MORPHOMETRIC ANALYSIS AND PREVALENCE OF PLANTAR CALCANEAL SPURS AMONG THE ADULT POPULATION OF THE PROVINCE OF VOJVODINA

Bojana KRSTONOŠIĆ1, Siniša S. BABOVIĆ1, Milan MILOVIĆ2, Radmila PERIĆ3, Dragan TURANJANIN1 and Milica GLEDA1

Original study
Originalni naučni rad
UDK 611.718:616.718.7(497.113)
https://doi.org/10.2298/MPNS2008195K

SUMMARY

Introduction. Plantar calcaneal spur is a bony outgrowth which is most often located on the inferior aspect of the calcaneus, penetrating the surrounding soft tissues. Symptomatic and asymptomatic cases of plantar calcaneal spurs have been described and their analysis suggested that they may be a variation in regular bone development, but the exact cause is still unknown. The goal of this study was to determine the size, shape and prevalence of plantar spurs in the population of the Province of Vojvodina. Material and Methods. This retrospective research included a total of 272 foot X-rays. The X-rays belonged to the Clinic of Orthopedic Surgery and Traumatology, Clinical Center of Vojvodina. The images were analyzed using a publicly available software Xrayline Workstation for 32-bit. Results. There was no statistically significant difference in the size of calcaneal spurs between sexes, as well as between the right/left foot. In regard to their shape, irregular calcaneal spurs were more frequent (61.9%) and all of the spurs were positioned horizontally. Conclusion. The results of this research were in agreement with the available literature data, showing no significant difference in morphometric analysis of the plantar spurs between sexes. Future researches should include data regarding the age, body weight, and comorbidities among examinees. Key words: Heel Spur; Calcaneus; Foot Diseases; Exostoses; Radiography; Anatomy; Morphological and Microscopic Findings; Pain

ZAKLJUČAK

Uvod. Tabanska petna spina predstavlja koštani trnasti nastavak koji se najčešće nalazi na donjoj strani petne kosti i prodire u okolno meko tkivo. Opisani su simptomatski i asimptomatski slučajevi prisustva petne spine, a njihovom analizom došlo se do zaključka da ona može biti posledica varijacije uobičajenog razvoja kosti, ali stvaran uzrok njenog nastanka još uvek je nepoznat. Cilj ovog rada bio je da se utvrdi veličina, oblik petnih spina i odredi njihova prevalencija u populaciji Vojvodine. MATERIJAL I METODE. U ovom retrospektivnom istraživanju analizirana su ukupno 272 rendgenska snimka stopala koji pripadaju Klinici za ortopedsku hirurgiju i traumatologiju Kliničkog centra Vojvodine. Snimci stopala su analizirani u javno dostupnom programu Xrayline Workstation 32bit. REZULTATI. Nije utvrđena statistički značajna razlika u veličini analiziranih petnih spina između polova ispitanika, kao ni između desnog i levoj stopala. Prema obliku petnih spina, zastupljen je oblik nepravilni (61,9%), a sve uočene spine bile su položene horizontalno. VREME ANATOMIJE POjavljivanje petnih spina kod običnih ljudi u Vojvodini.

Ključne reči: petna spina; petna kost; bolesti stopala; egzostoze; radiografija; anatomija; morfološki i mikroskopski nalazi; bol

In order to examine the causes of PCS, it is necessary to describe the anatomy of the foot. The PCS originates from the calcaneal tuberosity on the posterior surface of the calcaneus, most often in the area of the medial process, but sometimes from the lateral process or groove between processes [2–7]. The morphology of the PCSs is very variable, but generally they can be categorized into two types: simple or regular spurs (triangular in shape, with defined

Corresponding Author: Prof. dr Bojana Krstonošić, Univerzitet u Novom Sadu, Medicinski fakultet, Zavod za anatomiju, 21000 Novi Sad, Hajduk Veljkova 3, E-mail: bojana.krstonosic@mf.uns.ac.rs
borders, broad base and a sharp point) and irregular spurs (irregular in shape, with poorly defined borders) [8, 9]. The plantar fascia (PF), which consists of fibrous connective tissue, is stretched between the medial process of calcaneal tuberosity and digits of the foot. It is important in maintaining the medial longitudinal arch of the foot, as well as in receiving and transmitting forces placed on the foot across the mid-tarsal joints. The PF could be a critical structure in the PCS formation and it has been found that its thickness is significantly greater in people with PCS than in those without it [5]. Some studies found that the PCSs are pressed inside the PF, unlike others where PCSs are not attached to the fascia [10–12]. Many studies suggest that the PCS may occur as a result of the PF inflammation, which is followed by changes in the collagen structure, vascular hyperplasia and fibroblast accumulation [5].

There is a close relation between the PCS and muscles of the foot. The PCS can be a result of degenerative changes of the intrinsic group of foot muscles. Regardless to its origin, it can make a pressure onto the muscles and cause pain [2, 4, 6]. The flexor digitorum brevis muscle attaches to the medial process tuber calcanei or to the top of the PCS, if present [12]. The abductor digitii minimi can also be inserted directly into the periosteum of the PCS [11].

Close to the medial surface of the calcaneus, the posterior tibial artery bifurcates into the medial and the lateral plantar artery. These blood vessels, accompanied by their companion veins and nerves, make an intimate relationship with the PCS, if present. In such cases, pain, sense of burning and rarely paresthesia, or a disturbance of the circulation may occur [13–17]. Moreover, cause and effect relationship between the PCS and the tarsal tunnel syndrome has been described [6, 13, 14].

Many studies have confirmed the association between the heel pain and the presence of PCS, and also found the increased incidence of PCS in the elderly and obese people. In regard to the impaired quality of life of people with PCS and its great incidence in some populations, the aim of the study was to determine the incidence of the PCS and to describe its morphology in the population of the Province of Vojvodina.

**Material and Methods**

The study included a total of 272 X-rays of patients treated at the Clinic of Orthopedic Surgery and Traumatology of the Clinical Center of Vojvodina in a five-month-period (from July 1, 2017 to December 1, 2017). The retrospective study was performed in compliance with the principles of the Declaration of Helsinki (1964), with the approval of the Ethics Committee of the Clinical Center of Vojvodina and the Ethics Committee of the Faculty of Medicine, University of Novi Sad. Out of a total sample of 272 lateral foot X-rays, 36 showed a calcaneal spur (Figure 1A). Further, they were analyzed by morphometry. The X-ray images were loaded into specialized public software for image reconstruction and analysis Xrayline Workstation for 32-bit (http://www.xrayline.com/downloads.shtml). The calcaneal spur length was measured using the Ruler Tool. As the spurs are triangular in shape, their length was measured as the distance between the midpoint of the base and the top of the triangle (Figure 1B). Each spur was measured three times and the analyzed length represented the arithmetic mean of the obtained value. According to the literature data, the calcaneal spur is a thorny extension equal to or greater than 0.25 cm. Results were statistically analyzed using the Student’s t-test and presented in relation to gender and orientation - right/left foot. The second part of the research was a descriptive analysis of the calcaneal spur shape. Based on the appearance and sharpness of the edges, the spurs are classified into two groups: simple (regular) and irregular. Simple spurs were considered to be triangular in shape with clear-
ly visible edges (Figure 2A), while irregular spurs had irregular shapes and vague edges (Figure 2B). Also, the direction of spur formation, i.e. the position of its tip was observed and described.

**Results**

Of the 272 analyzed X-rays, 36 (13.2%) showed the presence of PCS, 14 (38.9%) in male and 22 (61.1%) in female subjects. The Table 1 shows statistically processed results of spur length, with minimum and maximum values, mean values and standard deviations. The results were presented in two groups: simple (regular) and irregular heel spurs. Accordingly, the results showed that 14 spurs (38.9%) were simple and 22 (61.1%) irregular in shape. More frequent occurrence of irregular spurs was seen in female subjects, as opposed to simple spurs, which were more frequent in males.

In regard to their direction, the PCSs were classified as horizontal or vertical. In this study, all the observed spurs had the same horizontal position, but the angle at which they were separated from the calcaneus differed (Figure 3). More specifically, 15 PSCs (41.7%) had a classic horizontal position, with the tips pointing forward, 16 of them (44.4%) with the tip pointing upwards, while 5 PSC (13.9%) were pointing downwards.

**Discussion**

Since 1900, when Plettner first used the term plantar calcaneal spur, till today, the exact etiology of spur is not known [16]. There are two hypotheses about its occurrence: the hypothesis of longitudinal traction (friction), according to which persistent friction of the PF on the surface of the calcaneus leads to the formation of a spur, and the hypothesis of vertical compression, according to which constant compression leads to microfractures of the calcaneus which consequently form connective-cartilage tumefactions. The prevailing view is that vertical compressions are more likely responsible for spur formation [16].

The goal of this study was to evaluate the prevalence of the PCSs in adults who underwent foot X-ray examination. The second part of the study focused on the appearance of the thorny heel spurs which were classified into two groups: simple (regular) and irregular heel spurs. The Table 2 shows the statistically processed results of spur length in males, with minimum and maximum values, mean values and standard deviations. The results were distributed according to the presence of spur on the right/left foot. There was no statistically significant difference in spur length between the right and left foot (p = 0.2). The Table 3 shows the statistically processed results of spur length in females, with minimum and maximum values, mean values and standard deviations. The results were distributed according to the presence of spur on the right/left foot. The Table 3 shows no statistically significant difference in spur length between subjects’ right and left foot (p = 0.27).

The second part of the study focused on the appearance of the thorny heel spurs which were classified into two groups: simple (regular) and irregular heel spurs. The Table 2 shows the statistically processed results of spur length in males, with minimum and maximum values, mean values and standard deviations. The results were distributed according to the presence of spur on the right/left foot. There was no statistically significant difference in spur length between the right and left foot (p = 0.2). The Table 3 shows the statistically processed results of spur length in females, with minimum and maximum values, mean values and standard deviations. The results were distributed according to the presence of spur on the right/left foot. The Table 3 shows no statistically significant difference in spur length between subjects’ right and left foot (p = 0.27).

The second part of the study focused on the appearance of the thorny heel spurs which were classified into two groups: simple (regular) and irregular heel spurs. Accordingly, the results showed that 14 spurs (38.9%) were simple and 22 (61.1%) irregular in shape. More frequent occurrence of irregular spurs was seen in female subjects, as opposed to simple spurs, which were more frequent in males.

In regard to their direction, the PCSs were classified as horizontal or vertical. In this study, all the observed spurs had the same horizontal position, but the angle at which they were separated from the calcaneus differed (Figure 3). More specifically, 15 PSCs (41.7%) had a classic horizontal position, with the tips pointing forward, 16 of them (44.4%) with the tip pointing upwards, while 5 PSC (13.9%) were pointing downwards.

**Discussion**

Since 1900, when Plettner first used the term plantar calcaneal spur, till today, the exact etiology of spur is not known [16]. There are two hypotheses about its occurrence: the hypothesis of longitudinal traction (friction), according to which persistent friction of the PF on the surface of the calcaneus leads to the formation of a spur, and the hypothesis of vertical compression, according to which constant compression leads to microfractures of the calcaneus which consequently form connective-cartilage tumefactions. The prevailing view is that vertical compressions are more likely responsible for spur formation [16].

The goal of this study was to evaluate the prevalence of the PCSs in adults who underwent foot X-ray examination. The second part of the study focused on the appearance of the thorny heel spurs which were classified into two groups: simple (regular) and irregular heel spurs. Accordingly, the results showed that 14 spurs (38.9%) were simple and 22 (61.1%) irregular in shape. More frequent occurrence of irregular spurs was seen in female subjects, as opposed to simple spurs, which were more frequent in males.

In regard to their direction, the PCSs were classified as horizontal or vertical. In this study, all the observed spurs had the same horizontal position, but the angle at which they were separated from the calcaneus differed (Figure 3). More specifically, 15 PSCs (41.7%) had a classic horizontal position, with the tips pointing forward, 16 of them (44.4%) with the tip pointing upwards, while 5 PSC (13.9%) were pointing downwards.

**Discussion**

Since 1900, when Plettner first used the term plantar calcaneal spur, till today, the exact etiology of spur is not known [16]. There are two hypotheses about its occurrence: the hypothesis of longitudinal traction (friction), according to which persistent friction of the PF on the surface of the calcaneus leads to the formation of a spur, and the hypothesis of vertical compression, according to which constant compression leads to microfractures of the calcaneus which consequently form connective-cartilage tumefactions. The prevailing view is that vertical compressions are more likely responsible for spur formation [16].

The goal of this study was to evaluate the prevalence of the PCSs in adults who underwent foot X-ray examination. The second part of the study focused on the appearance of the thorny heel spurs which were classified into two groups: simple (regular) and irregular heel spurs. Accordingly, the results showed that 14 spurs (38.9%) were simple and 22 (61.1%) irregular in shape. More frequent occurrence of irregular spurs was seen in female subjects, as opposed to simple spurs, which were more frequent in males.

In regard to their direction, the PCSs were classified as horizontal or vertical. In this study, all the observed spurs had the same horizontal position, but the angle at which they were separated from the calcaneus differed (Figure 3). More specifically, 15 PSCs (41.7%) had a classic horizontal position, with the tips pointing forward, 16 of them (44.4%) with the tip pointing upwards, while 5 PSC (13.9%) were pointing downwards.

**Discussion**

Since 1900, when Plettner first used the term plantar calcaneal spur, till today, the exact etiology of spur is not known [16]. There are two hypotheses about its occurrence: the hypothesis of longitudinal traction (friction), according to which persistent friction of the PF on the surface of the calcaneus leads to the formation of a spur, and the hypothesis of vertical compression, according to which constant compression leads to microfractures of the calcaneus which consequently form connective-cartilage tumefactions. The prevailing view is that vertical compressions are more likely responsible for spur formation [16].

The goal of this study was to evaluate the prevalence of the PCSs in adults who underwent foot X-ray examination. The second part of the study focused on the appearance of the thorny heel spurs which were classified into two groups: simple (regular) and irregular heel spurs. Accordingly, the results showed that 14 spurs (38.9%) were simple and 22 (61.1%) irregular in shape. More frequent occurrence of irregular spurs was seen in female subjects, as opposed to simple spurs, which were more frequent in males.

In regard to their direction, the PCSs were classified as horizontal or vertical. In this study, all the observed spurs had the same horizontal position, but the angle at which they were separated from the calcaneus differed (Figure 3). More specifically, 15 PSCs (41.7%) had a classic horizontal position, with the tips pointing forward, 16 of them (44.4%) with the tip pointing upwards, while 5 PSC (13.9%) were pointing downwards.

**Discussion**

Since 1900, when Plettner first used the term plantar calcaneal spur, till today, the exact etiology of spur is not known [16]. There are two hypotheses about its occurrence: the hypothesis of longitudinal traction (friction), according to which persistent friction of the PF on the surface of the calcaneus leads to the formation of a spur, and the hypothesis of vertical compression, according to which constant compression leads to microfractures of the calcaneus which consequently form connective-cartilage tumefactions. The prevailing view is that vertical compressions are more likely responsible for spur formation [16].

The goal of this study was to evaluate the prevalence of the PCSs in adults who underwent foot X-ray examination. The second part of the study focused on the appearance of the thorny heel spurs which were classified into two groups: simple (regular) and irregular heel spurs. Accordingly, the results showed that 14 spurs (38.9%) were simple and 22 (61.1%) irregular in shape. More frequent occurrence of irregular spurs was seen in female subjects, as opposed to simple spurs, which were more frequent in males.

In regard to their direction, the PCSs were classified as horizontal or vertical. In this study, all the observed spurs had the same horizontal position, but the angle at which they were separated from the calcaneus differed (Figure 3). More specifically, 15 PSCs (41.7%) had a classic horizontal position, with the tips pointing forward, 16 of them (44.4%) with the tip pointing upwards, while 5 PSC (13.9%) were pointing downwards.

**Discussion**

Since 1900, when Plettner first used the term plantar calcaneal spur, till today, the exact etiology of spur is not known [16]. There are two hypotheses about its occurrence: the hypothesis of longitudinal traction (friction), according to which persistent friction of the PF on the surface of the calcaneus leads to the formation of a spur, and the hypothesis of vertical compression, according to which constant compression leads to microfractures of the calcaneus which consequently form connective-cartilage tumefactions. The prevailing view is that vertical compressions are more likely responsible for spur formation [16].
due to trauma, inflammation processes or ankle joint pain. It was found that 13.2% of the sample had PCS, which correlates with the literature data found in young to middle aged populations [18, 19–23]. Menz et al. [7] showed that 55% of their sample had PCS, with significant incidence in obese examinees, respondents who had osteoarthritis in at least one body region, or those with current or previous heel pain. That was similar to results of Bassiouni [18] who found 72% of PCS in rheumatology patients, or results of Banadda et al. [21] with 50% prevalence of PCS in hospital patients over 51 years of age.

Several theories have shown that the predisposition for spur formation depends on the sex, age, body weight, genetic predisposition, comorbidities, as well as foot position and the type of footwear [2–4, 6, 7, 15–17, 24–26]. In the young and middle aged population, the PCS prevalence was 11–21% (11% in India, 13% in Ireland, 15% in Zimbabwe, 16% in Thailand, 17% in Europe, and 21% in America) [27, 28]. The prevalence increases with age to 55% in adults over 62 years of age and up to 81% in population with osteoarthritis [12, 16]. Diseases such as diabetes mellitus and osteoporosis can be accompanied by more common formation of bony outgrowths [13, 18, 29]. Feet injuries due to inadequate jogging, prolonged running on hard surfaces, feet in pronation and intense physical activity can contribute to the formation of the PSC [2, 4–6, 13, 17, 18, 25, 29]. However, despite numerous studies the exact cause of spur formation cannot be confirmed with certainty. Between 11% and 27% of population with the PCS live without any symptoms and disorders [2, 5–7, 13, 14, 16, 17, 25, 30]. Due to this very reason, some authors consider spur to be of little importance in describing the painful heel syndrome [5] and spurs are often discovered by accident, but if present, they undoubtedly impair the quality of life.

**Conclusion**

The results of this study confirmed the literature data, with no statistically significant difference between sexes and orientation - right/left foot. The limitations of the study are the lack of data on age and body weight, as well as potential comorbidities of the respondents. With these data, the scientific research would be more complete and obtained results more relevant and applicable. These limitations impose the need to continue the research, expand the sample and also monitor changes in the size and shape of plantar calcaneal spurs in the analyzed sample.

**References**

1. Çarlı AB, Tekin L, Akarsu S, Kiralp MZ. Calcaneal spur in an 18-month-old boy. Scand J Rheumatol. 2013;42(1):83-4.
2. Zhou B, Zhou Y, Tao X, Yuan C, Tang K. Classification of calcaneal spurs and their relationship with plantar fasciitis. J Foot Ankle Surg. 2015;54(4):594-600.
3. Thomas JL, Christensen JC, Kravitz SR, Mendicino RW, Schuberth JM, Vanore JV, et al. The diagnosis and treatment of heel pain: a clinical practice guideline – revision 2010. J Foot Ankle Surg. 2010;49(3 Suppl):S1-19.
4. Kosmahl EM, Kosmahl HE. Painful plantar heel, plantar fasciitis, and calcaneal spur: etiology and treatment. J Orthop Sports Phys Ther. 1987;9(1):17-24.
5. Abreu MR, Chung CB, Mendes L, Mohana-Borges A, Trudell D, Resnick D. Plantar calcaneal enthesophytes: new observations regarding sites of origin based on radiographic, MR imaging, anatomic, and paleopathologic analysis. Skeletal Radiol. 2003;32(1):13-21.
6. Nuhamni S. Plantar fasciitis: a review of current concepts. Indian Journal of Basic and Applied Medical Research. 2012;5(2):414-8.
7. Kirkpatrick J, Yassaie O, Mirjalili SA. The plantar calcaneal spur: a review of anatomy, histology, etiology and key associations. J Anat. 2017;230(6):743-51.
8. Rubin G, Witten M. Plantar calcaneal spurs. Am J Orthop. 1963;5:38-41.
9. McCarthy DJ, Gorecki GE. The anatomical basis of inferior calcaneal lesions. A criomicrotomy study. J Am Podiatry Assoc. 1979;69(9):527-36.
10. Kumai T, Benjamin M. Heel spur formation and the subcalcaneal entesis of the plantar fascia. J Rheumatol. 2002;29(9):1957-64.
11. Smith S, Tinley P, Gilheaney M, Grills B, Kingsford A. The inferior calcaneal spur – anatomical and histological considerations. Foot. 2007;17(1):25-31.
12. Li J, Muehleman C. Anatomic relationship of heel spur to surrounding soft tissues: greater variability than previously reported. Clin Anat. 2007;20(8):950-5.
13. Aldridge T. Diagnosing heel pain in adults. Am Fam Physician. 2004;70(2):332-8.
14. Alvarez-Nemegyei J, Canoso JJ. Heel pain: diagnosis and treatment step by step. Cleve Clin J Med. 2006;73(5):465-71.
15. Wearing SC, Smeathers JE, Urry SR, Hennig EM, Hills AP. The pathomechanics of plantar fasciitis. Sports Med. 2006;36(7):585-611.
16. Menz HB, Zammit GV, Landorf KB, Munteanu SE. Plantar calcaneal spurs in older people: longitudinal traction or vertical compression? J Foot Ankle Res. 2008;1(1):1-7.
17. Johal KS, Milner SA. Plantar fasciitis and the calcaneal spur: fact or fiction? Foot Ankle Surg. 2012;18(1):39-41.
18. Bassioumi M. Incidence of calcaneal spurs in osteoarthritis and rheumatoid arthritis, and in control patients. Ann Rheum Dis. 1965;24(5):490-3.
19. Alshami AM, Souvlis T, Coppieters MW. A review of plantar heel pain of neural origin: differential diagnosis and management. Man Ther. 2008;13(2):103-11.
20. Barrett SL, Day SV, Pignetti TT, Egly BR. Endoscopic heel anatomy: analysis of 200 fresh frozen specimens. J Foot Ankle Surg.1995;34(1):51-6.
21. Banadda BM, Gona O, Vaz R, Ndlovu DM. Calcaneal spurs in a black African population. Foot Ankle. 1992;13(6):352-4.
22. Benjamin M, Touni H, Ralphs JR, Bydder G, Best TM, Milz S. Where tendons and ligaments meet bone: attachment sites (‘entheses’) in relation to exercise and/or mechanical load. J Anat. 2006;208(4):471-90.

Rad je primljen 13. VII 2020.
Recenziran 17. VII 2020.
Prihvaćen za štampu 17. VII 2020.
BIBLID.0025-8105:(2020):LXXIII:7-8:195-199.