of neck on the disc but it put the neck on bad biomechanical alignment. This type of hard collar put the neck on slight extension that makes the intervertebral foramina in a narrowed position so compression on the nerve root by bad alignment of head position and the inflammatory process of the pinched nerve continues. So , put the nerve root in a compressed position ,consequently , brachialgia and ROM did not improved.

This result of this one piece hard collar **( fig.7)** in the current study is agreed with **Dehner et al.,** [19] who reported there are adverse effects with one piece hard collars including, pain, breathing restriction , tissue ischemia and hard collars are not recommended to manage pain. Also the current study is agreed with **Persson et al.,** [20] and **Stefan et al.,** [21] who reported adverse effect of using one piece hard collar especially in long period of time due to muscle atrophy. Also the current study is agreed with **Stone et al.,** [22] who reported that neck pain due to using one piece hard collar is due to increasing intracranial pressure .

**Figure 7: Philadelphia , hard collar one piece and two piece hard collar**

The results of our current study is not consistent with **Saal et al.,** [23] who reported that neck pain patients had good or excellent outcomes by using one piece hard collar. None of the patients had progressive neurological loss, and all patients with motor loss reached neurologic improvement. This difference between two studies attributed to the ice using instead of US as used in our study. Also **Saal et al.**, [23] focused on body mechanics instructions for the treatment that might correct the bad mechanics of one piece hard collar on the neck that leads to pain on the neck due to extension of the neck by one piece hard collar. Also that difference might also attribute to the absence of the control group for comparison at **Saal et al**. [23] study.

The result of our study found that there is significant decrease in brachialgia and increase in ROM of neck extension when using phyladifia( fig.7) and two pieces collar with more evidence for two pieces collar( fig.7) in decreasing of pain and increase ROM of extension .This may attributed to that both types of collar are hard so they decrease load of neck on disc so giving time for herniated disc to heal and decrease pain by decrease inflammatory process and as a result decreasing spasm of muscles of neck and increase ROM . The more evidence of two pieces collar than phyaldifia collar might be due to two pieces collar put the neck in slide side bending away from brachialgia side so increase space of foramen magnum more and as a result it decreases more the compression load on disc so more healing process. Also, it allows slight flexion of neck, so center of gravity shifts anteriorly away from disc and as a result decreases load on cervical disc. This result is agreed with **Thomas et al.,** [24] who reported that phyladiphia or two pieces collar restrict the cervical spine motion during flexion, extension, axial rotation, and lateral bending that aloud time to heal intervertebral disc .

Philadelphia collar is a two-piece collar. One part is for the back part of the neck while the other is for the front part and has a Velcro on left and right sides for easier removal and attachment. The total cervical arch support helps in maintaining cervical alignment. It is specially contoured for excellent stabilization and comfort. It is has a chin rest to make it comfortable for the wearer and to provide more immobilization. It is made from a stiffer material and has a hole in the middle for tracheostomy purposes. This is usually utilized if there is a great risk for respiratory function loss. If not used for tracheostomy purposes, the hole provides good ventilation for patient's comfort and helps in reducing heat and moisture build up.

The composition of Philadelphia collar is opposite to one piece hard collar because the former put the neck in good alignment but the latter one put it in slight extension so improvement was noticed in group of Philadelphia collar not in group of hard collar. Two pieces hard collar has the advantage of Philadelphia collar in addition two it can adjusted to put the neck in slight lateral flextion away from brachialgia side so more increase in the size of foramen magnum so more relaxed position of nerve away from compressed position so healing is more that explains why group of two pieces collar showed more significant improvement than other groups of the study. Also, it allows slight flexion of neck, so center of gravity shifts anteriorly away from disc and as a result decreases load on cervical disc. This is agreed with **Richter, et al.,** [25]**.**

**Nibhanipudi** [26] concluded that Philadelphia hard cervical collar were superior to the usage of soft cervical collar and it had shown that participants even with the hard cervical collar could move and this is consist with our study . on other hand, the current study is contradict with **Miller et al.,** [27] who concluded that soft collar and hard collar has similar effect on neck that difference between the two studies may explain as **Miller et al.,** [27] depended on proprioceptive guides, which allow patients to regulate their own cervical motion based on their level of comfort but our study measured ROM and level of pain or brachialgia .

## 5.Conclusion:

Two pieces hard collar and Philadelphia collar have a significant effect on management of pain and increase extension neck ROM in cases of radiculopathy due to cervical disc herniation but two pieces hard collar is more recommended for management of neck disc brachialgia. The more evidence of two pieces collar than Philadelphia collar might be due to increase space of foramen magnum more and as a result it decreases more the compression load on disc so more healing process because of sliding position of the neck by it. Also, two pieces collar allows slight flexion of neck, so center of gravity shifts anteriorly away from disc and as a result it decreases load on cervical disc**.**

## 6. References :


1. Fritz Julie M., Thackeray Anne, Brennan Gerard P. and Childs John D. "Exercise Only, Exercise With Mechanical Traction, or Exercise With Over-Door Traction for Patients With Cervical Radiculopathy, With or Without Consideration of Status on a Previously Described Subgrouping Rule: A Randomized Clinical Trial," J Orthop Sports Phys Ther .2014;44(2):45-57.
2. Sang Hyun Baek, Jae Woo Oh, Joon-Shik Shin, Jinho Lee, Yoon Jae Lee, Me-riong Kim, Yong-jun Ahn, Areum Choi, Ki Byung Park, Byung-Cheul Shin, Myeong Soo Lee, and In-Hyuk Ha. Long term follow-up of cervical intervertebral disc herniation inpatients treated with integrated complementary and alternative medicine: a prospective case series observational studyBMC Complement Altern Med. 2015;16: 52.
3. Kuijper B, Tans JTJ, Schimsheimer RJ, van der Kallen BFW, Beelen A, Nollet F, et al. Degenerative cervical radiculopathy: diagnosis and conservative treatment: a review. Eur J Neurol .2009;16:15-20.
4. Miyazaki M, Hong SW, Yoon SH, Zou J, Tow B, Alanay A, et al.Kinematic analysis of the relationship between the grade of disc degeneration and motion unit of the cervical spine. Spine 2008; 33(2):187.
5. Andrew G. Todd .Cervical spine: degenerative conditions. Curr Rev Musculoskelet Med. 2011; 4(4): 168–174.
6. Songning Zhang, Jacob Gardner and Xuan Liu .Effects of Capital™ Collar Enhanced on Head-Cervical Movements in Comparison with Miami J® Advanced and Aspen Vista® TX Collars Limitation of this study/ DeRoyal Industries, Inc. Biomechanics/Sports Medicine Laboratory Department of Exercise, Sport and Leisure Studies The University of Tennessee Knoxville, TN, USA . 2013
7. Robert Dunn.Brachialgia: Cervical radiculopathy and differential diagnosis Brachialgia had a wide differential diagnosis. CME .2011; 29 (9) .
8. Anderson DG, Albert TJ, Fraser JK, Risbud M, Wuisman P, Meisel HJ, et al. Cellular therapy for disc degeneration. Spine 2005;30:S14–19.
9. Howard S. An, Koichi Masuda and Nozomu Inoue .Intervertebral disc degeneration: biological and biomechanical factors. J Orthop Sci.2006; 11(5): 541–552.
10. Mannion AF, Klein GN, Dvorak J and Lanz C. Range of global motion of the cervical spine: intraindividual reliability and the influence of measurement device. Eur Spine J.2000;9(5):379-85.
11. Van Dijk Monique, Koot Hans M.,Huda Huijer Abu Saad, Tibboel Dick And Passchier Jan. Observational visual analog scale in pediatric pain assessment: Useful tool or good riddance? The Clinical journal of pain 2002;18 (5): 310-316.
12. Ruth Jackson. The Classic: The Cervical Syndrome. Clin Orthop Relat Res.2010; 468(7): 1739–1745.
13. Barbara Kuijper, Jos Th J Tans, Anita Beelen, Frans Nollet and Marianne de Visser .Cervical collar or physiotherapy versus wait and see policy for recent onset cervical radiculopathy: randomised trial .BMJ .2009;339 .
14. Boonstra AM1, Schiphorst Preuper HR, Reneman MF, Posthumus JB and Stewart RE. Reliability and validity of the visual analogue scale for disability in patients with chronic musculoskeletal pain. Int J Rehabil Res.2008;Jun;31(2):165-9.
15. JAMES P. Fletcher and William D. Bandy .Intrarater Reliability of CROM Measurement of Cervical Spine Active Range of Motion in Persons With and Without Neck Pain Orthop Sports Phys Ther . 2008;38(10):640-645.
16. Kirkwood BR and Stern JA .Essential medical statistics.2nd ed,Blackwell Publishing company, Australia.Pp:474-479. 2003.
17. Logan AJ and Holt MD.Management of whiplash injuries presenting to accident and emergency departments in Wales. Emerg Med J .2003;20:354–5.
18. Whitcroft KL1, Massouh L, Amirfeyz R and Bannister GC. A comparison of neck movement in the soft cervical collar and rigid cervical brace in healthy subjects. J Manipulative Physiol Ther. 2011;34(2):119-22.
19. Dehner C, Hartwig E, Strobel P, Scheich M, Scneider F and Elbel M, Kinzl L and Kramer M.Comparison of the relative benefits of 2 versus 10 days of soft cervical collar immobilization after acute whiplash injury. Arch Phys Med Rehabil 2006;87:1423–7.
20. Persson LC, Carlsson CA and Carlsson JY. Long lasting cervical radicular pain managed with surgery, physiotherapy, or a cervical collar: a prospective randomized study. Spine 1997;22(7):751–8.

21. Stefan Muzin, Zacharia Isaac,, Joseph Walker, Omar El Abd, and Jennifer Baima. When should a cervical collar be used to treat neck pain? Curr Rev Musculoskelet Med. 2008 ; 1(2): 114–119.
22. Stone MB, Tubridy CM and Curran R. The effect of rigid cervical collars on internal jugular vein dimensions. Academic emergency medicine: official journal of the Society for Academic Emergency Medicine. 2010; 17(1):100-102.
23. Saal JS, Saal JA and Yurth EF. Nonoperative management of herniated cervical intervertebral disc with radiculopathy. Spine 1996; 21:1877–83.
24. Thomas M. Gavin, Gerard Carandang, Robert Havey, Patrick Flanagan, Alexander Ghanayem and Avinash G. Patwardhan .Biomechanical analysis of cervical orthoses in flexion and extension: A comparison of cervical collars and cervical thoracic orthoses. journal of rehabilitation research and development 2003; 40 ( 6): 527 — 538.
25. Richter, D., Latta, L. L., Milne, E. L., Varkarakis, G. M., Biedermann, L., Ekkernkamp, A., and Ostermann, P. A. The stabilizing effects of different orthoses in the intact and unstable upper cervical spine: a cadaver study. J Trauma 2001; 50: 848-854.
26. Nibhanipudi K.A Study To Compare The Usefulness Of Double Soft Cervical Collar Versus Hard Cervical Collar (Philadelphia Collar) For Neck Immobilization. The Internet Journal of Emergency and Intensive Care Medicine 2014; 14 ( 1).
27. Miller CP., Bible CE, Zagade KA,Whang PG and Grauer JN.Soft and rigid collars provide similar restriction in cervical range of motion during fifteen activities of daily living. Spine 2010 ;1:35(13); 1271.

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