ARTICLE

The prevalence and topographic distribution of penile calcification in a large cohort: a retrospective cross-sectional study

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The prevalence of penile calcification in the population remains uncertain. This retrospective multicenter study aimed to determine the prevalence and characteristics of penile calcification in a large cohort of male patients undergoing non-contrast pelvic tomography. A total of 14 545 scans obtained from 19 participating centers between 2016 and 2022 were retrospectively analyzed within a 3-months period. Eligible scans ($n = 12\ 709$) were included in the analysis. Patient age, penile imaging status, presence of calcified plaque, and plaque measurements were recorded. Statistical analysis was performed to assess the relationships between calcified plaque, patient age, plaque characteristics, and plaque location. Among the analyzed scans, 767 (6.04%) patients were found to have at least one calcified plaque. Patients with calcified plaque had a significantly higher median age (64 years (IQR 56–72)) compared to those with normal penile evaluation (49 years (IQR 36-60) ($p < 0.001$). Of the patients with calcified plaque, 46.4% had only one plaque, while 53.6% had multiple plaques. There was a positive correlation between age and the number of plaques ($r = 0.31$, $p < 0.001$). The average dimensions of the calcified plaques were as follows: width: 3.9 ± 5 mm, length: 5.3 ± 5.2 mm, height: 3.5 ± 3.2 mm, with an average plaque area of 29 ± 165 mm^2 and mean plaque volume of 269 ± 3187 mm^3. Plaques were predominantly located in the proximal and mid-penile regions (44.1% and 40.5%, respectively), with 77.7% located on the dorsal side of the penis. The hardness level of plaques, assessed by Hounsfield units, median of 362 (IQR 250–487) (range: 100–1400). Patients with multiple plaques had significantly higher Hounsfield unit values compared to those with a single plaque ($p = 0.003$). Our study revealed that patients with calcified plaques are older and have multiple plaques predominantly located on the dorsal and proximal side of the penis.

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INTRODUCTION

Peyronie's Disease (PD) is a fibrotic process resulting from recurring microvascular injury or trauma to the tunica albuginea and, common symptoms are pain, penile curvature, palpable plaques, and, to some degree of erectile dysfunction [1, 2]. The exact etiology and pathophysiology of PD remain unclear, and the symptoms of PD display variations in their prevalence, intensity, and association with the disease's progression [3, 4]. The global prevalence of PD varies between 0.5 and 20.3% [5, 6]. It has been reported that this rate is higher, especially in patients with erectile

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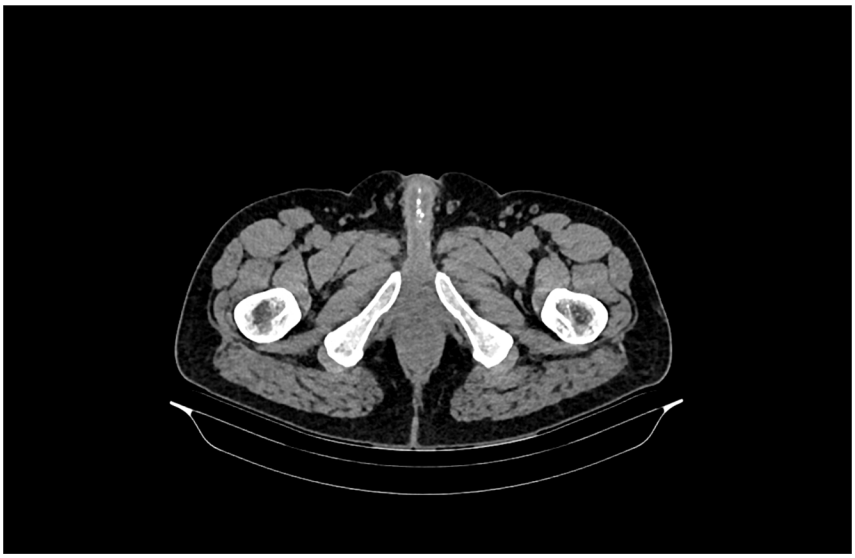

Fig. 1 Penile Interseptal Calcifications in NCPT Imaging. A sample NCPT image shows the multiple penile interseptal calcifications.

dysfunction and diabetes [7]. In a recently published study, Kadioglu et al. determined that the prevalence of PD was 5.3% in a large cohort [8]. Additionally, calcified plaque can be seen in 21–34.1% of PD patients [9]. The presence of calcification in PD is an important finding, which has been related to resistance to medical treatment and a higher chance of undergoing surgical intervention [10, 11].

The plaque formation in PD has been attributed to a multifactorial mechanism. Genetic predisposition, risk factors (age, diabetes, and erectile dysfunction), and microtrauma to the tunica albuginea cause a release of mediators such as Transforming Growth Factor-β, fibroblast growth factor, platelet-derived growth factor in the penile tissue [12]. Also differentiation of fibroblasts into myofibroblasts, the deposition of collagen in the extracellular matrix, 'lamellar calcifications' around the blood vessels in connective tissues, aberrant gene expression such as pleiotrophin, monocyte chemotactic precursor protein-1, and alpha smooth muscle actin, and additionally, different cell lineages have been proposed as the main actor in the formation of plaque and calcification [13–16]. In previous studies, the density of echogenic areas and the presence of acoustic shadows have been acknowledged as indicators of disease stability [17]. Nevertheless, recent investigations have demonstrated that calcification is observable even in the early stages of PD [10].

Although the accurate pathophysiology of calcification is still unclear, both demographic and clinical investigations on penile calcification may hold value in the management of PD. The assessment of calcified plaques in PD is usually made by penile ultrasonography, and the degree of calcification is subjectively reported [18]. The prevalence of penile calcification in the urologic population remains uncertain due to a lack of targeted research and technical limitations. This study primarily aims to investigate the prevalence of penile calcification in a multicenter approach with the collaboration of the Turkish Academy of Urology—Andrology study group.

SUBJECTS AND METHODS

A retrospective multicenter study was conducted to determine the prevalence of penile calcification.

Subjects

The inclusion criteria were male patients older than 18 years who applied to urology outpatient clinics, underwent a non-contrast pelvic tomography (NCPT) for various reasons (e.g., urinary stone disease, malignancy assessment, tumor staging, pain etiology). Patients who had devices that could impact the quality of NCPT images, such as urethral catheters or penile/hip prostheses, as well as those with incomplete visualization of the penis in NCPT, were excluded from the analysis.

Study design

For this purpose, nationwide announcements were made via email to members of the Turkish Urological Association. After one month of standby time, 19 centers from 10 provinces in Turkey expressed their intention to participate in the study. To ensure standardization, only NCPT protocols with a slice thickness of 2 mm or less, performed between 2016 and 2022, were accepted for the study (Fig. 1). To avoid duplication of NCPT protocols from the same patient obtained at different centers, an anonymized unique patient number was assigned. The technique for measuring the dimensions of calcified plaques in different axes (axial, sagittal, and coronal) was determined in collaboration with an experienced radiologist (RYB) to achieve standardization across departments. An online educational video demonstrating the measurement technique was shared with the participating departments.

Measures

Patient age, penile imaging status, presence of calcified plaque, and plaque measurements were recorded. All data were acquired from hospital data management systems. In the presence of calcified plaque, further measurements such as the number of plaques, plaque size (mm), location of the plaque in the penis (longitudinal, sagittal, side), and the maximum Hounsfield Unit (HU) of the plaque were obtained. In cases where multiple plaques were present, the largest one was considered for the measurements. The plaque area and volume were calculated by the ellipse area formula [pi × radius1 (width/2) × radius2 (length/2)] and the ellipsoid volume formula [3/4 × pi × radius1 (width/2) × radius2 (length/2) × radius3 (height/2)], respectively (pi=3.14).

Analysis

Statistical analysis was performed with SPSS version 21 (SPSS Inc., Chicago, IL, USA). The power of the study was calculated based on a recently published article using an online calculator (http://powerandsamplesize.com/Calculators/Test-1-Proportion/1-Sample-Equality) [19]. The normal distribution of continuous variables included in the statistical comparison was assessed using the Kolmogorov-Smirnov test. Since the continuous variables, such as age and HU, did not follow a normal distribution ($p < 0.001$), the Mann-Whitney test was employed for statistical comparisons. The correlation between variables was researched with Spearman's correlation test. A p value less than 0.05 was considered statistically significant. This study was conducted following the principles of the Declaration of Helsinki and approved by institutional Ethical Committee (Approval Date: 23/May/2022, Approval Number: 161 (Document No: E-48670771-514.99)).

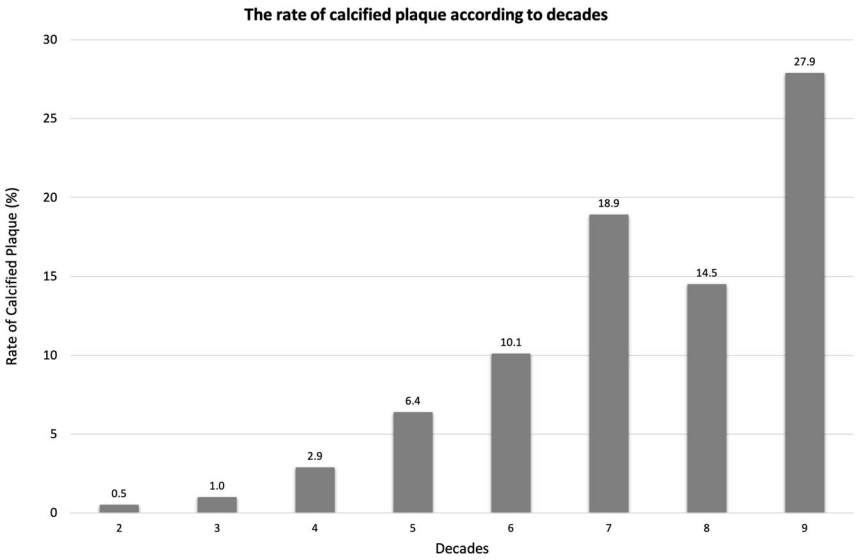

Fig. 2 Calcified Plaque Rate Across Patient Decades. The rate of calcified plaque according to decades of patients.

RESULTS

A total of 14 545 NCPT scans taken at 19 participating centers between 2016 and 2022 were retrospectively analyzed. It was determined that 12 709 (87.4%) of the NCPT scans were eligible for further evaluation and included in the analysis. The median age of the patients was 50 (IQR 37–61) in the entire cohort. At least one calcified plaque was observed in 767 (6.04%) patients. The post hoc calculated power of the study was 0.814 at 0.05 significance level.

The median age was 64 (IQR 56-72) in patients with calcified plaque, while it was 49 (IQR 36–60) in patients with normal penile evaluation, and the difference between groups was statistically significant ($p < 0.001$). Among the patients with calcified plaque, 356 (46.4%) had only one plaque, while 411 (53.6%) had multiple plaques. The median plaque number was 2 (IQR 1–3) in patients with calcified plaque. The median age was significantly different between patients who had single (61 years IQR (52–69)) or multiple calcified plaques (67 IQR 58–75 years) ($p < 0.001$). The frequency of calcified plaque increased with age (Fig. 2). Moreover, the number of calcified plaques was higher in older patients. There was a statistically significant positive correlation between age and the number of plaques ($r = 0.31$, $p < 0.001$). Additionally, when excluding patients over 75 years old who are clinically unrelated to treatment, the prevalence of calcified plaque decreased to 5.3%.

In the entire cohort calcified plaque measurements were calculated as mean width: 3.9 ± 5 mm, length: 5.3 ± 5.2 mm, and height: 3.5 ± 3.2 mm, while the mean plaque area was 29 ± 165 mm^2 and mean plaque volume was 269 ± 3187 mm^3. While there was a positive correlation observed between plaque area and volume with HU ($r = 0.21$, $p < 0.001$ and $r = 0.25$, $p < 0.001$ respectively), no statistically significant difference was found when investigating the correlation of plaque area ($p = 0.97$), volume ($p = 0.58$), and HU($p = 0.69$) with age.

Plaques were detected in proximal, mid-penile and, distal parts of the penis in 338 (44.1%), 311 (40.5%), and 118 (15.4%) patients respectively, and 596 (77.7%) of the plaques were located on the dorsal and 171 (22.3%) on the ventral side of the penis. Of the evaluated plaques, 299 (39.0%) were located in the interseptal region, 248 (32.3%) were located in the right and 220 (28.7%) were located in the left corpus cavernosum (Table 1). The evaluation of plaque hardness level revealed a median of 362 (IQR 250–487) HU, with values ranging from 100 to 1400. The median HU in patients with single and multiple plaques were 343 (IQR 235-443) and 389 (IQR 265-524) respectively, and the difference in HU was significantly higher ($p < 0.001$).

Table. 1. The distribution of calcified plaques according the location in the penis.

Longitudinal		Frequency	%
	Proximal	338	44.1
	Mid-shaft	311	40.5
	Distal	118	15.4
Sagittal			
	Dorsal	596	77.7
	Ventral	171	22.3
Side			
	Left	220	28.7
	Right	248	32.3
	Interseptal	299	39
Number			
	Single	356	46.4
	Multiple	411	53.6

DISCUSSION

The penile calcification rate in the Turkish male population over 18 years old was found to be 6.04%. However, when the age limit was restricted to 75 years old, the prevalence decreased to 5.3%. The most common localizations of the calcification were proximal in the longitudinal plane, dorsal in sagittal plane, and interseptal in the side planes. Patients with plaques were older than those without plaques, and the median HU value was calculated 362. The frequency and number of plaques were found to increase with the age.

The PD plaques have been evaluated with different imaging modalities in the literature [18, 20]. NCPT has been found as an effective method for evaluating calcification. Andersen et al. concluded that the calcifications had been identified through NCPT with a 100% sensitivity [21]. Moreover, the records of NCPT are an invaluable source for searching the prevalence of penile calcification in a retrospective manner, and measuring the HU is another advantage of the NCPT for conducting prevalence research.

The evaluation of plaques in PD was usually reported as a secondary outcome of the studies. Different prevalence rates have been reported in a wide range. In their comprehensive study, Levine et al. reported a 34% plaque calcification in PD patients [10]. In another study Bekos et al. summarized that 88% of PD patients had calcification [17]. However, only one study with limited cases sought calcification prevalence in the general population and reported a 6.6% rate. The researchers have also emphasized that most of the patients have multiple plaques and the most common location was the middle portion of the penis [19]. In our study, we confirmed that the prevalence of calcified plaque is 6.04% and most of the patients have multiple calcified plaques (53.6%). However, the proximal location of the calcified plaque was the prevalent location in our study. Another difference in our study was determining the HU of calcified plaque.

HU is a dimensionless unit used to express the density of the region of interest in the CT images [22]. The HU value ranges from −1024 to 3071, including a value added for 0 and based on the values for air (−1 000 HU), water (0 HU), and bone density (+1 000 HU) [23]. HU has also been used to classify kidney stones based on their density, which predicts the success of shock wave lithotripsy [24, 25]. To our knowledge, this is the first study to determine the median HU as 362 (IQR 250–487) for penile calcification with a range of 100–1400. The correlation between plaque area and volume with HU indicates that plaque hardness increases with plaque size.

In recent years, with the introduction of the Collagenase Clostridium Histolyticum (CCH) treatment, the plaque features gained importance. Wymer et al. reported that plaque calcification was related to the worst treatment outcomes with CCH in PD [11]. In another study, Breyer et al. showed that patients with a calcified plaque resisted medical treatment and had a higher chance of undergoing surgical interventions [26]. Instead, a recently published study by Goldstein et al. emphasized that the result of CCH treatment in PD patients with or without calcified plaque were similar [9]. On the other hand, these studies only evaluated the presence of any kind of calcification without consideration of the location or hardness of the plaque. In light of these data, we may speculate that the localization and hardness of the calcified plaque may have an effect on the medical treatment, and any research appraising these variables would contribute to the literature.

The existing literature on the classification of calcified plaques is limited. Various classification systems have been proposed [10, 17] to evaluate plaques based on criteria such as number, length, location, and subjective assessments of hardness, considering the shadow behind the plaque. However, these systems are fundamentally subjective in nature. Despite the USG, being an easy, cheap, and noninvasive method for evaluating PD plaque, it is operator-dependent [27] and classification systems are based on prejudiced information [28]. On the other hand, measuring the HU with NCPT might provide insight into the plaque characteristics and the severity of mineralization. Future studies are needed to search the relation between the level of mineralization and medical or surgical outcomes of PD with calcified plaque.

The proximal localization of the calcified plaque has the highest rate according to our results (44.1%). In their study, McCullough et al. reported a 64% rate of corporal abnormality proximal to the pubic symphysis in PD patients [29]. Although there is no defined clinical presentation of PD in the proximal part of the penis, another question brought to mind by the results of our study is the patients who are admitted to urology with perineal pain and, diagnosed as chronic pelvic pain syndrome or chronic prostatitis. They may simply have PD arising from the proximal and non-palpable parts of the penis. Evaluating the patients for PD with pain in the perineal area, especially after intercourse or an erection, could provide valuable insights.

The retrospective design of our study is a significant limitation as it restricts our ability to directly compare the study results and clinical status of patients with respect to PD diagnosis, medical history, physical examination findings, and co-morbidities. It is important to note that the evaluation of penile calcification and the diagnosis of PD are distinct entities. Therefore, our study cohort may not be representative of the specific PD population. We acknowledge this limitation, which highlights the need for caution in generalizing our findings to the broader PD population. Future research with a prospective design and a more targeted focus on patients diagnosed with PD would be valuable in addressing these limitations and providing more comprehensive insights into the relationship between penile calcification and PD. Another limitation is cohort was constituted of patients who were admitted to the urology outpatient clinic, which might inherently elevate the calcification prevalence. The multicenter study design led to the evaluation of the results of different tomography devices together. Therewithal, conducting a multicentric study with the participation of 19 departments from 10 different cities for prevalence study is the main strength of our study.

In conclusion, our study provides valuable insights regarding the prevalence of calcified plaque in PD. The determination of the mean HU value for penile calcification and the recognition of proximal plaque localization underscore the necessity for additional research in this field. According to our knowledge, our study is the first of its kind which defines the penile calcification features evaluating over twelve thousand patients and establishing a mean value of HU for penile calcification. The findings of our study lay the groundwork for future investigations focused on understanding penile calcification and enhancing treatment efficacy in PD.

DATA AVAILABILITY

The dataset generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

REFERENCES

1. Devine CJ, Somers KD, Jordan SG, Schlossberg SM. Proposal: trauma as the cause of the Peyronie's lesion. J Urol. 1997;157:285–90.
2. Chung E, Ralph D, Kadioglu A, Garaffa G, Shamsodini A, Bivalacqua T, et al. Evidence-based management guidelines on Peyronie's disease. J Sex Med. 2016;13:905–23.
3. Di Maida F, Cito G, Lambertini L, Valastro F, Morelli G, Mari A, et al. The natural history of Peyronie's disease. World J Mens Health. 2021;39:399–405.
4. Garaffa G, Trost LW, Serefoglu EC, Ralph D, Hellstrom WJG. Understanding the course of Peyronie's disease. Int J Clin Pract. 2013;67:781–8.
5. Sommer F, Schwarzer U, Wassmer G, Bloch W, Braun M, Klotz T, et al. Epidemiology of Peyronie's disease. Int J Impot Res. 2002;14:379–83.
6. Schwarzer U, Sommer F, Klotz T, Braun M, Reifenrath B, Engelmann U. The prevalence of Peyronie's disease: results of a large survey. BJU Int. 2001;88:727–30.
7. Arafa M, Eid H, El-Badry A, Ezz-Eldine K, Shamloul R. The prevalence of Peyronie's disease in diabetic patients with erectile dysfunction. Int J Impot Res. 2007;19:213–7.
8. Kadioglu A, Dincer M, Salabas E, Culha MG, Akdere H, Cilesiz NC. A population-based study of Peyronie's disease in Turkey: prevalence and related comorbidities. Sex Med. 2020;8:679–85.
9. Goldstein I, McLane MP, Xiang Q, Wolfe HR, Hu Y, Gelbard MK. Long-term curvature deformity characterization in men previously treated with Collagenase Clostridium Histolyticum for Peyronie's disease, subgrouped by penile plaque calcification. Urology. 2020;146:145–51.
10. Levine L, Rybak J, Corder C, Farrel MR. Peyronie's disease plaque calcification–prevalence, time to identification, and development of a new grading classification. J Sex Med. 2013;10:3121–8.
11. Wymer K, Ziegelmann M, Savage J, Kohler T, Trost L. Plaque calcification: an important predictor of collagenase clostridium histolyticum treatment outcomes for men with Peyronie's disease. Urology 2018;119:109–14.
12. Patel DP, Christensen MB, Hotaling JM, Pastuszak AW. A review of inflammation and fibrosis: implications for the pathogenesis of Peyronie's disease. World J Urol. 2020;38:253–61.

13. Vernet D, Nolazco G, Cantini L, Magee TR, Qian A, Rajfer J, et al. Evidence that osteogenic progenitor cells in the human tunica albuginea may originate from stem cells: implications for peyronie disease. Biol Reprod. 2005;73:1199–210.
14. Gonzalez-Cadavid NF, Magee TR, Ferrini M, Qian A, Vernet D, Rajfer J. Gene expression in Peyronie's disease. Int J Impot Res. 2002;14:361–74.
15. Rainer QC, Rodriguez AA, Bajic P, Galor A, Ramasamy R, Masterson TA. Implications of calcification in Peyronie's disease, a review of the literature. Urology. 2021;152:52–9.
16. Vande Berg JS, Devine CJ, Horton CE, Somers KD, Wright GL, Leffell MS, et al. Mechanisms of calcification in Peyronie's disease. J Urol 1982;127:52–4.
17. Bekos A, Arvaniti M, Hatzimouratidis K, Moysidis K, Tzortzis V, Hatzichristou D. The natural history of Peyronie's disease: an ultrasonography-based study. Eur Urol. 2008;53:644–50.
18. Parmar M, Masterson JM, Masterson TA. The role of imaging in the diagnosis and management of Peyronie's disease. Curr Opin Urol. 2020;30:283–9.
19. Gündoğdu E, Emekli E. Calcified Peyronie's disease frequency on computed tomography. Turk J Urol. 2022;48:196–200.
20. Pawłowska E, Bianek-Bodzak A. Imaging modalities and clinical assesment in men affected with Peyronie's disease. Pol J Radiol. 2011;76:33–7.
21. Andresen R, Wegner HE, Miller K, Banzer D. Imaging modalities in Peyronie's disease. An intrapersonal comparison of ultrasound sonography, X-ray in mammography technique, computerized tomography, and nuclear magnetic resonance in 20 patients. Eur Urol 1998;34:128–34.
22. Hounsfield GN. Computed medical imaging. Nobel lecture, Decemberr 8, 1979. J Comput Assist Tomogr. 1980;4:665–74.
23. Glide-Hurst C, Chen D, Zhong H, Chetty IJ. Changes realized from extended bit-depth and metal artifact reduction in CT. Med Phys. 2013;40:061711.
24. Ouzaid I, Al-qahtani S, Dominique S, Hupertan V, Fernandez P, Hermieu JF, et al. A 970 Hounsfield units (HU) threshold of kidney stone density on non-contrast computed tomography (NCCT) improves patients' selection for extracorporeal shockwave lithotripsy (ESWL): evidence from a prospective study. BJU Int. 2012;110:E438–442.
25. Nakasato T, Morita J, Ogawa Y. Evaluation of hounsfield units as a predictive factor for the outcome of extracorporeal shock wave lithotripsy and stone composition. Urolithiasis. 2015;43:69–75.
26. Breyer BN, Shindel AW, Huang YC, Eisenberg ML, Weiss DA, Lue TF, et al. Are sonographic characteristics associated with progression to surgery in men with Peyronie's disease? J Urol. 2010;183:1484–8.
27. Trama F, Illiano E, Iacono F, Ruffo A, di Lauro G, Aveta A, et al. Use of penile shear wave elastosonography for the diagnosis of Peyronie's Disease: a prospective case-control study. Basic Clin Androl. 2022;15:32.
28. Yuruk E, Serefoglu EC. Re: Peyronie's disease plaque calcification–prevalence, time to identification, and development of a new grading classification. J Sex Med. 2014;11:1351.
29. McCullough A, Trussler J, Alnammi M, Schober J, Flacke S. The use of penile computed tomography cavernosogram in the evaluation of Peyronie's disease: a pilot study. J Sex Med. 2020;17:1041–3.

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AUTHOR CONTRIBUTIONS

CB, MGÇ, RYB, AÖ, AK conceived and design the study; CB, MGÇ, BCÖ, ABB, ÇÖ, HMÇ, BA, AA, EA, MSO, TK, CK, MEA, KEE, MY, MÇ, HMD, SG, BB, KD, ÖE, MKA, AY, YOD, ED, MBCB, CTG, MT, MC, MKK, MA, SY, GÇ, VG, AG collected the data; CB, MGÇ, AÖ, AK performed analysis; CB and MGÇ created draft; RYB, AÖ, AK revised and finalized draft; all authors have read and approved final manuscript.

COMPETING INTERESTS

The authors declare no competing interests.

ETHICAL APPROVAL

This study was conducted following the principles of the Declaration of Helsinki and approved by institutional Ethical Committee (Approval Date: 23/May/2022, Approval Number: 161 (Document No: E-48670771-514.99)).

ADDITIONAL INFORMATION

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