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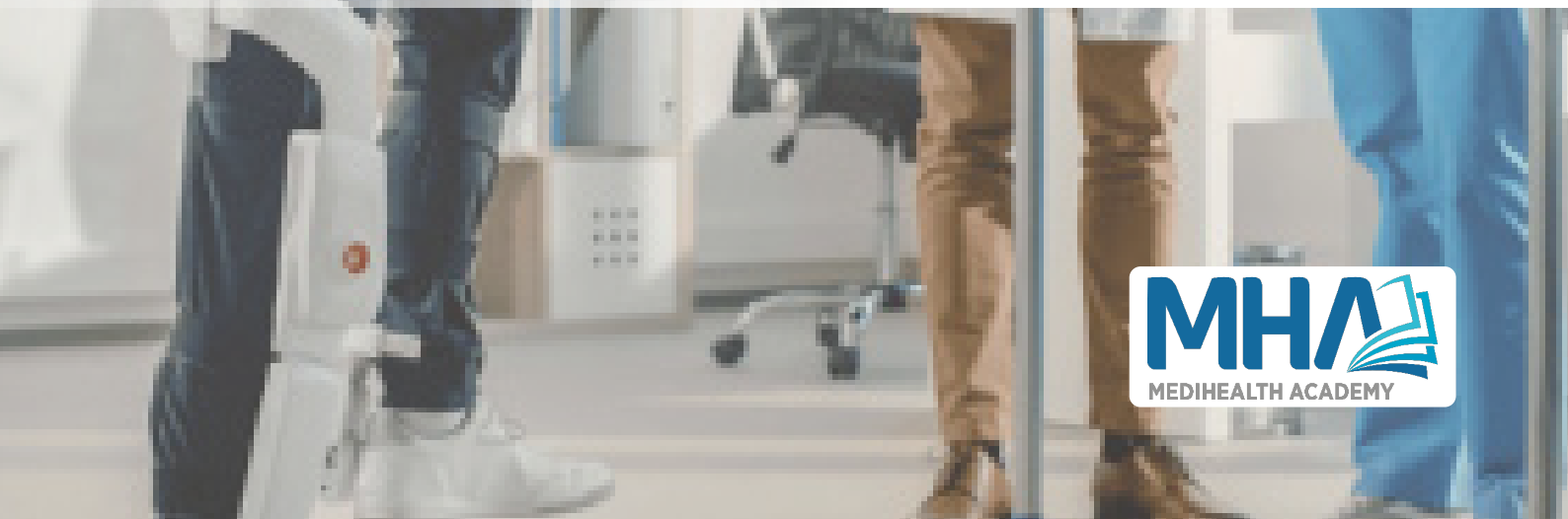

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CASE REPORT

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Original Article

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Evaluation of cranio-cervical muscle activity in adolescents with different malocclusions: a pilot surface EMG study

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ABSTRACT

Aims: This study aimed to investigate potential differences in cranio-cervical muscular activation among adolescents with different types of malocclusion.

Methods: This study involved thirty-two adolescents aged 10-15 years, categorized into three groups based on angle classification: angle class I/control group (n=10), angle class II (n=12), and angle class III (n=10). Surface electromyography (EMG) was utilized to evaluate the activation levels of the masseter, temporalis anterior, cervical erector spinae, sternocleidomastoid, and upper trapezius (UT) muscles. Measurements were obtained during mandibular rest, maximum clenching, and chewing tasks.

Results: The surface EMG activity of the UT muscle exhibited significant elevation in participants with class III malocclusions relative to the other groups ($p<0.05$). While cranio-cervical muscle activities tended to be higher in the groups of angle class II and class III in comparison to the angle class I, these differences did not achieve statistical significance, with the exception of the UT muscle ($p>0.05$).

Conclusion: These findings indicate a link between malocclusion types and modified muscle activation patterns in the cranio-cervical region, specifically involving the UT muscle. Insights into cranio-cervical muscle activity can enhance the comprehensive evaluation of malocclusion effects and provide valuable guidance for orthodontic and rehabilitation interventions.

Keywords: Craniocervical, adolescents, muscle activity, EMG, malocclusion

INTRODUCTION

The stomatognathic system, which encompasses the teeth, jaws, masticatory muscles, and associated soft tissues, plays a crucial role in essential functions such as speech, swallowing, and harmonious chewing.[1] However, dysfunctions within this system can lead to occlusal problems, particularly during adolescence, a period marked by rapid bodily growth and changes.[2,3]

Malocclusion refers to an abnormality in the alignment of the teeth and jaws, encompassing dental disorders and skeletal disharmony.[3,4] The classification system for occlusions, introduced in 1889 by Dr. Edward H. angle, categorizes the interrelationship between the maxillary and mandibular dental arches into three distinct classes. Angle class I represents a normal occlusion, where the upper and lower dental arches exhibit a proper alignment, particularly in the interrelationship between the molars. Specifically, the mesiobuccal cusp of the upper first molar aligns with the buccal groove of the lower first molar, indicating an ideal occlusal relationship. It should be noted that minor deviations or discrepancies in other teeth, excluding the molars, may still be considered within the normal range. However, the classification criteria primarily rely on the alignment of the molars as the defining factor for angle class I occlusion. Angle class II refers to a condition where the upper first molar occludes anteriorly to the lower first molar, while angle class III indicates a situation where the upper first molar occludes posteriorly to the lower first molar.[5]

In the field of orthodontics, understanding the classification of malocclusions is crucial for assessing and treating occlusal abnormalities. The angle classification system provides a standardized framework to describe and differentiate various occlusal relationships. By identifying the specific class of malocclusion, orthodontic professionals can tailor their treatment plans accordingly, aiming to achieve proper alignment and functional occlusion.

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Numerous studies have focused on the potential effects of different malocclusion types. Various malocclusions can result in distinct muscle activities, which may exacerbate occlusal problems or interfere with the treatment process.[6] Consequently, electromyography (EMG) has been employed in several studies to examine muscle activities associated with different malocclusions.[7-9] However, these studies have predominantly focused on assessing the activities of masticatory muscles. Considering the potential interplay between dentofacial deformities and the musculature of the neck region, it is beneficial to assess the entire craniocervical region. Hence, the main aim of the current research was to explore and analyze the craniocervical muscle activity across different malocclusion types utilizing surface EMG techniques.

METHODS

Participants

The sample for this preliminary investigation comprised a total of thirty-two adolescent individuals who were recruited from those seeking orthodontic treatment at the Department of Orthodontics, Faculty of Dental Medicine, Ankara University. The subjects were recruited from a pool of applicants within a specific timeframe, meeting the predetermined inclusion criteria. The surface EMG analysis was conducted at a physiotherapy and rehabilitation clinic located within the Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Gazi University. Prior to the study, a participant's agreement was obtained from each participant and his or her legal guardians, and the research ethics committee granted ethical approval (Date: 11.01.2019, Decision No: 77092166-302.08.01-4715). The study adhered to the ethical guidelines for human experimentation and followed the 2013 edition of the Declaration of Helsinki.

Inclusion criteria stipulated that participants should be adolescents presenting with orthodontic craniofacial anomalies, while possessing normal vertical facial dimension values. Exclusion criteria entailed individuals with congenital tooth agenesis, hereditary or inborn craniofacial abnormalities, temporomandibular joint dysfunctions, prior orthodontic intervention history, surgical procedures involving the upper body, persistent pain limiting activity, scoliosis, and systemic disorders. Additionally, as part of the inclusion criteria, participants were required to exhibit no neck pain or limitations in joint range of motion during the evaluation process. The participants were allocated into three distinct groups (angle class I: 10 participants, angle class II: 12 participants, angle class III: 10 participants) based on cephalometric measurements.

Assessments

Surface EMG measurement: The Noraxon MiniDTS system (Noraxon U.S.A. Inc.) equipped with eight-channel surface EMG was utilized for data collection in this study. Disposable self-adhesive Ag/AgCl electrodes with a width of one centimeter (Noraxon Dual EMG Electrode) were employed to capture the EMG signals. The system demonstrated a differential input impedance exceeding 10 Mohm, while the sampling rate ranged from 1500 to 3000 Hz per channel. Moreover, the common-mode rejection ratio exceeded 80 dB, ensuring robust signal quality. Prior to electrode placement, the skin surface was meticulously cleansed with alcohol to minimize skin-electrode impedance. Subsequently, the surface electrodes were carefully positioned on the targeted muscles following the guidelines outlined in the European Recommendations for Surface Electromyography (SENIAM).[10]

The placement of electrodes for muscle assessment was as follows:

Sternocleidomastoid (SCM): The electrodes were bilateral positioned at a location approximately one-third of the distance between the sternal notch and the mastoid process. It was placed in a parallel orientation over the muscle belly.[11]

Cervical erector spinae (CES): The electrodes were bilateral placed laterally, 2 cm away from the C4 spinous process.[12]

Upper trapezius (UT): The electrodes were bilateral positioned laterally to the midpoint of an imaginary line formed by the posterior aspect of the acromion and the spinous process of C7.[12]

Previous studies[13-15] did not report any significant difference between the right and left anterior temporalis (AT) and masseter (MS) muscle activities. Therefore, the AT and MS muscles were evaluated unilaterally, specifically on the right side, by positioning the electrode on the belly of the muscles and parallel to the direction of the muscle f ibers. By employing this methodology, the utilization of an 8-channel surface EMG system enabled the investigation and assessment of a broader range of muscles, thereby facilitating the examination of a greater diversity of muscle activities.

The acquired EMG data were processed utilizing the Noraxon MyoResearch XP Master Edition software (Noraxon USA Inc). In the preprocessing stage, the raw EMG signals underwent rectification and band-pass filtering within the frequency range of 20-500 Hz. Subsequently, the signals were subjected to a root-mean-square moving-window function with a time constant of 100 ms to achieve smoothing. In order to normalize the surface EMG data, reference activation signals were recorded, while the participants engaged in maximal voluntary isometric contraction (MVC) trials lasting for 5 seconds in the manual muscle testing positions for the SCM, UT, and CES muscles. For the normalization of the AT and MS muscle data, signals were captured during a 5-second maximum voluntary teeth clenching maneuver, while bilateral interposition of two cotton rolls occurred between the second mandibular premolars and first molars.[14] A resting period of 3 minutes was allowed between each MVC trial. The recorded values corresponded to the average of three successful repetitions, and the median value obtained during the 5-second trial at the 3rd second was selected for further analysis.

Surface EMG data were obtained across four distinct conditions: I) the mandibular resting position while in a seated posture, II) the mandibular resting position while in a standing posture, III) during chewing while in a seated position, and IV) during maximum teeth clenching while in a seated position.

Sitting position: Each participant assumed a comfortable seated posture on a chair while maintaining their habitual position, fixing their gaze straight ahead, and refraining from any mandibular, head, or body movements during the data collection. Three 10-second recordings were conducted.

Standing position: Participants were instructed to stand in a relaxed and comfortable manner with their arms by their sides, maintaining a forward gaze without any mandibular, head, or body movements throughout the recording. Three 10-second recordings were performed.

Chewing position: Prior to the chewing recordings, participants were provided with a medium soft, sugar-free gum and asked to chew it for two minutes to soften the gum. Following a one-minute rest period, participants were instructed to chew the gum using their normal chewing pattern, and three 10-second recordings were obtained while in a seated position.

Maximum teeth clench: Bilateral placement of cotton rolls between the second mandibular premolars and first molars was performed. Subsequently, participants were instructed to perform a maximum teeth clenching action for five seconds while in a seated position. This procedure was repeated three times.

A two-minute resting interval was allowed between each of the four recording positions to prevent potential fatigue.

Statistical Analysis

The data analysis was conducted using the Statistical Package for Social Sciences (SPSS; 22.0, Chicago, USA). The normal distribution of the data was examined using the ShapiroWilk test and visualization of histograms. Descriptive statistics were presented as medians and interquartile ranges (IQR 25/75). The gender data was subjected to chi-square test for comparison. To analyze the differences among the three groups, Kruskal-Wallis analysis was performed, and post-hoc pairwise comparisons were performed if significant differences were observed. Statistical significance was determined as $p<0.05$ for the chi-square and Kruskal-Wallis analyses. Post-hoc comparisons were conducted using MannWhitney U test, and a significant level of $p<0.017$ was applied after adjusting for multiple comparisons using the Bonferroni correction.

RESULTS

The mean age of the participants was 12.47±1.74 years, and the mean body mass index (BMI) was 18.37±3.44 kg/m^2. Comprehensive details regarding the participants characteristics are provided in Table 1. There were no statistically significant differences observed between the groups in terms of gender, age, and BMI ($p>0.05$). The surface EMG activities recorded under the four different conditions are summarized in Table 2. The surface EMG activity of the cervical muscles is illustrated in Figures 1-4. The EMG activity of the UT muscle was significantly higher in the angle class III group relative to the other two groups in all positions ($p<0.05$, Table 2).

Table 1. Physical characteristics of the groups

	Angle class I	Angle class II	Angle class III	p*
	Median (IQR 25/75)	Median (IQR 25/75)	Median (IQR 25/75)	
Age (years)	12.50	12.00	13.00	0.997
BMI (kg/m²)	18.40 (16.32/20.25)	16.65 (14.85/19.77)	18.60 (15.65/22.62)	0.652

*: Kruskal-Wallis analysis, IQR 25/75: The interquartile range 25/75, BMI: Body mass index, $p<0.05$.

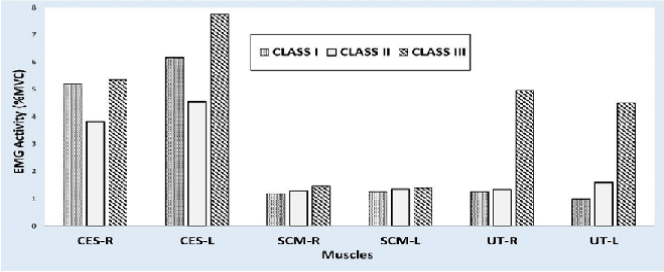

Figure 1. SEMG activity of cervical muscles at mandibular rest position during standing

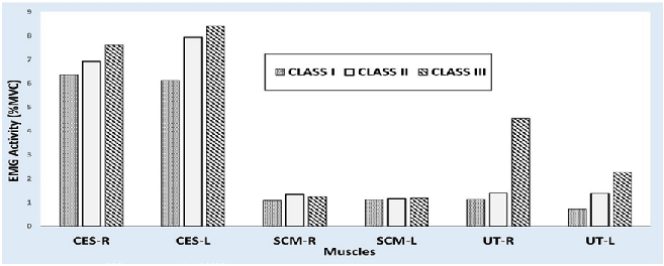

Figure 2. SEMG activity of cervical muscles at mandibular rest position during sitting

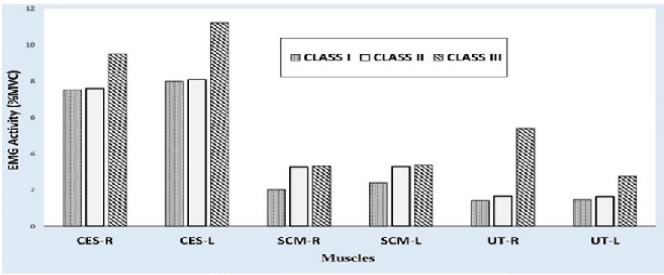

Figure 3. SEMG activity of cervical muscles during chewing

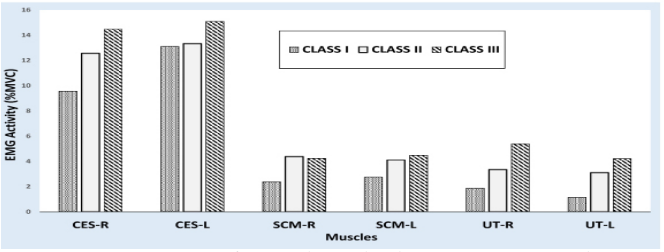

Figure 4. SEMG activity of cervical muscles during maximum teeth clenching

When pairwise comparisons were considered, the analysis revealed that the activation values of the UT muscle were significantly higher in the class III group compared to the class I group ($p<0.017$); however, no statistically significant differences were found between the class I and class II groups ($p>0.017$), or between the class II and class III groups ($p>0.017$)(Table 2).

Table 2. Muscle activities of the muscles in groups

		Mandibular rest at sitting median (IQR 25/75)				Mandibular rest at sitting median (IQR 25/75)				Chewing median (IQR 25/75)				Maximum teeth clench median (IQR 25/75)			
		Class I	Class II	Class III	p*	Class I	Class II	Class III	p*	Class I	Class II	Class III	p*	Class I	Class II	Class III	p*
CES	R	6.35 (3.90/8.90)	6.92 (3.37/10.13)	7.60 (3.62/18.16)	0.694	5.19 (2.73/7.82)	3.82 (2.50/8.81)	5.35 (2.85/20.70)	0.694	7.51 (4.75/10.71)	7.59 (4.70/12.28)	9.50 (3.96/18.14)	0.848	9.55 (6.36/14.42)	12.55 (5.53/19.19)	14.48 (8.62/30.56)	0.212
	L	6.12 (3.93/8.58)	7.94 (4.00/12.04)	8.41 (4.20/12.80)	0.693	6.16 (2.53/9.22)	4.54 (3.22/14.59)	7.75 (3.27/13.50)	0.823	7.98 (6.47/11.02)	8.08 (5.69/16.46)	11.21 (6.59/14.82)	0.665	13.10 (8.12/24.34)	13.33 (8.29/19.86)	15.09 (12.24/18.54)	0.709
SCM	R	1.08 (0.90/1.66)	1.33 (0.87/2.20)	1.24 (0.97/1.80)	0.644	1.17 (0.95/1.66)	1.27 (0.87/2.54)	1.45 (1.05/1.79)	0.809	2.01 (1.37/2.72)	3.26 (2.46/3.67)	3.31 (1.82/4.83)	0.127	2.83 (1.62/6.34)	4.37 (2.68/5.99)	4.22 (2.75/6.39)	0.520
	L	1.12 (0.77/1.54)	1.16 (0.89/1.48)	1.18 (0.93/1.83)	0.764	1.24 (0.97/1.77)	1.34 (0.79/1.83)	1.38 (1.08/1.69)	0.786	2.38 (1.73/3.22)	3.28 (2.07/4.17)	3.38 (2.11/3.99)	0.346	2.73 (2.14/5.09)	4.10 (2.32/5.61)	4.46 (2.33/6.40)	0.646
UT	R	1.13 (0.77/1.50)	1.39 (0.76/6.09)	4.52 (1.61/6.81)	0.049 p1:0.418 p2:0.004 p3:0.314	1.24 (0.93/2.22)	1.33 (0.70/3.56)	4.96 (1.62/8.58)	0.027 p1:0.923 p2:0.009 p3:0.036	1.42 (1.12/2.08)	1.64 (0.97/4.75)	5.39 (2.55/6.42)	0.028 p1:0.456 p2:0.005 p3:0.093	1.87 (1.07/2.89)	3.35 (2.04/5.85)	5.38 (3.27/10.10)	0.008 p1:0.036 p2:0.004 p3:0.140
	L	0.71 (0.55/0.92)	1.38 (0.45/5.98)	2.27 (1.51/4.36)	0.034 p1:0.283 p2:0.003 p3:0.314	0.98 (0.49/1.5)	1.58 (0.57/4.70)	4.51 (1.71/9.58)	0.012 p1:0.228 p2:0.002 p3:0.080	1.46 (1.12/1.87)	1.63 (0.70/4.85)	2.74 (1.81/5.94)	0.084	1.14 (0.82/2.47)	3.09 (1.42/6.71)	4.21 (1.93/8.61)	0.019 p1:0.017 p2:0.015 p3:0.539
MS		1.84 (1.00/2.62)	1.19 (0.99/2.15)	1.53 (0.89/2.13)	0.413	1.7 (1.00/1.95)	1.22 (0.98/1.67)	1.57 (0.87/2.14)	0.517	30.96 (24.03/40.48)	33.13 (21.81/43.53)	36.99 (26.21/50.88)	0.616	136.83 (123.00/261.66)	206.16 (168.33/278.25)	165.50 (129.90/282.25)	0.342
TEMPORALIS		3.68 (2.27/5.20)	2.77 (2.08/3.73)	5.12 (2.95/7.18)	0.205	3.35 (2.23/4.34)	2.65 (1.81/3.87)	4.43 (3.09/5.48)	0.245	35.63 (28.71/44.81)	40.45 (22.29/57.18)	37.40 (26.94/43.49)	0.861	122.00 (94.39/144.08)	135.33 (98.76/179.00)	112.53 (74.65/144.75)	0.430

*: Kruskal-Wallis analysis, IQR 25/75: The interquartile range 25/75, R: right, L: left, p < 0.p1: class I, class II, p2: class I, class III, p3: class II, class III, p1-3<0.01

DISCUSSION

The main aim of the current research was to ascertain potential disparities in craniocervical muscle activities among adolescents exhibiting various types of malocclusions. The findings of our investigation revealed a statistically significant elevation in the UT muscle activity among adolescents diagnosed with angle class III malocclusion relative to those with angle class I and class II malocclusions across diverse actions. This finding suggests that craniocervical muscle activity may vary depending on the malocclusion type.

According to available information, this research represents a pioneering investigation that offers a comprehensive evaluation encompassing both the jaw muscles and the musculature of the neck region in adolescents presenting with malocclusions. Prior research endeavors have predominantly concentrated on assessing the muscle activities specific to the jaw region, particularly the MS and AT muscles.[9] Nevertheless, it is essential to recognize the functional interrelationships that exist among the masticatory, neck, and trunk muscles, owing to the reciprocal innervation mediated by the trigeminal nerve and cervical nerves.[16] Therefore, in order to achieve a thorough evaluation, it becomes imperative to examine not only the masticatory muscles but also the musculature within the craniocervical region. This holistic approach allows for a more comprehensive understanding of the neuromuscular dynamics associated with malocclusions in adolescents.

The existing literature exploring the muscle activity of masticatory muscles in various malocclusion types has generated divergent outcomes.[6,8,13,17] Nevertheless, majorities of studies have reported an increased masticatory muscle activity in individuals with angle class II or angle class III malocclusions relative to those with angle class I malocclusions.[8,13,17] In line with these findings, our investigation demonstrated that participants with angle class II or angle class III malocclusions exhibited heightened activation of masticatory muscles, particularly during mastication and maximum voluntary clenching. The outcomes obtained in this study are in line with previous investigations, indicating increased activation of masticatory muscles in individuals with specific malocclusion types. These results contribute to our understanding of the relationship between malocclusion and heightened engagement of the masticatory muscles.

A study conducted by Tecco et al.[15] in adult females showed similar results to our study. Their study revealed significantly higher EMG activities in the posterior cervical and UT muscles among participants with angle class III malocclusion, in contrast to the other two groups. However, in our study, the statistically significant difference was only observed in the UT muscle. The divergence in results may be attributed to variations in the age composition of the study populations and the duration of malocclusion. Previous studies have reported that angle class II and angle class III malocclusions could contribute to craniocervical postural maladaptations when compared to angle class I malocclusions.[3,18,19] Therefore, prolonged periods of malocclusion may exert an influence on muscle activity and potentially impact posture. It is plausible that the prolonged duration of malocclusion affects muscle activity, which in turn may have implications for cranio-cervical postural adaptations. These findings suggest that individuals with angle class II and angle class III malocclusions may be more prone to experiencing postural changes in the cranio-cervical region relative to those with angle class I malocclusions.

The SCM muscle plays a crucial role in maintaining optimal head and neck posture. Previous research has shown that SCM muscle activation is altered, particularly in individuals with forward head posture.[20] However, there is limited literature investigating the activity of the SCM muscle in relation to occlusal problems.[7,21] Bergamini et al.[7] suggested that achieving occlusal balance may have a positive impact on SCM muscle activity. Ferrario et al.,[21] on the other hand, reported that complete or partial angle class I dental relationships did not significantly affect the muscle activities of the MS, temporalis, and SCM muscles. In contrast, even in the absence of statistically significant differences, our study found that participants with angle class II and angle class III malocclusions exhibited higher SCM muscle activity relative to those with angle class I malocclusion. Considering the association between SCM muscle and forward head posture, our findings suggest that class II and class III malocclusions may be more prone to forward head posture.

Although statistically significant differences were not observed, the present study uncovered higher CES muscle activities in individuals with angle class II or angle class III malocclusions. This observation implies that occlusal abnormalities may exert an influence not only on muscle activation within the jaw region but also in other regions of the cranio-cervical complex. The observed increase in CES muscle activities among individuals with class II and class III malocclusions may indicate compensatory mechanisms or adaptations to accommodate occlusal discrepancies. These findings suggest that the neuromuscular system undergoes adjustments in response to malocclusion, potentially influencing muscle activation patterns. Additionally, these findings raise interesting questions regarding the potential interplay between occlusal factors and the neuromuscular system beyond the scope of mastication. Understanding the broader implications of occlusal defects on muscle activity may provide valuable insights for orthodontic intervention strategies.

Limitations

The primary limitation encountered in this research was the limited sample size, which led us to consider it as a pilot study. Conducting future studies with a similar design and a larger number of participants would enable us to draw more definitive conclusions. Additionally, owing to the restricted participant pool, potential gender-based variations were not examined in this study. Further studies focusing on normalizing higher muscle activity through various approaches such as exercise and physiotherapy methods may provide further insights into this issue.

CONCLUSION

Our findings indicate a statistically significant increase in UT muscle activation in diverse positions among adolescents diagnosed with angle class III malocclusion. This highlights the potential role of the UT muscle in the cranio-cervical muscle activity of individuals with malocclusions. These findings support the notion that adolescents with angle class II and class III malocclusions may exhibit increased activation of craniocervical muscles relative to those with angle class I malocclusion. This suggests the presence of potential neuromuscular adaptations in response to malocclusion severity. It would be beneficial for future studies to examine muscle activations in the cranio-cervical region during different activities to gain a comprehensive understanding of the effects of malocclusion.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Ethical Committee of Gazi University (Date: 11.01.2019, Decision No: 77092166-302.08.01-4715).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation

Process Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The Authors declare that they have no known competing financial interests or personal relationships that could have appeared the work reported in this paper.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that theyave approved the final version.

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Original Article

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Evaluation of the diagnostic efficacy of computed tomography imaging in trauma patients

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ABSTRACT

Aims: The objective of this study was to assess the efficacy of computed tomography imaging tests ordered for trauma patients in the emergency medicine service and to identify pathologies in the imaging.

Methods: A retrospective evaluation was conducted on trauma patients who applied to our hospital's Emergency Medicine Department between 01 January 2023 and 01 October 2023 and underwent diagnostic computed tomography imaging (CT).

Results: A total of 4193 CT scans were analysed in 3641 patients. Falls were the most common etiological cause (n=3451, 82.3%). Pathology was detected in 25.87% of CT orders. The most frequently used CT type was cranial CT (n=1687, 40.22%). The highest rate of pathology was found in scapula CT (75%), while the lowest rate was observed in cervical spine CT (13%). The most common pathology was detected in cranial CT (n=457).

Conclusion: The accessibility of relevant specialists to emergency physicians reduces the number of unnecessary CT imaging orders. In the emergency department, physicians should adhere to internationally accepted guidelines when ordering advanced imaging studies.

Keywords: Emergency department, computed tomography, efficiency, consultation, trauma

INTRODUCTION

Emergency departments are areas where diagnostic tests and treatments are carried out simultaneously. In evaluating patients, it is important to take an adequate medical history, perform a thorough physical examination, and conduct necessary diagnostic tests. However, in busy emergency departments, it may not always be possible to obtain an adequate patient and family history, and physical examinations may be limited to the affected system. To prevent unnecessary radiation exposure and reduce the cost of unnecessary examinations, it is important for physicians to determine the appropriate examinations that will lead to a diagnosis and order the necessary diagnostic tests. This will also help to prevent time loss.[1,2]

On the other hand, one of the most critical issues affecting emergency departments is the problem of crowding. This issue of crowding is a multifaceted problem affecting emergency services.[1] In this challenging environment, emergency physicians have increasingly relied on advanced technology rather than their clinical skills to minimise errors in clinical diagnoses. This approach aims to ensure objectivity and precision in the diagnostic process.[3]

In recent years, radiological imaging methods have become increasingly important for diagnosing patients and diseases. Conventional radiographs and computed tomography (CT) imaging are particularly accessible in almost every emergency department. However, this easy accessibility has led to a significant increase in the number of unnecessary radiological imaging examinations without appropriate indications. The increasing number of off-label investigations has led to a rise in health expenditures, raising concerns about cost-effectiveness.[4]

The use of high-level imaging methods, particularly CT, has increased in emergency departments due to the growing significance of imaging in diagnosis and the ease of access to imaging techniques such as CT and magnetic resonance imaging (MRI). Consequently, patients and healthcare personnel are exposed to higher levels of radiation. Requests for investigations should only be made when appropriate indications are present. Failure to do so can lead to increased length of stay for patients in the emergency department, which in turn contributes to overcrowding and increased healthcare expenditures and personnel utilisation.[5,6]

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Providing an efficient, safe, and effective imaging service in emergency departments requires attention to three main factors: awareness, compliance, and control. Healthcare professionals and patients must be informed about the harmful effects of radiation. Guidelines and compliance criteria should be followed when requesting imaging, and routine clinical audits should be conducted to ensure control. Excessive imaging can be prevented by analyzing the underlying factors. This approach can protect patients and healthcare workers from the harmful effects of radiation, while also reducing emergency department density and health expenditures to some extent.[5]

The study evaluated CT imaging of patients admitted to the emergency department of Kahramankazan State Hospital due to trauma with various etiological factors during the first 9 months of 2023. The objective of our study was to analyse the demographics of CT imaging requests in the emergency department, including the presence or absence of pathology in the imaging, the time of day during which CT orders were requested, and the distribution of speciality areas among requesting physicians.

METHODS

This is a retrospective cross-sectional study conducted in the Emergency Medicine Department of Kahramankazan State Hospital. The study received ethics committee approval from Ankara Etlik City Hospital No. 1 Clinical Research Ethics Committee (Date: 22.11.2023, Decision No: AEŞH-EK1-2023-702) and was carried out in accordance with the principles of the Declaration of Helsinki.

This study included patients aged 12 years and older who were admitted to the Emergency Department of Kahramankazan State Hospital between 01 January 2023 and 01 October 2023 for trauma and underwent CT scans for diagnostic purposes. Patients without radiological imaging despite a CT order, patients with CT imaging that was not reported by the radiology clinic, and patients with missing imaging data were excluded from the study.

The patient files and hospital information system contain age and gender information, as well as the type of CT requested, which may include cranial CT, maxillofacial CT, cervical spine CT, scapula CT, shoulder CT, elbow CT, hand-wrist-arm CT, thorax CT, thoracic spine CT, lumbar spine CT, pelvis CT, hip CT, or knee CT, and foot-ankle CT. The study investigated the physician who requested the CT examinations, the time period during which the CT examination was requested, the results of the CT reports, the body region in which pathology was observed in patients with pathology, and the type of pathology observed.

The study divided the examination results into two categories: those with pathology (+) and those without pathology (-). The primary objective was to determine the rate of pathology detection in the requested CT scans. The study also analyzed the demographics of the requested CT scans, the distribution of the ordering physician's branch, and the comparison of working hours.

The analysis compared patients who had CT scans ordered based on their socio-demographic data, pathology in imaging results, study period, and the physician's branch. Patient ages were grouped and recorded. Patients who had CT scans ordered were analyzed within their respective age and CT type groups.

Statistical Analysis

Statistical analyses were conducted using SPSS version 21.0 (IBM®, Chicago, USA). Descriptive statistics were presented as mean and standard deviation for normally distributed numerical data, median and lower-upper value for non-normally distributed data, and number and percentage for nominal data. Two-group comparisons of normally distributed variables were performed using an independent samples t-test, while non-normally distributed variables were compared using the Mann-Whitney U test. The study analysed nominal data between the two groups using the Chi-square test and Fisher exact test. Statistical analyses considered comparisons with a p-value below 0.05 as statistically significant.

RESULTS

The study included 3,641 patients who underwent a total of 4,193 CT scans. The mean age of the patients was 42.97±22.66 years (range 12-99 years), with the most common age group being 22-45 years (37.1%). Of the patients, 56.6% (n=2061) were male (Table 1).

Table 1. Demographic characteristics of study participants

		n	%	n	
Gender	Female	1580	43.4	3641	100
	Male	2061	56.6		
Age	12-21	731	20.1	3641	100
	22-45	1350	37.1		
	46-60	659	18.1		
	61 and older	901	24.7		
	Min. 2	Max. 99	Average 42.97	SD 22.66	

Min: Minimum, Max: Maximum, SD: Standart deviation

Among patients who underwent CT imaging, falls (n=3451, 82.3%) were the most common cause, followed by traffic accidents (n=339, 8.06%) (Table 2). Table 2 also provides information on other causes. 60.4% of the patients (n=2534) presented to the emergency department outside of working hours as the time period in which radiological examination was performed.

Table 2. Reasons for admission to the emergency department and the time period of admission

		n	%	n	
Diagnosis	Fall	3451	82.3	4193	100
	Traffic Accident	338	8.06		
	Assault	186	4.44		
	Work accident	156	3.72		
	Other	62	1.48		
Time period of radiological examination	Working hours	1659	39.6	4193	100
	Off-hours	2534	60.4		

The most frequently requested CT scans from patients were cranial CT (n=1687, 40.22%) and pelvis CT (n=1237, 29.49%). The other CT types were thorax CT (n=548, 13.07%), lumbar spine CT

(n=187, 4.46%), cervical spine CT (n=156, 3.72%), thoracic spine CT (n=156, 3.72%), maxillofacial CT (n=58, 1. 38%), foot-ankle CT (n=39, 0.93%), hip CT (n=29, 0.69%), hand-wrist-arm CT (n=27, 0.67%), shoulder CT (n=25, 0.62%), knee CT (n=25, 0.60%), elbow CT (n=14, 0.33%), scapula CT (n=4, 0.10%). No pathology was observed in 74.13% (n=3108) of the patients, while pathology was observed in 25.87% (n=1085)(Table 3). The CT type with the highest percentage of pathology was scapular CT (n=3, 75%). The CT type with the second highest percentage of pathology was hand-wrist-arm CT (n=20, 71%).

Table 3. Distribution of the types of CT requested and the presence of positive findings

Requested CT type	CT count	CT ratio	Number of CTs with positive pathological findings	Pathological finding positive CT rate
Cranial CT	1687	40.22%	457	27%
Pelvis CT	1237	29.49%	279	23%
Thorax CT	548	13.07%	123	22%
Lumbar spine CT	187	4.46%	47	25%
Cervical spine CT	156	3.72%	21	13%
Thoracic spine CT	156	3.72%	34	22%
Maxillofacial CT	58	1.38%	22	38%
Foot-ankle CT	39	0.93%	24	62%
Hip CT	29	0.69%	19	66%
Hand-wrist-arm CT	27	0.67%	20	71%
Shoulder CT	25	0.62%	18	69%
Knee CT	25	0.60%	10	40%
Elbow CT	14	0.33%	8	57%
Scapula CT	4	0.10%	3	75%
Total	4193	100%	1085	% 25.87

CT: Computed tomography

Imaging tests were ordered by general practitioners in 49.2% of cases (n=2063), by emergency medicine specialists in 30.6% (n=1283), and by consultant specialists in 20.2% (n=847) (Table 4). Consultation procedures were performed during off-hours 56.6% of the time (Table 5).

Table 4. Distribution of the specialty of the physician who requested the CT imaging

	n	%
General practitioner	2063	49.2
Specialist in emergency medicine	1283	30.6
Specialist consultant	847	20.2

CT: Computed tomography

Table 5. Distribution of consultation time

Time period consulted with consultant physician	n	%
Working hours	368	43.4
Off-hours	479	56.6
Total	847	100

The frequency of pathology in CT imaging ordered by consultant physicians was significantly higher than that ordered by general practitioners or emergency specialists ($p<0.001$). Statistically significant differences were observed for wrist-arm CT, hip CT, cranial CT, maxillofacial CT, shoulder CT, pelvis CT, cervical spine CT, trochal spine CT and thorax CT. There was no statistically significant difference found between consultant specialists and general practitioners in foot-ankle CT, elbow CT, and knee CT imaging. The study did not include CT imaging requested by emergency medicine specialists in these three CT imaging groups. Additionally, no statistically significant difference was found between the three physician branches in CT imaging of the lumbar spine ($p=0.0516$)(Table 6).

Table 6. Distribution of the presence of pathology according to CT imaging types according to the requesting physician's branch

CT Type	Presence of pathology	Specialist consultant n	Specialist consultant %	Specialist in EM n	Specialist in EM %	General Practitioner n	General Practitioner %	Total n	Total %	Statistical analysis
Foot-foot ankle CT	+	15	1.80	-	-	9	0.44	24	0.6	X^2:0.488 p:0.485
	-	11	1.30	-	-	4	0.20	15	0.4	
Elbow CT	+	7	0.80	-	-	1	0.04	8	0.2	X^2:0.884 p:0.347
	-	4	0.50	-	-	2	0.10	6	0.1	
Knee CT	+	9	1.10	-	-	1	0.04	10	0.22	X^2:1.22 p:0.3269
	-	10	1.20	-	-	4	0.20	14	0.3	
Hand-wrist-arm CT	+	19	2.20	-	-	1	0.04	20	0.5	X^2:14.9 p<0.001
	-	2	0.20	-	-	6	0.30	8	0.2	
Hip CT	+	16	1.90	-	-	3	0.14	19	0.5	X^2:3.83 p:0.04
	-	5	0.60	-	-	5	0.24	10	0.23	
Cranial CT	+	46	5.40	164	12.8	247	12.00	457	10.90	X^2:5.107 p<0.001
	-	31	3.70	597	46.5	602	29.18	1230	29.31	
Lumbar spine CT	+	5	0.60	15	1.17	27	1.30	47	1.12	X^2:1.325 p:0.516
	-	8	0.90	48	3.7	84	4.10	140	3.33	
Maxillofacial CT	+	6	0.70	7	0.55	9	0.44	22	0.50	X^2:7.904 p:0.01
	-	1	0.10	13	1.53	22	1.10	36	0.90	
Shoulder CT	+	2	0.20	4	0.31	11	0.60	18	0.43	X^2:2.215 p:0.033
	-	1	0.10	4	0.31	3	0.14	8	0.20	
Pelvis CT	+	147	17.40	4	0.31	128	6.20	279	6.70	X^2:15.873 p<0.001
	-	445	52.50	76	5.9	437	21.10	958	22.80	
Cervical spine CT	+	4	0.50	2	0.16	15	0.70	21	0.50	X^2:11.541 p:0.003
	-	6	0.70	54	4.2	75	3.60	135	3.20	
Thoracic spine CT	+	7	0.80	14	1.1	13	0.60	34	0.80	X^2:12.182 p:0.002
	-	4	0.50	59	4.6	59	2.90	122	2.90	
Thorax CT	+	16	1.90	39	3.04	72	3.50	127	3.02	X^2:13.221 p<0.001
	-	20	2.40	183	14.3	222	10.80	425	10.14	
Total		847	20.2	1283	30.6	2063	49.2	4193	100	X^2:6.724 p<0.001

CT: Computed tomography, EM: Emergency medicine

DISCUSSION

The rise in the use of imaging techniques in emergency medical services has garnered global attention. Some studies analyzing this increase have found no significant change in the profit/loss ratio despite increased use of CT.[7,8] However, data suggests that the rate of emergency department admissions has doubled in about 15 years. An increase in the number of admissions leads to a linear increase in the number of investigations ordered.[9]

The use of advanced imaging modalities and its effectiveness and results are important research topics. According to the European Union (EU) Health Statistics Report, Turkiye ranked first in MRI scans and eighth in CT scans between 2011 and 2014. While the EU average saw a 49% increase in CT utilization, Turkey experienced a 60% increase.[10]

In the field of emergency medicine services, Oğuz et al.[11] observed a 3.6% increase in the number of patients admitted to the emergency department in 2000 compared to 1998. Additionally, the frequency of CT requests increased by 69%. The study found that normal results in cranial, maxillofacial, and cervical CT imaging increased in 2000, while major and minor findings decreased. The main objective of our study was to demonstrate the frequency of pathology observed in CT imaging studies ordered in emergency medicine services. We did not investigate the number of investigations requested by year. However, our findings indicate that the majority (74.13%) of diagnostic imaging studies ordered in emergency departments did not reveal any pathological findings.

Yıldız et al.[12] analysed 1700 patients admitted to the emergency department of a secondary care hospital who underwent CT scans. The study found that cranial CT was the most frequently requested scan for patients admitted due to trauma. Pathology was observed in 7% of patients who underwent cranial CT and 10.7% of patients who underwent thoracic CT. Furthermore, it was reported that 98.5% of cranial imaging studies conducted on childhood trauma patients showed no signs of pathology. Similarly, in our study, cranial CT scans were the most commonly requested type (40.22%). We found pathology in 27% of cranial CT results, indicating a higher rate of positive pathological findings compared to the aforementioned study.

Yıldız et al.[12] conducted a study which found that pathology was detected in approximately 71% of patients who underwent CT of the spine. The rates of pathology detection in maxillofacial CT and extremity CT were 53.8% and 65.1%, respectively. These CT imaging modalities, especially for the affected trauma site, increased the frequency of pathology detection. This suggests that CT imaging of the trauma focus, after careful examination, would be more effective in multiple trauma patients. The study found that the incidence of pathological findings on CT imaging of the cervical, thoracic, and lumbar spine was 13%, 22%, and 25%, respectively. These results suggest that a more detailed examination of the spine should be performed in patients presenting to the emergency department. Routine pan-spine CT imaging should be avoided in multitrauma patients, even if no positive findings are present.

Arslan et al.[13] conducted a study evaluating 2012 CT scans ordered for trauma patients admitted to a tertiary emergency medicine service. The study found that 23.9% of CT orders showed pathology, with cranial CT being the most frequently ordered type (64.3%). Our study, which parallels Arslan et al.'s findings, showed a 25.87% rate of positive pathological findings in CT orders. Similarly, the most commonly ordered type of CT in our study was cranial CT.

In our study, the type of CT with the highest percentage of positive pathology was scapular CT (n=3, 75%). However, we believe that this result may be due to the low number of isolated scapular CT orders. The CT type we use to detect scapular pathology in trauma patients is thoracic CT, which is generally useful in revealing accompanying costal pathologies. Therefore, we believe that a certain proportion of patients with scapular pathology may be included in the thorax CT request type.

Swartzberg and Goldstein[14] evaluated CT orders in patients admitted to the adult emergency department over a 4-month period in 2018. The study found that CT was requested in only 4.6% of admitted patients, with the majority of requests coming from trauma patients. Of the cranial CTs performed, 53.8% yielded positive results. This rate was 47.1% in trauma patients and 61.8% in non-trauma patients. Based on these findings, it can be concluded that imaging modalities ordered in the emergency department yield a high rate of negative results not only in our country but also in other countries. This issue is not limited to a specific region or nation, but rather a global problem. To address this, it is crucial to implement diagnostic and clinical decision-making algorithms when using these diagnostic methods in the emergency department. This will help prevent unnecessary imaging requests.

Our study found a higher rate of positive pathology in extremity and maxillofacial CT types compared to spine and cranial CT types. This may be attributed to the fact that our hospital had 3 orthopaedic surgeons and 2 ENT specialists during the study period, but no spine surgeon or neurosurgeon. In daily emergency department consultation procedures, the general practitioner or emergency medicine specialist can easily consult the relevant specialist physician. Conventional radiographs and CT scans are ordered only after the patient has been examined by the specialist physician. This approach significantly reduces the number of unnecessary CT scans. It has been concluded that improving access to relevant specialist physicians can reduce the number of unnecessary CT scans. With this aspect of our study, it is concluded that the number of unnecessary CT imaging will decrease in cases where access to the relevant specialist physician becomes easier.

Several measures have been proposed to reduce the number of unnecessary requests for CT imaging. The 'New Orleans' and 'Canadian CT HeadRule' criteria have been shown to have high sensitivity in central nervous system imaging for trauma patients. Similar guidelines have also been established for non-traumatic patients.[15] In a 2015 study by Kanzaria et al.,[16] 435 emergency physicians were evaluated. The study found that 85% of physicians believed that too many diagnostic tests were being requested in their emergency department. Additionally, almost all physicians reported that some of the advanced imaging tests requested were medically unnecessary. Physicians have suggested that reducing the number of unnecessary imaging tests could be achieved through malpractice reform, patient education, providing feedback to physicians on test requests, and educating physicians on diagnostic imaging tests.

Limitations

The study has some limitations. Firstly, we only evaluated CT orders for admissions within a 9-month period, which may have limited the comprehensiveness of our results. Secondly, due to the retrospective nature of the study, we were unable to evaluate the clinical findings of the patients. Instead, we considered the reason for ordering the examination and the presence or absence of pathology in the examination results. Another limitation of our study is that we did not evaluate the frequency of CT orders and the density of patients in the emergency department according

to the number of patients and the increase in the number of patients according to the years.

Further studies, which will include the clinical findings of the patients and emergency department patient density data, can evaluate the frequency of CT ordering in emergency departments, the reasons for CT ordering by emergency department physicians, the fear of malpractice and the extent of defensive medicine.

CONCLUSION

The high frequency of requests for cranial and pelvic CT scans, coupled with the high rate of negative results, highlights the need for caution when ordering these scans. It is important to conduct a thorough physical examination of the patient before ordering these scans and to carefully analyze the reasons for the request. As a result of our study, we found that easier access to relevant specialist physicians increased the rate of positive pathology in CT imaging. To reduce the number of examination orders and healthcare costs, physicians should use internationally accepted guidelines when ordering radiological imaging.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Ankara Etlik City Hospital No. 1 Clinical Researches Ethics Committee (Date: 22.11.2023, Decision No: AEŞH-EK1-2023-702).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Original Article

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Effects of myofascial trigger point injection on the disease activity in patients with comorbidity of fibromyalgia and cervical myofascial pain syndrome

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ABSTRACT

Aims: To investigate the effect of myofascial trigger point injection on the disease activity of FS in patients with myofascial trigger points in the coexistence of fibromyalgia syndrome (FS) and chronic cervical myofascial pain syndrome (MAS).

Methods: 30 consenting patients between the ages of 18-60 who has had FS for at least 3 months and also MPS in trapezius, levator scapula, splenius capitis, and multifidus muscles in the cervical region and 15 patients with FS but without MPS were included in the present study. Patients newly diagnosed with FS were evaluated for the presence of MPS and FS, and disease activity was evaluated before administering treatment and after the administration of trigger point injection treatment for cervical MPS. In the group with only FS, cervical region tender point injection was carried out. Patients were evaluated before injection and one month after injection. The severity of pain was evaluated with VAS (visual analog scale), pressure pain threshold was measured with an algometer, total myalgic score (TMS), fibromyalgia impact questionnaire (FIQ), Pittsburgh sleep quality index (PSQI), Beck depression inventory (BDI), Beck anxiety inventory (BAI), fatigue severity scale (FSS) results were evaluated before and after treatment.

Results: When patients were evaluated at 1st month after myofascial trigger point and cervical tender point injections statistically significant decrease was found in VAS, TMS, PSQI, FIQ, FSS, BAI, and BAI scores, and the number of trigger points in both FS and the FS+MAS groups (for all parameters $p<0.005$). However, this decrease was more evident in FS+MPS group.

Conclusion: In the comorbidity of MPS and FS, which is one of the most common causes of widespread musculoskeletal pain, it has been shown that treatment of MPS with trigger point injection may have positive effects on the severity of FS, mood disorders, sleep, and fatigue. In the treatment ofFS, the treatment of MPS, which is one of the peripheral pain generators, should be given priority.

Keywords: Fibromyalgia syndrome, myofascial pain syndrome, peripheral pain generators, trigger and tender points

INTRODUCTION

Fibromyalgia is a chronic musculoskeletal disease of unknown etiology, accompanied by various pathologies such as sleep disorder, irritable bowel syndrome, depression, migraine, temporomandibular joint disorder, female urethral syndrome, and frequently seen in women between the ages of 30-60 years.[1] It is thought that genetic and environmental factors play a role in the etiology of the disease. The main symptoms seen in FS are pain, stiffness, subjective feeling of swelling in soft tissues and joints, fatigue, insomnia, paresthesias, depression, and cognitive disorders. Patients with FS may be accompanied by central sensitization syndromes such as tension-type headache, migraine, chronic fatigue syndrome, irritable bowel syndrome, temporomandibular disorder, interstitial cystitis, restless legs syndrome, and sensitivity to multiple chemicals.[2]

Myofascial pain syndrome (MAS) is a local pain syndrome originating from muscle and/or fascia that may be accompanied by findings such as muscle spasm, fatigue, stiffness, tenderness, and limitation of movement, as well as autonomic dysfunction findings such as increased lacrimation, abnormal sweating, nasal secretion and vasomotor symptoms.[3] MAS is caused by trigger points, and contracted tense bands within the muscle. The most common cause of musculoskeletal pain is MAS. An average of 30-50% of patients who consult a physician with musculoskeletal pain, most commonly back and neck pain,

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have MAS. The etiology of MAS is not fully known. Excessive load on the muscles and trauma are thought to be important factors in trigger point formation. In addition, fatigue, stress, genetic and structural disorders, infections, psychosocial factors, vitamin and mineral deficiencies are predisposing factors for trigger point formation. The most common symptoms of MAS are pain, limitation of movement, muscle weakness and referred pain. When pressure is applied to the trigger point, it causes referred pain in addition to local pain. The most common places where MAS occurs are the head, neck, back, shoulder and waist area.[1-3]

It has been reported that ¼ of the patients with cervical MAS are also accompanied by FS, and psychological and comorbid symptoms are more common in patients with these two syndromes together.[4] There are also studies supporting the view that the general spontaneous pain seen in FS is caused by trigger points.[5] In fact, trigger points and sensitive points have been discussed for many years, and are still ongoing today, and these two diseases are considered to be the same disease or a spectrum of diseases that are intertwined with each other.[6] These two syndromes are so intertwined that central sensitization caused by MAS has begun to be blamed in the etiopathogenesis of FS.[4]

It has been reported that MAS, which is among various musculoskeletal system disorders such as osteoarthritis, lateral epicondylitis, MAS, meniscopathy, plantar fasciitis, costochondritis, bursitis, tendinitis, entrapment neuropathies, migraine, irritable bowel syndrome, interstitial cystitis, described as peripheral pain generators, has an important role in increasing FS disease activity.[7] It is claimed that FS complaints can be reduced by reducing central sensitization by suppressing nociceptive pain arising from trigger points.[8]

Three studies similar to ours stand out in the literature.[8-10] The first of the studies was conducted in a limited number of cases, and it was determined that trigger point local anesthetic injection and cervical joint range of motion exercises caused improvement in pain and pressure pain threshold parameters only in patients with MAS and the combination of MAS and FS. However, it has been reported that comorbid patients have a more delayed and less treatment response than the group with neck MAS alone.[9] In another study, patients with FS and chronic neck MAS were compared with patients with FS and joint pain. In this study, active trigger point injection and placebo local trigger point injection were applied to two groups. In both the FS+MAS and FS+ joint pain groups, a decrease in MAS and joint pain attacks was detected in those who received active trigger point injections. It was observed that the pain intensity of FS decreased and the pain threshold increased at sensitive points.[8] The third of the studies examined the effectiveness of lidocaine injections into the sensitive points of the trapezius muscle in FS patients and it was shown that the injection increased the trapezius muscle pressure pain threshold values and reduced secondary heat hyperalgesia.[10] The effect of MAS trigger point injection on FS disease activity, depression, anxiety, sleep quality, and fatigue severity in patients with chronic neck MAS and FS has not been well studied.

This study aims to investigate the effect of myofascial trigger point injection on the disease activity, depression, anxiety, sleep quality and fatigue severity of FS, and chronic neck MAS.

METHODS

The study included patients between the ages of 18-60 who had FS meeting the 2013 American College of Rheumatology (ACR) criteria[11] and cervical chronic MAS who met the diagnostic criteria of Travell and Simons[12] who applied to the Physical Medicine and Rehabilitation outpatient clinic of the Ankara Training and Research Hospital of the University of Health Sciences. A total of 45 patients were included, 30 patients with FS+MAS and 15 patients withFS without cervical MAS. Local institution approval was obtained, but ethics committee approval was not obtained for this thesis study (before 2020). We obtained an informed consent form from all patients for the procedure. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Evaluation of Myofascial Trigger Points

The trapezius, levator scapula, splenius capitis and multifidus muscles of both groups were evaluated bilaterally for active and latent trigger points by a physiatrist experienced in myofascial pain syndrome.[13] Myofascial trigger point diagnosis; It was determined according to the criteria of 1) the presence of a palpable taut band in the skeletal muscle, 2) the presence of a hypersensitive trigger point within the taut band, 3) the occurrence of a local twitch response with palpation of the taut band, and 4) the occurrence of reference pain in response to the compression of the trigger point. Trigger point; If reference pain similar to the patient's pain was revealed with point compression, this trigger point was considered an "active trigger point". If the patient's reference pain did not cause pain similar to the patient's previous pain, this trigger point was considered a "latent trigger point".[12]

Inclusion criteria: FS who met the 2013 ACR criteria, aged 18-60 years, and who were diagnosed with cervical chronic MAS according to Travel and Simons' criteria and had a palpable taut band in the trapezius, levator scapula, splenius capitis and multifidus muscles and at least 1 active trigger point.

Exclusion Criteria: Those diagnosed with cervical radiculopathy, myelopathy, local or systemic infection, received treatment for MAS in the last 3 months, symptom duration less than 3 months, pregnancy, tumor history, uncompensated cardiovascular disease, inflammatory disease history, Patients with a history of bleeding diathesis, anticoagulant use, and uncooperative patients were not included in the study.

Pain pressure Threshold Evaluation

Pain pressure threshold (PPT) is defined as the minimal amount of pressure at which the pressure sensation first changes to a pain sensation at a given point. PPT evaluation was made with a Fischer algometer device, which has a pressure surface of 1 cm^2 and an oval-shaped rubber on its tip. Patients were informed before the measurement. They were asked to express the moment when they first felt pain, not the most painful moment, where the aim was to measure the pain threshold. The measurement was made three times and the average of these values was taken. The average value obtained was recorded. Each of the 18 tender point areas defined by the ACR in 1990 was evaluated with the Fischer algometer device.[14] Points below 4 kg/cm^2 were determined as tender points (TP). Control points (CP) (bilateral thumbnail and mid-thigh part) were also measured with the Fischer

algometer device. The severity of FS was determined by the total myalgic score (TMS). TMS; 18 tender points and 4 control points (bilateral thumb pulp and mid-thigh section) were determined by summing the pressure pain threshold values.

Functional evaluation of both groups was made with the Fibromyalgia Impact Questionnaire (FIQ).[15] Pain intensity was evaluated with visual analog scale (VAS). (0 no pain, 10 unbearable pain). Beck Depression Inventory (BDI)[16] and Beck Anxiety Inventory (BAI)[17] were used to measure depression and anxiety levels. Sleep quality was evaluated with the Pittsburgh sleep quality index (PSQI).[18] The fatigue level of the participants was measured using the Fatigue severity scale (FSS).[19]

The PPT, FIQ, VAS, PSQI, BDI, and BAI evaluations mentioned above were applied by a researcher who did not know which group the patients in the study were in.

Injection Procedure

In the FS+MAS group, trigger point areas were determined by palpation and marked with a pen, and the skin was cleaned with a suitable antiseptic agent. For injection, 1 ml of 2% lidocaine was applied to the trigger points by infiltration from multiple points, using a sterile 31 gauge insulin syringe, according to the injection technique described by Travell and Simons. The subcutaneous tissue was entered with the needle tip perpendicular to the skin. The needle tip was advanced into the muscle until the trigger point within the muscle band was found. After aspiration was performed and 0.2 ml of local anesthetic was injected, the same point was pricked 8-10 times with inward and outward needle movements. Injections were made at each trigger point along the taut band at a few mm intervals. In overweight patients, some pressure was applied to reach target areas. This method was applied in 1 session. Patients were monitored for 30 minutes after the injection for complications (tinnitus, hypotension, numbness around the mouth, dizziness, speech disorders, nystagmus, tremor, convulsion, respiratory depression, and allergy) that may occur with this treatment technique.

In the group with FS without cervical MAS, local anesthetic was applied with an insulin syringe to 4 of the 18 tender points (midpoint of the upper border of the trapezius bilaterally and the supraspinatus medially on the scapula) previously determined according to ACR 1990 criteria for the classification of FS.[1]

PPT, VAS, FIQ, PSQI, FSS, BDI, and BAI values of all patients were evaluated before injection and 1 month after injection. The person making the assessments was blinded to group allocation.

Statistical Analysis

SPSS 22.0 for Windows package program was used for statistical analysis.Whether the data conformed to parametric distribution was evaluated with the Kolmogorov-Smirnov test. Data are shown as mean±standard deviation (min-max). The Mann-Whitney U test was used to compare numerical data between groups, and the Wilcoxon rank test was used to compare repeated measurements within groups. Nominal (categorical) data were shown as numbers (%), and whether they were significant or not was checked using the Fisher Exact test or Pearson Chi-square test, as appropriate. Results were considered statistically significant for $p<0.05$.

RESULTS

While the average age of the FS group was 40.63±4.6, the average age of the FS+MAS group was 40.63±6.46 and there was no significant difference between them (p=0.809). There was no significant difference between the groups in height, weight, body mass index (BMI), educational status, marital status and smoking (p>0.05). The mean disease duration of the FS+MAS group was significantly longer than the FS group (p=0.010). The demographical characteristics of the patients are shown in Table 1.

Table 1. Demographical characteristics of the patients

	FS (n=15)	FS+MAS (n=30)	p[a]
Age (years)	40.53±4.6 (32-48)	40.63±6.46 (27-50)	0.809
Height (m)	1.62±0.04 (1.55-1.7)	1.6±0.05 (1.48-1.7)	0.179
Weight (kg)	73.2±15.36 (48-117)	68.57±11.66 (52-92)	0.385
BMI (kg/cm²)	27.2±5 (19-41)	26.6±4.92 (19-37)	0.923
Disease duration (months)	16.33±7.96 (9-36)	38.6±45.9 (3-240)	0.010
	n (%)	**n (%)**	**p[b]**
Education			
Illiterate	1 (%6.67)	2 (%6.67)	1.000
Primary-high school	14 (%93.33)	28 (%93.33)	
Marital status			
Married	13 (%86.67)	26 (%86.67)	1.000
Single	2 (%13.33)	4 (%13.33)	
Smoking	3 (%20)	10 (%33.33)	0.492

BMI: Body mass index, values mean ± standart deviation (min-max) or n (%), [a]: Mann-Whitney U testi, [b]: Fisher's exact testi

Pre-treatment TMS values were significantly higher in the FS+MAS group (p=0.001). After treatment, TMS values of the FS+MAS group were significantly higher than the FS group (p<0.001). The within-group decreases in TMS values were also significant in both the FS and FS+MAS groups (p<0.001, p<0.001, respectively). When the changes in one-month TMS values were compared, the difference in the FS+MAS group was significantly greater than the FS group (p<0.001).

When the pre-treatment CPS values of the FS and FS+MAS groups were compared, the pre-treatment CPS values of the FS+MAS group were significantly higher (p=0.026). After treatment, the CPS values of the FS+MAS group were significantly higher than the values of the FS group (p=0.016). When the changes in CPS values were compared, no significant difference was detected between the two groups (p=0.932).

When the pre-treatment TPC of the FS and FS+MAS groups was compared, there was no significant difference between the two groups (p=0.487). When post-treatment values were compared, the TPC of the FS group was significantly higher than the FS+MAS group (p<0.001). When the TPC change was compared, the difference in the FS+MAS group was significantly higher than the FS group (p<0.001). The mean TMS, CPS, and TPC values of the groups before and after injection treatment and the difference between the values before and after treatment are shown in Table 2.

Table 2. The mean TMS, CPS and TPC values of the groups before and after injection treatment and the difference between the values before and after treatment

	FS (n=15)	p^b	FS+MAS (n=30)	p^b	p^a
TMS BT	71.07±8.23 (60-91)	0.001	85.4±13.25 (51-109)	<0.001	0.001
TMS AT	79.87±8.12 (72-103)		105.33±12.98 (76-127)		<0.001
TMS D	8.8±4.39 (2-16)		19.93±6.35 (4-34)		<0.001
CPS BT	17.93±1.79 (15-21)	0.083	20.6±4.96 (9.5-28)	0.114	0.026
CPS AT	18.13±2 (15-22)		20.9±5.13 (8.5-30)		0.016
CPS D	0.2±0.41 (0-1)		0.31±1.04 (-2-4)		0.932
TPC BT	15.67±1.72 (12-18)	0.001	16±1.98 (12-18)	<0.001	0.487
TPC AT	13.2±1.7 (10-16)		10.13±2.21 (7-15)		<0.001
TPC D	2.47±1.46 (0-5)		5.87±2.05 (2-10)		<0.001

TMS: Total myalgic score, CPS: Control point score, TPC: Tender point count, BT: Before treatment, AT: After treatment, D: Difference, [a]:Mann-Whitney U testi, [b]:Wilcoxon rank testi, values mean ± standart deviation (min-max)

VAS values of the FS group were significantly higher before treatment (p=0.034). After injection treatment, VAS values decreased significantly in both FS and FS+MAS groups (p=0.003, p<0.001, respectively). When the changes in VAS values before and after treatment were compared, the improvement in the FS+MAS group was significantly higher than the FS group (p<0.001).

When the pre-treatment FIQ scores of the FS and FS+MAS groups were compared, there was no significant difference between the two groups (p=0.148). However, when the post-treatment values were compared, the FIQ score of the FS group was significantly higher than the value of the FS+MAS group (p<0.001).Post-treatment intra-group decreases in FIQ values were also significant in both the FS and FS+MAS groups (p=0.001, p<0.001, respectively). When the changes in FIQ values were compared, the difference in the FS+MAS group was significantly higher than in the FS group (p<0.001).

PSQI scores of the FS+MAS group were higher before treatment (p=0.010). However, no significant difference was detected between the two groups in terms of the 1st month post-treatment values (p=0.874). Intragroup improvements in PSQI values were also significant in both the FS and FS+MAS groups (p=0.001, p<0.001, respectively). When the difference in PSQI values after treatment was compared, the improvements in the FS+MAS group were significantly higher than in the FS group (p<0.001).

When the pre-treatment FSS scores of the FS and FS+MAS groups were compared, there was no significant difference between the two groups (p=0.348). However, when the post-treatment values were compared, the FSS score of the FS group was significantly higher than the value of the FS+MAS group (p<0.001). The intragroup decreases in FSS values were significant in both the FS and FS+MAS groups (p=0.001, p<0.001, respectively). When the changes in one-month FSS values were compared, the decrease in the FS+MAS group was more pronounced than in the FS group (p<0.001).

When the pre-treatment BDI scores of the FS and FS+MAS groups were compared, there was no significant difference between the two groups (p=0.288).When the post-treatment values were compared, there was no significant difference between the BDI scores of both groups (p=0.141). Within-group decreases in BDI values were significant in both the FS and FS+MAS groups (p=0.003, p<0.001, respectively). When the changes in BDI values were compared, the decrease in the FS+MAS group was significantly higher than the FS group (p<0.001).

When the pre-treatment BAI scores of the FS and FS+MAS groups were compared, there was no significant difference between the two groups (p=0.120). When the post-treatment values were compared, the BAI scores of the FS group were significantly higher than the scores of the FS+MAS group (p=0.002). BAI values were also significant within the group, both in the FS and FS+MAS groups (p=0.002, p<0.001, respectively). When the changes in BAI values were compared, the difference in the FS+MAS group was significantly higher than the FS group (p<0.001). The mean VAS, FIQ, PSQI, FSS, BDI, and BAI values of the groups before and after injection treatment and the difference between the values before and after treatment are shown in Table 3.

Table 3. The mean VAS, PSQI, FIQ, FSS, BDI and BAI values of the groups before and after injection treatment and the difference between the values before and after treatment

	FS (n=15)	p^b	FS+MAS (n=30)	p^b	p^a
VAS BT	8.8±1.21 (6-10)	0.003	7.87±1.48 (5-10)	<0.001	0.034
VAS AT	7.67±1.29 (5-10)		5±1.66 (2-9)		<0.001
VAS D	1.13±0.83 (2-0)		2.87±1.2 (6-0)		<0.001
PSQI BT	6.93±1.67 (4-10)	0.001	7.87±1.48 (5-10)	<0.001	0.010
PSQI AT	6.13±1.81 (4-10)		5±1.66 (2-9)		0.874
PSQI D	0.8±0.56 (2-0)		2.87±1.2 (6-0)		<0.001
FIQ BT	63.27±10.23 (44-75)	0.001	57.83±12.48 (31-76.5)	<0.001	0.148
FIQ AT	58.07±9.94 (39-72)		32.37±8.98 (14-52)		<0.001
FIQ D	5.2±2.76 (10-1)		25.47±8.77 (44-12)		<0.001
FSS BT	5.8±0.86 (4-7)	0.003	5.27±1.47 (1-4.7)	<0.001	0.348
FSS AT	5.2±1.15 (3-7)		3.22±1.13 (1-5)		<0.001
FSS D	0.6±0.51 (1-0)		2.05±0.68 (3-0.4)		<0.001
BDI BT	20.2±8.91 (6-38)	0.001	23.63±9.81 (8-44)	<0.001	0.288
BDI AT	17.2±8.53 (4-35)		13.93±6.66 (6-32)		0.141
BDI D	3±1.6 (5-0)		9.7±4.4 (19-2)		<0.001
BAI BT	25.67±11.27 (5-40)	0.002	20.4±10.49 (4-45)	<0.001	0.120
BAI AT	22.87±11.09 (5-40)		11.9±6.58 (3-28)		0.002
BAI D	2.8±2.01 (7-0)		8.5±4.42 (17-1)		<0.001

VAS: Visual analogue scale, PSQI: Pitsburg sleep quality index, FIQ: Fibromyalgia impact questionnaire, FSS: Fatique severity scale, BDI: Beck depression inventory, BAI: Beck anxiety inventory, BT: Before treatment, AT: After treatment, D: Difference, [a]:Mann-Whitney U test, [b]:Wilcoxon rank test, values mean ± standart deviation (min-max)

DISCUSSION

In our study, a significant improvement was found in the pain, fatigue, sleep, depression, and anxiety levels of the patients after trigger point injections in patients with comorbid FS and chronic cervical MAS and cervical tender point injections in patients with FS without cervical MAS. This improvement was more evident in the group with cervical MAS which received trigger point injection treatment.

Many studies in the literature have emphasized the association and comorbidity of FS and MAS. It is known that these two diseases are intertwined syndromes.[4,6,20]

In fact, trigger points seen in MAS and tender points seen in FS were used interchangeably by some authors, and the conceptual confusion continued for years.[21] In a study by Fernández et al.,[22] trigger points seen in MAS are related to FS, and previous studies have supported the view that the general spontaneous pain seen in FS is caused by trigger points. It has been emphasized that complaints in FS will decrease by reducing central sensitization by suppressing nociceptive pain arising from trigger points. Our aim in our study was to show the effect of MAS treatment, which we frequently see together in FS, on FS-related pain, fatigue, and sleep problems, and we detected an improvement in these parameters after MAS trigger point injection. Thus, we think that treating MAS may reduce the disease activity of FS.

In a study by Cakit et al.,[4] they reported that ¼ of the patients with cervical MAS were also concomitant by FS. In this study, it was stated that psychological and comorbid symptoms were more common in patients with these two syndromes together. They claimed that MAS, which is a peripheral pain generator, may cause FS or worsen symptoms by triggering central sensitization, therefore early treatment of MAS should be done before the progression of FS. Considering the disease duration of our patients, the disease duration was longer in the comorbid group, which supports the authors. TMS values were lower in the comorbid group. However, no difference was detected between groups in depression and anxiety levels before treatment. While conducting our study, we had difficulty finding FS patients without MAS, and we see the coexistence of these two syndromes quite frequently in our clinical practice.

In a study by Giannapia Affaitati et al.,[8] active trigger point injection and placebo local trigger point injection were administered to two groups: patients with FS and MAS and patients with FS and joint pain.In both the FS+MAS and FS+ joint pain groups, a decrease in MAS and joint pain attacks was detected in those who received active trigger point injections. The pain intensity of FS was found to decrease and the pain threshold at tender points increased. It was stated that the severity of FS in these patients at the 3rd-week follow-up was lower than in the group that did not receive treatment. It is thought that local trigger points and joint pain cause central sensitization in FS by creating peripheral stimulation, and it has been emphasized that the treatments of these conditions may be effective in the treatment of FS. In our study, we found that VAS values after myofascial trigger point injection and trapezius muscle tender point injection decreased significantly in both the FS and FS+MAS groups. When the changes in VAS values before and after treatment were compared, the improvement in the FS+MAS group was significantly greater than in the FS group. We think that MAS is a peripheral pain generator that increases the severity of FS and its treatment may reduce the disease severity of FS patients.

Reddy et al.[23] performed tender point injection in 41 patients with FS and showed that tender point injection provided improvement in FS. In this study, they reported that FS patients with high levels of anxiety and depression showed a shorter recovery. Staud et al.[10] examined the effectiveness of lidocaine injections into the sensitive points of the trapezius muscle in FM patients and showed that the injection increased the PPT values of the trapezius muscle and reduced secondary heat hyperalgesia. It has been thought that peripheral pain inputs may be responsible for general pain and widespread hypersensitivity in chronic pain syndromes such as FS. We also observed the beneficial effects of local anesthetic injection on the trapezius tender point in FS patients without MAS on the pain, fatigue, disease severity and depression levels of these patients. We believe that, as in the study of Staud et al.,[10] injection into the tender point improves hyperalgesia, which is common in FS, and the reduction in pain also reduces depression and anxiety.

Hong et al.[24] applied active trigger point injection therapy to two groups: patients with MAS and FS and patients with MAS but without FS. They found that trigger point injection was an effective and valuable treatment method in both groups. They showed that the recovery in the MAS and FS group was later than in the group with MAS and no FS, but there was a significant improvement in both groups. In our study, we applied injection treatment to two groups: patients with FS and MAS and patients with only FS. Although there was improvement in both groups, we observed that the improvement in the FS and MAS groups was greater than in the FS group alone. However, we think that both trigger point injection and tender point injection in the cervical region are effective treatment methods in this patient group.

Steiner et al.[25] found a strong relationship between pain intensity, physical function and depression in patients with FS. They suggested that depression may be the factor that increases the severity of pain and worsens physical function in patients with FS. They argued that early intervention for depression and other psychological factors is necessary in the treatment of FS. In our study, we found the intra-group decreases in BDI values to be significant in both the FS and FS+MAS groups. In our patients, consistent with the literature, the decrease in pain in FS and FS+MAS patients was parallel to the decrease in depression.

Andrade et al.[26] found that the prevalence of sleep disorders determined by PSQI in patients with fibromyalgia was 92.9%. It has been claimed that sleep disorders are quite common in patients with FS and that early treatment of these disorders will provide clinical improvement in FS. In our study, we found significant intra-group improvements in PSQI values after trigger point injection and cervical tender point injection treatment in both the FS and FS+MAS groups. When the changes in PSQI values were compared, the improvements in the FS+MAS group were significantly greater than those in the FS group. We evaluated the clinical improvement in sleep quality after injection treatment as a part of the improvement observed in FS syndrome. Ulus et al.[27] tried to explain the factors affecting sleep quality in patients with FS and rheumatoid arthritis (RA). They suggested that sleep quality was poor in both FS and RA patients and that this situation was related to pain. We believe that the reduction in pain after treatment has a positive effect on our patient's sleep quality.

Limitations

The limitations of our study include the inclusion of only female patients and the lack of a third control group consisting of healthy individuals. However, since FS is much more common in women and we were trying to create a more diffuse patient group, we included only women in the study. In addition, our low number of cases and short follow-up period are other important limitations.

CONCLUSION

As a result, it has been observed that the treatment of cervical MAS with trigger point injection in the comorbidity of FS and MAS, which are the most common causes of widespread musculoskeletal pain, has beneficial effects on the severity of FS, mood disorders, sleep and fatigue. Treatment of MAS, one of the peripheral pain generators, should be one of the priority treatment strategies in the treatment of FS.

ETHICAL DECLARATIONS

Ethics Committee Approval

Since the study produced from a thesis before 2020, ethics committee approval was not obtained for this thesis study.

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Original Article

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Has the COVID-19 pandemic affected injury in football? Example of a professional football team

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ABSTRACT

Aims: Events that cause a state of isolation, such as a pandemic, and affect the training status of athletes can lead to loss of performance and increased risk of injury. The aim of this study was to compare the injuries of football players faced with the isolation and lack of training caused by COVID-19 and an intense match tempo after stress and uncertainty between pre- and post-pandemic seasons.

Methods: Injury follow-up data (number, time, severity, type, location, tissue of interest, side, mechanism, rule violation, and recurrence) of a professional football team in Turkey for the 2019-2020, 2020-2021, and 2021-2022 seasons were analysed.

Results: Data were analysed from 38 male athletes with a mean age of 28±4.55 (19-38). In the 2019-2020 season, there were a total of 23 injuries, which increased after the pandemic. With a tighter match schedule, there were 31 injuries in the 2020-2021 season and 51 in the 2021-2022 season. The injury rate per match also increased to 0.53, 0.70, and 1.08, respectively. Injury severity, location of injury, tissues involved ($p<0.05$), mechanism of injury, and rules violations ($p<0.001$) were significantly different between seasons.

Conclusion: The isolation period caused by the pandemic and the tight match schedules affected injury rates per match and injury characteristics. It was observed that these effects continued in the post-pandemic period with the contribution of the continuation of isolation rules and the rule changes made for the new season.

Keywords: COVID-19, pandemic, football, injury

INTRODUCTION

The novel coronavirus (COVID-19), which emerged in China in December 2019, is defined as a respiratory disease that can be fatal. COVID-19 infection was recognized as a pandemic by the World Health Organization (WHO) on March 11, 2020, due to its high rate of spread. Social distancing and isolation policies have been implemented worldwide to slow the spread of infection. Both global and local sporting events such as the European Football Championship, Tokyo 2020 Olympic Matches have also been suspended or cancelled indefinitely as of February 2020.[1] In Turkiye, football leagues were postponed until an indefinite date with a decision taken on March 19, 2020 (at the end of the 26th week of the 2019-2020 season).[2] As a result, the athletes had to pause their training or continue unsupervised because of the precautions.[3] Three months after the league was postponed, the spread of the infection slowed down, and the Turkish Football Federation (TFF) decided to continue league matches on June 12, 2020. The players had to complete the remaining matches after a three-month break. In 2019, after a 12-week end-of-season break between May and August, the 2019-2020 season started, and a three-week break was given between December and January within the season. After 8 postponed matches were played, a 7-week end-of-season break was given and then the 2020-2021 season was started under post-pandemic conditions. There was no break for this season and the schedule was tighter. We thought that all these conditions could force the football players to return after the pandemic and affect them in terms of injuries.

Reducing the risk of injury is the main part of the regular training programme in addition to the mental and physical preparation for sports competitions.[4-6] From the opposite perspective, detraining can be defined as the reduction or complete cessation of exercise frequency, intensity, or duration in the regular training routine of athletes. Detraining circumstances result in the loss of

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activity in the neuromuscular and cardiovascular systems that are obtained from regular training, such as the maintenance of physiological gains and performance characteristics. It can also lead to a decrease in strength, speed, flexibility, and endurance, which are critical to body composition and performance in competition. Consequently, all detraining processes become a predisposing risk factor for musculoskeletal injuries.[1,7-9] Perez et al.[10] found that football-specific actions such as acceleration/deceleration, change of direction, and sprinting were found to be difficult to perform under stay-at-home protocols, even though the athletes were supported by home training exercises. However, when the new season began after the quarantine, matches were scheduled at shorter intervals than usual so that the leagues could be completed on time. Professional football players went through three months of rest during the pandemic period, after which their schedule changed and they faced a tight season. To minimize the negative impact of the new season after quarantine, training and in-match arrangements were made in some countries. The decision to increase the number of in-match substitutions from three to five was one of the new changes implemented in many countries.[10,11]

The social and psychological impact, combined with quarantine and lack of training, can lead to performance loss and increased risk of injury.[9] Soft tissue injuries are known to increase when athletes return to sports after lockouts, and these are examples of the potential impact of a pandemic-induced isolation period.[9,12] Various analyses of the impact on injury rates in professional sports also show that the COVID-19 pandemic is causing increases in injury rates and changes in injury patterns.[13-15] In contrast, it was noted that the increase in injuries in the new season after the pandemic was prevented by the training strategies of the football clubs and some in-match rules. 10 Although there are data on this topic from many different countries, there are no data from Turkiye. This research attempted to compare the results of the pre-pandemic and post-pandemic seasons in terms of injury risk in football players who, after a period of lack of training, were faced with the uncertainty and stress caused by the pandemic, using a professional football team in Turkiye as an example.

METHODS

The study was designed as a cross-sectional descriptive study conducted at the Super League Football Club. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethics committee approval of the study was obtained from the Ethics Committee of Gazi University (Date: 26.04.2021, Decision No: E.80609). Informed consent was obtained from the players to use injury tracking data for the 2019-2020, 2020-2021 and 2021-2022 seasons.

Data collecting

All injuries were diagnosed, classified, and recorded by the same medical staff throughout the seasons. This football club routinely monitors performance and injury data. The data obtained as a result of this monitoring is objectively recorded in digital media. Injury data is categorised weekly, monthly, and annually in an Excel file. Within the scope of the research, the injury data within the period requested by the researchers were separated and anonymised by the club's medical team and sent to the principal investigator as an excel file. Injury data were available prospectively for the 2021-2022 season and retrospectively for the other seasons. After the break due to the announcement of the pandemic in the 2019-2020 season, the remaining 8 matches of the local league and 2 matches of the Union of European Football Associations (UEFA) Europa League were not included.

Injuries were grouped according to whether they occurred during the match or during training. The injury rates of the athletes per match were calculated as the number of injuries/number of matches.

In addition to the overall injury incidence, we also focused on a detailed analysis of typical football injuries. The injury severity were classified as minor if participation to the matches interrupted for less than 1 week, injuries requiring more than 1 week but less than 1 month of absence as moderate, and injuries requiring more than 1 month of absence as major injury.16 The type of injuries was classified as soft tissue injury, fracture and other. The side of the injury, anatomical site and related tissue were recorded in detail. In addition, the mechanism of injury was recorded as contact and noncontact. Whether the injury occurred as a result of a rule violation and the party who committed the rule violation were recorded. The presence of recurrence was also recorded by medical staff.

Statistical Analysis

Data were analysed using IBM SPSS Statistics Standard Concurrent User Version 24 (IBM Corp., Armonk, New York, USA). Categorical variables were expressed as percentages. Categorical analysis of nominal data was performed using the Chi-square test. A p-value less than 0.05 was considered statistically significant.

RESULTS

Data were analysed from 38 male athletes with a mean age of 28±4.55 (19-38). When the last 3 football seasons were examined it was found that 43 matches were played in the 2019-2020 season, 44 matches in the 2020-2021 season, and 47 matches in the 2021-2022 season. The injury rate per match had increased to levels of 0.53, 0.70, and 1.08, respectively. In the comparison between seasons, there were significant differences in the rates of injury severity, injury location, injured tissue ($p<0.05$), injury mechanism, and rule violation ($p<0.001$). Table presents the comparison of injury data for seasons.

Table Compare injury data by season

		2019-2020 Season	2020-2021 Season	2021-2022 Season	p
		Total number of injuries (%)			
Injury time	Training	10 (43.5)	12 (38.7)	16 (31.4)	0.569
	Match	13 (56.5)	19 (61.3)	35 (68.6)	
Injury severity	Minor	8 (34.8)	22 (71)	34 (66.7)	0.036*
	Moderate	11 (47.8)	5 (16.1)	14 (27.5)	
	Major	4 (17.4)	4 (12.9)	3 (5.9)	
Injury type	Sprain	3 (13)	6 (19.4)	11 (21.6)	0.315
	Strain	13 (56.5)	15 (48.4)	34 (66.7)	
	Fracture	1 (4.3)	2 (6.5)	1 (2)	
	Other	6 (26)	8 (25.8)	5 (9.8)	
Injury location	Foot	2 (8.7)	0	0	0.014*
	Ankle	1 (4.3)	4 (12.9)	7 (13.7)	
	Calf	3 (13)	2 (6.5)	6 (11.8)	
	Knee	4 (17.4)	5 (16.1)	6 (11.8)	
	Thigh	13 (56.5)	11 (35.5)	16 (44,4)	
	Hip	0	3 (9.7)	2 (3.9)	
	Groin	0	3 (9.7)	13 (25.5)	
	Lumbal	0	2 (6.5)	0	
	Shoulder	0	1 (3.2)	1 (2)	
Injured tissue	Muscle	15 (65.2)	17 (54.8)	33 (64.7)	0.039*
	Tendon	0	1 (3.2)	3 (5.9)	
	Tendon bone junction	1 (4.3)	1 (3.2)	0	
	Capsule	2 (8.7)	2 (6.5)	1 (2)	
	Limatchnt	1 (4.3)	6 (19.4)	12 (23.5)	
	Bone	1 (4.3)	2 (6.5)	2 (3.9)	
	Aponeurosis	0	2 (6.5)	0	
	Meniscus	3 (13)	0	0	
Injured side	Left	13 (56.5)	14 (45.2)	22 (43.1)	0.793
	Right	10 (43.5)	17 (54.8)	27 (52.9)	
	Bilateral	0	0	1 (2)	
Injury mechanism	Noncontact	13 (56.5)	21 (67.7)	48 (94.1)	<0.001*
	Contact	10 (43.5)	10 (32.3)	3 (5.9)	
Rule violation	No	14 (60.9)	26 (83.9)	50 (98)	<0.001*
	Yes	0	2 (6.5)	1 (2)	
	Opponent	9 (39.1)	3 (%9.7)	0	
Recurrence	Yes	1 (4.3)	3 (9.7)	1 (2)	0.290
	No	22 (95.7)	28 (90.3)	50 (98)	

Most of the injuries happened during the matches. Moderate injuries were more common in the pre-pandemic season (47.8%), while minor injuries were more common after the pandemic (71%) and post-pandemic seasons (66.7%). Although strain was the most common type of injury in all seasons, this rate decreased by 8.1% in the pandemic season and increased by 10.2% in the post-pandemic season. The thigh was the most injured area in all three seasons, but this rate decreased in the pandemic season.

While there were no lumbal injuries in the pre-pandemic and post-pandemic seasons, back injuries occurred at a rate of 6.5% in the pandemic season. Also while there were no groin injuries in the pre-pandemic period, its' rate had increased during (9.7%) and after the pandemic period (25.5%).

The muscle was the most injured tissue in all seasons, but the rate decreased in the pandemic season. While the contact injury rate was 43.5% in the 2019-2020 season, it decreased to 32.3% in the pandemic and 5.9% post-pandemic season. On the other hand, non-contact injuries were observed to increase at the opposite rate. And while rule violation was the least in the pre-pandemic season (60.9%), it was the highest in the post-pandemic season (98%). The recurrence rate (9.7%) was higher during the pandemic season. Table presents the comparison of injury data for seasons.

DISCUSSION

Using a professional football team in Turkiye as an example, this study compared injury data from the pre and post-pandemic seasons in football players who faced isolation, new season and match rules, uncertainties and stress brought by the pandemic. It is the first study to compare the injuries of a football team in the Turkish Super League before and after the COVID-19 season. As the 2020-2021 matches, all of which coincided with the pandemic period, were held with a tighter schedule, an increase in the number of injuries and injury rate per match was expected. This rate increased during the pandemic and continued to increase after the pandemic.

Many experts in the literature have predicted that injuries will increase after the pandemic returns to the league.[1,7] However, some studies conducted during this period have also shown that injuries can be reduced when returning to the season after isolation and quarantine.[17,18] Bisciotti et al.[1] stated that after the COVID-19 pandemic, in returning to the season in football, important problems such as loss of performance, increased risk of injury, and the consequences of systemic changes may be encountered due to the lack of training brought about by social isolation measures. Mannino et al.[19] on the other hand stated that injuries increased in the 2020-2021 season affected by the pandemic, and the reason for this could be a tight fixture. The results of this study also support this situation. On the contrary, Lorentsen et al.[20] reported that there was no difference between seasons in terms of injury severity, number of days lost, or number of missed matches, and that a tight match schedule could be a reliable alternative for future seasons, based on the data they obtained from 8 football teams. Increasing the number of substitutions during the match from three to five with the decisions taken by the International Association of Football Federations (FIFA) has also been stated as another factor that may be effective in reducing the incidence of injury during the pandemic period.[17]

Seshadri et al.[14] stated that the rate of injury per match increased. Krutsch et al.[17] stated that the injuries of football players in the German league did not increase with the return after the pandemic rather the injury rates decreased. They stated that the reason for this was the effect of continuing the training and albeit individually. Although this seems to affect the injuries positively, the training conditions that each player has for their home environment may not be sufficient. Although the players in our study also train at home during the break, it is seen that this does not have a positive contribution to the process. Therefore, the effects of individual or home training in this process are controversial.

In a study conducted with the players in the Italia Serie A-League, the most moderate injuries were seen in the pre-pandemic and post-pandemic seasons.[21] Similarly, in our study, while moderate injuries were higher before the pandemic, minor injuries were more common during and after the pandemic. Considering the mechanism of injury, non-contact injuries had increased. This increase may affect the severity of the injury and cause more minor injuries.

While hip injuries were more common before the pandemic, knee injuries were more common in matches played after isolation according to Krutsch et al.[17] Hip injuries were the most common injury in all three seasons in the current study.

This was followed by the groin, knee, and calf regions. Therefore, in the periods played with tight fixtures, more positive results can be obtained in terms of injury rates by evaluating and following complex regions such as hips, groin, knees, and calves in terms of injury risk. In the study of Seshadri et al.[14] muscle injuries were seen in German football league players mostly when returning to football after quarantine. Similarly, in our study, the most common injury was muscle injury every season, while this rate was less in the pandemic season. However, there was an increase again in the post-pandemic season. We think that the reason for this situation may be the result of the reflection of the injury of the muscle groups that were forced in the pandemic to the next season.

Limitations

To our knowledge, this study was the first one to compare the injuries of a football team in the Turkish Super League in the pre-and post-COVID-19 season. And this is a strength of our study. This research, which was conducted with data from a Super League-level team from Turkiye, supports these results from the literature. But our study has also limitations. The main limitation of our study is the analysis of results specific to a single team. Another limitation is that the number of studies we can discuss our study is limited. We recommend that the results be supported by studies involving more football teams. It should also be considered that football will not only be affected by the specified evaluation parameters but may be affected by many factors such as stress factors, technical teams, medical teams, training methods, season-specific goals, and success situations.

CONCLUSION

The rate of injuries per match had increased thorough and after the pandemic seasons. The detraining caused by the isolation period from the pandemic and tight match fixtures may be the ones to blame for this outcome. Also between the pre and post-pandemic seasons the rates of injury severity, injury location, injured tissue, injury mechanism, and rule violation differed significantly.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Ethics Committee of Gazi University (Date: 26.04.2021, Decision No: E.80609).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Case Report

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A rare case with atypical findings: schwannoma of the radial nerve

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ABSTRACT

A 53-year-old male complained of weakness in the dorsum of the 5-4-3rd fingers of the right hand. The musculus extensor digitorum communis was heavy and the musculus extensor indices proprius was light involved in the needle electroneuromyography study. Radial nerve ultrasonography showed a mass (schwannoma) which located on the radial nerve course after the lateral epicondyle at the elbow level. In conclusion, we should consider radial nerve schwannoma in patients with radial nerve injury and when there is an atypical involvement of the muscles innervated by the radial nerve, we should utilize ultrasonography for evaluation.

Keywords: Schwannoma, radial nerve, electromyography, ultrasonography

INTRODUCTION

Schwannomas are the most common tumors of peripheral nerves composed of neural crest-derived Schwann cells. They are benign and generally solitary.[1,2] Sometimes there can be multiple lesions associated with neurofibromatosis. They usually grow slowly and the diagnosis is delayed and difficult as neuronal adaptation develops.[2] Schwannomas are located at the the flexor surfaces of the upper and lower extremities.[3,4] The radial nerve's schwannomas at the extensor compartment are very rare.[4] Herein, we present a rare case of schwannoma of the radial nerve presenting with finger weakness and atypical examination and EMG findings.

CASE

A 53-year-old male complained of numbness in the dorsum of the 5-4-3rd fingers of the right hand 3 years ago. Weakness was added to the complaint of numbness over time. The patient had no history of trauma. The extansor carpi ulnaris, extansor indicis proprius and abductor pollicis brevis muscle strengts were found 4/5 (according to the Medical Research Council Muscle Strength Scale). The extansor digitorum communis muscle strength was found 1/5. In sensorial examination, Right C6-7-8 ve T1 dermatoms were hypoestesic. Deep tendon reflexes were normoactive and there were no pathologic reflexes. Electrophysiologic study was made for the diagnosis. In right radial superficial nerve sensory nerve conduction study, sensory nerve conduction velocity was decreased and the sensory nerve action potential amplitude was reduced. Also in right radial nerve motor nerve conduction study, nerve conduction velocity was decreased and the motor nerve action potential amplitude was reduced. Right median nerve motor and sensory nerve conduction studies were shown that he had moderate carpal tunnel syndrome. Right ulnar nerve motor and sensory nerve conduction studies were normal. Needle electromyography (EMG), findings were summarized in Table. EMG revealed chronic damage to the right radial nerve after it branches to the musculus extensor radialis longus and moderate carpal tunnel syndrome. Since the patient's musculus extensor digitorum communis strength (according to the Medical Research Council (MRC) Muscle Strength Scale) was 1/5 and the musculus extensor indices proprius strength was 4/5 and the musculus extensor digitorum communis was heavy involved and the musculus extensor indices proprius was light involved in the needle EMG study, radial nerve ultrasonography (USG) was performed because of the suspicion about the etiology of radial nerve injury. Ultrasonographic examination showed a mass which located on the radial nerve course after the lateral epicondyle at the elbow level (Figure-1a and 1b). Contrast-enhanced Magnetic resonance imaging (MRI) of the patient revealed a lesion in the right radial nerve with a diameter increase of approximately 2 cm in the proximal part of the antecubital region, isointense on T1-weighted MRI (Figure-2a), hyperintense on T2-weighted fatsat MRI (Figure-2b), with marked contrast enhancement in the post-contrast series (Figure-2c), and the lesion was primarily evaluated in favor of schwannoma.

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Table 1. The needle EMG findings of case

Right	Extansor indicis proprius	Extansor digitorum communis	Extansor carpi ulnaris	Extansor Carpi radialis longus	Brachioradialis	Triceps brachi	Abductor pollicis brevis	First dorsal interosseus
Spontaneous activity								
Abnormal spontaneus activity	-	-	-	-	-	-	-	-
MUAP analyses								
Amplitude (Mv)	0.5-5	0.5-5	0.5-5	0.5-3	0.5-3	0.5-3	0.5-5	0.5-3
Duration (msec)	5-19	5-19	5- 9	5-15	5-15	5-15	5-19	5-15
Polyphasic MUAP ratio	Normal	increased	Normal	Normal	Normal	Normal	Normal	Normal
Recruitment pattern	↓	↓↓↓	↓↓	Normal	Normal	Normal	↓	Normal

(-): No abnormal spontaneous activity; (+): Abnormal spontaneous activities, MUAP: Motor unit action potential, Abnormal values are written in bold

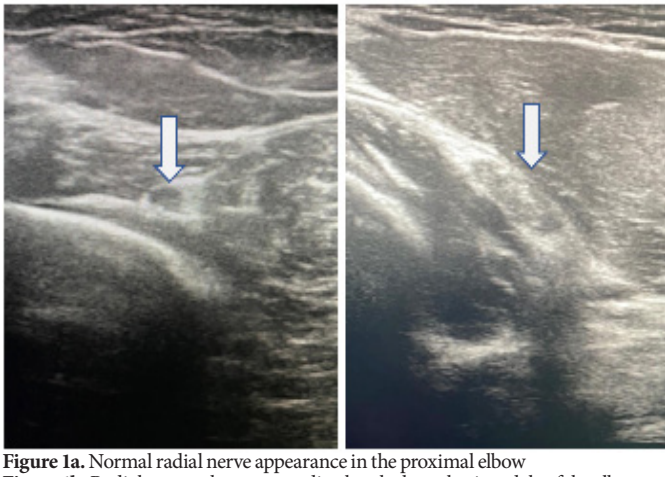

Figure 1a. Normal radial nerve appearance in the proximal elbow
Figure 1b. Radial nerve schwannoma distal to the lateral epicondyle of the elbow

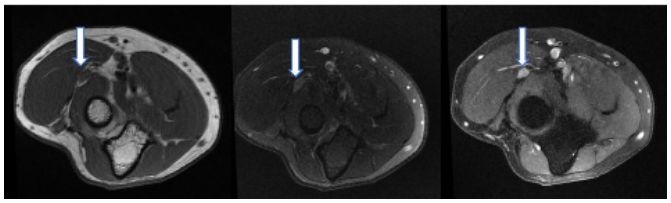

Figure 2a. The lesion is isointense on T1-weighted MRI
Figure 2b. The lesion is hyperintense on T2-weighted fatsat MRI
Figure 2c. The lesion is with marked contrast enhancement in the post-contrast series

DISCUSSION

Here, we report a rare case of radial nerve schwannoma presenting with weakness in the extensor muscles of the hand fingers, diagnosed by ultrasonography and EMG. The schwannoma is usually seen in 30 to 60 years old patients and our patient was in the common age range reported in the literature.[5] The frequency of radial schwannomas is 7% but in the literature, there is a few case reports.[6] According to the literature, median and ulnar nerve schwannomas are the most common peripheral nerve schwannomas.[7,8] Pain and paresthesia are generally seen as the symtoms.[4] Our patient had no pain and he had numbness and serious weakness. Patients with schwannomas can be delayed up to 37 years in being diagnosed and undergoing surgery.[5] Pertea et al.[8] reported that their patients had symtomps since 2-5 years. Our patient was diagnosed in the 3rd year after the onset of symptoms. If our case had not had weakness in hand muscle strength, it may have been diagnosed later or not diagnosed at all. Like the other tumoral lesions, USG and MRI are useful for diagnosis of schwannomas. Schwannomas are homogeneous, hypoechoic lesions and origin the nerve on USG.[9] On MRI, schwannomas are seen as bright in T2-weighted images similar to our case.[10] Perhaps we performed EMG 3 years later, after the beginning of symptoms, any abnormal spontaneous activity was not found in our case. But there were chronic dennervation findings in extansor digitorum communis, extansor carpi ulnaris and extansor indicis proprius muscles.

Radial nerve schwannomas in the literature, usually presented with pain and paresthesia and were diagnosed by MRI or USG. Unlike the literature, our case presented with slowly developing paresthesia followed by weakness. There are few cases of schwannomas with clearly defined EMG findings in literature. Depending on the way the tumor involves the nerve fiber, the EMG may be completely normal. In this case, the heavy involvement of the extensor digitorum communis muscle and the lighter involvement of the extensor indis proprius muscle seem to be related to the invasion of the tumor to the nerve fibers. We think that this case contributes to the literature because of the difference in symptoms, examination and EMG findings and the inclusion of detailed EMG findings. It is also one of the cases showing that ultrasonography is very important in the differential diagnosis of nerve lesions. In this respect, it makes a significant contribution to the literature.

CONCLUSION

In this case, we present a rare case of radial schvannoma. This case showed us that we should consider radial nerve schwannoma in patients with radial nerve injury but atypical involvement of the muscles innervated by the radial nerve on neurologic examination and EMG findings, we should utilize ultrasonography of the radial nerve in the evaluation of such patients.

ETHICAL DECLARATIONS

Informed Consent

Patient signed the free and informed consent form.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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