Investigation of the Relationship Between Disc Degeneration and Cross-Sectional Area of Deep Extensor Muscles in Patients with Chronic Non-specific Neck Pain

Kronik Non-spesifik Boyun Ağrısı Olan Hastalarda Disk Dejenerasyonu ile Derin Ekstansör Kasların Kesit Alanı Arasındaki İlişkinin İncelenmesi

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ABSTRACT

Objective: The objective of our research is to analyze the impact of the degree of C4-C5 disc degeneration on the relative cross-sectional area of the deep extensor muscles (R-CSA$_{DEs}$).

Methods: A total of 162 patients, 98 (60.5%) females and 64 (39.5%) males, who presented to our hospital between 2020 and 2022 with chronic non-specific neck pain, were included in our study. Retrospectively, the degrees of C4-C5 disc degeneration were determined through magnetic resonance imaging, and the R-CSA$_{DEs}$ was measured.

Results: The average age of 162 patients was found to be 42.30±8.8, and the average relative CSA of the deep cervical extensor muscles (R-CSA$_{DEs}$) was found to be 1.96±0.45. C4-C5 disc degeneration was found in 41 (25.3%) patients at grade 0, in 99 (61.1%) patients at grade 1, and in 22 (13.6%) patients at grade 2. The mean R-CSA$_{DEs}$ of male were higher than those of female, and this elevation was statistically significant (p<0.05). It was observed that both female (p<0.001) and male patients (p<0.01) had an increased age as the degeneration grade increased. There was a significant difference in R-CSA$_{DEs}$ between the degrees of disc degeneration in female (p<0.001).

Conclusion: In patients with chronic neck pain, especially in female, there is a significant decrease in the R-CSA$_{DEs}$ as the degree of disc degeneration increases.

Keywords: Intervertebral disc degeneration, MRI, neck muscles

ÖZ

Amaç: Çalışmamızın amacı C4-C5 disk dejenerasyonu derecesinin derin ekstansör kasların alanı üzerindeki etkisinin incelenmesidir.

Yöntemler: Araştırmamıza 2020-2022 yılları arasında kronik non-spesifik boyun ağrısı nedeni ile hastanemize başvuran 98'i (%60,5) kadın, 64'ü (%39,5) erkek olmak üzere toplam 162 hasta dahil edildi. Retrospektif olarak manyetik rezonans görüntülemeleri üzerinden C4-C5 disk dejenerasyonu dereceleri belirlenip derin ekstansör kasların alanları ölçüldü.

Bulgular: Yüz altmış iki hastanın yaş ortalaması 42,30±8,8 ve derin servikal ekstansör kasların göreceli kesit alanı (R-CSA$_{DEs}$) ortalaması 1,96±0,45 bulundu. C4-C5 disk dejenerasyonu 41 (%25,3) hastada derece 0,99 (%61,1) hastada derece 1,22 (%13,6) hastada derece 2 olarak bulundu. Erkeklerin R-CSA$_{DEs}$ ortalamaları kadınlardan daha yüksekti ve bu yükseklik istatistiksel olarak anlamlıydı (p<0,05). Hem kadın (p<0,001) hem de erkek hastalarda (p<0,01) yaş arttıkça dejenerasyon derecesinin arttığı saptandı. Kadınlarda disk dejenerasyon dereceleri arasında R-CSA$_{DEs}$ değerinde anlamlı fark bulundu (p<0,001).

Sonuç: Kronik boyun ağrılı hastalarda özellikle kadınlarda disk dejenerasyonunun derecesi arttıkça derin ekstansör kasların alanında anlamlı bir azalma gerçekleşir.

Anahtar Sözcükler: İntervertebral disk dejenerasyonu, MRG, boyun kasları

Introduction

Neck pain is the most common musculoskeletal problem worldwide (1,2) and it can be classified based on its severity, type, etiology, and duration. Among different classification methods, duration is the best indicator and pain lasting beyond twelve weeks is considered chronic (3). In most cases of chronic neck pain, the pain is classified as non-specific because it cannot be attributed to a specific pathological condition (4).

Intervertebral discs are believed to be a major source of neck pain when they undergo degeneration due to their crucial role in the mobility and stabilization of the spine (5,6). Disc degeneration in the cervical region mostly occurs after middle age (7). As disc degeneration progresses, it can lead to herniation and spinal canal stenosis, resulting in costly interventions such as surgical treatment (8). The deep cervical extensor muscles, due to their direct connection of vertebrae to one another, hold a significance in the stabilization of the cervical spine and postural control, comparable to the importance of discs (9,10). Furthermore, it has been noted that there is a negative impact of neck pain on the cross-sectional area (CSA) of the deep cervical extensor muscles (11). Measurements of the CSA of the muscles are significant indicators of fundamental changes in muscle structure, particularly in terms of muscle strength and atrophy (12-14).

It is indeed crucial to diagnose and prevent the progression of disc degeneration and changes in muscle area in individuals with neck pain and those above middle age, to provide treatment without the need for surgical intervention. Therefore, our study aims to analyze the relationship among relative CSA of the deep extensor muscles (R-CSA$_{DEs}$) and disc degeneration, which we observed to be lacking in the literature, using cervical magnetic resonance imaging (MRI) (15), which are considered the gold standard for chronic neck pain patients.

Methods

Study Group

Between December 2020 and September 2022, a total of 1140 patients who presented to our clinic with complaints of chronic neck pain and underwent cervical MRI were retrospectively evaluated. Patients with masses in the cervical region, vertebral fracture or operation, spondylolysis or spondylolisthesis, congenital malformations, a history of cancer, symptoms related to sensory or motor impairments, and any disorders affecting the cervical region other than chronic neck pain were excluded from the study. Additionally, only three patients were found to have grade III disc degeneration and they were excluded from the research to prevent statistical bias. Finally, a total of 162 patients between the ages of 18 and 65 who met the inclusion criteria were investigated within the scope of the study. This research received approval from Kocaeli University Non-Interventional Clinical Research Ethics Committee (decision number: KÜ GOKAEK-2023/12.02 date: 13.07.2023). Consent was obtained from the patients participating in our study.

Evaluation of Disc Degeneration

T2-weighted MRI is widely used for the evaluation of disc degeneration (16). Cervical MRIs were obtained using a protocol designed for the evaluation of the cervical region from the hospital's Picture Archiving and Communications System radiographic system. MR images were acquired using a 1.5T MRI scanner (GE Healthcare), producing sagittal and axial views.

A comprehensive grading system and algorithm were developed based on previously used grading systems and literature reviews to determine cervical disc degeneration. In our study, we utilized this comprehensive grading system. Cervical disc degeneration was divided into four grades: Grade 0 indicating no degenerative changes, grade 1 (slight degeneration) representing low-density changes in the nucleus pulposus, grade 2 (moderate degeneration) involving annulus fibrosus degeneration along with disc bulging or herniation and finally grade 3 (severe degeneration) indicating more significant degeneration with a reduction in disc height by more than ¼ (17-18).

Calculating Cervical Muscle Area

Calculating muscle CSA based on MR scans, which is considered the top reference for muscle scanning, is an objective and non-invasive assessment method (19). The muscle CSA was measured on axial T2-weighted and T1-weighted scans at the level of the C4-C5 intervertebral disc. The imaging parameters included: Slice thickness=4 mm, field of view=160×160 mm, repetition time/echo time=4438/116 ms, and matrix=160×256, acquired from 16 slices. To minimize the influence of segmental levels, all muscles were examined at the same level (C4-C5 intervertebral disc level) (20). The reason for selecting the C4-C5 level was that the angle between the axial image passing through this level and the plane of the floor was minimal compared to other levels.

The CSAs of the bilateral multifidus cervicis and semispinalis cervicis muscles, which together form the deep cervical extensors, were measured by following the boundaries of the fascia and recorded in square millimeters (mm²) by using the Sectra software program (Sectra workstation IDS7, Linköping, Sweden). Since the semispinalis cervicis and multifidus muscles could not be clearly distinguished, the measurements were combined (4). To control alterations in the muscle areas caused by changing body mass index, the relative muscle CSA/vertebral body area (VBA) ratios were preferred instead of exact muscle CSA values. The relative CSAs (R-CSAs), defined as the ratios of muscle CSA/VBA, were calculated by measuring the C5 VBAs on axial images (21). At the level of the C4-C5 intervertebral disc, the CSAs of the deep extensors on the right and left sides were individually summed and divided by the C5 VBAs to calculate the relative CSAs of the deep extensors (R-CSA$_{DEs}$) (Figure 1). All MRI evaluations, degeneration grades and R-CSA$_{DEs}$ measurements were performed under the supervision of two experienced radiologists in the field.

Statistical Analysis

The statistical analysis was conducted utilizing IBM SPSS 20.0 (IBM Corp., Armonk) software package. The normal distribution assumption was assessed utilizing the Kolmogorov-Smirnov and Shapiro-Wilk tests. Numerical variables were presented as mean ± standard deviation or median (25th-75th percentile), while categorical variables were presented as frequency (percentage). Differences among groups were identified through independent samples t-test, Mann-Whitney U test, one-way analysis of variance (ANOVA), and Kruskal-Wallis test. Tukey and Dunn tests were utilized for multiple comparisons. The relationships among numerical variables were examined utilizing Pearson and Spearman correlation analysis. The relationships among categorical variables were defined utilizing the chi-square test. A p-value less than 0.05 was evaluated statistically significant for hypothesis testing.
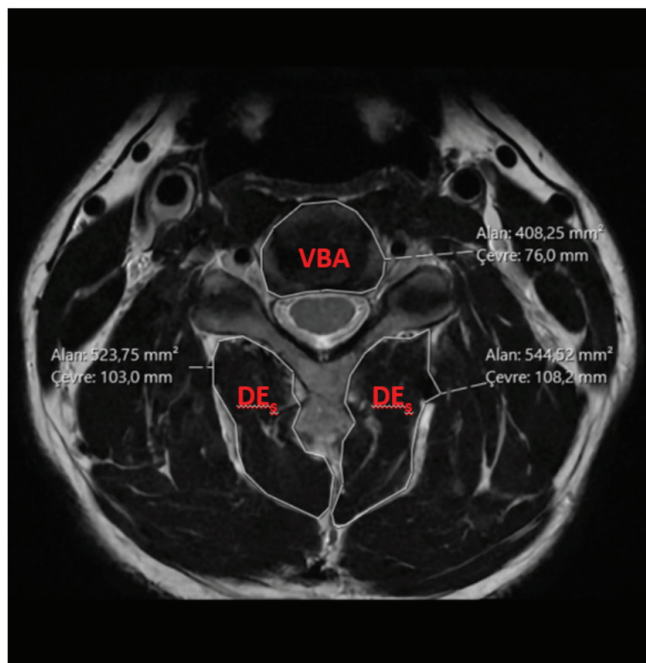
Figure 1. Measurements of the deep extensor muscles areas on axial T2-weighted passing through the C4-C5 disc level

DEs: Deep extensors, VBA: Vertebral body area

Results

One hundred sixty-two patients were included in the research, composed of 98 (60.5%) females and 64 (39.5%) males. The average age of the 162 patients was 42.30±8.8 and the average R-CSA$_{DEs}$ was 1.96±0.45. The degree of disc degeneration at the C4-C5 level was grade 0 in 41 (25.3%) patients, grade 1 in 99 (61.1%) patients and grade 2 in 22 (13.6%) patients. There was no significant difference in age among females and males (p=0.93). But a significant difference was found in the degree of degeneration between genders (p=0.049). The grade 0 degree was statistically significantly more detected in females comparison to males (p=0.022), while the grade 1 degree was statistically significantly more detectedin males than females (p=0.023). No significant difference was detected among genders regarding the grade 2 degeneration. A notable distinction was detected in the mean R-CSA$_{DEs}$ among genders (p=0.038), with males having higher mean R-CSA$_{DEs}$ than females (Table 1).

When examined both in all patients (p<0.001) and separately in female patients (p<0.001) and male patients (p=0.004), it was observed that age increased with the increase in degeneration grade. Significant differences in age were found between grade 0 and grade 1, grade 0 and grade 2, and grade 1 and grade 2 in both total patients and female patients. However, in male patients, significant differences in age were only observed between grade 0 and grade 2, and grade 1 and grade 2. It was observed that there was a decrease in R-CSA$_{DEs}$ value with an increase in degeneration grade in both all patients and female and male patients. In both total patients and female patients, significant differences in R-CSA$_{DEs}$ value were found between grade 0 and grade 2, and grade 1 and grade 2 (p<0.001). But, in male patients, no significant difference in R-CSA$_{DEs}$ value was found among all grades (p=0.130) (Table 2).

There was no correlation found between age and R-CSA$_{DEs}$ value in the total population, as well as when analyzed separately for females and males (Table 3).

Discussion

Neck pain complaints are most common in middle-aged people and female (22,23), has a prevalence rate of 37.2% in the adult population and is increasing gradually (24). Non-specific neck pain diminishes patients' quality of life by negatively impacting

Table 1. Characteristics, disc degeneration and cervical muscle area of study groups

	Total (n=162)	Female (n=98)	Male (n=64)	p-value
Age (year)	42.30±8.83*	43 (35-49.25)**	43 (36.25-47.75)**	0.93
Grade, n (%)				
0	41 (25.3)	31 (31.6)	10 (15.6)	
1	99 (61.1)	53 (54.1)	46 (71.9)	0.049
2	22 (13.6)	14 (14.3)	8 (12.5)	
R-CSA$_{DEs}$	1.96±0.45*	1.90±0.45*	2.05±0.43*	0.038

*: mean ± standard deviation, **: Median (interquartile range)

Table 2. Relationships between cervical muscle area and age with disc degeneration				
	Grade 0	Grade 1	Grade 2	p-value
Total, mean ± SD				
Age (year)	36.29±7.49	42.48±7.63	52.64±6.09	0.001
R-CSA$_{DEs}$	(2.12±0.38)^a	(1.97±0.45)^{ab}	(1.65±0.40)^c	0.001
Female, median (interquartile range)				
Age (year)	37 (31-42)	43 (38-49)	52 (49.75-56.75)	0.001
R-CSA$_{DEs}$	2.09 (1.85-2.21)^a	1.87 (1.52-2.26)^{ab}	1.35 (1.22-1.75)^c	0.001
Male, median (interquartile range)				
Age (year)	42.50 (32.75-43.25)	42 (35-47)	54 (48.25-58.75)	0.004
R-CSA$_{DEs}$	2.22 (1.99-2.60)	1.94 (1.72-2.37)	1.93 (1.70-2.06)	0.130

SD: Standard deviation, R-CSA$_{DEs}$: Relative cross-sectional area of the deep extensor muscles
Different letters indicate statistically significant differences

Table 3. Correlation of cervical muscle area and age	
Total	**R-CSA$_{DEs}$**
Age (year)	r-0.088
	p 0.266

R-CSA$_{DEs}$: Relative cross-sectional area of the deep extensor muscles

their social interactions and participation in daily life activities (25). There are very few studies in the literature that compare the degrees of cervical disc degeneration in male and female with neck pain. In a study comparing 31 females and 31 males with neck pain, it was found that females had statistically lower disc narrowing, and protrusion compared to males (26). In the group without severe neck pain, females showed statistically lower disc height narrowing and C4-C5 degeneration degree compared to males (27). Like our study, despite females having a lower degree of disc degeneration compared to males, one of the reasons for their higher clinical presentation might be attributed to females having lower pain perception thresholds than males (28). A study conducted on full-body MRI of 468 individuals indicated that females had less skeletal muscle mass compared to males (29). In accordance with the literature, we can suggest that the greater R-CSA$_{DEs}$ in males compared to females may arise from gender-related differences in total muscle mass (Table 1) (30,31).

As age advances, biochemical changes such as a reduction in proteoglycan content and water within the disc, particularly in the nucleus pulposus, contribute to the progression of degeneration in intervertebral discs (32). Furthermore, genetic, traumatic, biomechanical, and nutritional factors can also contribute to degeneration in the intervertebral discs (33). Numerous studies investigating the relationship between degenerative changes in the cervical region and age have consistently indicated that as age increases, the degree of disc degeneration also increases (18,19,34). In a study conducted on 143 female patients, a significant decrease in R-CSA$_{DEs}$, specifically the multifidus muscle, was observed with an increase in the degree of degeneration after grade 2 (34).

We confirmed an increase in the degree of disc degeneration with age in both female and male. Based on our results, we can say that aging, along with multifactorial effects, is the main pathogenesis

of degeneration (35). As one of the first studies examining the relationship between R-CSA$_{DEs}$ value and the degree of C4-C5 disc degeneration, we detected a statistically significant decrease in the R-CSA$_{DEs}$ value as the degree of disc degeneration increased in female patients. However, in male patients, we found that the decrease in R-CSA$_{DEs}$ value with an increase in disc degeneration was not statistically significant (Table 2).

Indeed, as the degree of degeneration in the disc increases, we can say that there is atrophy of the cervical deep extensor muscles (DEs) area in females. The decrease in the R-CSA$_{DEs}$ has been reported to reduce stabilization in the cervical spine and increase the severity of pain and the neck disability index (36). As a result, we can say that disc degeneration affects the R-CSA$_{DEs}$ in males to a lesser extent than in females, and the decrease in R-CSA$_{DEs}$ in females leads to experiencing more pain and consequently seeking medical attention more frequently than males.

Age-related reduction in muscle volume has been observed, particularly after the age of fifty or sixty (32,37). Additionally, it has been noted that the CSA of cervical extensor muscles also decreases after the age of fifty (30). In our study, the average age was 43, and since we had only 29 patients who were over 50 years old, we believe that we could not find any relationship between age and the R-CSA$_{DEs}$ value (Table 3).

Study Limitations

Our study had a few limitations. Firstly, we were unable to inquire about the history of chronic illnesses for example diabetes that could be related to smoking, alcohol use, occupation, and disc degeneration. Secondly, we believe that comparing our data with healthy individuals without chronic neck pain would provide more comprehensive information on this subject.

Conclusion

According to our study, as age advances, the degree of disc degeneration increases, and as the degree of disc degeneration increases, the R-CSA$_{DEs}$ decreases. As a result, there is a weakening tendency in DEs, especially in females with chronic neck pain and intervertebral disc degeneration. Therefore, we believe that strengthening exercises for DEs should be added to rehabilitation

programs, especially for female patients with chronic neck pain, to reduce pain intensity and prevent further disability problems.

Ethics

Ethics Committee Approval: This research received approval from Kocaeli University Non-Interventional Clinical Research Ethics Committee (decision number: KÜ GOKAEK-2023/12.02, date: 13.07.2023). The study was carried out in accordance with the ethical rules of the Declaration of Helsinki.

Informed Consent: Consent was obtained from the patients participating in our study.

Authorship Contributions

Concept: A.T., G.G., Design: A.T., G.G., T.Ç., Data Collection or Processing: A.T., G.G., Ö.Ç., Analysis or Interpretation: A.T., G.G., T.Ç., Ö.Ç., Literature Search: A.T., G.G., Writing: A.T., G.G., T.Ç.

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