

THE BONE SCINTIGRAPHY AS A COMPLEMENTARY EXAM IN THE DIAGNOSIS OF THE AVASCULAR NECROSIS OF THE SESAMOID

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ABSTRACT

Objective: This study aimed to present seven cases of avascular necrosis of the sesamoid and report the role of bone scintigraphy in the diagnosis of these patients. **Methods:** Seven patients with clinical suspicion of avascular necrosis of the sesamoid underwent three-phase bone scintigraphy with 30 mCi of ^{99m}Tc-MDP. **Results:** Most of the patients were young female adults with complaints of limiting pain in the forefoot, who were making use of inappropriate footwear and/or had a history of injury with or without fracture. There was no predominance of either of the feet or between the femoral or tibial sesamoid. Two patients (28.57%) had a bipartite tibial sesamoid and one (14.29%) had splitting of the tibial and fibular sesamoids. In 100% of the patients, three-phase bone

scintigraphy, combined with other propaedeutic methods, proved to be crucial for the diagnosis. The initial procedure in all cases was conservative. In four cases (57.14%), there was no remission of symptoms, and surgical excision of the necrotized sesamoid tissue was performed. In all the patients, the therapy used was effective, with complete remission of symptoms, without complications or deformities of the forefoot. **Conclusions:** Three-phase bone scintigraphy becomes a cornerstone of the propaedeutics when avascular necrosis of the sesamoid is suspected, through contributing towards early and accurate diagnosis and enabling allowing appropriate specialized treatment.

Keywords – Osteonecrosis; Radionuclide Imaging; Technetium Tc 99m Medronate

INTRODUCTION

Sesamoid is a term derived from the Greek work *sesamen*, because of the similarity between these bones and the seeds of a plant, *Sesamum indicum*, which was used as a purgative in ancient Greece. Around two thousand years ago, it was imagined that the sesamoids were a repository for the soul after death⁽¹⁾.

The sesamoids are two small accessory bones that are inserted into the tendons of the short flexor of the hallux, adjacent to the medial and lateral facets of the head of the first metatarsal. The tibial sesamoid has an average size of between 12 and 15 mm, and the fibular sesamoid has an average size of between 10 and 12 mm. The upper faces of the sesamoids are covered with cartilage and articulate with the head of the first

metatarsal and the capsule of the first metatarsophalangeal joint, into which its tendons are inserted. The two sesamoids are firmly joined together by the thick intersesamoid ligament and to the base of the proximal phalange by means of the sesamoid-phalangeal ligament. In addition, they are also fixed by means of the deep transverse intermetatarsal ligament and are therefore anatomically interlinked with the second metatarsal^(2,3). A bone crest divides the plantar surface of the head of the metatarsal into two longitudinal joint grooves, which are coated with joint cartilage and guide the movement of the sesamoid bones. The tendon of the long flexor of the hallux goes between the sesamoid bones, in close contact with the plantar face of the intersesamoid ligament⁽³⁾.

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The sesamoids are generally chance and asymptomatic findings in imaging examinations, but should not be ignored as sites that possibly cause pain. They absorb pressure, reduce attrition and protect and stabilize the metatarsophalangeal joint and the tendons of the long flexors of the hallux. They act as a fulcrum for increasing the mechanical resistance of the tendons at the time of the impulse of gait and provide a dynamic function to the hallux, through raising the head of the first metatarsal and distributing the weight-bearing in the lateral projection of the forefoot⁽³⁻⁵⁾. Despite the crucial role played by the sesamoid bones in the mechanics of the forefoot, complaints resulting from pathological conditions in these structures are often neglected or poorly diagnosed and managed.

The main blood irrigation for these small bones comes through the posterior tibial artery, which branches into the medial plantar artery and divides on entering the medial and lateral sesamoid bones at their proximal poles. Although vessels from the peripheral soft tissues are abundant, they do not appear to penetrate the cortex of the sesamoid bones. Thus, the blood supply to the sesamoid bones may come from up to three vessels. Arteries penetrate the lateral and medial sesamoid bones proximally through a single vessel that proceeds distally with a network of ramifications. In the plantar projection, vessels penetrate the non-joint surfaces of the sesamoid bones, thus forming a second source of vascularization. Lastly, small vessels also penetrate the sesamoid bones by means of the medial and lateral capsular adnexa^(4,6).

Disorders of the sesamoid bones are a cause of metatarsal pain and, because of the complex anatomy and numerous pain-sensitive structures in the region, their differential diagnosis may be challenging, taking into consideration the possible causes of congenital, traumatic, arthritic, infectious and ischemic nature. Dislocation of the sesamoids may be associated with metatarsalgia, callus formation and stress fractures⁽²⁾. In 1924, Renander⁽⁷⁾ was one of the first authors to draw attention to avascular necrosis of the sesamoid. This is a very uncommon clinical entity, and its low incidence and incomplete definition may lead to erroneous diagnoses and delayed treatment. It needs to be differentiated from other pathological conditions such as fractures, pseudarthrosis or osteomyelitis. The present study had the aim of presenting seven cases of avascular necrosis of the sesamoids and report on the role of bone scintigraphy in diagnosing these patients.

METHODS

Seven patients with a clinical suspicion of avascular necrosis of the sesamoids underwent a dynamic study of blood flow in a high-resolution gamma chamber with a rectangular double detector, in anterior and posterior projections of the region of interest. Sequential images were produced immediately after injection of 30 mCi of ^{99m}Tc-MDP for one minute, followed by static images at equilibrium. After three hours of intravenous administration of the radiopharmaceutical, images of the whole body were obtained in anterior and posterior projections, along with special late-stage static images of the regions of interest.

RESULTS

The patients' ages ranged from 20 to 46 years, with a mean of 31 and median of 32 years. Among the patients, six (85.71%) were female and one (14.29%) was male.

Three patients (42.86%) presented a pathological condition in their right foot and four (57.14%) in their left foot. All of them presented the symptom of pain in the affected forefoot, and one (14.29%) was also found to present localized edema and rubor.

In four patient (57.14%), the sesamoid affected was the tibial, and in three (42.86%), the fibular. Four patients (57.14%) presented undivided sesamoids, two (28.57%) presented bipartite tibial sesamoids and one (14.29%) patient presented bipartition of the tibial and fibular sesamoids.

All the patients were found to have been using inadequate footwear and/or they reported suffering traumatic events with or without associated fracturing. One of the patients was practicing ballet and another, soccer.

Two of the female patients (28.57%) were using contraceptives.

In 100% of the patients, triphasic bone scintigraphy in association with other propaedeutic methods was shown to be fundamental for the diagnosis (Figures 1, 2 and 3).

The initial approach in all the cases was to prohibit the use of high heels among the female patients, suspend the use of contraceptives when these were used, provide guidance regarding the use of adequate footwear, introduce the use of insoles with retrocapital support, prescribe non-steroidal anti-inflammatory drugs and prescribe physiotherapy.

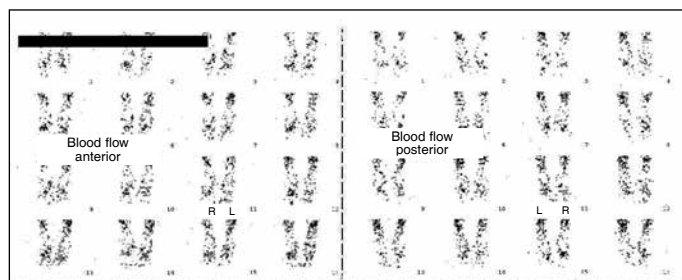


Figure 1 – Images of blood flow in the feet in anterior and posterior projections, showing slightly increased flow in the projection of the medial bone of the right metatarsal.

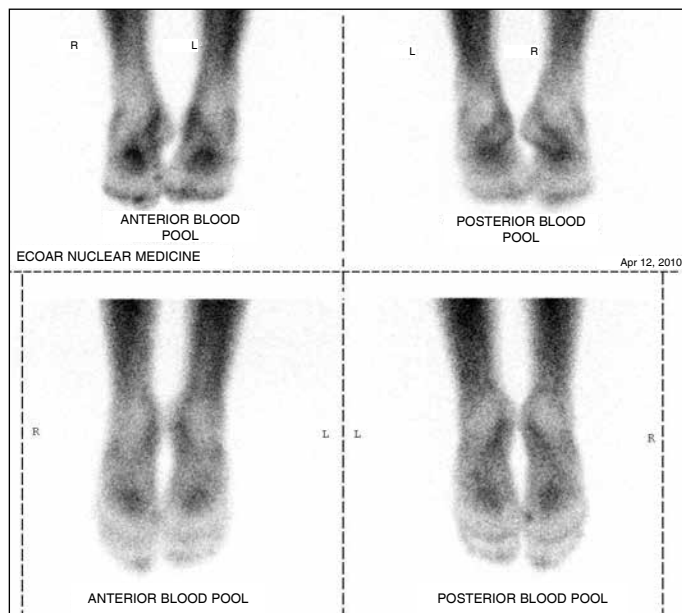


Figure 2 – Images at equilibrium (vascular permeability) with the feet in anterior, posterior and plantar projections of the medial sesamoid of the right metatarsal.

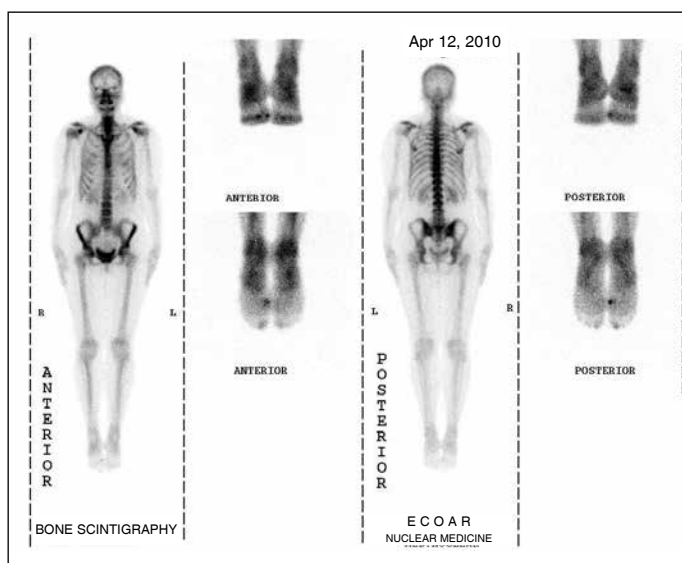


Figure 3 – Late-stage images of the whole body and static images of the feet in anterior, posterior and plantar projections, showing heterogeneous distribution of the radiopharmaceutical, with focal high uptake of the drug in the medial sesamoid of the right metatarsal.

In four cases (57.14%), there was no remission of the symptoms and surgical excision of the necrotized sesamoid tissue was performed. One of the patients evolved with pain, edema and localized paresthesia, which resulted in slight claudication. This was treated conservatively with non-steroidal anti-inflammatory drugs and physiotherapy sessions.

In all the patients, the therapy used was shown to be effective, with complete remission of the symptoms. Clinical inspection, radiological findings and, notably, scintigraphic findings demonstrated that the condition had been resolved, with complete pain relief and without complications or deformities of the forefoot.

DISCUSSION

Both metatarsal sesamoid bones are always present, and their complete ossification takes place between the ages of nine and fourteen years^(8,9). This generally occurs earlier for the lateral sesamoid^(1,10) and among females⁽¹⁰⁾. Ossification starting from more than one bone center leads to partition of the sesamoid bone in around 30% of individuals^(1,8,9). The sesamoids are surrounded by a fibrous ligament structure that forms the sesamoid-phalangeal apparatus and moves under the head of the metatarsal head, thus playing an important role as shock absorbers and thereby facilitating gentle footfall from the heel to the extremity of the toes. They also increase the muscle strength at the impulsion stage of gait and protect the metatarsophalangeal joint and the tendon of the long and short flexors of the hallux⁽⁴⁾.

Regarding the physiopathology of the osteonecrosis, changes to the vascular supply to the accessory center of the sesamoid or fragility of the ossification centers have been reported. Repeated trauma affecting the tendons and serous membranes of the sesamoid-phalangeal apparatus and fracturing of the sesamoid bone may result in ischemia with osteonecrosis. The most frequent precipitating factors are microtrauma, sports activities such as athletics and dancing, and alignment disorders of the hind foot, such as pes cavus or pes valgus^(2,8).

Osteonecrosis of the sesamoid bones has unknown prevalence and is probably underdiagnosed. Most of the patients are adolescents or young adults, and

women are more affected than men^(2,8). Although both of the sesamoids may be affected, the tibial sesamoid is subjected to greater loads and is therefore more susceptible to this condition^(1,3,5,10). Another cause of this condition could be the natural pronation of the first metatarsal, which places the tibial sesamoid in a more prominent position⁽²⁾. It also has to be taken into consideration that sesamoid partition is more common in the tibial than in the fibular sesamoid⁽¹⁻³⁾ and more common in women than in men⁽¹¹⁾, and that bipartite sesamoid bones fracture under lower force than do undivided sesamoids^(1,3,9). The incidence of unilaterally bipartite medial sesamoids is around 10.7%, while bilaterally bipartite medial sesamoids occur in around 25% to 85%⁽²⁾.

Regarding blood perfusion, Pretterklieber and Wanivenhaus⁽¹²⁾ demonstrated that the tibial sesamoid is fed by a single vessel in 64% of women and 43% of men. The fibular sesamoid is irrigated by a single vessel in 57% of women and 50% of men. This may also explain the greater incidence of avascular necrosis in tibial sesamoids and in women. In studying the vascular supply of the sesamoids, these authors also demonstrated that the sesamoids of the left foot tend to be smaller and denser than those in the right foot, and those of males tend to be bigger than those of females. They also showed that the sesamoids of the left foot have a greater blood supply than those of the right foot and that the sesamoids of males have a greater blood supply than those of females. These authors believed that this explained the difference in size between the sesamoids observed in these groups.

The differential diagnoses include nonspecific sesamoiditis; osteomyelitis; trauma with fractures; pseudarthrosis; bursitis; sympathetic-reflex dystrophy syndrome; gout and other diseases with deposition of crystals, such as hyperuricemia; joint inflammation diseases such as rheumatoid arthritis, psoriatic arthritis and reactive arthritis; and abnormal alignment, dislocation and osteoarthritis of the sesamoid bone^(1,2,5,8,10).

The main symptom is mechanical pain that starts gradually and is reflected in the plantar surface of the head of the first metatarsal, on palpation, on putting weight on the hallux and in the final phase of the gait cycle. It is worsened by forced dorsiflexion of the

hallux until becoming incapacitating. Antalgic supination of the forefoot while walking is noted^(2-4,8,10).

Bone scintigraphy is fundamental for early diagnosis, since scintigraphic abnormalities often precede the radiographic findings. Areas with very high uptake of radiopharmaceutical, or even with very low uptake, can be observed at the beginning of the process of necrosis^(1,3,8,10,13).

The initial treatment is based mainly on elimination of weight-bearing and support for the metatarsal arch by means of personalized footwear and molded insoles, with insertion of a pressure point posteriorly to the head of the metatarsus and an opening under the affected sesamoid^(2,8). Non-steroidal anti-inflammatory drugs and temporary immobilization may be necessary⁽¹⁾. There is controversy regarding the use of intra-articular injections of glucocorticoids⁽²⁾. If the pain lasts for more than six months and is refractory to appropriate conservative treatment, partial or total sesamoidectomy with excision of the necrosed part becomes an alternative. Preference is given to a dorsal approach⁽⁸⁾ in order to avoid painful scars or formation of cheloids in weight-bearing areas. Surgeons should take care to protect the neurovascular bundle in repositioning the intrinsic tendons and ligaments. Anatomical knowledge of the course and distribution of the vessels becomes necessary for understanding the pathogenesis of avascular necrosis, so that orthopedists are knowledgeable about correct use of the surgical technique. It is important to keep the contralateral sesamoid bone and the surrounding fibrous structure, which stabilizes the metatarsophalangeal joint⁽⁸⁾. Occasionally, patients may develop hallux varus after complete excision of the fibular sesamoid, or hallux valgus after excision of the tibial sesamoid^(2,4), which may be followed by pain in the contralateral sesamoid and may even require a second sesamoidectomy^(4,8). Plantar pain in the first metatarsal⁽⁴⁾ or a "claw" deformity of the interphalangeal joint due to diminished strength of the short flexor of the hallux^(2,8) may occur after bilateral sesamoidectomy. If such complications occur, analgesics and orthoses may be useful. Histological evaluations generally reveal proliferation of granulation tissue, necrosed trabeculae, reactive processes of out-of-position bone reconstitution and chondroid metaplasia⁽³⁾.

CONCLUSIONS

The recent literature provides support for initial non-surgical management of cases of avascular necrosis of the sesamoid, using therapy consisting of anti-inflammatory medications, adequate footwear and elimination of weight-bearing. After the condition has continued for more than six months, surgical intervention should be considered.

Triphasic bone scintigraphy plays an important role in

the propaedeutics of avascular necrosis of the sesamoid. Scintigraphic studies become crucial through contributing towards an early and accurate diagnosis of the complex disorders of the sesamoid bone, which is invariably a challenge for specialists. Scintigraphy is therefore an important tool for guiding physicians regarding the appropriate treatment, thereby avoiding potentially harmful dysfunctions that drag on for a long time and especially comprise the patient's social and working lives.

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