BJCR
Brazilian Journal of Case Reports

PCAA
Publicações Científicas de Acesso Aberto

Medical Hypothesis

Metatarsal Sesamoids: Borges-Napoleon Sign

Yuri Borges Morais [1, 2, 3, *], Levy da Costa Felix [1], Jones Aguiar de Azevedo [4]

[1] Christus University Center (UNICHRISTUS), Fortaleza, CE, Brazil.
[2] Full Member Brazilian Academy Radiological Sciences (ABCR), Brasília, DF, Brazil.
[3] Inflammation Physiopharmacology Laboratory (LAFFIN), Higher Institute of Biomedical Sciences (ISCB), State University of Ceará (UECE), Fortaleza, CE, Brazil.
[4] Division of Traumatology, Department Surgery, Walter Cantidio University Hospital (HUWC), Fortaleza, CE, Brazil.

* Correspondence: yuri.morais@unichristus.edu.br.

Abstract: The metatarsal sesamoids have been well studied due to their consistent presence in humans and relatively common involvement in foot pathologies. The manifestations of sesamoid lesions on imaging depend on the nature of the pathology and generally overlap. During observation in sectional examinations, an anatomical pattern sign of the sesamoid bones of the first metatarsal was identified to be assessed by specialists in diagnostic imaging to note alterations that deviate from this anatomical pattern sign. Would the anatomical pattern sign in question help in the diagnosis of pathological alterations once it has been de-characterized? The presentation of the Borges-Napoleon sign characterizes the normality of the bones involved in the image, making it safe to diagnose pathological alterations that compromise their structure. Therefore, presenting this idealization could help improve medical reports. The sign is described as the "Borges-Napoleon Sign" because of its resemblance to the silhouette of the Frenchman Napoleon Bonaparte and in reference to the creator of the imaging description, Yuri Borges Morais. Pathological alterations such as traumatic injuries, sesamoiditis, dislocations, fractures, and hallux valgus ("bunions"), among others, de-characterize the Borges-Napoleon sign; the absence of the sign is indicative of an abnormality in the metatarsal-sesamoid-phalangeal region.

Keywords: Multidetector Computed Tomography; Sesamoid Bone; Stress Fractures; Radiology and Orthopedics.

Citation: Morais YB, Felix LC, Azevedo JA. Metatarsal Sesamoids: Borges-Napoleon Sign. Brazilian Journal of Case Reports. 2024 Oct-Dec;04(4):118-125.

Received: 30 December 2023
Accepted: 18 April 2024
Published: 14 May 2024

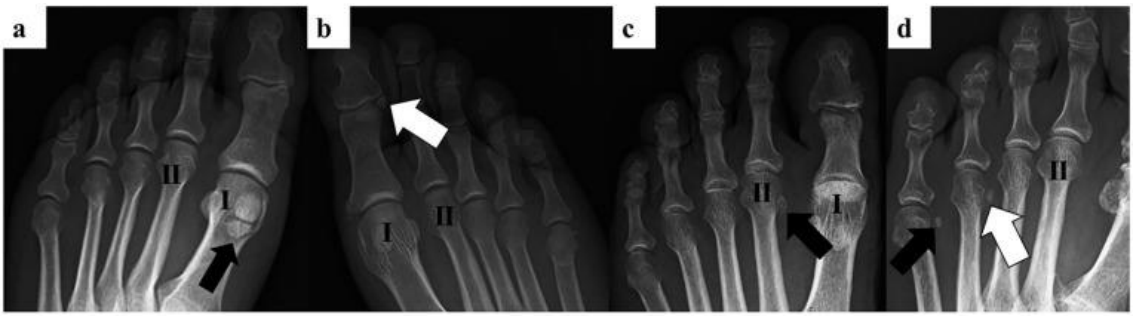
1. Introduction

The metatarsal sesamoids have been well studied due to their consistent presence in humans and their relatively common involvement in foot pathologies, including fractures, dislocations, infections, arthritis, and osteonecrosis [1, 2]. Accessory ossicles, sesamoid bones and bifalangism of the toes are the most common developmental variations of the foot. These bones can be associated with pain syndromes; however, their clinical importance is not well understood because the reported prevalence varies greatly [3]. Bipartite sesamoid bones of the hallux were observed in 1.8% and interphalangeal sesamoid bones of the hallux in 0.7% of the radiographs (Figure 1). Metatarsophalangeal sesamoid bones were found in 0.6%, 0.06%, 0.6% and 5.8% of the second, third, fourth and fifth digits, respectively [3].

It is notable that the sesamoid bones are very common anatomical variations, which can affect one or more ossification centers in the same limb. The following article will look specifically at the metatarsal sesamoids and their great importance when analyzing

imaging exams. Galen was the first to describe these bones as sesamoids, due to their resemblance to sesame seeds or sesame seed-like shape [1].

Figure 1. A. Bipartite halucal sesamoid. B. Halucal interphalangeal sesamoid. C. Second metatarsal sesamoid. D. Fourth and fifth metatarsal sesamoid. The black arrows show the sesamoid bones. The white arrows show the halucal interphalangeal sesamoid (in b) and the fourth metatarsal sesamoid (in d) [3].



Sesamoid bones are small bones present in the tendons where they cross the joints at various locations in the limbs, including the hands, wrists, knees and feet. They are usually oval or round with sizes ranging from 5 to 10 mm. They are mainly formed by means of a single ossification center. If they are formed from multi-ossification centers, they remain unfused [4, 5]. Most of these variations are recognized incidentally during radiological imaging in clinical practice (Figure 2). Evidence from reported studies shows that the prevalence and appearance of sesamoid bones in the foot vary considerably between different populations and ethnic groups [6, 7, 8].

Figure 2. Three-dimensional (3D) reconstruction of the forefoot using computed tomography.

Although the first metatarsophalangeal joint (MTF) is anatomically small, it plays an important role in supporting great propulsion during normal walking [9]. Around 80% of body weight is carried on the first MTF joint during barefoot walking, and this figure increases from 200% to 300% during physical activity; moreover, during running and jumping, this figure increases to 800% [10]. By facilitating sliding movements, these bony nodules reduce friction on the tendons and thus protect them from injury [1]. In addition,

morphological variation in the metatarsal sesamoids was identified in 12.09% of the feet, with variations classified into three distinct types according to the size of the bone and the number of ossification centers. Ossification begins in the MTF joints of the hallux at around 8 years of age, with the final ossification center showing in the sesamoid bone of the fourth MTF joint at 28 years of age [2].

Sesamoid bones are associated with various pathological conditions, including fractures, degeneration of the subsesamoid joint and sesamoiditis [11, 12]. Injuries to the halucal sesamoids can cause disabling pain, which can be devastating for an athlete. Although traumatic injuries can usually be easily diagnosed, other pathological conditions can go undetected. Careful physical and radiological examinations are necessary to determine the cause of the pain and allow a recommendation of the optimal treatment. Surgical treatment can include partial or complete resection of the sesamoid, shaving of a prominent tibial sesamoid or autogenous bone grafting for pseudoarthrosis [13].

Sesamoid fractures comprise trauma associated with overloading the first MTF joint. Using a typical protocol, the hallux is slightly plantar flexed and fixed for 4 to 6 weeks; it then gradually returns to normal activity after walking with partial weight bearing [14]. Most sesamoid fractures heal with appropriate treatment; however, a potential complication of conservative treatment for sesamoid fractures is non-union [15]. Activities involving running, jumping and repeated passive dorsiflexion are associated with an increased risk of sesamoid injury. Golfers, as described above, are vulnerable to sesamoid injury because of the repetitive hyperdorsiflexion of the MTF joint of the hallux [16].

The blood supply to the hallux sesamoids is mainly extraosseous, originating in the proximal and plantar directions via the proper plantar arteries and the first plantar metatarsal. For this reason, the sesamoids are particularly vulnerable to ischemia and osteonecrosis after injury [17]. The hallux sesamoids are well evaluated in the transverse and sagittal planes. The imaging manifestations of sesamoid injury depend on the nature of the pathology and usually overlap. Sesamoid stress reaction and sesamoiditis manifest as hyperintense signal on fluid-sensitive images, although sesamoiditis most commonly involves both sesamoids and may have associated findings of tenosynovitis, tendinosis and bursitis. Sesamoid fractures usually involve the tibial sesamoid and can be visible as transparent fracture lines oriented transversely on radiographs [18].

2. Medical Hypothesis

During observation in sectional Computed Tomography (CT) (Figure 3) and Nuclear Magnetic Resonance (NMR) (Figure 4 and 5) scans, an anatomical pattern sign was identified for the sesamoid bones of the 1st metatarsal, which should be identified by specialists in diagnostic imaging, in order to notice any alterations that deviate from this anatomical pattern sign. The sign is described as the "Borges-Napoleon Sign" because of its resemblance to the silhouette of the Frenchman Napoleon Bonaparte and in reference to the creator of the imagery, professor, and researcher Dr. Yuri Borges Morais.

Napoleon Bonaparte was a French general who gained prominence during the French Revolution and rose to power through a coup; victories in the military and economic fields led him to become emperor, he wore a specific hat and was marked in history [19] (Figure 6). Sesamoiditis is a generic term for numerous conditions involving the sesamoids, including osteonecrosis, chondromalacia, or mechanical overload. It can be characterized by avascular changes or just inflammation of the sesamoids without radiographic changes, fragmentation, fracture, or sclerosis. Patients may also present with painful, swollen plantar bursitis. The etiology is typically repetitive trauma most seen in young adults [17].

Fractures with displacement are usually evident on X-rays, while subtle fractures without displacement can be hidden radiographically. On MRI (Figure 7), a sign of focal edema of the spinal cord in a patient with a history of injury and negative X-rays should lead to the search for a fracture line [20].

Figure 3. Computed tomography image of the foot in transverse plane.

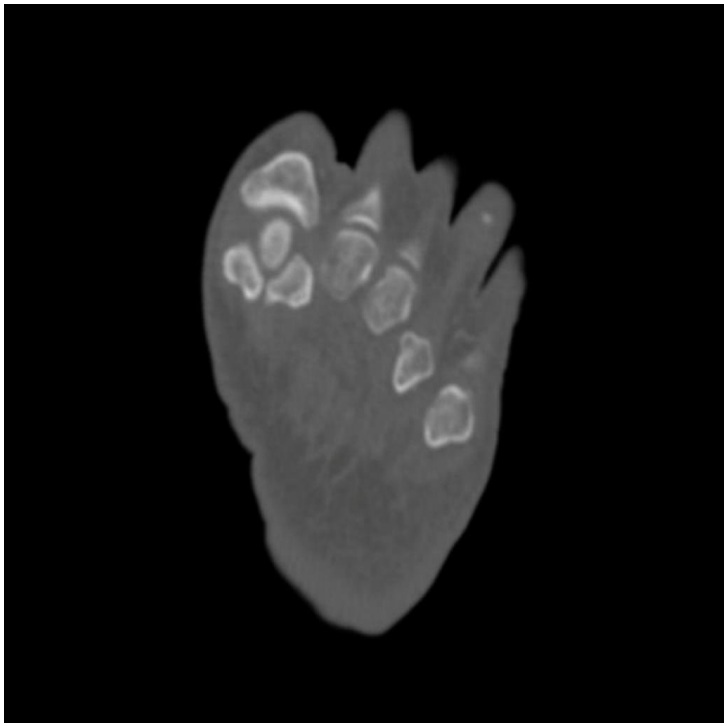
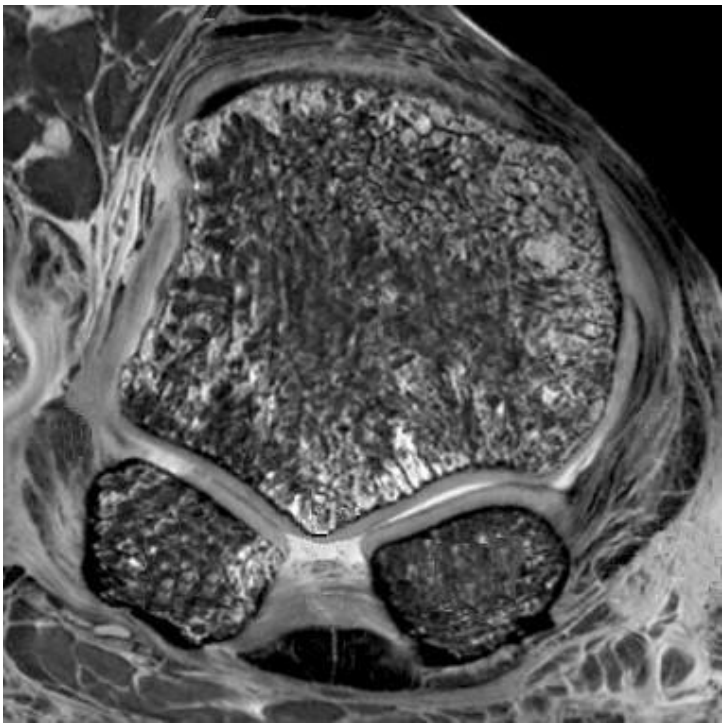


Figure 4. Nuclear magnetic resonance image of the first metatarsosesamoid joint in coronal plane.



Hallux valgus, commonly known as bunion deformity, is the lateral deviation of the hallux in relation to the first metatarsal. It is often associated with medial deviation of the first metatarsal, known as metatarsus primus varus. The cause of hallux valgus is probably a combination of family predisposition and unsuitable footwear. A bunion deformity

can be quantified by measuring the hallux valgus angle and the first second intermetatarsal angle [21].

Figure 5. Computed tomography image of the foot in transverse plane with descriptive anatomy of the structures.

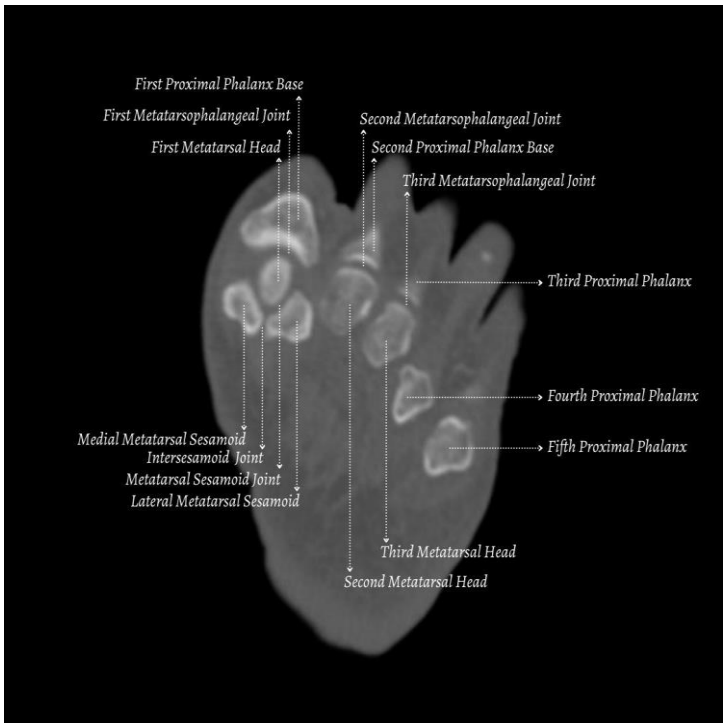


Figure 6. Artistic illustration by Napoleon Bonapart [19].

The analogy of the Borges-Napoleon sign was created by the similarity between the image of Napoleon Bonapart and the cross-section showing the first metatarsal, medial and lateral sesamoid bones and the first proximal phalanx of the foot, as shown in figure 8.

Figure 7. Nuclear magnetic resonance image of the foot in transverse plane of a 23-year-old female dancer with chronic pain and tenderness under the great toe for several months. metatarsosesamoid joint. The medical report shows chronic osteonecrosis of the medial sesamoid with collapse [22].

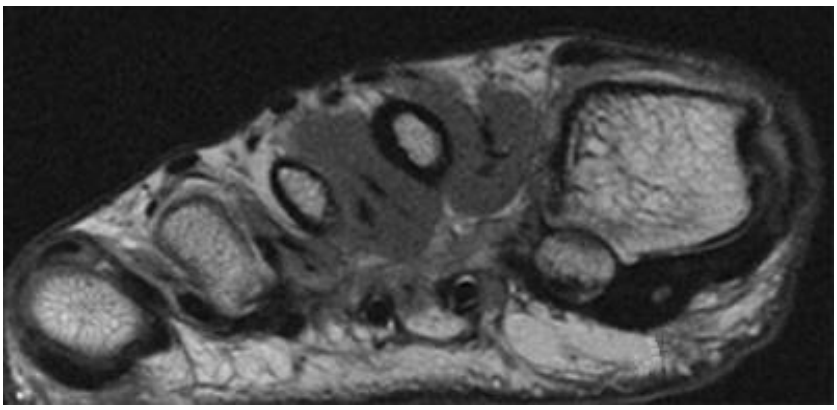
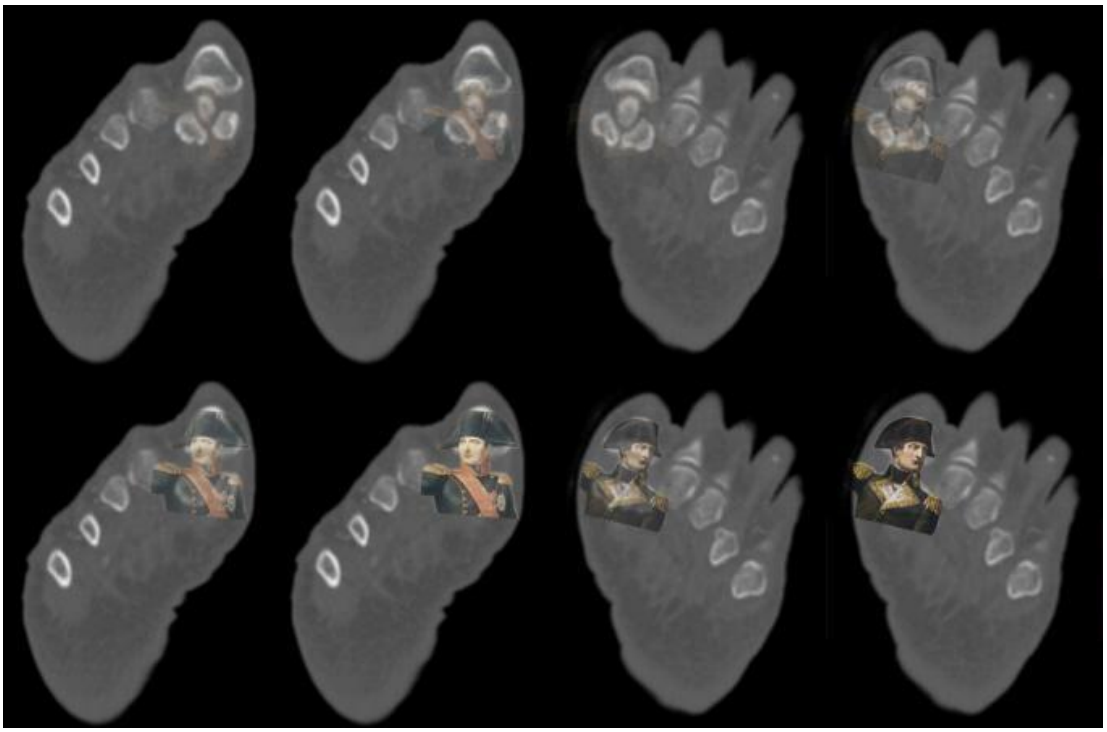


Figure 8. Image of the right and left feet by cross-sectional computed tomography with superimposition of Napoleon Bonapart's image at different levels of transparency.



3. How to test this hypothesis

By presenting research based on relevant studies on the metatarsal sesamoids, the idealization of a new medical hypothesis was described with the aim of being used in reports by doctors specializing in diagnostic imaging. Pathological alterations such as traumatic injuries, sesamoiditis, dislocations, fractures, hallux valgus, among others, de-characterize the Borges-Napoleon anatomical pattern sign, being described as the "negative Borges-Napoleon sign", the absence of which is indicative of an abnormality in the metatarsal-sesamoid-phalangeal region. The sign is clearly visible in cross-sectional CT and MRI scans.

4. Future perspectives

It is estimated that the Borges-Napoleon sign is well accepted in the medical community, especially by doctors specializing in diagnostic imaging. Subsequently, we will seek feedback from radiologists and orthopedic surgeons on the clinical usefulness of the signal in their daily practices to consolidate its use.

Funding: None.

Research Ethics Committee Approval: In this study, the informed consent form is waived, as this article is not a specific clinical case, but rather a new medical hypothesis using images from databases provided by the Fernandes Távora Hospital, located in Fortaleza, Ceará, through a letter of consent and a bona-fide depositary term signed by the medical director, as well as articles already referenced.

Acknowledgments: None.

Conflicts of Interest: None.

References

1. Yammine K. The sesamoids of the feet in humans: a systematic review and meta-analysis. Anat Sci Int. 2015 Jun;90(3):144-60. doi: 10.1007/s12565-014-0239-9. Epub 2014 May 7. PMID: 24801385.
2. Sun T, Wang L, Zhao H, Wu W, Hu W. Prevalence, morphological variation and ossification of sesamoid bones of the forefoot: a retrospective radiographic study of 8,716 Chinese subjects. J Clin Transl Res. 2016 Aug 15;2(3):91-96. PMID: 30873467; PMCID: PMC6410651.
3. Candan B, Torun E, Dikici R. The Prevalence of Accessory Ossicles, Sesamoid Bones, and Biphalangism of the Foot and Ankle: A Radiographic Study. Foot Ankle Orthop. 2022 Jan 18;7(1):24730114211068792. doi: 10.1177/24730114211068792. PMID: 35097490; PMCID: PMC8777356.
4. Bizarro AH. On Sesamoid and Supernumerary Bones of the Limbs. J Anat. 1921 Jul;55(Pt 4):256-68. PMID: 17103926; PMCID: PMC1262938.
5. Chadwick KP, Regnault S, Allen V, Hutchinson JR. Three-dimensional anatomy of the ostrich (Struthio camelus) knee joint. PeerJ. 2014 Dec 23;2:e706. doi: 10.7717/peerj.706. PMID: 25551024; PMCID: PMC4277484.
6. Al Shabibi A, Sirasanagandla SR, Al Thuhli Z, Al Dhuhli H, Al Mushaiqri M, Jaju S. Radiological Study on Sesamoid Bones of the Foot among Omani Subjects. Oman Med J. 2020 Jul 31;35(4):e163. doi: 10.5001/omj.2020.105. PMID: 32879736; PMCID: PMC7448576.
7. Msamati BC, Igbigbi PS. Radiographic appearance of sesamoid bones in the hands and feet of Malawian subjects. Clin Anat. 2001 Jul;14(4):248-53. doi: 10.1002/ca.1042. PMID: 11424198.
8. Dharap AS, Al-Hashimi H, Kassab S, Abu-Hijleh MF. Incidence and ossification of sesamoid bones in the hands and feet: a radiographic study in an Arab population. Clin Anat. 2007 May;20(4):416-23. doi: 10.1002/ca.20378. PMID: 16944528.
9. Mason LW, Molloy AP. Turf Toe and Disorders of the Sesamoid Complex. Clin Sports Med. 2015 Oct;34(4):725-39. doi: 10.1016/j.csm.2015.06.008. PMID: 26409592.
10. Wyss UP, McBride I, Murphy L, Cooke TD, Olney SJ. Joint reaction forces at the first MTP joint in a normal elderly population. J Biomech. 1990;23(10):977-84. doi: 10.1016/0021-9290(90)90312-q. PMID: 2229095.
11. Mellado JM, Ramos A, Salvadó E, Camins A, Danús M, Saurí A. Accessory ossicles and sesamoid bones of the ankle and foot: imaging findings, clinical significance and differential diagnosis. Eur Radiol. 2003 Dec;13 Suppl 4:L164-77. doi: 10.1007/s00330-003-2011-8. PMID: 15018183.
12. Sims AL, Kurup HV. Painful sesamoid of the great toe. World J Orthop. 2014 Apr 18;5(2):146-50. doi: 10.5312/wjo.v5.i2.146. PMID: 24829877; PMCID: PMC4017307.
13. Richardson EG. Hallucal sesamoid pain: causes and surgical treatment. J Am Acad Orthop Surg. 1999 Jul-Aug;7(4):270-8. doi: 10.5435/00124635-199907000-00007. PMID: 10434081.
14. Kadakia AR, Molloy A. Current concepts review: traumatic disorders of the first metatarsophalangeal joint and sesamoid complex. Foot Ankle Int. 2011 Aug;32(8):834-9. doi: 10.3113/FAI.2011.0834. PMID: 22049873.
15. York PJ, Wydra FB, Hunt KJ. Injuries to the great toe. Curr Rev Musculoskelet Med. 2017 Mar;10(1):104-112. doi: 10.1007/s12178-017-9390-y. PMID: 28124292; PMCID: PMC5344861.
16. Petrella RJ, Cogliano A. Intra-articular Hyaluronic Acid Treatment for Golfer's Toe: Keeping Older Golfers on Course. Phys Sportsmed. 2004 Jul;32(7):41-5. doi: 10.3810/psm.2004.07.453. PMID: 20086421.
17. Cohen BE. Hallux sesamoid disorders. Foot Ankle Clin. 2009 Mar;14(1):91-104. doi: 10.1016/j.fcl.2008.11.003. PMID: 19232995.
18. Burge AJ, Gold SL, Potter HG. Imaging of sports-related midfoot and forefoot injuries. Sports Health. 2012 Nov;4(6):518-34. doi: 10.1177/1941738112459489. PMID: 24179592; PMCID: PMC3497949.
19. Carvalho DG. French Revolution. 1st ed. New York: Editora Contexto; 2022. 176 p. ISBN: 978-65-5541-164-5.

20. Mandracchia VJ, Mandi DM, Toney PA, Halligan JB, Nickles WA. Fractures of the forefoot. Clin Podiatr Med Surg. 2006 Apr;23(2):283-301, vi. doi: 10.1016/j.cpm.2006.01.009. PMID: 16903154.
21. Hockenbury RT. Forefoot problems in athletes. Med Sci Sports Exerc. 1999 Jul;31(7 Suppl):S448-58. doi: 10.1097/00005768-199907001-00006. PMID: 10416546.
22. Rehmani R, Endo Y, Bauman P, Hamilton W, Potter H, Adler R. Lower Extremity Injury Patterns in Elite Ballet Dancers: Ultrasound/MRI Imaging Features and an Institutional Overview of Therapeutic Ultrasound Guided Percutaneous Interventions. HSS J. 2015 Oct;11(3):258-77. doi: 10.1007/s11420-015-9442-z. Epub 2015 Jul 10. PMID: 26788031; PMCID: PMC4712185.