Original Clinical Article

JOURNAL OF CHILDREN'S ORTHOPAEDICS

A retrospective study on factors predictive of operative intervention in symptomatic accessory navicular

D. M. Knapik[1,2,3]
H. D. Archibald[3]
K. K. Xie[3]
R. W. Liu[1,2,3]

Abstract

Purpose The variables causing symptomatic accessory navicular are largely unknown and may inform management of symptomatic patients. The purpose of this study was to examine patient specific factors associated with the development of accessory navicular symptoms.

Methods A total of 71 patients with clinical and radiographic evidence of accessory navicular syndrome were evaluated. Patient gender, race, date of birth, date of earliest foot complaint and laterality were recorded. Treatment was defined as conservative *versus* surgical. Skeletal maturity was assessed based on calcaneal ossification, accessory navicular subtype and the presence of pes planus based on talo-first metatarsal angle were assessed.

Results Female patients comprised 72% of the subjects and trended towards symptoms at younger ages than male patients (p = 0.06), while no significant difference in presentation age was appreciated between male and female patients. Skeletal maturity was significantly associated with earlier complaints and age at presentation but was not associated with increased need for surgical management. Patients with pes planus were significantly more likely to undergo operative management. Accessory navicular subtype was significantly correlated with skeletal maturity.

Conclusion Female patients were more likely to report symptoms and present with symptomatic accessory navicular. The stage of skeletal maturity is not a predictor of future surgical management but patients with a higher first-metatarsal angle were more likely to require surgery. The correlation between accessory navicular subtype and skeletal maturity suggests that Type II ossicles are likely to develop into Type III over time. Radiographic evaluation of the accessory navicular may lend prognostic data on the necessity of future surgical intervention.

Level of Evidence IV, Case Series

Cite this article: Knapik DM, Archibald HD, Xie KK, Liu RW. A retrospective study on factors predictive of operative intervention in symptomatic accessory navicular. *J Child Orthop* 2019;13:107-113. DOI: 10.1302/1863-2548.13.180168

Keywords: accessory navicular; ossicle; paediatric; foot; pain

Introduction

The accessory navicular is a common variant in skeletal foot anatomy, characterized by an additional ossification *versus* a bony prominence off the navicular. The prevalence of accessory navicular in children is estimated at 10% to 12%.[1,2] The development of symptoms secondary to the presence of an accessory navicular have been reported to occur in 0.1% (1 in 1000) of adult patients.[3] When symptomatic, patients typically present with a tender, erythematous bony prominence on the medial aspect of the foot, with pain exacerbated by walking, athletics, footwear, eversion and plantarflexion.[4] Diagnosis of accessory navicular is generally confirmed based on the presence of medial foot pain with radiographs demonstrating the presence of an secondary ossification off the navicular.[5] Current guidelines recommend initial conservative management including observation, anti-inflammatories, orthotics and walking boots, with surgical excision or debridement advised in patients with continued symptoms despite conservative treatment.[6-9]

To date, it remains unknown why accessory navicular symptoms occur in some patients with an accessory navicular and not others. Previous authors have speculated the role of concomitant posterior tibial tendonitis, pressure inflammation over the bony prominence, ligamentous laxity, trauma to the synchondrosis and alterations in midfoot biomechanics as potential sources for pain.[10-12]

[1] Rainbow and Babies Hospital at Case Western Reserve University, Cleveland, Ohio, USA
[2] University Hospitals Cleveland Medical Center, Cleveland, Ohio, USA
[3] Case Western Reserve University, School of Medicine, Cleveland, Ohio, USA

Correspondence should be sent to D. M. Knapik, M.D., University Hospitals Cleveland Medical Center, 11100 Euclid Ave., Cleveland, Ohio 44106, USA.
E-mail: derrick.knapik@gmail.com

Flat-foot deformity, or pes planus, has also been reported to be associated with symptomatic accessory navicular, with authors suggesting that this foot profile leads to greater stress on the accessory navicular during weight-bearing, however this theory remains controversial.[5,13]

Patients rarely complain of pain prior to adolescence, with the majority reporting symptoms beginning in the second decade of life.[9,13] Studies examining for association between skeletal maturity and accessory navicular appearance have demonstrated that female patients present significantly earlier than male patients.[2,9] However, no study has determined the association between the timing of accessory navicular appearance and the onset of symptoms.

The purpose of this study was to evaluate patient-specific factors, including skeletal maturity and the presence of pes planus, and their relation to the presentation of symptoms in skeletally immature patients with symptomatic accessory navicular. The authors hypothesized that the initial presentation would correlate with more advanced stages of skeletal maturation and the presence of pes planus would correlate with increased rate of surgery.

Materials and methods

Following approval by the institutional review board at the senior author's (RWL) institution (University Hospitals Cleveland Medical Center, Cleveland, Ohio), the electronic medical records of patients with a diagnosis of accessory navicular (International Classification of Diseases-9 code: 755.67)[14] treated between 01 January 2007 and 31 December 2012 were evaluated. Patients between the ages of eight and 18 years at the time of initial presentation with clinical and radiographic diagnosis of accessory navicular syndrome were included in this study. Patients were excluded if they were 19 years or older at the time of diagnosis or were without a diagnosis of accessory navicular upon review of the records. We recorded patient gender, race, date of birth, date of earliest foot complaint and laterality. The presence of any reported preceding trauma to the affected foot was also recorded. Management of symptoms was recorded based on whether patients were either treated conservatively using a combination of rest, anti-inflammatories, ice, physical therapy, orthotic inserts, corticosteroid injection or immobilization in a cast or walking boot *versus* operative treatment consisting of complete accessory navicular excision with debridement/shaving of the base *versus* partial excision with debridement/shaving of the accessory navicular in cases where a separate fragment was not present.

Accessory navicular classification was assessed by examining oblique and anteroposterior radiographs of the foot using the previously defined and validated classification system by Coughlin et al.[5] Type I is a bone completely separate from the navicular, Type II is continuous with but not fused to the navicular and Type III is similar to Type II but is fused to the navicular (Fig. 1). Skeletal maturity was graded based on the extent of ossification of the calcaneus on lateral radiographs and scored using the skeletal maturity grading system developed by Nicholson et al.[15] The classification is divided into six stages: Stage 0, no ossification; Stage 1, ossification of the calcaneus with < 50% of the metaphysis; Stage 2, > 50% apophyseal ossification without fully covering the plantar surface; Stage 3, apophyseal extension over the plantar surface and within 2 mm of the calcaneal concavity; Stage 4, evidence of initial fusion between the apophysis and the metaphysis; and Stage 5, complete fusion. The amount of pes planus was assessed on standing radiographs by measuring the lateral talo-first metatarsal (Meary's) angle, evaluating the intersecting angle between a line drawn along the longitudinal axes of the first metatarsal and the talus.[16] Patients with measurements ≥ 4° were classified as possessing pes planus.[17] For all patients, the earliest available radiographs

Fig. 1 Anteroposterior radiographs of the foot demonstrating accessory navicular subtype based on the classification system establish by Coughlin et al:[5] Type I, complete boney separation the navicular (a, red arrow); Type II, ossicle is continuous without fusion to the navicular (b, red arrow); Type III, ossicle fused to navicular (c, red arrow).

following complaint of symptoms were used for subtype classification of the accessory navicular, skeletal maturity grading and measurements of the first metatarsal angle.

Cohen's κ was measured to determine agreement between two authors using 50 radiographs for accessory navicular subtype and skeletal maturity stage. Intra-class correlation coefficients (ICC) were calculated for lateral talo-first metatarsal angle measurements to assess inter-relator reliability. Pearson correlation values were calculated to evaluate for associations between skeletal maturity and accessory navicular subtype and the initial chronologic age when symptoms were first reported. A student's *t*-test and chi-squared analysis were used to evaluate for differences in age at initial presentation, age when symptoms were first reported, surgical treatment and the stage of skeletal maturity between genders. All statistical analyses were performed using SPSS 24.0 software (IBM Corporation, Armonk, New York).

Results

A total of 71 patients (n = 20 male; n = 51 female) met inclusion/exclusion criteria. Female patients comprised 72% of subjects (Table 1). Female patients reported symptoms at a younger age (11.7 years; SD 2.6) when compared with male patients (12.8 years; SD 2.0) at a rate that approached significance (p = 0.06) while also presenting at an earlier age (12.5 years; SD 2.3), when compared with male patients (13.3 years; SD 1.9), however, this difference was not significant (p = 0.16) (Table 2). A total of 69 patients (97%) (n = 20 male, n = 49 female) had radiographs of the foot available for accessory navicular subtype classification. Grading of accessory subtype classification produced substantial agreement between authors, κ = 0.759 (p < 0.005). Accessory navicular type was not significantly different when comparing female patients (n = 1 Type I, n = 57 Type II, n = 16 Type III) with male patients (n = 0 Type I, n = 20 Type II, n = 8 Type III) (p = 0.41).

In all, 70 patients (99%) had lateral radiographs of the calcaneus allowing for measurement of skeletal maturity grading based on calcaneal ossification. There was excellent agreement between authors in skeletal maturity grading, κ = 0.939 (p < 0.005). Mean overall grade of calcaneal maturity on radiograph was 3.3 (SD 1.2). Assessment of skeletal maturity found no significant difference in mean calcaneal grade between female (3.5; SD 1.2) and male patients (3.0; SD 1.4) (p = 0.19) (Table 2). The stage of skeletal maturity positively correlated with both the age at initial presentation (p < 0.0001) and the age at initial symptoms (p < 0.0001) in both male and female patients (Table 3) with older age at presentation corresponding to a greater skeletal maturity grade.

In total, 42 patients (59%) (n = 12 male, n = 30 female) had weight-bearing radiographs available for

Table 1 Patient characteristics and laterality

Characteristics	Percentage total		
Gender			
Females	*72* (n = 51/71)		
Males	*28* (n = 20/71)		
Race			
Caucasian	*73* (n = 52/71)		
African American	*20* (n = 14/71)		
Asian American	*3* (n = 2/71)		
No race listed	*4* (n = 3/71)		
Laterality	**Percentage total**	**Percentage symptomatic**	**Percentage asymptomatic**
Accessory navicular right foot	*87* of pts, (n = 62)	*97* (n = 60/62)	*3* (n = 2/62)
Accessory navicular left foot	*59* of pts, (n = 42)	*93* (n = 39/42)	*7* (n = 3/42)
Bilateral	*46* of pts, (n = 33)	*94* (n = 31/33)	*6* (n = 2/33)

pts, patients

Table 2 Gender comparison

	Male	Female	p-value
Age at presentation (yrs)	13.3 (SD 1.9) (n = 20)	12.5 (SD 2.3) (n = 51)	0.16*
Age at symptoms (yrs)	12.8 (SD 2.0) (n = 20)	11.7 (SD 2.6) (n = 51)	0.06*
Calcaneal grade	3.0 (SD 1.4) (n = 19)	3.5 (SD 1.2) (n = 51)	0.19*
Accessory navicular type	2.30 (n = 20)	2.20 (n = 49)	0.36*
Rate of surgical treatment	0.35 (n = 7/20)	0.51 (n = 26/51)	0.23†

*p-value calculated using student's *t*-test
†p-value calculated using chi-square analysis

talo-first metatarsal angle measurement. The mean angle was 9.9° (SD 8.4°) with excellent inter-relator agreement between authors (ICC = 0.978). Talo-first metatarsal angle measurements were found to correlate significantly with age of patient's complaints and treatment, as patients with higher angle reported symptoms significantly earlier (p = 0.02) and were more frequently treated with operative management (p = 0.02). Higher talo-first metatarsal angle measurement was not significantly correlated with earlier age at patient presentation (p = 0.13) (Table 3).

A total of 24% (n = 17) of patients reported trauma preceding or related to symptoms. In all 92% (n = 65) of patients underwent conservative treatment, detailed in Table 4. A total of 52% of patients used a cast/walking boot (n = 37), 54% used orthotics (n = 38), 32% used anti-inflammatories (n = 23), 34% used rest/ice (n = 24), 35% used physical therapy (n = 25), while 3% underwent corticosteroid injection (n = 2.) Operative intervention was performed in 46% of patients (n = 33/71) undergoing a total of 45 procedures: 40 unilateral (seven of which were interval corrections of both feet of one patient), four bilateral (both feet fixed in one operation) and one revision procedure due to incomplete excision with a persistent prominence of the navicular leading to irritation of the posterior tibial tendon. Mean age at surgery was 13.1 years (SD 2.3) and patients reported symptoms for an average of 1.2 years (SD 1.0) prior to surgery. Of these patients, 100% (n = 33 of 33) had initially attempted and failed conservative management. All surgeries were performed by five fellowship trained orthopaedic surgeons. There was no significant difference in the proportion of female patients undergoing surgery (n = 26/51) compared with male patients (n = 7/20) (p = 0.23) (Table 2). The total number of procedures performed in female patients was 34 compared with 11 procedures in male patients. The accessory navicular was completely excised in 76% of surgeries (n = 34/45), while partial excision was performed in 24% of surgeries (n = 11/45.) The posterior tibial tendon was detached and advanced onto the navicular using suture anchors in 4% (n = 2) of surgeries. No intraoperative complications were reported while one patient required revision surgery due to pain from incomplete excision of an inferiorly located accessory navicular fragment. Type II accessory navicular feet had a similar rate of surgical intervention (n = 32/77) to type III accessory navicular feet (n = 12/24) (p = 0.75) (Table 4). Moreover, the stage of skeletal maturation based on calcaneal grade was not found to predict whether or not a patient required operative management (p = 0.14) (Table 3 and Fig. 2).

Discussion

The principle findings from this retrospective investigation were that female patients reported symptoms secondary to accessory navicular at a younger age that approached significance when compared with male patients, and a higher degree of pes planus was associated with an earlier presentation and a greater likelihood of operative excision. Patients with a Type II accessory navicular were as likely to require operative management as patients with a Type III accessory navicular, while no association between the stage of skeletal maturity and operative management was appreciated.

In a prospective study of 50 patients randomized to Kidner *versus* simple excision procedures, Macnicol et al[10] reported that no patients were found to possess a Type III accessory navicular. Similarly, Prichasuk and Sinphurmsukskul[18] and Jegal et al[19] each reported that all patients requiring surgery were diagnosed with only Type II accessory naviculars. Furthermore, Grogan et al[11] found that 100% (n = 23 of 23) of patients with symptomatic Type II accessory naviculars required surgery compared with only 50% (n = 2 of 4) of patients with Type III accessory naviculars. We report a 42% rate of operative management on Type II *versus* a 50% rate of operative management for Type III. Grogan et al[11] suggested that pain in Type II accessory naviculars occurs from chronic irritation and inflammation of the synchondrosis between the accessory navicular and the navicular, as the accessory navicular has been shown to displace with eversion stress.[19] Overall, we cannot make any definitive conclusions as to whether a Type II accessory navicular is more likely to be symptomatic than a Type III.

Table 3 Pearson correlations

	Calcaneal maturity grade	p-value†	Age at symptoms (yrs)	p-value†	Max talo-first metatarsal angle (°)	p-value†
Age at presentation (yrs)	R = 0.721* (n = 70)	< 0.0001	-	-	R = -0.238 (n = 42)	0.13
Age at symptoms (yrs)	R = 0.614* (n = 70)	< 0.0001	-	-	R = -0.373* (n = 42)	0.02
Max acc. nav. type	R = 0.324* (n = 69)	0.01	R = 0.247* (n = 69)	0.04	-	-
Min acc. nav. type	R = 0.235* (n = 69)	0.05	R = 0.266* (n = 69)	0.03	-	-
Surgical treatment	R = 0.177 (n = 70)	0.142	-	-	R = 0.355* (n = 42)	0.02

*denotes statistical significance ($p < 0.05$)
†p-values calculated using Pearson correlation
Max, maximum; acc. nav., accessory navicular; Min, minimum; yrs, years

Table 4 Treatment data

	Male	Female	p-value*
Age at surgery (yrs)	13.7 (SD 1.5) (n = 7)	13.0 (SD 2.5) (n = 26)	0.39
Skeletal maturity at surgery	3.3 (SD 1.4) (n = 7)	3.9 (SD 1.1) (n = 26)	0.30
Male and female treatment data (%)			
Conservative therapy total	*92* (n = 65/71)		
Cast/walking boot	*52* (n = 37/71)		
Orthotics	*54* (n = 38/71)		
Anti-inflammatories	*32* (n = 23/71)		
Rest/ice	*34* (n = 24/71)		
Physical therapy	*35* (n = 25/71)		
Corticosteroid injury	*3* (n = 2/71)		
Conservative treatment prior to surgery	*100* (n = 33/33 pts)		
Skeletal maturity at surgery	3.8 (SD 1.2) (n = 33)		
Complete AN excision	*76* (n = 34/45)		
Partial AN excision	24 (n = 11/45)		
Posterior tibial tendon advanced and reattached	*4* (n = 2/45)		
Complications	*2* (n = 1/45)		
Type II AN surgical rate	*42* (n = 32/77)		
Type III AN surgical rate	*50* (n = 12/24)		

*p-value calculated using student's *t*-test
AN, accessory navicular; pts, patients

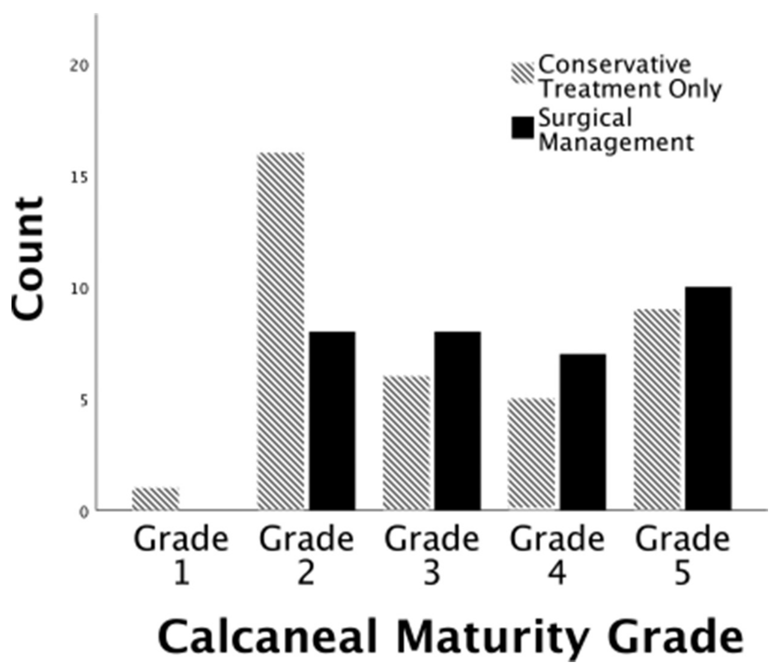

Fig. 2 Histogram showing calcaneal grade and treatment. There was no association between skeletal maturity and treatment for accessory navicular.

The correlation between higher talo-first metatarsal angle and earlier age of symptoms suggests that flat foot deformity may initiate or exacerbate accessory navicular symptoms. However, the relationship between pes planus and accessory navicular is debated in the literature. Kidner[20] reported that the presence of pes planus and accessory navicular were related, suggesting that the insertion of the tibialis posterior tendon inserts on the accessory navicular and disrupts the medial longitudinal arch. In contrast, Bennett et al[13] argued that pes planus is an incidental finding, providing evidence from other studies that reinsertion of the tibialis posterior tendon does not successfully restore the medial arch. Data from this investigation also found that a higher talo-first metatarsal angle was positively correlated with earlier symptoms and a greater chance of patient's requiring surgery. Moreover, Macnicol et al[10] reported that the navicular forms part of the midfoot arch, such that in patients with pes planus, the accessory navicular is effectively closer to the ground and at greater risk for repetitive trauma.

Skeletal maturity grade correlated positively with accessory navicular type, supporting the belief that accessory navicular type changes with development. Type II accessory naviculars are bridged histologically by a synchondrosis of fibrocartilage.[11] Type III is a similar shape and size, but the bridge is composed of bone and fused to the navicular. This bridge may form from the Type II fibrocartilage synchondrosis with development. Longitudinal bony fusion has been previously described in the literature, with Knapik et al[2] reporting a natural fusion rate of 42% (n = 8 of 19) and Nakayama et al[21] describing a 10% to 14% fusion rate for symptomatic of Type II accessory naviculars.[2] Our data supports those reports with a trend of decreasing Type II and increasing Type III frequency with more advanced stages of skeletal maturity. Greater longitudinal radiographic analyses are necessary to better understand the behaviour and natural history of accessory navicular sub-types and development.

Surgery remains a common method of treatment for accessory navicular, as 46% of patients in our study underwent at least one surgery (n = 33/71). This percentage is lower than those reported by Jegal et al[19] and Grogan et al[11] in which operative management was performed in 89% (n = 57/64) and 77% (n=17/22) of patients, respectively. However, Grogan et al[11] report using conservative treatment in only 41% (n = 16 of 39) of feet with accessory naviculars. Meanwhile, Jegal et al[19] required at least six months of conservative management, but 37% (n = 29/79) of patients were athletes, perhaps desiring operative management in order to achieve relief and return to play.

This study was not without limitations. As this was a retrospective review, the authors were limited to only data reported in the patient's medical charts. In addition, the authors were unable to make conclusions of cause and effect due to the inherent limitations of the retrospective nature of the study. Imaging was only obtained in symptomatic feet, limiting information regarding accessory navicular incidence and timing in asymptomatic feet. No symptom severity scale was utilized, as only the presence or absence of symptomatic accessory navicular was recorded. Moreover, postoperative management strategies and protocols were not recorded. Furthermore, not all patients included in the study had weight-bearing radiographs required for measurement of the talo-first metatarsal angle. Lastly, our cohort was limited geographically and not necessarily representative of a broader population.

In conclusion, accessory navicular symptoms were associated with skeletal maturity and higher talo-first metatarsal angle measurements. Due to the small sample size and retrospective nature of the investigation, the authors are unable to support or refute the suggestions by Knapik et al[2] that accessory navicular may be treated more conservatively in skeletally immature patients due to the possibility of fusion of the synchondrosis with time. Furthermore, in patients with symptomatic accessory navicular with concomitant higher talo-first metatarsal angle, there may exist a greater risk for operative management in the future. The authors believe that the information presented in the study will assist surgeons caring for patients with accessory navicular by demonstrating factors associated with development of symptomatic accessory navicular maturity (skeletal maturity and female gender) and future operative intervention (higher talo-first metatarsal angle). By providing surgeons with variables which may help predict the development of symptomatic pain and dysfunction in this patient population, more aggressive conservative management, such as corticosteroid injection, may be indicated in patients at higher risk for requiring surgery in the future. Future prospective studies further examining the natural history of accessory navicular behaviour in skeletally immature patients are needed to further elucidate potential factors predicting the need for operative management in symptomatic patients.

Received 03 October 2018; accepted after revision 27 December 2018.

COMPLIANCE WITH ETHICAL STANDARDS

FUNDING STATEMENT

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

ETHICAL STATEMENT

Ethical approval: Institutional review board approval was obtained from the senior author's hospital for this retrospective chart review.
Informed consent: Not required for this work.

JOURNAL OF CHILDREN'S ORTHOPAEDICS

ICMJE CONFLICT OF INTEREST STATEMENT

RWL reports royalties paid to his institution by the Orthopediatrics Corporation, part of which are placed into a research fund that he controls. All other authors report no conflicts of interest.

AUTHOR CONTRIBUTIONS

DMK: study conception, data collection, data analysis, manuscript preparation.
HDA: data collection, data analysis, manuscript preparation.
KKX: data analysis, statistical analysis, manuscript preparation.
RWL: study conception, data analysis, manuscript preparation.

REFERENCES

1. **Zadek I, Gold AM.** The accessory tarsal scaphoid. *J Bone Joint Surg [Am]* 1948;30-A:957-968.

2. **Knapik DM, Guraya SS, Conry KT, Cooperman DR, Liu RW.** Longitudinal radiographic behavior of accessory navicular in pediatric patients. *J Child Orthop* 2016;10:685-689.

3. **Harris RI, Beath T.** *Army foot survey: an investigation offoot ailments in Canadian soldiers.* Ottawa: National Research Council, 1947.

4. **Sella EJ, Lawson JP.** Biomechanics of the accessory navicular synchondrosis. *Foot Ankle* 1987;8:156-163.

5. **Coughlin MJ, Saltzman CJ, Anderson RB.** Sesamoids and accessory bones of the foot. In: Coughlin MJ, Saltzman CL, Anderson RB. *Mann's Surgery of the Foot and Ankle Ninth, Edition.* Vol 9. Philadelphia: Elsevier Saunders, 2014:544-551.

6. **Kim JR, Park CI, Moon YJ, Wang SI, Kwon KS.** Concomitant calcaneo-cuboid-cuneiform osteotomies and the modified Kidner procedure for severe flatfoot associated with symptomatic accessory navicular in children and adolescents. *J Orthop Surg Res* 2014;9:131.

7. **Kopp FJ, Marcus RE.** Clinical outcome of surgical treatment of the symptomatic accessory navicular. *Foot Ankle Int* 2004;25:27-30.

8. **Chung JW, Chu IT.** Outcome of fusion of a painful accessory navicular to the primary navicular. *Foot Ankle Int* 2009;30:106-109.

9. **Lawson JP, Ogden JA, Sella E, Barwick KW.** The painful accessory navicular. *Skeletal Radiol* 1984;12:250-262.

10. **Macnicol MF, Voutsinas S.** Surgical treatment of the symptomatic accessory navicular. *J Bone Joint Surg [Br]* 1984;66-B:218-226.

11. **Grogan DP, Gasser SI, Ogden JA.** The painful accessory navicular: a clinical and histopathological study. *Foot Ankle* 1989;10:164-169.

12. **Choi YS, Lee KT, Kang HS, Kim EK.** MR imaging findings of painful type II accessory navicular bone: correlation with surgical and pathologic studies. *Korean J Radiol* 2004;5:274-279.

13. **Bennett GL, Weiner DS, Leighley B.** Surgical treatment of symptomatic accessory tarsal navicular. *J Pediatr Orthop* 1990;10:445-449.

14. **Centers for Disease Control and Prevention.** International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). https://www.cms.gov/medicare/coding/icd9providerdiagnosticcodes/codes.html (date last accessed 15 January 2019).

15. **Nicholson AD, Liu RW, Sanders JO, Cooperman DR.** Relationship of calcaneal and iliac apophyseal ossification to peak height velocity timing in children. *J Bone Joint Surg [Am]* 2015;97:147-154.

16. **Davids JR, Gibson TW, Pugh LI.** Quantitative segmental analysis of weight-bearing radiographs of the foot and ankle for children: normal alignment. *J Pediatr Orthop* 2005;25:769-776.

17. **Dyal CM, Feder J, Deland JT, Thompson FM.** Pes planus in patients with posterior tibial tendon insufficiency: asymptomatic versus symptomatic foot. *Foot Ankle Int* 1997;18:85-88.

18. **Prichasuk S, Sinphurmsukskul O.** Kidner procedure for symptomatic accessory navicular and its relation to pes planus. *Foot Ankle Int.* 1995;16:500-503.

19. **Jegal H, Park YU, Kim JS, et al.** Accessory navicular syndrome in athlete vs general population. *Foot Ankle Int.* 2016;37:862-867.

20. **Kidner FC.** The prehallux in relation to flatfoot. *JAMA* 1933;101:1539-1542.

21. **Nakayama S, Sugimoto K, Takakura Y, Tanaka Y, Kasanami R.** Percutaneous drilling of symptomatic accessory navicular in young athletes. *Am J Sports Med* 2005;33:531-535.