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# The Cadaverous Carnage- Aseptic Bone Necrosis

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## Abstract

Aseptic necrosis is a commonly discerned degenerative condition of the bone characteristically constituted of deteriorated cellular components. Generally, the condition arises secondary to discontinuity of subchondral vascular effusion. The disorder is additionally designated as avascular necrosis, osteonecrosis or ischemic bone necrosis and no bone is exempt. Specific sites incriminated are the tibial tuberosity as encountered in Osgood-Schlatter's disease or proximal femoral epiphysis as denominated in Legg-Calve'-Perthes disease.

**Keywords:** Aseptic necrosis

## Introduction

Arthritis emerges as a complication on account of fractures appearing within articular surfaces of hip, knee and major joints or due to collapse of necrotic bone segments or occurrence of reparative peripheral granulomas which destroy the infarcted bone. The condition may engender cartilaginous detachment and secondary degenerative joint disease. Preliminary recognition and pertinent therapeutic intervention are essential and advantageous. Disease Characteristics Aseptic necrosis is commonly enunciated within the hip, although the knee, talus, jaw, femoral or humeral head and miniature bones of the carpus as the lunate may be incriminated. Besides, no bone is exempt and aseptic necrosis may involve the entire skeleton. Typically, epiphysis of long bones of weight-bearing joints are implicated. Decimation of subchondral bone or collapse of an entire joint indicates severity of disease. An estimated 50% instances are multifocal, Nearly 10% of joint replacements are contingent to aseptic necrosis. Classically, aseptic necrosis arises in individuals between 30 years to 65 years. A slight male predominance is observed although aseptic necrosis occurring due to autoimmune conditions as systemic lupus erythematosus demonstrate a female preponderance [1,2]. Additionally, uncommon variants such as Preiser disease, constituted by osteonecrosis of scaphoid are observed within the dominant hand of middle-aged women. Besides, Keinbock's disease, comprised of osteonecrosis of lunate, is frequent in middle-aged males subjected to manual labour. Children may also be implicated. Aseptic necrosis of head of femur is classified into traumatic or atraumatic lesions. An estimated 70% of atraumatic instances are bilateral. Aseptic necrosis of hip demonstrates distinct disease progression contingent to precise clinical and radiographic features wherein stage I is disease initiation in the absence of cogent radiological features and end stage IV is associated with collapse of femoral head and flattening or narrowing of joint space. Spontaneous aseptic necrosis of the knee is commonly discerned within the sixth decade and exemplifies a female preponderance. Medial femoral condyle is implicated in a majority (74%) of instances wherein medial knee pain is a predominant clinical symptom [1,2].

Secondary aseptic necrosis of the knee occurs in young subjects and is contingent to several contributory factors. The infrequent post arthroscopic aseptic necrosis appears

in around 4% subjects following arthroscopic meniscectomy. Disease progression occurs in definitive stages wherein stage 1 is indicative of clinical disease in the absence of specific radiographic features and degenerative stage 4 demonstrates osteosclerosis and configuration of osteophytes adjacent to the condyles. Aseptic necrosis of shoulder is generally traumatic in origin although factors such as extensive corticosteroid therapy, altered vascular perfusion of the head, extension of posteromedial metaphyseal head and integrity of medial hinge are significant in engendering the necrosis. Aseptic necrosis of shoulder can be categorized into distinct stages where stage I delineates normal radiography with necrosis discernible upon magnetic resonance imaging (MRI), stage IV demonstrates flattening and collapse of humeral head and end stage V displays degenerative modifications involving the glenoid [1,2].

Aseptic necrosis of talus is commonly traumatic in origin and appears secondary to displaced fractures of the neck of talus. Incidence of necrosis is enhanced with coexistent dislocation of ankle subtalar joint. Aseptic necrosis of talus is frequent due to a preponderant cartilaginous surface which curtails vascular effusion. Generally, the pathognomonic subchondral radiolucent zone, denominated as "Hawkins sign", is absent upon plain radiographs at 6 weeks to 8 weeks following commencement of disease. Aseptic necrosis of lunate, designated as "Keinbock's disease" configures a collapsed lunate on account of vascular insufficiency and avascular bone necrosis. Contributing factors are repetitive trauma, biomechanical elements due to variance of ulna and anatomic factors such as occurrence of dual dorsal and palmar vascular perfusion [1,2].

Distinctive stages include stage I where radiographic features are apparent, stage II demonstrates lunate sclerosis with maintenance of bone height, stage III delineates lunate collapse and palmar scaphoid rotation whereas inter-carpal joint degeneration is predominant in end stage IV disease [1,2]. Aseptic necrosis of scaphoid, designated as "Preiser disease", is a condition of obscure aetiology classically implicating the dominant hand of middle aged male subjects. Bilateral lesions may ensue. Contributory factors include alcoholism, trauma, excessive ingestion of steroids and concomitant connective tissue disorders [3,4].

Plain radiographs depict sclerosis of scaphoid in preliminary disease whereas delayed stage exhibits cystic change and bone fragmentation. Magnetic resonance imaging (MRI) may discern alterations of signal intensities with T1 and T2 imaging throughout the scaphoid, especially within the proximal pole. Disease progression is contingent to specific stages commencing with stage I exhibiting modifications within scaphoid's proximal pole and stage IV exemplifying eventual carpal collapse [3,4].

## Disease Pathogenesis

Aseptic bone necrosis may be engendered by diverse conditions such as fracture, dislocation, vasculitis, exposure to radiation, vascular compression, venous hypertension, adoption of corticosteroids, alcoholism, metabolic diseases as Gaucher's disease, release of nitrogen bubbles in dysbarism or thrombosis as occurring in sickle cell disease. Decimation of subchondral vascular effusion is posited to engender aseptic necrosis although the aetiology can be multifactorial. Decline of subchondral vascular effusion induces cellular hypoxia with disintegrated cell membrane integrity, cellular necrosis and consequent infiltration of neutrophils and macrophages leading to degeneration of joint and subchondral space [3,4].

Diverse factors are hypothesized to contribute to the vascular impairment such as

- Direct cellular toxicity induced by chemotherapy, radiotherapy, thermal injury or smoking,
- Extra-osseous arterial fracture engendered due to dislocation of hip, fracture neck femur, iatrogenic fracture possibly arising following surgery or congenital arterial anomalies.
- Extra-osseous venous aberrations or venous stasis.
- Intraosseous extravascular compression arising due to haemorrhage, enhanced bone marrow pressure, extensive and elevated levels of corticosteroids followed by infiltration of bone marrow with mature adipose tissue, cellular hypertrophy, marrow infiltration as encountered in Gaucher's disease, bone marrow oedema or displaced fractures.
- Intraosseous intravascular occlusion as occurring with coagulation disorders such as thrombophilia, hypofibrinolysis and sickle cell crisis. Few instances demonstrate an autosomal dominant pattern of disease
- Inheritance with genomic mutations of COL2A1 gene which encodes for production of type II collagen.
- Repetitive trauma may engender aseptic bone necrosis.
- However, several instances are devoid of pertinent disease aetiology and are nomenclated as "idiopathic osteonecrosis".

Non-traumatic factors impact vascular outflow to the implicated bone such as Exposure to radiation induces alterations within the bone marrow with consequent aseptic necrosis. Hyperlipidaemia significantly obstructs miniature vascular articulations with declining vascular outflow and subsequent decimation of nutrients provided to the bone [3,4]. Sickle cell anaemia decreases vascular supply to the bone. Bones with minimal collaterals or retrograde vascular flow such as the carpus display an enhanced possibility of aseptic necrosis. Unique anatomical articulation of the talus with significant surface area of articular cartilage restricts

vascular outflow. Prolonged ingestion of significant quantities of glucocorticoid may induce apoptosis of osteocytes which disturbs lacunar- canalicular articulations with consequent aseptic necrosis. Additional contributory factors may be excessive alcohol intake, blood dyscrasia or autoimmune disorders such as systemic lupus erythematosus. An estimated 25% individuals are associated with an obscure aetiology of vascular disruption, as encountered with Kienbock's and Preiser's disease [3,4].

## Clinical Elucidation

Non-traumatic instances of aseptic necrosis typically manifest diffuse mechanical pain of variable onset and severity. Preliminary instances are devoid of definitive physical findings. Pertinent history of contributory events such as recent trauma with insidious commencement of pain, intakes of steroids, alcohol, tobacco, occurrence of autoimmune or connective tissue disorders, sickle cell disease, excessive physical activity, altered gait and reduced range of motion may be elicited. Preliminary stage of aseptic necrosis of hip is asymptomatic. Pain in the hip or groin is common, indicative of progressive or delayed stage of disease and is associated with referred pain within the buttock or thigh. Majority of individuals depict pain at rest. Reduce mobility, stiffness and altered gait is observed [5,6].

Incriminated knee displays an acute onset of disease with knee pain at night time and upon weight bearing. Osteoporosis or osteopenia are common along with absence of recent trauma. Physical assessment depicts reduced range of motion and pain upon joint palpation, especially over medial femoral condyle. Aseptic necrosis of shoulder joint implicates the proximal humerus and appears secondary to trauma. Typically, pulsating pain radiating to elbow and decimated range of motion is observed. Aseptic necrosis of talus is associated with trauma or polyarticular disease. Pain, delayed recovery and difficult ambulation ensue following a traumatic episode. Aseptic necrosis of lunate and scaphoid lacks a specific history of trauma. Skilled workers are usually implicated and exemplify unilateral pain upon dorsum and radial aspect of wrist. Reduced range of motion, swelling of wrist and a weak grip are also encountered [5,6].

## Histological Elucidation

On gross examination, articular cartilage is intact whereas perimeter of necrotic zone exhibits cracking and folding. Foci of bone necrosis appear yellow, opaque or chalky whereas circumscribing fibrous tissue delineates hyperaemia. Foci of adjoining bone may be thickened. Delayed stage demonstrates discontinuous contour of incriminated bone such as head of femur. Also, degeneration of articular cartilage, loose bodies and marginal osteophytes are discerned, indicative of accompanying degenerative joint disease. On microscopic examination, intensely stained necrotic bone trabeculae depict empty lacunae, ragged boundaries and distinct zones of accumulated osteoclasts and osteoblasts. Lacunae may be enlarged, cystic or unchanged and are imbued with pyknotic nuclei. Calcium deposition occurs upon emerging necrotic adipocytes and within the bone marrow [5,6].

Upon microscopy, osteocytes subjected to apoptosis are non-replaceable and devoid of phagocytic activity. Consequently, bone remodelling is inadequate and osteosclerosis is imperfect. The condition commences with necrosis within bone epiphysis with variable necrosis of adjoining cartilage. The necrotic bone is gradually resorbed by a phenomenon of "creeping substitution". Engendered new bone is soft, may be abraded and initiates degenerative joint disease. On account of "creeping substitution" the un-resorbed dead trabeculae spared by osteoclasts appear as scaffolds for deposition of new, viable bone [5,6].

## Differential Diagnosis

Aseptic necrosis mandates a segregation from diverse conditions such as bone marrow oedema syndrome or transient osteopenia, complex regional pain syndrome, inflammatory synovitis, neoplastic bone conditions, subchondral fractures, osteochondrosis, osteoarthritis, osteomyelitis, osteoporosis, rheumatoid arthritis, septic arthritis or soft tissue trauma such as labral or meniscal tears [1,2].

## Investigative Assay

Plain radiography is beneficial although may be non-informative in preliminary stage of the disease. Magnetic resonance imaging (MRI) is recommended for optimal assessment of preliminary disease as bone oedema can be adequately discerned. Magnetic resonance imaging (MRI) demonstrates osteosclerotic alterations appearing as a consequence to decimated bone resorption and deranged function of osteoclasts. Specifically, T2 signal intensity is enhanced whereas T1 signal intensity is reduced on account of oedematous adipose tissue cells or bone marrow ischemia. Magnetic resonance imaging can aptly discern pre-clinical lesions or magnitude of existing lesions [7,8].

## Therapeutic Options

Majority of instances of aseptic necrosis of hip mandate a total hip arthroplasty. Nevertheless, manoeuvers of joint salvage such as core decompression may be adopted with variable outcomes. The procedure is efficacious in preliminary stages of aseptic necrosis where minimum surface of weight-bearing zone of femoral head is implicated. Vascularised bone

grafts or biologic agents augmenting bone repair may also be advantageously adopted. Core decompression and bone grafting may circumvent progression of aseptic necrosis of hip although total hip arthroplasty may be required for treating instances with disease progression or failure of joint preserving surgery [8,9]. Majority of spontaneous aseptic necrosis of the knee may resolve with partial weight-bearing and physiotherapy. Elderly subjects with spontaneous necrosis of knee can be treated with uni-compartmental knee replacement, a procedure which is associated with a superior prognosis and reduced period of rehabilitation. Enlarged lesions are adequately treated with total knee replacement. Miniature lesions subjected to intraosseous decompression demonstrate favourable operative outcomes [8,9].

Preliminary aseptic necrosis of shoulder is optimally treated with core decompression. Resurfacing of head of humerus or hemiarthroplasty is a recommended procedure for mid stage disease whereas end stage necrosis is preferably treated with total shoulder replacement. Proportionate aseptic necrosis of neck of talus can be reduced by operative manoeuvers of anatomic reduction and stable fixation. Preliminary stage of Keinbock's disease can be aptly managed by revascularization of lunate in association with bone grafts or offloading the lunate. Immobilization and external fixation can be employed in stage I and stage II disease. Carpal collapse occurring in stage III can be managed with surgical intervention whereas advanced disease may be adequately treated with joint sacrificing procedures such as wrist arthrodesis [8,9].

Preliminary stage of Preiser disease can be managed with immobilization, injectable cortisone, radial wedge osteotomy or bone grafts. Delayed stage necessitates manoeuvers such as arthroscopic debridement, scaphoid excision, proximal row carpectomy or arthrodesis. Typically, surgical intervention is mandated in a majority of subjects [9,10]. Aseptic necrosis is accompanied by an inferior prognosis irrespective of initial therapeutic strategy. Disease progression is indicated by persistent pain, debilitation and significant joint destruction. Around 59% of asymptomatic lesions may progress with emergence of cogent clinical symptoms or collapse of incriminated bone. Nearly 81% of individuals with aseptic necrosis of humeral head demonstrate total joint failure and necessitate arthroplasty as disease onset is associated with gradual and persistent disease progression. Core decompression and hemiarthroplasty of preliminary aseptic necrosis of shoulder are accompanied by superior prognosis. However, total shoulder arthroplasty adopted for end stage disease is associated with significant complications. Preliminary stages of Preiser and Kienbock's disease are aptly managed with immobilization although eventual surgical intervention is necessitated. Surgically corrected aseptic necrosis of talus occurring in young individuals displays a significantly favorable outcome. Commonly, surgical extermination of aseptic bone necrosis is associated with distinctive postoperative complications such as infection of surgical site, malfunctioning prosthesis and neurovascular derangements. Persistently progressive disease following surgery or associated comorbid conditions display an enhanced percentage of complications and therapeutic failure [9,10] (Figures 1-8).

**Figure 1:** Aseptic necrosis of bone depicting a yellow, opaque perimeter with cracking, folding and an irregular contour [11].

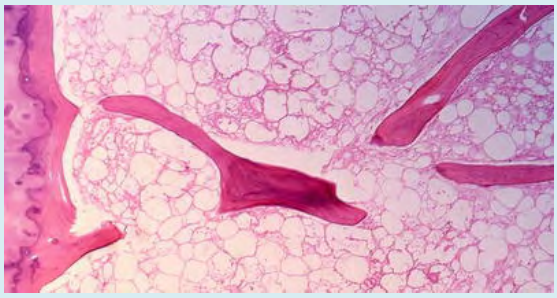

**Figure 2:** Aseptic necrosis of bone delineating intensely stained trabeculae with empty lacunae, focal calcification and foci of necrotic adipocytes [12].

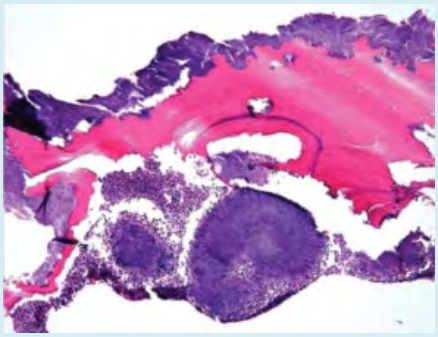

**Figure 3:** Aseptic necrosis of jaw bone displaying necrotic, intensely stained bone trabeculae with focal calcification, vacant lacunae and a perimeter of fibrous tissue [13].

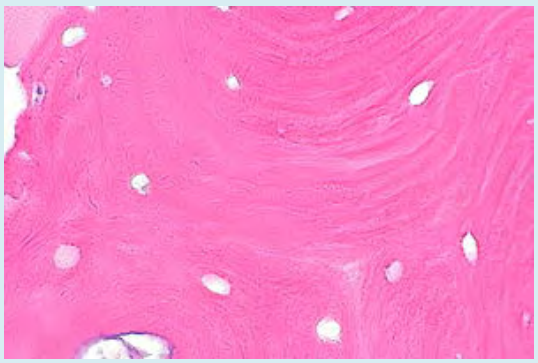

**Figure 4:** Aseptic necrosis of bone exhibiting a dense, uniform appearance with empty lacunae and a margin of fibrotic tissue [14].

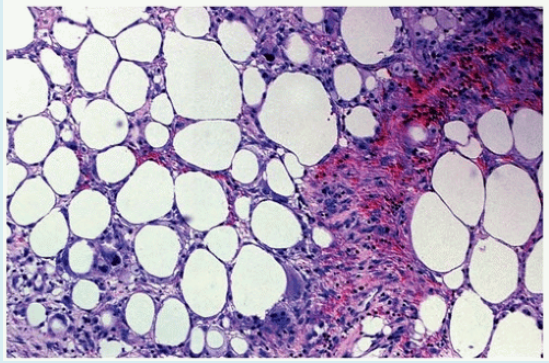

**Figure 5:** Aseptic necrosis of bone with necrotic adipose tissue, calcified, intensely stained bone trabeculae and circumscribing fibrous tissue [15].

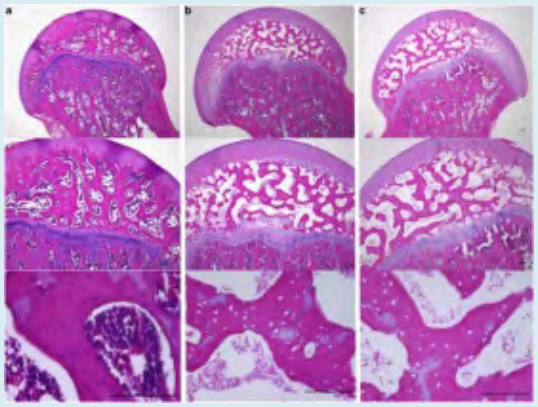

**Figure 6:** Aseptic necrosis of femur demonstrating diverse stages with empty lacunae, cracking and discontinuity of bone contour, intensely stained dead bone, calcification of adipose tissue and necrotic bone and peripheral fibrous tissue [16].

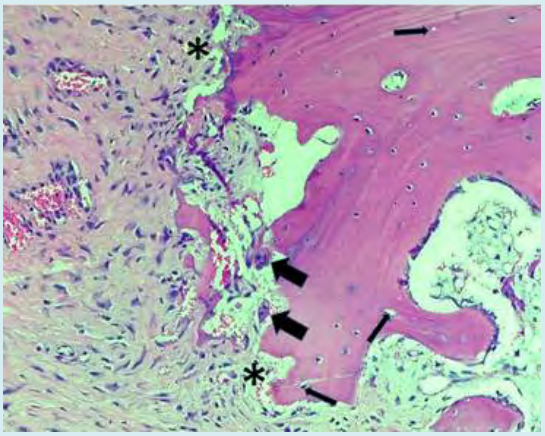

**Figure 7:** Aseptic necrosis exemplifying darkly stained bone trabeculae with deposits of calcium, necrotic adipocytes and a circumscription by fibrous tissue [17].

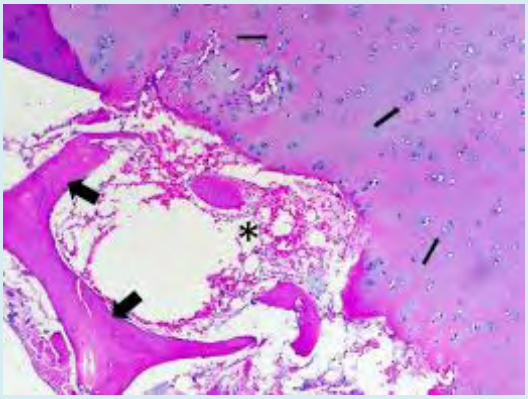

**Figure 8:** Aseptic necrosis of bone enunciating darkly stained trabeculae of dead bone, necrotic bone marrow elements and a perimeter of fibrous tissue [18].

## Conclusion

Aseptic necrosis is a frequently encountered, degenerative bone condition typically constituted of deteriorated cellular components. Aseptic necrosis is commonly enunciated within the hip, although no bone is exempt and the knee, talus, jaw, femoral or humeral head and miniature bones of the carpus as the lunate may be incriminated. Aseptic bone necrosis may be engendered by diverse conditions such as fracture, dislocation, vasculitis, exposure to radiation, vascular compression, venous hypertension, adoption of corticosteroids, alcoholism, metabolic diseases as Gaucher's disease, release of nitrogen bubbles in dysbarism or thrombosis as occurring in sickle cell disease. Non-traumatic aseptic necrosis typically manifest diffuse mechanical pain of variable onset and severity. Microscopically, intensely

stained necrotic bone trabeculae display empty lacunae, ragged boundaries along with distinct zones of accumulated osteoclasts and osteoblasts. Aseptic necrosis mandates a segregation from diverse conditions such as bone marrow oedema syndrome or transient osteopenia, complex regional pain syndrome, inflammatory synovitis, neoplastic bone conditions, subchondral fractures, osteochondrosis, osteoarthritis, osteomyelitis, osteoporosis, rheumatoid arthritis, septic arthritis and soft tissue trauma such as labral or meniscal tears. Magnetic resonance imaging (MRI) is recommended for optimal assessment of preliminary disease. Aseptic necrosis of hip mandate a total hip arthroplasty although diverse variants can be appropriately treated with partial weight-bearing, core decompression and physiotherapy.

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