



# Trunk position sense, postural stability, and spine posture in fibromyalgia

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## Abstract

This study aimed to investigate trunk position sense, postural stability, and spine posture in women with fibromyalgia syndrome (FMS). Fifteen (15) women with FMS and age- and gender-matched fifteen (15) healthy controls were included. Trunk position sense as indicated by trunk reposition errors (TRE) and spine posture (thoracic and lumbar curvature) was measured with a digital inclinometer. Postural stability [eyes open (EO) and eyes closed (EC) on bipedal stance (BS), EO on monopodal stance (MS), and limits of stability (LOS)] was assessed with a computerized stabilometer (Prokin, Tecno-Body S.R.L., Dalmine, 24044 Bergamo, Italy). TRE ( $p=0.002$ ) and the angle of thoracic curvature ( $p=0.009$ ) were found higher in women with FMS compared to healthy controls; however, the angle of lumbar curvature was similar ( $p=0.467$ ). It was seen that women with FMS had higher anterior–posterior sway in EO-BS ( $p=0.009$ ) and EC-BS ( $p=0.001$ ), ellipse area in EC-BS ( $p=0.015$ ), EO-MS of the dominant side ( $p=0.021$ ), and EO-MS of the non-dominant side ( $p=0.007$ ), and medial–lateral sway in EO-MS of the dominant (DM) side ( $p=0.004$ ) and the non-dominant (NDM) side ( $p=0.002$ ). Ellipse area in EO-BS ( $p=0.054$ ), medial–lateral sway in EO-BS ( $p=0.983$ ) and EC-BS ( $p=0.290$ ), anterior–posterior sway in EO-MS of the DM ( $p=0.059$ ) and the NDM side ( $p=0.065$ ), and LOS did not differ between groups ( $p=0.274$ ). Women with FMS had poor trunk position sense and postural instability, and alterations in spine posture. Therefore, the training of trunk position sense, postural stability, and posture might be beneficial and, thus, should be considered while planning an optimal treatment.

**Keywords** Fibromyalgia · Position sense · Postural balance · Spinal curvature · Trunk

## Introduction

Fibromyalgia syndrome (FMS) is an idiopathic chronic condition characterized by persistent widespread pain, fatigue, sleep disorders, cognitive impairment, and emotional disturbances including anxiety and depression [1–3]. Symptoms associated with FMS have a substantial negative impact on daily activities and social and occupational function, resulting in a decrease in the quality of life of patients with FMS [2]. FMS is a worldwide problem and more prevalent among women. The prevalence of FMS is between 0.2 and 6.6% in the general population, whereas it varies in a range of 2.4–6.8% in women [4].

The trunk is the central key point of the body, playing an essential role for postural control, balance, the coordination of the extremities, and functional activities [5–7]. Therefore, the trunk is an important component of the rehabilitation process [6]. Spinal alignment of the trunk is associated with position sense [8]. Trunk position sense, one component of

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proprioception, is the ability to position the trunk between determined reference points in the sagittal plane [7, 9]. Trunk position sense is known to be important for postural control, balance, and fall avoidance [7, 9]. Although balance disorders and falls are increasingly observed in patients with FMS [10], to the best of the authors' knowledge, trunk position sense in FMS has not been considered in the literature.

Balance is a multifaceted task involving the integration of multidirectional sensory (somatosensory, visual, and vestibular), motor, and cognitive inputs to carry out appropriate neuromuscular activities needed to maintain postural stability [11]. In a survey of 2596 people with FMS, balance disorder was reported to be one of the most common symptoms with a reported prevalence of 45% [12]. It is predicted that sensory deficit and cognitive impairment as well as clinical symptoms, such as pain, sleep problems, fatigue, depression and anxiety, muscle weakness, may cause balance disorders [10, 13–16]. The limits of stability (LOS) test, one of the components of postural stability assessment, evaluates the volitional control of the center of gravity [17]. The LOS test is essential because it provides predictable information regarding the possible risk of falling [18]. Although balance disorders and falls are well known, just a few studies have focused on investigating the LOS in FMS [10, 19]; moreover, the results of these studies were contradictory.

One of the major symptoms of FMS is chronic pain [1, 3]. Pain was associated with postural abnormalities [20], which have been demonstrated in previous studies in various populations, such as in patients with neck pain [21] and rheumatoid arthritis [22]. Sempere-Rubio et al. [23] reported that women with FMS present with an altered trunk posture and an inability to maintain the trunk position. However, they indicated that the lumbar spinal curvature should be investigated to explore the contribution of possible restrictions of the lower body to hyperkyphosis [23]. Therefore, one of the aims of this study was to compare lumbar curvature in FMS patients with that in healthy people.

There are few studies investigating various parameters related to the trunk, such as trunk muscle endurance and flexibility, in FMS [16, 24]. Studies in which other parameters of the trunk are evaluated in FMS are scarce. Therefore, the aim of this study was to investigate trunk position sense, postural stability, and spine posture in women with FMS.

## Methods

### Design

The study was designed as a case–control study. The study design was approved by the ethics committee of Ankara Yildirim Beyazit University (Approval number: 43/43). Prior to evaluations, the participants read and signed a consent

form, which was also approved by the ethics committee. The study was performed in compliance with the Helsinki Declaration, where applicable. The study protocol was also registered at <http://clinicaltrials.gov> (NCT0757702).

### Participants

The study was performed in women in the age range of 18–65, diagnosed with FMS according to the American College of Rheumatology criteria [3]. In addition, age- and gender-matched healthy controls without any musculoskeletal or rheumatologic complaints were included in the study. Women with FMS experiencing moderate to severe pain were enrolled from outpatient rheumatology clinics between July 2018 and December 2018 and healthy controls were recruited from the community. In the FMS group, women with any of the following conditions were excluded from the study: neurologic, infectious, endocrine, or any other severe psychological disorders, malignancy, being pregnant, any condition interfering with evaluations (advanced respiratory or orthopedic problems such as fracture, sprain or strain, spine surgery, and inflammatory rheumatic diseases), doing regular exercise, and not being volunteer. Controls were also excluded if they had complaints of any musculoskeletal, neurological, rheumatologic disorders, or any condition interfering with evaluations (advanced respiratory or orthopedic problems, such as fracture, sprain or strain, spine surgery) during the previous 12 months, if they were pregnant or doing regular exercise, or they did not volunteer to participate.

### Measurements

Demographic and physical characteristics (age, height, weight, education years) and medication use were recorded. The level of pain was assessed using a visual analog scale (VAS). Women with FMS were asked to mark their perceived pain level on a 10-cm VAS, where 0 indicated “no pain” and 10 indicated “unbearable pain”.

### Trunk position sense

Trunk position sense, as indicated by trunk reposition errors (TRE), was assessed with a digital inclinometer (Acumar<sup>®</sup>, Dual Digital Inclinometer, Lafayette Instrument Company, IN, USA) [25]. The participants were asked to stand upright in a comfortable position. The inferior angle of the scapula was first palpated as a bony landmark to find the spinous process of T4. After the placement of the inclinometer over the spinous process of T4, the participants were asked to flex the trunk approximately 30° in the sagittal plane and hold this position for 3 s in eyes closed position. After returning to the neutral upright position, they were asked to duplicate

the previously attained position and held the position for 3 s for five times in a row. The absolute differences between the original position and the other five attempts were recorded. The highest and lowest scores were discarded and the mean of the tree remaining scores was used to assess the trunk position sense.

### Postural stability

Postural stability was assessed with a stabilometric platform (Prokin, TecnoBody S.R.L., Dalmine, 24044 Bergamo, Italy), which is a force platform that assesses postural sway off the center of pressure. First, the tests were explained to the participants and then the device was calibrated according to each participant's age, height, and body mass.

To assess postural stability in bipedal stance (BS), the participants stood barefoot on the platform in a standardized position according to *x*-axis and *y*-axis and were asked to look straight at the computer screen and keep their arms at their sides. All participants completed two tests, 30 s each, in the eyes open (EO) and closed (EC) positions, respectively. The ellipse areas indicating the overall postural stability (measured in mm<sup>2</sup>), anterior–posterior sway (measured in mm<sup>2</sup>), and medial–lateral sway (measured in mm<sup>2</sup>) were recorded.

To assess postural stability in a monopodal stance (MS), participants were instructed to stand unassisted on one leg while the other leg was flexed off the floor. All participants completed two tests, 30 s each on the dominant (DM) and non-dominant (NDM) legs, respectively. The ellipse area (measured in mm<sup>2</sup>), anterior–posterior sway (measured in mm<sup>2</sup>), medial–lateral sway (measured in mm<sup>2</sup>) were recorded.

To assess the LOS, the participants were asked to move a cursor as quickly and accurately as possible from the center of a computer screen to one of the eight targets, which were positioned at 45° intervals around the center and highlighted one by one. Participants were instructed to keep their body in a straight line during the test and return to the center before the next target is displayed on the screen. The test was completed when all eight targets have been displayed. The percentage of how much the participants reached the highlighted eight targets was recorded.

### Spine posture

Thoracic curvature test was performed with a digital inclinometer (Acumar®, Dual Digital Inclinometer, Lafayette Instrument Company, IN, USA) according to the protocol described by Lewis et al. [26]. Prior to testing, all participants were asked to swing their arms slowly backward and forward by their sides in standing position to find a natural and comfortable position. The same standardized

verbal instructions were given to each participant. The 7th cervical vertebra, the most prominent spinous process, and the sacrum were used as reference points to palpate the spinal processes of T1–T2 and T12–L1, respectively. The feet of the inclinometers were placed as simultaneously as possible over T1–T2 and T12–L1. The angle on the digital display of the inclinometer was recorded as degree. The mean of three successful measurements was used.

Lumbar curvature test was performed with a digital inclinometer (Acumar®, Dual Digital Inclinometer Lafayette Instrument Company, IN, USA) according to the protocol described by Ng et al. [27]. Prior to testing, all participants were asked to stand erect in a relaxed position with their feet about shoulder width apart and their arms by their sides, looking straight ahead. The same standardized verbal instructions were given to each participant. The sacrum and iliac crest were used as reference points to palpate the spinal processes of T12–L1 and L5–S1, respectively. The feet of the inclinometers were placed as simultaneously as possible over T12–L1 and L5–S1. The angle on the digital display of the inclinometer was recorded in degrees.

### Statistical analysis

Sample size calculation made using a statistical power analysis program (G\*Power Version 3.0.10, Franz Faul, Universität Kiel, Germany) indicated that 15 participants for each group were adequate to detect a large effect of Cohen's  $d=1.38$  with an alpha error probability of 0.05 and power of 95%. The result of trunk position sense test was used to estimate the sample size. Data analysis and calculations were conducted using IBM SPSS Statistics 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0., Armonk, NY: IBM Corp.) and MS-Excel 2007. An overall  $p$  value of less than 0.05 was considered to show a statistically significant result.

The variables were investigated using visual (histograms, probability plots) and analytical methods (Shapiro–Wilk test) to determine whether they were normally distributed. Descriptive statistics were calculated for all variables and normally distributed data were shown as mean  $\pm$  standard deviation (SD), non-normal distributions were shown as median (minimum–maximum), and ordinal variables were shown as frequency and percentage. While the age, BMI, trunk position sense, LOS, and thoracic and lumbar spinal curvature parameters were normally distributed, postural stability parameters and education years were not normally distributed. To compare the group differences, the independent samples  $t$  test was used for normally distributed data, and the Mann–Whitney  $U$  test was used for not normally distributed data.

## Results

Thirty-five participants were assessed for eligibility. Five of them were excluded due to various reasons. A relevant flowchart was constructed to detail the enrollment process (Fig. 1). The study was completed with 15 patients with FMS and 15 age- and gender-matched control, with a total of 30 participants. The physical and demographic characteristics of the participants are presented in Table 1. There were no differences between the groups in terms of physical and demographic characteristics ( $p > 0.05$ ) (Table 1). The mean pain level was  $7.67 \pm 1.48$  cm as reported by the FMS group. Four of the fifteen (26.7%) patients reported that they had been using analgesic medicine, eight of the fifteen (53.3%) patients had been using anti-depressant, and three of the fifteen (20.0%) patients had not used any medicine prior to the study.

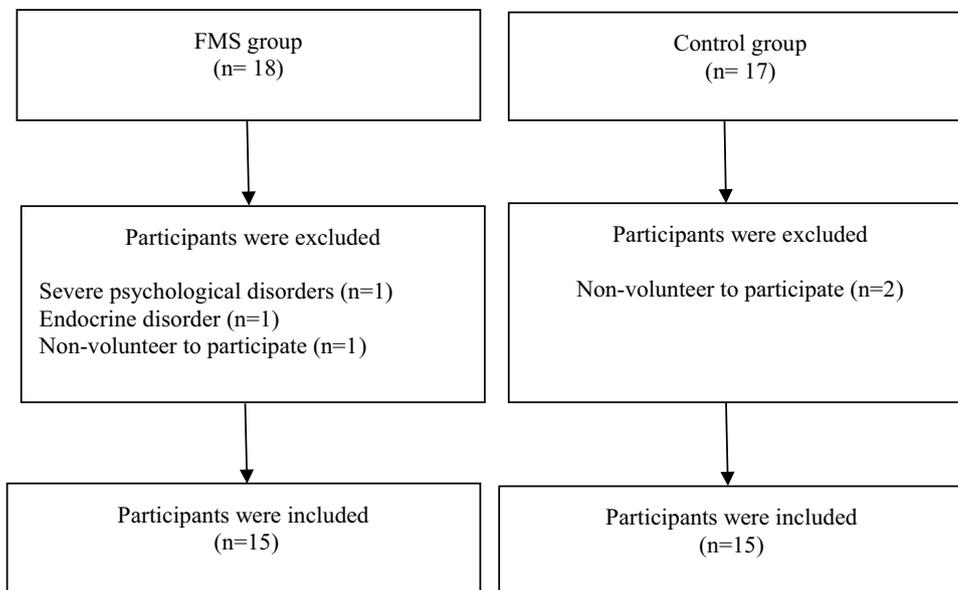
Comparisons of trunk position sense, postural stability, and posture are shown in Table 2. TRE, in which higher scores indicate poorer trunk position sense, was higher in the FMS group compared to the control group ( $p = 0.002$ ). Of the postural stability parameters, ellipse area in EC

position ( $p = 0.015$ ) and anterior-postural sway in EO and EC positions ( $p = 0.009$ ,  $p = 0.0001$ , respectively) during bipedal stance (BS), and ellipse area for DM and NDM legs ( $p = 0.021$ ,  $p = 0.007$ , respectively) and medial-lateral sway for DM and NDM legs ( $p = 0.004$ ,  $p = 0.002$ , respectively) increased in the FMS group in comparison to the control group. Ellipse area in EO position ( $p = 0.054$ ), medial-lateral sway in EO and EC positions during BS ( $p = 0.983$ ,  $p = 0.290$ , respectively), anterior-posterior sway for DM and NDM legs ( $p = 0.059$ ,  $p = 0.065$ , respectively) during monopodal stance (MS), and LOS were not significantly different between the groups ( $p = 0.274$ ). The degree of thoracic curvature was higher ( $p = 0.009$ ) in the FMS group compared to controls whereas the degree of lumbar lordosis was not significantly different between the groups ( $p = 0.467$ ).

## Discussion

Our study yielded the following major findings: Compared to controls, women with FMS had poorer trunk position sense and higher degrees of thoracic curvature. In addition, the

**Fig. 1** Flowchart of the study



**Table 1** Physical and demographic characteristic of participants

Characteristics	FMS group (n = 15)	Control group (n = 15)	p
Age (year, mean $\pm$ SD)	39.7 $\pm$ 10.5	39 $\pm$ 6.9	0.824 <sup>a</sup>
BMI (kg/m <sup>2</sup> , mean $\pm$ SD)	24.6 $\pm$ 3.4	23.8 $\pm$ 2.1	0.419 <sup>a</sup>
Education (years, median; min–max)	12.0; 5.0–16.0	8.0; 5.0–16.0	0.359 <sup>b</sup>

FMS fibromyalgia syndrome, BMI body mass index, SD standard deviation, Min–max minimum–maximum

<sup>a</sup>Independent sample *t* test

<sup>b</sup>Mann–Whitney *U* test

**Table 2** Comparison of trunk position sense, postural stability and posture of the groups

Characteristics	FMS group ( <i>n</i> =15)	Control group ( <i>n</i> =15)	<i>p</i>
Trunk position sense (TRE)	3.64 ± 2.36	1.51 ± 0.60	0.002* <sup>a</sup>
Postural stability			
Bipedal			
EO			
Ellipse area [mm <sup>2</sup> , median (min; max)]	337.07 (86.32; 1983.68)	176.93 (57.60; 1894.52)	0.054 <sup>b</sup>
Anterior–posterior sway [mm <sup>2</sup> , median (min; max)]	6.19 (3.72; 17.94)	4.59 (1.83; 9.14)	0.009* <sup>b</sup>
Medial–lateral sway [mm <sup>2</sup> , median (min; max)]	2.99 (1.31; 6.34)	2.49 (1.95; 11.70)	0.983 <sup>b</sup>
EC			
Ellipse area [mm <sup>2</sup> , median (min; max)]	314.73 (118.18; 1064.99)	210.39 (56.85; 553.29)	0.015* <sup>b</sup>
Anterior–posterior sway [mm <sup>2</sup> , median (min; max)]	6.40 (4.34; 13.48)	4.54 (2.07; 8.50)	0.001* <sup>b</sup>
Medial lateral sway [mm <sup>2</sup> , median( min; max)]	2.38 (1.44; 8.27)	2.42 (0.87; 4.15)	0.290 <sup>b</sup>
Monopedal			
DM			
Ellipse area (DM) [mm <sup>2</sup> , median (min; max)]	1103.70 (335.69; 4358.65)	521.78 (281.29; 1845.67)	0.021* <sup>b</sup>
Anterior–posterior sway [mm <sup>2</sup> , median (min; max)]	9.51 (4.71; 19.43)	6.41 (4.30; 15.67)	0.059 <sup>b</sup>
Medial–lateral sway [mm <sup>2</sup> , median (min; max)]	7.02 (4.17; 11.91)	4.27 (3.39; 6.40)	0.004* <sup>b</sup>
NDM			
Ellipse area (NDM) (mm <sup>2</sup> , mean ± SD)	1132.30 ± 523.47	667.17 ± 322.89	0.007* <sup>a</sup>
Anterior–posterior sway [mm <sup>2</sup> , median (min; max)]	8.39 (5.43; 18.72)	6.52 (4.20; 12.89)	0.065 <sup>b</sup>
Medial–lateral sway (mm <sup>2</sup> , mean ± SD)	6.31 ± 1.59	4.67 ± 0.93	0.002* <sup>a</sup>
Limits of stability (%)	82.72 ± 7.56	85.45 ± 5.66	0.274 <sup>a</sup>
Spine posture			
Thoracic curvature (°, mean ± SD)	40.20 ± 7.37	33.26 ± 6.11	0.009* <sup>a</sup>
Lumbar curvature (°, mean ± SD)	13.73 ± 4.81	12.40 ± 5.08	0.467 <sup>a</sup>

EO eyes open, EC eyes closed, DM dominant, NDM non-dominant, TRE trunk reposition error, FMS fibromyalgia syndrome, SD standard deviation

\**p* < 0.05

<sup>a</sup>Independent samples *t* test

<sup>b</sup>Mann–Whitney *U* test

overall postural stability during BS and MS, anterior–posterior sway during BS, and medial–lateral sway during MS decreased in women with FMS.

Position sense plays a fundamental role in human movement, and it is crucial for daily activities, exercises, and sports [28]. In women with FMS, position sense has been investigated in different studies focusing on neck and knee joints [29, 30]. Although not significant differences have been reported for knee position sense, neck proprioception deficits have been shown between patients with FMS and healthy controls. The present study also focused on trunk position sense considering its effects on trunk stability for balance, coordinated functional extremity movements, and the risk of falling [7, 9] and our findings showed that women with FMS had poorer trunk position sense compared to controls. Especially, the decrease in proprioception or position sense related to neck and trunk may be due to the frequent axial pain in FMS and intense trigger points in these areas. Moreover, any dysfunction in a proximal area may also

cause an altered energy transfer and dysfunction in distal areas, which highlights the importance of proximal stability, such as trunk stability [31]. Due to the fact that postural instability and fall were increasingly observed in FMS [10], the addition of trunk position sense training to rehabilitation programs might be effective in decreasing the number of falls and improving postural stability in women with FMS.

Over the years, the postural stability of patients with FMS has been the topic of numerous studies in which different methods or tools, such as computerized systems [10, 14], clinical tests [16], or scales [32], have been used. Our results are consistent with these studies and indicate that patients with FMS have an altered postural stability. In addition, similar to our study, Trevisan et al. [15] conducted a study to determine the static postural sway of women with or without FMS in which posturography was used for assessment. They also reported a decreased overall postural stability and increased anterior–posterior sway in EO and EC positions during BS in the FMS group. Increased thoracic curvature

of the women with FMS, as seen in the present study, might have caused an increased anterior–posterior sway in BS. However, during MS, our findings suggested an increased medial–lateral sway instead of an anterior–posterior sway. MS might have created a new altered base of support in which balance demand was high. Various strategies might be used to maintain a tighter control of the body center of mass (CoM) above the decreased base of support, such as shifting the center of pressure and counter-rotating the segments around the CoM. While both mechanisms contribute to balance during BS, the latter contribution was shown to be considerable for MS [33]. Therefore, the fact that these strategies maintain postural stability between MS and BS might cause postural sway toward different directions. Lastly, in the literature, some studies have reported contradictory results about the LOS [10, 19]. However, our study was similar to the study of Jones et al., which suggested that there was no significant difference in the LOS between patients with FMS and healthy controls [10]. According to all these results related to postural stability, postural stability training might be added into treatment programs of women with FMS to improve functional status and decrease injuries. In addition, studies related to the LOS in FMS are also needed.

Symptoms that most of the patients with FMS complain include stiffness and pain, which are probably associated with the alteration of the posture. Adoption of postural strategies to keep the CoM within safe boundaries might include stiffening as a strategy [34]. In addition, the long-held notion that bad posture and poor postural control cause pain and trigger points, especially in the back and neck region in which FMS pain was reported to be heavily concentrated [35, 36]. Parallel to that studies that have reported increased thoracic curvature [37], Sembere-Rubio et al. [23] conducted a study suggesting that there were implications for future studies which should focus on the lumbar curvature beside the thoracic curvature. Therefore, the assessment of the lumbar curvature in addition to the thoracic curvature was included in the present study. Regarding the degree of the thoracic curvature, the FMS group showed an average increase of  $7^\circ$  compared with that of the controls in the present study. However, the lumbar spinal curvature was not different between the women with FMS and the controls. We expected that the women with FMS would have an altered lumbar curvature in addition to an increased thoracic curvature considering that thoracic and lumbar regions are biomechanically inter-related, i.e., any change in one might be caused by the postural alterations in the other region [21]. Surprisingly, the lumbar curvature of the women with FMS was not different from that of the controls. To our knowledge, this is the first study investigating both thoracic and lumbar curvature together in women with FMS. However, there exist studies investigating both thoracic and lumbar curvature

conducted in different populations. Two earlier studies [38, 39], conducted in healthy adults and students with thoracic and lumbar pain, respectively, have reported contradictory results—one showed a positive relationship [39] and consistent with the present study, and Mirbagher et al. showed no association between the thoracic and lumbar curvature [38]. According to these results, postural trainings, especially those focusing on the thoracic curvature, might be an effective way to tailor the most suited therapeutic approach to decrease pain and stiffness, and to prevent postural dysfunctions in women with FMS.

Our study has some limitations. The first limitation of the study was the sampling of women only. However, FMS can affect both genders. Therefore, our findings might not be generalized to the men with FMS. We conducted this study with only women considering that FMS is much more common among women than men. The second limitation was that even though we assessed postural stability, we did not assess the fall frequency of the participants, which may be investigated in further studies. Besides, future studies can also focus on functional activities and determine the relationship between trunk position sense, postural stability, and posture. The third limitation was that the medication use status of the patients was different and 20% of the patients had used no medication. Medication may specifically affect postural stability, which should be taken into account in further studies.

## Conclusion

Our study demonstrated that women with FMS had poor trunk position sense, postural stability, and spine posture. The multiplicity and complexity of the symptoms in women with FMS require multifaceted symptom management interventions. For this purpose, consideration of the training of trunk position sense, postural stability, and spine posture might be beneficial in optimal treatment planning.

**Author contributions** STE: the design of the work, the analysis and interpretation of data for the work OM: the design of the work, the acquisition and interpretation of data for the work. OC: the acquisition, analysis and interpretation of data for the work. DO: the interpretation of data for the work. SE: the interpretation of data for the work, the acquisition of data for the work.

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## Compliance with ethical standards

**Conflict of interest** Author Toprak Celenay, author Mete, author Coban, author Oskay, and author Erten declare that they have no conflict of interest.

**Ethical approval** Patients were informed and their informed consents were obtained prior to the study. The study design was approved by the ethics committee of Ankara Yildirim Beyazit University (approval number: 43/43).

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