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Original Research

Comparison of Cervical Motion Restriction Between Soft and Rigid Collars

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ABSTRACT

Background: *Cervical collars are commonly used to provide comfort and restrict cervical motion in post-operative and pain management patients, with an average usage rate of 80.8% in cervical injury cases. Different collar types offer varying degrees of motion restriction, which is critical in patient recovery.*
Purpose: *This study aims to compare the degree of neck movement restriction between soft cervical collars and rigid cervical collars.*
Methods: *This quantitative research used a cross-sectional study design. A purposive sampling technique was applied to select 20 respondents from a population of 212, based on predefined inclusion and exclusion criteria. Respondents were divided into two intervention groups: 10 participants wore soft collars, and 10 wore rigid collars. Neck movement restriction angles were measured using the Angulus application, focusing on six directions of movement: flexion, extension, right and left lateral flexion, and right and left rotation.*
Results: *The results showed significant differences in restriction angles between the two collar types. Rigid collars demonstrated greater restriction than soft collars, with mean differences as follows: 29.35˚ (flexion), 15.10˚ (extension), 17.72˚ (right lateral flexion), 17.78˚ (left lateral flexion), 21.93˚ (right rotation), and 24.02˚ (left rotation).*
Conclusion: *There is a statistically significant difference in neck movement restriction between soft and rigid collars. Rigid collars are more effective in limiting cervical motion across all measured directions. These findings highlight the importance of selecting the appropriate collar type based on the desired level of immobilization for optimal clinical outcomes.*

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INTRODUCTION

A cervical collar is an orthotic device used to limit cervical spine movement, particularly in patients who have experienced trauma or are at risk of spinal Injury (2). Its primary function is to immobilize the cervical region to prevent further damage in cases of suspected spinal instability, or as part of postoperative stabilization (1). Immobilization with cervical collars is widely recommended in trauma protocols involving high-risk mechanisms or positive clinical findings suggestive of cervical spine injury (8).

Cervical orthoses come in several forms, including Cervical Orthosis (CO), Head-Cervical Orthosis (HCO), Cervicothoracic Orthosis (CTO), Minerva orthosis, Halo skeletal fixator, and the Sterno-Occipito-Mandibular Immobilizer (SOMI) (9). Among these, the cervical collar is the most commonly used, and it is typically classified into two main types: soft collars and rigid collars. Soft collars, often constructed from foam or rubber and covered with fabric, are designed to offer minimal restriction and are commonly prescribed for neck pain or minor injuries. They provide warmth, psychological reassurance, and serve as a kinesthetic reminder to limit motion, with relatively low mechanical support (17); (10); (9). In contrast, rigid collars are composed of hard plastic with padded interiors and are used to restrict neck motion significantly—especially in postoperative care or cases of suspected cervical fractures (3).

Several studies have examined the efficacy of soft versus rigid collars in terms of motion restriction. For instance, (4) found that rigid collars reduced flexion by up to 59%, compared to 39% with soft collars. Similarly, rigid collars limited lateral rotation to 18%, while soft collars only achieved an 11% reduction. These differences are clinically relevant because controlling cervical movement is crucial in reducing the risk of secondary injury, ensuring surgical healing, and improving patient outcomes (12)

Despite their widespread use, cervical collars are not without complications. Pressure injuries are among the most common adverse effects, with incidence rates reported to range from 1.1% to 78.4% across eight studies (6). Misuse is also a significant issue; Kasnavieh et al. (2023) found that patients with underlying medical histories were more likely to receive cervical collars unnecessarily compared to those without (47.96% vs. 12.5%). On the other hand, a systematic review of 25 studies confirmed that the proper application of cervical collars can reduce postoperative pain and contribute positively to patient recovery (13).

However, despite the growing body of literature, there is a significant gap in detailed, quantitative data regarding the angular restriction capabilities of commonly used collars—specifically in terms of flexion, extension, lateral bending, and axial rotation. Much of the existing data remains generalized or incomplete, making it difficult for prosthetic-orthotic practitioners to make evidence-based decisions regarding collar selection or design. This limitation can have critical clinical implications. Without accurate knowledge of a collar's restrictive force, practitioners may select devices that under- or over-restrict motion, potentially compromising patient safety, comfort, and rehabilitation outcomes (11).

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Given the importance of tailored cervical immobilization in both trauma and surgical contexts, it is essential to fill this gap by providing comparative, objective data on the mechanical performance of different collar types. Such data would support more informed clinical decision-making, guide device development, and enhance patient care through personalized orthotic intervention.

Therefore, this study aims to quantitatively evaluate the differences in cervical motion restriction—specifically in flexion, extension, lateral flexion, and rotation—between soft and rigid cervical collars. The hypothesis of this study is that there is a significant difference in the degree of cervical motion restriction between soft and rigid collars.

METHOD

Research Type

This study used a quantitative approach with a cross-sectional survey design. Sampling used a purposive sampling technique on 20 healthy orthotic prosthetic students. Data were collected in August 2023 using a validated angulus application and analyzed with an independent sample T-test to determine the comparison of the large angle of neck movement restriction between the use of soft and rigid collars.

Population and Sample

The population in this study was 212 students from the Orthotic Prosthetics Department who completed a Google form, both willing and unwilling to participate. Sampling was conducted using a purposive sampling technique. The inclusion criteria were: (1) willingness to participate in the study (2) healthy physical condition (3) ability to move the neck within normal ROM). Exclusion criteria were: (1) history of chronic neck pain (2) spinal injury (3) previous spinal surgery. Twenty respondents met the inclusion and exclusion criteria. These 20 respondents were divided into two groups with one treatment: 10 respondents received a soft collar and 10 others received a rigid collar. Randomization is done by drawing odd and even numbers. Odd numbers are for rigid collars and even numbers are for soft collars.

The limited number of respondents in this study was due to low volunteer interest and the specific requirements of the sampling technique chosen. Therefore, this study is exploratory in nature and can serve as a starting point for further research with a larger sample size and a more robust design. The selection of healthy respondents in this study was based on scientific considerations to avoid interfering variables such as pain, limited active movement, and structural instability, which are common in patients with cervical spine disorders. Healthy subjects allowed researchers to objectively and accurately measure the extent to which collars (both soft and rigid) restricted neck movement. This approach also aligns with research safety principles.

Research Location

This study was conducted in Surakarta City, with respondents being orthotic prosthetics students. They possess a relevant academic background and a basic understanding of anatomy, biomechanics, and the use of orthotic devices. This allows them to provide a more accurate and controlled response to the treatment (rigid and soft collar use), thus minimizing external variables that could influence the study results.

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Instrumentation or Tools

Measurements of joint angles were performed using the Angulus app, which can be downloaded from the Play Store. The validity and reliability of the Angulus app were evaluated in a study by (15) which compared joint angle measurements using Angulus with a universal goniometer. The results showed that correlation values between the Angulus app and a conventional goniometer were mostly above r = 0.70, with an Intraclass Correlation Coefficient (ICC) of more than 0.75, indicating good to excellent reliability. These findings are supported by other systematic studies, such as that conducted by Shimizu et al., (2022), which showed that various smartphone-based angle measuring apps have high validity and reliability in measuring joint range of motion when compared with standard clinical tools.

The measurement method uses the photographic analysis method, which begins with marking the tragus area, sternal notch, acromion, middle top of the head, base of the nose and tip of the nose (18). Then taking photos of the subject in three different conditions, namely the condition before using the collar, when using the soft collar and when using the rigid collar. Then perform analysis using the Angulus application to determine the size of the resulting angle. By manually placing the axis, static, and dynamic points, the angle will automatically come out. Measurement of neck flexion extension by placing the axis on the tragus with a vertical static line with the tragus and a straight dynamic line with the base of the nose. Measurement of lateral flexion by placing the axis on the sternal notch with a straight static line with the acromion and a dynamic line in the middle of the nose. Measurement of head rotation by placing the axis on the top of the middle head with a static line straight with the acromion and a straight dynamic line with the tip of the nose (18).

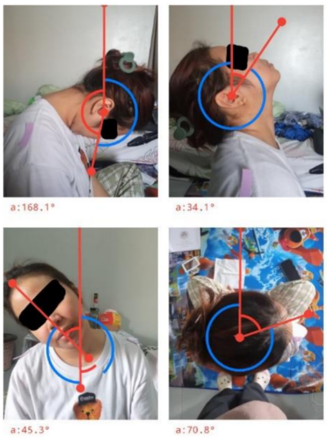

Figure 1. Photographic analysis

Data Collection Procedures

Data collection in this study was conducted using the Angulus application to measure neck angles for four types of movements: flexion, extension, lateral flexion, and rotation. The first measurement was performed without the use of assistive devices, followed by the fitting of cervical collars according to the groups: a rigid collar for the rigid group and a soft collar for the soft group. After the collars were fitted, measurements for the same four types of movements were repeated using the same method. All data collection was carried out through photographic

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documentation, which was then analyzed to determine the magnitude of the restriction angle produced by each type of cervical collar.

Data Analysis

The results of the research data were analyzed using the Statistical Product and Service Solutions (SPSS) program with the parametric statistical test Independent Sample T-Test to determine the significance of the comparison of the angle of neck movement restriction when using soft collars and rigid collars.

Ethical Approval

This study has received approval from the ethics committee of the Poltekkes Kemenkes Semarang with number No. 040 / EA / KEPK / 2024.

RESULTS

The sampling technique used purposive sampling with inclusion and exclusion criteria, from 212 populations there were 65 respondents willing to do the research, which met the criteria as many as 20 respondents. Of the 20 respondents were divided into two groups with one treatment, 10 respondents used a soft collar and 10 others used a rigid collar. The measuring instrument used in this study was the angulus application.

1. Subject characteristics based on gender, age, BMI and hobbies

Based on the data obtained, the characteristics of research respondents based on gender, age, BMI, and hobbies are as follows:

Table 1. Characteristics of research respondents

Respondent characteristics	Amount	%
Age (Years)		
18	1	5%
19	4	20%
20	10	50%
21	5	25%
Gender		
Woman	15	75%
Man	5	25%
Hobby		
Athletics	5	5%
Non-athletic	15	75%
IMT		
Thin	1	5%
Normal	16	80%
Fat	2	10%
Obesity 1	1	5%
Obesity 2	0	0%

The most respondents were aged 20 years, 10 people, and the least were aged 18 years. However, none of the respondents were much older than 20 years, so it is still possible to achieve normal neck movement. The gender in this study was mostly female and BMI was generally normal, but according to (20) men tended to display a reduced ROM compared to women. Meanwhile, for the description of

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daily activities, most respondents do not have activities in the field of athletics/sports with a total of 15 respondents.

2. Subject characteristics based on neck circumference

Table 2. Characteristics based on neck circumference

	Neck Circumference											Total
	28	29	30	30.5	31	32	32.5	33	34.5	35.5	37	
n	1	1	1	1	6	3	1	3	1	1	1	20

Based on the table, it is known that the average neck circumference of respondents is 31.9 cm with the largest number being 6 people with a neck circumference of 31 cm.

3. The average condition of the subject's neck ROM before collar application

Table 3. Average ROM of the neck before collar application

Collar	Flexibility	Extensions	Right Flexion Lat	Left Flexion Lat	Right Rotation	Left Rotation
Soft	69.8°	67.12°	44.5°	43.52°	72.04°	74.13°
Rigid	72.49°	63.64°	43.9°	44.51°	78.74°	73.05°

4. Average ROM condition of the neck after being given a collar

Table 4. Average ROM of the neck after being given a soft and rigid collar

Collar	Flexibility	Extensions	Right Flexion Lat	Left Flexion Lat	Right Rotation	Left Rotation
Soft	20.58°	28.74°	9.15°	9.8°	22.34°	18.73°
Rigid	49.93°	43.84°	26.87°	27.58°	44.27°	42.69°

5. Data normality test

Data normality testing was carried out using the Shapiro Wiljk test, because the number of respondents was <50 people, namely 20 people.

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Table 5. Data Normality Test

Soft Collar Restriction	Shapiro Wiljk		Information
	n	Significance	
Soft collar flex	10	0.130	Normal
Rigid collar flexion	10	0.960	Normal
Soft collar extension	10	0.280	Normal
Rigid collar extension	10	0.587	Normal
Lat. Flexion right soft collar	10	0.053	Normal
Lat. Flexion dextra rigid collar	10	0.216	Normal
Lat. Flexion Sinistra Soft Collar	10	0.088	Normal
Lat. Sinistra Rigid Collar Flexion	10	0.753	Normal
Dextra Soft Collar Rotation	10	0.393	Normal
Rigid Collar Right Rotation	10	0.860	Normal
Soft Collar Sinistra Rotation	10	0.753	Normal
Rigid Collar Left Rotation	10	0.589	Normal

Based on the results of the normality test, it shows that all ROM data on the neck given a soft collar or rigid collar is normally distributed, so a parametric hypothesis test is carried out, namely the Independent Sample T-Test.

6. Hypothesis Testing

The hypothesis test used was the Independent Sample T-Test to determine the significance of the comparison of the magnitude of the neck motion restriction angle in the use of soft collars and rigid collars.

Table 6. Hypothesis Testing

		Mean	Std. Deviations	P-value
Flexion	Soft collar	20.58˚	16.51934	0.001
	Rigid collar	49.93˚	16.70795	
Extension	Soft collar	28.74˚	11.60280	0.003
	Rigid collar	43.84˚	7.50499	
Lateral flexion dextra	Soft collar	9.15˚	5.94890	0.000
	rigid collar	26.87˚	5.97663	
Lateral flexion sinistra	Soft Collar	9.8˚	8.08744	0.000
	Rigid Collar	27.58˚	6.23071	
Roration Dextra	Soft Collar	22.34˚	8.43145	0.001
	Rigid Collar	44.27˚	14.12909	
Rotation sinistra	Soft Collar	18.73˚	11.23784	0,000
	Rigid Collar	42.75˚	11.69589	

Based on the results of the hypothesis test, there was a statistically significant difference between the restriction of flexion, extension, lateral flexion, and rotation movements from the use of a soft collar and a rigid collar.

DISCUSSION

Interpretation of Key Findings

This study was conducted to determine the magnitude of the restriction angle produced in the use of soft collar and rigid collar. The respondents of this

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study were 20 respondents divided into two groups, namely the soft collar treatment group with 10 respondents and the rigid collar treatment group with 10 respondents.

Several publications recommend the effectiveness of collars in terms of their ability to limit neck range of motion (ROM). Collars are generally designed for prehospital trauma management, with the goal of providing support and management of the spine following injury, surgery, or degenerative changes. The use of rigid cervical collars in preclinical trauma care is known to be a method used to immobilize the neck (Jung et al., 2021). In trauma hard collars are used to immobilise the cervical spine in order to reduce pain and reduce the risk of displacement or deformity. Use of a hard collar is considered to be a safe therapy with low morbidity (Brannigan et al., 2022). Most studies compare range of motion in the sagittal (flexion and extension), transverse (lateral bending), and axial (rotation) planes with and without an orthosis to observe the differences that occur in each of these planes (19).

From the results of this study, there is a statistically significant difference between the restriction of flexion, extension, lateral flexion, and rotation of the soft collar and the rigid collar. The results of statistical tests on the restriction angle variable in the use of soft collar and rigid collar obtained a difference in motion restriction of 29.35˚ in flexion motion, 15.10˚ in extension motion, 17.72˚ in right lateral flexion motion, 17.78˚ in left lateral flexion motion, 21.93˚ in right rotation motion, and 24.02˚ in left rotation motion. With a large percentage of the restriction angle in the use of soft collars in flexion motion of 29%, extension 43%, right lateral flexion 21%, left lateral flexion 23%, right rotation 31% and left rotation 25%. While in the use of rigid collars in flexion motion of 69%, extension 69%, right lateral flexion 61%, left lateral flexion 62%, right rotation 56% and left rotation 58%. The results obtained all movements decreased significantly when the subjects used soft collars and rigid collars. The difference in material density in soft collar and rigid collar causes different restriction results. Another influence of the large difference in restriction can also be caused by the trimline of the collar. Based on (1) the amount of movement restriction is an important measurement in determining the efficacy of a cervical collar.

Based on a brief interview shortly after using the collar, respondents from the soft collar group stated that the soft collar provided a warm feeling in the neck area. Respondents also felt an improvement in neck posture when the device was used, becoming slightly more upright. Respondents realized that the use of the soft collar was less restrictive in terms of movement, because respondents could still move their necks as much as possible. This is in accordance with a study conducted by Asha et al. in 2021 entitled "Neurologic Outcomes Following The Introduction Of A Policy For Using Soft Cervical Collars In Suspected Traumatic Cervical Spine Injury". (2) stated that the soft collar serves as a reminder for staff and patients to maintain spinal immobilization techniques while minimizing the side effects associated with rigid collars.

Respondents from the rigid collar group stated that the rigid collar significantly restricted movement. Respondents gave different reactions, some said it was uncomfortable because the neck felt very stiff, some said it was comfortable even after doing normal activities. This is in accordance with research conducted by (7). With the title "Effect of a cervical collar on head and neck acceleration profiles during emergency spinal immobilization and extrication procedures in elite

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football (soccer) players" said that rigid collar is used to protect the cervical spine from adverse movements within certain limits (7). Rigid collar is made of stiffer material and is more restrictive than soft collar. It is commonly used in cases of post-operative immobilization, cervical spine fractures, and other neck problems such as spondylodiscitis 5). With this research, prosthetic orthotics can be used as a consideration in making collars with trimline bellow chin upper sternal notch and providing collars based on their restrictive strength.

Knowledge of the size of the ROM restriction on each type of collar is very necessary to reduce the risk for patients to receive an inappropriate collar. Because an inappropriate collar can cause optimal ROM restrictions that can cause neck disorders and increase complications (12). The effectiveness of using a collar will also decrease if the neck position is not adjusted correctly, which can cause skin problems and potential hyperextension (14).

Based on research, the use of soft collars for trauma and post-surgery is adjusted according to the degree of restriction required. Patients with severe trauma and post-operative pain typically require greater immobilization to prevent certain movements. Therefore, when these conditions occur, a rigid collar is recommended. However, patients with mild trauma who only require support can be given a soft collar to help speed recovery.

This study encountered several research obstacles, including a small sample size due to the small number of people willing or interested in participating in the sample. Furthermore, this study was conducted on non-patients because if it were conducted on patients, it could potentially increase injuries if they were forced to perform movements according to research instructions, thereby reducing the validity of the research results. Once the research results are obtained, the new device can be implemented on patients. These findings can be used as a reference in selecting the right collar for patients based on the degree of restriction in each movement. If the patient requires a maximum degree of neck restriction, a rigid collar can be used, and vice versa, if the patient requires a slight degree of restriction, a soft collar can be used.

LIMITATIONS AND CAUTIONS

Obstacles in this study were that the subjects' neck motion ROM used did not start with the same range, and the height of the device was not adjustable for each respondent. The study should have begun with subjects with the same ROM to increase the uniformity of the results. Furthermore, the device used should have been sized using an adjustable collar to adjust to the height/length of the subjects' necks.

CONCLUSION

The results showed that there was a statistically significant difference between the flexion, extension, lateral flexion, and rotation restrictions of the soft collar and the rigid collar. With the p value of each neck movement, namely the flexion p value = 0.001 in flexion motion, the extension p value = 0.003, the right lateral flexion p value = 0.000, the left lateral flexion p value = 0.000, the right rotation p value = 0.001, and the left rotation p value = 0.000 with ($p <0.05$). The results of the statistical test on the restriction angle variable in the use of the soft collar and rigid collar obtained a difference in motion restriction of 29.35° in flexion

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