



Research Article/Özgün Araştırma

Calcaneal and dorsal spur morphological and morphometric measurements; 'A radiological study'

Kalkaneal ve dorsal spur ile ayağın diğer morfolojik özelliklerinin ilişkisinin radyolojik olarak araştırılması

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Abstract

Aim: The foot is one of the most neglected parts of our body. One of the causes of foot pain is the plantar calcaneal spur (PCS), which is the bone protrusion formed under the calcaneal bone, and the dorsal spur (DS), which is seen dorsal to the calcaneus. Our study aimed to examine PCS and DS morphologically.

Materials and Methods: 235 patients with PCS were included in this retrospective study. Plantar calcaneal spur length (PCSL), plantar calcaneal spur thickness (PCST), Fowler-Philip angle (FPA), and plantar calcaneal fat tissue thickness (PCFT) with radiology in patients with the calcaneal spur, and also to classify plantar calcaneal spur (PCS) and dorsal spur (DS).

Results: Bilateral PCS was found in 57.4% of the patients. DS was found in 43.5% of the patients with right PCS and 40.3% of the patients with left PCS. Large DS types were found at a higher level in males than females. Right PCFT was found to be significantly higher in patients with PCS compared to the control group ($p=0.034$).

Conclusion: It was concluded that the majority of PCS patients had bilateral PCS, DS could be seen and there was a strong correlation between PCSL and PCST.

Keywords: Adipose tissue; Calcaneus; Heel spur; Radiography.

Öz

Amaç: Ayak, vücudumuzun en çok ihmal edilen kısımlarından biridir. Ayak ağrısının nedenlerinden biri, kalkaneal kemiğin altında oluşan kemik çıkıntısı olan plantar kalkaneal mahmuz (PCS) ve kalkaneusun dorsalinde görülen dorsal mahmuzdur (DS). Çalışmamızın amacı PCS ve DS'yi morfolojik olarak incelemektir

Gereç ve Yöntem: PCS'li 235 hasta dahil edildi. Plantar kalkaneal mahmuz uzunluğu (PCSL), plantar kalkaneal mahmuz kalınlığı (PCST), Fowler-Philip açısı (FPA) ve plantar kalkaneal yağ dokusu kalınlığı (PCFT) bakıldı ve kalkaneal mahmuzlu hastalarda plantar kalkaneal mahmuz (PCS) ve dorsal mahmuz (DS) sınıflandırmaları yapıldı.

Bulgular: Hastaların %57,4'ünde bilateral PCS bulundu. Sağ PCS'li hastaların %43,5'inde ve sol PCS'li hastaların %40,3'ünde DS bulundu. Büyük DS tipleri erkeklerde kadınlardan daha yüksek düzeyde bulundu. Sağ PCFT'nin PCS'li hastalarda kontrol grubuna göre anlamlı olarak daha yüksek olduğu bulundu ($p=0,034$).

Sonuç: PKS hastalarının çoğunluğunun iki taraflı PKS'ye sahip olduğu, DS'nin görülebildiği ve PKS ile PCS arasında güçlü bir korelasyon olduğu sonucuna varıldı.

Anahtar Kelimeler: Yağ dokusu; Kalkaneus; Topuk diken; Radyografi.

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Introduction

Bone spurs, also called enthesophytes, are found at the attachment sites of muscle to bone. These are bone growths that extend from the skeleton to the soft tissue. The most common bone spurs are the dorsal spur (DS) of the Achilles tendon in the calcaneus and the plantar calcaneal spur (PCS) of the plantar fascia.¹ PCS is defined as bone growth anteriorly from the medial calcaneal tuberosity. Its incidence in different populations varies between 11-21%.^{1,2} Obesity, pes planus, microtrauma, aging, and some specific sports activities such as running, jumping and ballet are risk factors that may contribute to the development of PC.³⁻⁵ The main symptom, usually in people over the age of 40, is increased pain along the inside of the heel. In some cases, mild swelling and erythema may be seen. The duration of symptoms can vary from a few weeks to many years.⁶

In the literature, there are studies in which the length of the plantar calcaneal spur (PCSL) was measured by computer-assisted linear measurement method on lateral calcaneal X-ray images. In these studies, PCSL was found to be associated with age and body mass index.^{7,8} It was observed that the plantar calcaneal spur thickness (PCST) was not evaluated in these studies, and the relationship on this issue was not known. In addition to these, it has been reported that ossifications observed in the Achilles tendon attachment area at the posterior edge of the calcaneus may accompany patients with PCS.⁹ These DSs can cause deformity in the calcaneus (Haglund's deformity) and be symptomatic. In the evaluation of this, the measurement of the Fowler-Philip angle (FPA) can be made.¹⁰ However, no radiological study examining the morphological relationship between ossifications detected in the posterior calcaneus and PCS has been observed. Although the shock-reducing and protective effects of plantar calcaneal adipose tissue on the plantar fascia and calcaneus are known, the relationship between plantar calcaneal fat tissue thickness (PCFT) and PCS is not clear.¹¹⁻¹³ Different classifications of PCS have been made according to various morphological

features. Among these, shape features such as vertical, horizontal, hook, and length measurement methods have been used.¹⁵ PCS has also been evaluated with the visual evaluation method in the form of small, medium, and large.¹⁶

This study aimed to radiologically investigate the relationship between PCSL, PCST, FPA, and PCFT. In addition, classification of PCS and DS was aimed.

Materials and Methods

Study population

This retrospective study included 235 patients (370 ankles) who were followed up in the Hatay Mustafa Kemal University Hospital Physical Therapy and Rehabilitation Outpatient Clinic between July 2016 and 2021. Patients were identified through the hospital electronic database using the International Classification of Diseases (ICD)-10 code M77.3 for PCS. Lateral ankle X-ray images were scanned retrospectively. Patients with no PCS, no X-ray images of the right and left feet, unclear measurement sites, previous fracture or surgery in the ankle and foot, and rheumatological disease were excluded from the study. The lateral ankle radiographs of 88 patients (135 ankles) without PCS and DS were included in the study in order to compare the FPA and PCFT values (Figure 1, Figure 2, Figure 3).

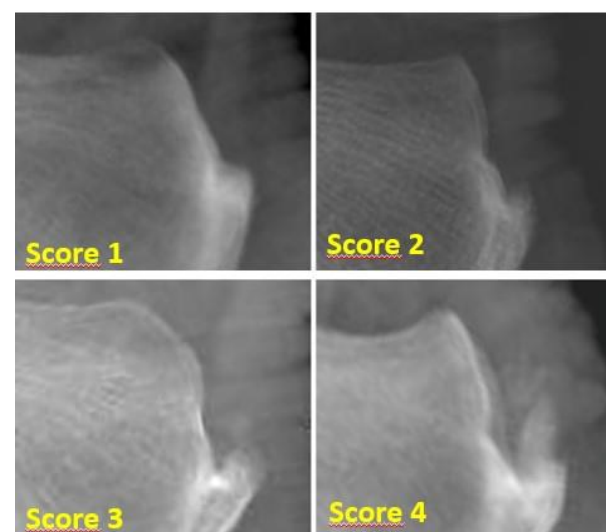


Figure 1. Classification of dorsal spur



Figure 2. Classification of calcaneal plantar spur



Figure 3. Morphometric measurements. (A: The plantar calcaneal spur thickness, B: Fowler-Philip angle, C: Plantar calcaneal fat tissue thickness)

Data collection

Age (at the time when foot radiograph was taken) and sex data of the patients were collected.

Measurements were made on lateral foot-ankle X-ray images. In the lateral X-ray images, PCST was measured from the junction of the PCS with the calcaneal tuberosity. PCSL was measured by drawing it between the midpoint of the line for the measurement of PCST and the most distal point of the spur.⁷ The angle between the posterosuperior edge of the calcaneus and the calcaneus tuberosity-inferior cuboid joint line was used for FPA measurement. In the FPA measurement, between 44° and 69° was considered normal, and 75° and above was considered in favor of Haglund's deformity.¹⁴ The shortest distance between the skin and the tip of the base of the calcaneus was measured on the lateral X-ray images for PCFT.¹¹ In accordance with the Duran et al.¹⁶ classification, PCS scores were recorded between 1-3 and DS scores between 1-4. All images were taken from foot radiographs from the PASC system by a person with at least 10 years of radiological experience. Morphometric measurements were examined by two different researchers, and in cases where a consensus could not be reached, the images were re-examined with a third researcher and an agreement was reached (Figure 2).

Statistical analysis

To estimate the sample size, the type 1 error (α) was set to 0.05 in the power analysis G Power (version 3.1.9.4) program. The test was performed at 95% power and 95% confidence intervals, and it was calculated that the hypothesis was suitable for testing. The sample confidence interval was determined as %95. It was calculated that 40 cases should be taken. Analyzes were performed using SPSS 21.0 (IBM, New York, USA) for Windows. Kolmogorov-Smirnov, Skewness, and Kurtosis were used for the normal distribution of the data¹⁷. Data determined by measurement were expressed as mean (Mean) and standard deviation (SD), while categorical variables were expressed as percentage (%). Chi-Square Test was used to calculate descriptive statistics of variation types according to lateralization. The Student's t-test was used to compare normally distributed variables between sexes, and Mann-Whitney U-test was used for non-normally distributed numerical variables.

Pearson correlation analysis was performed to evaluate the relationship between the data p -value less than 0.05 was considered to be statistically significant.

Ethics committee approval

Hatay Mustafa Kemal University Faculty of Medicine Clinical Research Ethics Committee with the ethics committee decision numbered 11/29 and dated 04.10.2021. This study conformed to the Helsinki Declaration This study conformed to the Helsinki Declaration.

Results

A total of 235 patients (168 (72%) female, 67 (28%) male) were included in the study. The mean age of the patients taking part in the study was 50.54±10.59 (25-79). 184 patients had right PCS and 186 patients had left PCS. Bilateral PCS was detected in 135 patients (57.4%). DS was detected in 80 (43.5%) patients with right PCS and 75 (40.3%) patients with left PCS. Bilateral PKS was detected at a rate of 52.2% in men and 59.5% in women (Table 1).

Table 1. Distribution of PCS and DS by sex

		Total		Male		Female		p	x ²
		N	%	N	%	N	%		
PCS	B	135	57.4	35	52.2	100	59.5	0,516	1,322
	R	49	20.9	14	20.9	35	20.8		
	L	51	21.7	18	26.9	33	19.6		
PCS	R	184	100	49	100.0	135	100.0	0.008	7.020
	L	186	100	53	100.0	133	100.0	0.023	5,137
RDS	+	80	43.5	25	51.0	55	40.7	0,905	0.014
	-	104	56.5	24	49.0	80	59.3		
LDS	-	75	40.3	22	41.5	53	39.8	0,411	0,676
	-	111	59.7	31	58.5	80	60.2		

(+: yes, -: No, N: Number of individuals, PCS: plantar calcaneal spur, DS: Dorsal spur, B: bilateral, R: right, L: left)

PCS classification scores were determined as right (1; 32.6%, 2; 42.9%, 3; 24.5%) and left (1; 30.1%, 2; 43.5%, 3; 26.3%). Left PCS score 1 was detected 39.6% in men and 26.3% in women. Left PCS score 2 was detected 47.4% in women and 34.0% in men. Right PCS score 1 was found to be 32.7% in men and 32.6% in women. Right PCS score 2 was found to be 42.9% in men and 43.0% in women (Table 2). 67.5% of patients with right DS and 62.7% of patients with left DS were in score 1 and 2

groups (Table 1, Figure 1). While DS was detected at a rate of 51.0% on the right and 41.5% on the left in men, this rate was determined as 40.7% on the right and 39.8% on the left in women. Percentage distributions of advanced scores were found to be higher in DS types in males compared to those in females. Right DS scores 3 and 4 were 48.0% in men, 25.4% in women, while left DS scores 3 and 4 were 45.5% in men and 34.0% in women (Table 2).

Table 2. Distribution of PKS and DS scores by sex

	Score	Total		Male		Female	
		N	%	N	%	N	%
RPCS (N=184)	1	60	32.6	16	32.7	44	32.6
	2	79	42.9	21	42.9	58	43.0
	3	45	24.5	12	24.5	33	24.4
LPCS (N=186)	1	56	30.1	21	39.6	35	26.3
	2	81	43.5	18	34.0	63	47.4
	3	49	26.3	14	26.4	35	26.3
RDS (N=80)	1	34	42.5	6	24.0	28	50.9
	2	20	25.0	7	28.0	13	23.6
	3	18	22.5	10	40.0	8	14.5
	4	8	10.0	2	8.0	6	10.9
LDS (N=75)	1	24	32.0	5	22.7	19	35.8
	2	23	30.7	7	31.8	16	30.2
	3	16	21.3	6	27.3	10	18.9
	4	12	16.0	4	18.2	8	15.1

(N: Number of individuals, PCS: Plantar calcaneal spur, DS: Dorsal spur, R: Right, L: Left)

PCSL was found to be 4.92±2.05 mm on the right and 5.03±2.12 mm on the left. PCST was determined as 6.56±2.19 mm on the right and 6.54±2.15 mm on the left. There was no significant difference between the patient group with PCS and the control group in the

right and left FPA measurements ($p>0.05$). While right PCFT was found to be significantly higher than the control group in patients with PCS ($p=0.034$), although it was found to be higher on the left, it was not significant ($p>0.05$) (Table 3).

Table 3. Comparison of PCS characteristics, FPA and adipose tissue between patient and control groups

	Patient (with PCS)				Control (no PCS)				p
	N	Min.	Max.	Mean±SD	N	Min.	Max.	Mean±SD	
Age	235	25.00	79.00	50.54±10.59	88	18.00	79.00	40.89±13.82	0.001*
RPCSL	184	1.03	13.18	4.92±2.05					
LPCSL	186	1.19	12.43	5.03±2.12					
RPCST	184	1.99	14.61	6.56±2.19					
LPCST	186	2.19	15.13	6.54±2.15					
RFPA	184	48.00	75.18	63.03±5.39	73	46.37	77.47	62.15±5.99	0.275
LFPA	186	37.06	78.73	63.04±5.89	62	50.92	81.88	62.26±6.09	0.383
RPCFT	184	9.85	32.45	20.25±3.75	73	9.45	29.80	19.12±3.87	0.034*
LPCFT	186	11.67	32.24	20.17±3.73	62	10.79	26.00	19.12±3.72	0.580

(N: Number of individuals, PCSL: Plantar calcaneal spur length (mm), PCST: Plantar calcaneal spur thickness (mm), FPA: Fowler-Philip angle (°), PCFT: Plantar calcaneal fat tissue thickness (mm), * $p<0.05$ significant, R: Right, L: Left)

There was no significant difference between the sexes on the right and left in PCSL and PCST values ($p>0.05$). There was no significant difference between the sexes in the FPA values of patients with PCS, both in the control group and in the patient group

($p>0.05$). There was no significant difference between sexes in PCFT values in patients with PCS, both in the control group and in the patient group ($p>0.05$) (Table 4, Table 5, Figure 3).

Table 4. Comparison of patient groups by sex

	Patient (with PCS)								p
	Male				Female				
	N	Min.	Max.	Mean±SD	N	Min.	Max.	Mean±SD	
Age (year)	67	25	76	51.22±11.38	168	29	79	50.26±10.28	0.549
RPCSL	49	1.03	9.56	4.95±2.28	135	1.34	13.18	4.91±1.97	0.921
LPCSL	53	1.45	12.43	4.63±2.02	133	1.19	12.00	5.18±2.15	0.101
RPCST	49	1.99	14.36	7.05±2.54	135	2.47	14.61	6.38±2.03	0.098
LPCST	53	3.08	13.05	6.79±2.28	133	2.19	15.13	6.44±2.09	0.339
RFPA	49	48.87	72.80	62.38±5.35	135	48.00	75.18	63.27±5.41	0.324
LFPA	53	37.06	78.73	62.11±7.07	133	46.17	75.67	63.41±5.34	0.234
RPCFT	49	13.72	26.64	21.05±3.47	135	9.85	32.45	19.96±3.81	0.070
LPCFT	53	13.43	32.24	20.97±3.53	133	11.67	30.99	19.85±3.77	0.600

(PCSL: Plantar calcaneal spur length (mm), PCST: Plantar calcaneal spur thickness (mm), FPA: Fowler-Philip angle (°), PCFT: Plantar calcaneal fat tissue thickness(mm), R: Right, L: Left)

Table 5. Comparison of control groups by sex

	Control (no PCS)								p
	Male				Female				
	N	Min.	Max.	Mean±SD	N	Min.	Max.	Mean±SD	
Age (year)	37	18	64	39.24±12.96	51	18	79	42.08±14.43	0.337
RFPA	30	46.37	74.33	60.8±6.85	43	55.48	77.47	63.08±5.18	0.129
LFPA	29	50.92	81.88	62.54±7.05	33	52.46	74.32	62.02±5.2	0.746
R PCFT	30	13.02	29.80	19.22±3.57	43	9.45	25.90	19.04±4.1	0.840
LPCFT	29	11.76	26.00	20.04±3.31	33	10.79	24.86	18.31±3.92	0.066

(PCSL: Plantar calcaneal spur length (mm), PCST: Plantar calcaneal spur thickness (mm), FPA: Fowler-Philip angle (°), PCFT: Plantar calcaneal fat tissue thickness (mm), R: Right, L: Left)

In the comparison of the right and left sides, a strong positive correlation was detected between the values of PCSL, PCST, FPA, and PCFT ($r=0.473$; 0.567 ; 0.683 ; 0.922 , respectively). There was a weak negative

correlation between the right PCST and the right FPA ($r=-0.145$). There was a strong positive correlation between PCSL and PCST on the right and left sides ($r=0.666$; 0.635 , respectively) (Table 6).

Table 6. Correlation values of patients with PCS

		Right PCSL	Right PCST	Right FPA	Right PCFT	Left PCSL	Left PCST	Left FPA	Left PCFT
Left PCFT	r	-0.120	-0.077	0.087	0.922**	0.103	0.057	0.082	1
	p	0.166	0.373	0.316	0.000	0.160	0.439	0.265	
Left FPA	r	-0.084	-0.045	0.683**	0.175*	0.048	0.091	1	
	p	0.331	0.602	0.000	0.042	0.516	0.218		
Left PCST	r	0.384**	0.567**	-0.006	0.071	0.635**	1		
	p	0.000	0.000	0.942	0.412	0.000			
Left PCSL	r	0.473**	0.371**	-0.133	0.101	1			
	p	0.000	0.000	0.124	0.246				
Right PCFT	r	-0.049	0.008	0.045	1				
	p	0.508	0.912	0.543					
Right FPA	r	-0.142	-0.145*	1					
	p	0.055	0.049						
Right PCST	r	0.666**	1						
	p	0.000							
Right PCSL	r	1							
	p								

(PCS: Plantar calcaneal spur, PCSL: Plantar calcaneal spur length, PCST: Plantar calcaneal spur thickness, FPA: Fowler-Philip angle, PCFT: Plantar calcaneal fat tissue thickness. **Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level)

Discussion

In this study, the relationship between spur measurements of PCS patients and other morphometric features of the foot was investigated. Bilateral PCS was observed in 57.4% of the patients in the study. DS was detected in nearly half (40.3%-43.5%) of the patients with PCS. The incidence and characteristics of PCS on the right and left were similar between the sexes. While right PCFT was found to be significantly higher than the control group in patients with PCS, although it was found to be higher on the left, it was not significant. PCST was determined as 6.56 ± 2.19 mm on the right and 6.54 ± 2.15 mm on the left. PCSL was found to be 4.92 ± 2.05 mm on the right and 5.03 ± 2.12 mm on the left. A strong positive correlation was detected between PCSL and PCST on the right and left sides.

PCS is an important cause of heel pain. It can cause pain and functional limitation as well as being asymptomatic. Kuyucu et al.⁷ detected bilateral PCS in 20% of 84 patients with a diagnosis of plantar fasciitis. In this study, the rate was 57.4%, which differs from the literature. It is thought that the higher rate in this study may be related to the inclusion of patients with radiological PCS in the study.

Baytemur et al.⁹ evaluated 1335 lateral ankle radiographs associated with trauma. In their study, they found PCS in 32.2%, DS in

13.1%, and both PCS and DS in 9.8% of all patients. They found that the presence of PCS and DS did not differ in terms of sex and side. In this study examining patients with PCS, the coexistence of PCS and DS ranged from 40.3% to 43.5%. This value is higher than that in the previous study. This may be related to the fact that the mean age of the patients in this study was high. In addition, patients with non-traumatic foot pain were included in this study. In this study, the incidence of spur was found to be similar to the literature in terms of sexes and sides.

In the study of Hayta et al.¹⁹, the PCSL value was found to be 5.7 ± 1.0 mm in 80 PCS patients. Ercan et al.¹⁸ found the PCSL value of the patients as 4.5 (0.1-11.3) mm in their study with 54 PCS patients. In the study of Ermutlu et al.²⁰, PCSL was found to be 5.44 (2.20-9.81) mm in 70 patients. In this study, PCSL was found to be 4.92 (1.03-13.18) mm on the right and 5.03 (1.19-12.43) mm on the left, which was similar to the literature.

Different typing methods have been used for PCS. Zhou et al.²¹ examined PCS in two groups, as inside the plantar fascia and superior to the plantar fascia. Ahmad et al.¹⁵ used four groups (absent, horizontal, vertical and hooked) for PCS classification in their study involving 109 patients. They were found to be absent (23.8%), horizontal (60.6%), vertical (3.7%) and hooked (11.9%). In another study, PCS (1; small, 2; moderate, 3 severe) and DS

(1; small, 2,3,4; large) classifications of gout patients were made. While 44.7% of the patients had a PCS of 2 or more, a DS of 2 or more was found in 44.7%.¹⁶ In this study, spur values of 2 and above were found to be higher for both PCS and DS. This difference may be due to the fact that the study of Duran et al.¹⁶ included gout patients and that the study group also included patients without PCS. This study included patients with PCS. In this study, values of 2 and above for PCS were determined as 67.4-69.9%, and values of 2 and above for DS were determined as 57.5-68%.

PCS may occur as a result of damage to the plantar fascia by repetitive microtraumas. The shock absorbing effect of plantar adipose tissue reduces the damage of microtraumas. Belhan et al.¹² examined PCFT in 50 patients with plantar fasciitis using ultrasonography. In their study, they determined the adipose tissue thickness as 19.45 mm. In the same study, the other non-symptomatic feet of patients with plantar fasciitis were evaluated as the control group. In addition they determined that the PCFT value of the side with plantar fasciitis was significantly lower. In another study, PCFT was evaluated by weight bearing with ultrasonography. PCFT was found to be significantly higher in patients with heel pain than that in healthy individuals.¹³ Turgut et al.¹¹ found similar PCFT values between the groups in their study with 120 healthy people (240 feet) and 73 patients with heel pain (103 feet). In this study, PCFT was evaluated radiologically, and the mean value of PCFT was found to be 20.25 mm on the right and 20.17 mm on the left. PCFT was found to be 19.12 mm in the control group, and no significant difference was found between the patient groups. Although the results of this study are similar to those of the study of Turgut et al.¹¹ there was no significant difference between the patient and control groups, unlike the literature. It may be due to the difference in the measurement method and the mean age of the patient group.

PCS can also be seen in psoriatic arthritis, which is in the spondyloarthritis disease group. Gladman et al.²² compared PCSL and PCST values of 101 psoriatic arthritis patients with the control group in their study. Both PCSL

and PCST were higher in the psoriatic arthritis group than those in the control group. Başdelioğlu²³ stated in his study that obesity is one of the important causes of PCS. The incidence of PCS is significantly increased in people with a BMI > 30, and the incidence of PCS in women is significantly higher than in men. Changes in the CIA change the mechanical forces acting on the foot, causing PCS. However, no study examining the relationship between PCSL and PCST has been found in the literature. In this study, a strong positive correlation was found between PCSL and PCST values on the right and left sides.

Riepert et al.²⁴ reported that the rates of PCS in the right and left feet were similar. A similar result was found in our study.

FPA is an angle in which the posterosuperior part of the calcaneus is evaluated, and a high angle is in favor of Haglund's deformity.¹⁴ Bulstra et al.¹⁰ found this angle as 60.91 ± 6.81 in patients with Haglund's deformity in their study. Gutierrez et al.²⁵ found the FPA values on the right and left as 61.2 ± 5.1 and 62.9 ± 5.9 , respectively, in their study. The FPA values of the patients in this study are similar to the values in both studies.

Limitations

There are some weaknesses of the study. Among these, it can be said that the study was done retrospectively through hospital records, the number of people in the control group was low and the average age was low. There is also a need for studies investigating the relationship between PCS parameters and clinical findings.

Conclusion

Our study may offer a new perspective on PCS with unclear pathophysiology. In this study, it was concluded that bilateral PCS can be observed in the majority of patients, DS may accompany those with PCS, and there is a strong correlation between PCSL and PCST values. The relationship of these data with patient clinical findings, weight, occupational and environmental exposure is also an area open to research.

Ethics Committee Approval

Hatay Mustafa Kemal University Faculty of Medicine Clinical Research Ethics Committee with the ethics committee decision numbered 11/29 and dated 04.10.2021. This study conformed to the Helsinki Declaration This study conformed to the Helsinki Declaration.

Author Contributions

Study concept/design, data collecting: HÖ., BT., DAS., data analysis and interpretation BT, NA, DAS., literature review, writers: HÖ., DAS., MTY., The final version of this article was read and approved by all authors.

Conflict of Interest

There is no conflict of interest to declare.

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Peer-review

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