

Concomitant septic arthritis of the hip joint and femoral head avascular necrosis in patients with recent covid-19 infection: A cautionary report

Mohammad vahedian Ardakani

Tehran University of Medical Sciences, End of Keshavarz Blvd

Sara parviz

Tehran University of Medical Sciences, End of Keshavarz Blvd

Ehsan ghadimi

Tehran University of Medical Sciences, End of Keshavarz Blvd

Zahra zamani

Tehran University of Medical Sciences, End of Keshavarz Blvd

Mohammadreza salehi

Tehran University of Medical Sciences, End of Keshavarz Blvd

Mohammad Ayati

Tehran University of Medical Sciences, End of Keshavarz Blvd

Javad SM Mortazavi (✉ smjmort@yahoo.com)

Tehran University of Medical Sciences, End of Keshavarz Blvd

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Abstract

Purpose

At present, concomitant avascular necrosis (AVN) of femoral head and septic arthritis (SA) as a sequel of COVID-19 infection has yet not been documented. By large-scale use of life-saving corticosteroids (CS) in COVID-19 cases, our aim is to warn of the occurrence of hip joint infection in these patients.

Methods

We report a series of five cases in which patients developed septic arthritis concomitant with AVN after being treated for COVID-19 infection. The mean dose of prednisolone used in these cases was 1695.2 mg. The time period of onset of hip symptoms in our cases from the beginning of the COVID-19 infection was 56 days in the first case, 43 days in the second case, 30 days in the third case, 29 days in the fourth case and 50 days in the last case, with an average time of 41.6 days. All patients underwent surgery depending on the extent of articular cartilage damage by direct anterior approach.

Results

Clinical and laboratory symptoms improved significantly in all patients. The mean visual analogue pain score of the patients decreased from 9.4 (9–10) before surgery to 2.8 (1–4) after one week of operation.

Conclusion

In any patient with the history of COVID-19 infection specially those who have been treated with corticosteroid as one of the medications prescribed during the disease, any joint symptom specially in the hips should draw our attention to the joint infection and with timely diagnosis and surgery, their hip joint can be saved.

Introduction

In December 2019 a cluster of severe respiratory infection was reported in Wuhan, Hubei province, China. In January 2020 the first case of death from the virus were reported in China. Positive case reports from other countries such as Thailand, Japan, South Korea and United states has made things worse. The result of this great epidemic is filling hospital beds, excessive fatigue of medical team, severe lack of personal protective equipment, infection of hospital staff, lack of manpower and the spread of disease and anxiety of the people of the countries of the world.

Numerous evidences shows that COVID-19 can affect different human body organs as a part of 'Long COVID-19' such as Guillain-Barre syndrome, lung fibrosis, pulmonary emboli, cardiomyopathy, skin and joints, sensory dysfunction and stroke(1, 2).

'Long COVID-19' is a term used to describe symptoms in patients that continue for weeks or months after recovery from COVID-19(2).

Some cadaveric studies confirm the presence of intravascular thrombosis and coagulopathy in patients with covid-19 infection(3–5) which can be one of the causes of femoral head avascular necrosis in these patients. Numerous cases have been reported with a diagnosis of avascular necrosis or reactive arthritis following COVID-19 infection(6–10). All of these patients were treated with a dose of CS as part of the COVID-19 treatment regimen.

To date, no cases of purulent joint infection due to covid-19 infection have been reported, and in particular the association of septic arthritis with avascular necrosis has not been reported. In the continuation of this article we report five cases with septic arthritis of hip joints with some degree of AVN of femoral head following recovery from COVID-19 disease. They all received CS (methyl-prednisolone, prednisolone, dexamethasone) during their COVID-19 disease period along with other antiviral medications. All these cases were negative for Antinuclear antibodies, rheumatoid factor, anti-cyclic citrullinated peptide antibodies, hepatitis B virus surface antigen, anti-hepatitis C virus antibodies and anti-human immunodeficiency virus antibodies. Examination of joint fluid for crystals were also negative in all cases.

Materials And Methods

Case 1

A 34 year-old male patient was diagnosed with COVID-19 on 22nd June 2021. During his hospitalization the patient was administered intra-venous (IV) dexamethasone 16 mg per day for ten days and 250 mg IV methylprednisolone in one dose and IV remdesivir and sub-cutaneous enoxaparin. Total steroid received by the patient was 1384.5 mg of prednisolone equivalent. After 56 days from the onset of COVID-19 disease the patient developed rapidly increasing pain in the left hip joint. His laboratory and radiological findings indicated an infectious process with severe cartilage damage in his hip joint. Therefore, he underwent first stage of total hip arthroplasty (THA). After two months when the inflammatory markers became negative, the second stage of surgery was performed. At the time of submitting this article for publication two weeks have passed since surgery and he lives a painless life. He was treated with vancomycin and imipenem with the consult of an infectious disease specialist (Fig. 1).

Case 2

A 14 year-old female patient known case of ALL was diagnosed with COVID-19 on 18th July 2021, for which IV remdesivir and IV methylprednisolone (750 mg) and 16 mg dexamethasone per day for ten days was given equivalent to 2009.5 mg prednisolone. One month after being diagnosed with COVID-19 disease she contracted salmonella bacteremia and forty three days post COVID-19 detection she developed pain in the bilateral groin that was very increasing. The pain was more severe on the right side. Laboratory markers indicated an inflammatory process and radiological findings indicated destruction of the right articular cartilage and active infection without cartilage damage in the left hip joint. Non-typhoidal salmonella group D grew on both sides of the hip aspiration. Finally she underwent arthrotomy and irrigation and debridement for left side and the first stage of two-stage THA for the right side. Intra-operative cultures of salmonella were also reported for both sides. She was treated with ceftriaxone and ciprofloxacin with the opinion of an infectious disease specialist (Fig. 2).

Case 3

A 52 year-old woman was diagnosed with COVID-19 on 25th April 2021. The patient was given oral dexamethasone 25 mg per day for eight days and in tapering dose over ten days (total 300 mg equivalent to 2010 mg of prednisolone). She was known case of breast cancer and underwent 30 sessions of radiotherapy and several rounds of chemotherapy, last time one year ago. Thirty days after the COVID-19 diagnosis the patient began to have increasing pain in her right hip joint. Laboratory and radiologic findings revealed hip joint infection and osteomyelitis. The hip joint aspiration cultures was reported to be negative. The decision for two-stage THA surgery was made for her and eventually she underwent first stage and is waiting for the next surgery. She is being treated with vancomycin and imipenem with the guidance of infectious disease specialist (Fig. 3).

Case 4

A 54 year-old woman patient presented to the emergency department with a history of fever and weakness and dry cough on April second 2021 and was diagnosed with COVID-19 infection. She completed ten-day course of dexamethasone (16 mg daily equivalent to 1072 mg of prednisolone) as well as a 500 mg dose of IV methylprednisolone. The total dose of CS prescribed for her was equivalent to 1697 mg prednisolone. Hydroxychloroquine and azithromycin were administered too. 29 days after the diagnosis of COVID-19 both hips pain and flexion contracture were developed that were rapidly increasing. Laboratory and radiological evidence indicated that there was infection of both hip joints with underlying AVN. Aspiration culture of both hips were done and *Serratia marcescens* grew in culture media on both sides. The first stage of two-stage THA and cement placement was performed for both hip joints in two sessions. Clinical symptoms have improved a lot and she is waiting for the second stage of the surgery. She was treated with vancomycin and imipenem with the opinion of infectious disease specialist (Fig. 4)

Case 5

A 38 year-old male patient was diagnosed with COVID-19 on forth August 2021. Ten days later, the patient was admitted to intensive care at another hospital because of pulmonary involvement and dropping saturation. During his hospitalization the patient received IV methylprednisolone 75 mg per day for twelve days (total dose of 900 mg of methylprednisolone equivalent to 1125 mg prednisolone) and IV remdesivir and IV actemra. After discharge, oral prednisolone was administered in tapering dose for 20 days (total dose of 250 mg). The total steroid received by the patient was 1375 mg of prednisolone equivalent. Fifty days after the COVID-19 diagnosis, the patient developed pain in the right groin. A few days later, fever and pain in the left groin started. Radiograph and MRI of hips done (67 days since COVID-19 diagnosis) and showed bilateral hip AVN (Ficat-arlet stage two on both hips).

The patient was admitted for bilateral core decompression surgery in another hospital. Fever, constitutional symptoms, elevated Erythrocyte Sedimentation Rate (ESR) (112mm/h) and C-Reactive Protein (CRP) (145 mg/liter) make the previous diagnosis to be suspected. Though the planned surgery was canceled, the patient was referred to our clinic for further evaluation. With suspicion of an infectious process bilateral hip arthrocentesis was done. The specimen was pusy, and coagulase-positive staphylococcus grew up in the specimens of both sides. After diagnosis of bilateral SA of the hips, bilateral hip arthrotomy and irrigation and debridement was done. Despite a period of improvement in the symptoms, the pain in the right hip continued and an X-ray showed severe hip destruction in the right side. With the diagnosis of osteomyelitis we decided to perform first stage of two-stage THA. After the second surgery the laboratory and clinical findings improved dramatically. The patient was discharged with IV targocid for six weeks under the guidance of infectious disease specialist. Improvement in clinical and laboratory tests persisted and the patient is a candidate for second stage of THA in near future.

Imaging findings

Pre-operative imaging was done for all patients including a standard pelvic X-ray (antero-posterior view) and also pelvic and hip MRI with a standard protocol. In two cases MRI with gadolinium was performed (case two and case four).

X-ray evaluation shows sclerosis and collapse of femoral head compatible with classic avascular necrosis. An X-ray clue for the presence of an intra-articular inflammatory process was displaced gluteal fat plans. Joint space narrowing was seen in cases with cartilage damage (Fig. 6).

In the MRI evaluation, all patients show classic findings of femoral head AVN as bone marrow edema and serpiginous lines of abnormal signal in the superior and medial aspect of the femoral head (Fig. 7).

An additional finding was the presence of joint effusion in the involved hip joint. Mild reactive effusion could be seen in association with the femoral head AVN especially in the advanced stage due to the superimposed degenerative changes.

In the cases included in our study the amount of joint effusion was more than expected and was associated with synovial thickening and enhancement. An important clue was edema and inflammation in the peri-articular soft tissue including the adductor and gluteal muscle groups, which were not routinely seen in the femoral head AVN (Fig. 8)

Another sign of inflammation was the presence of pelvic enlarged lymph nodes ipsilateral to the involved joint (Fig. 9).

Regarding these findings associated septic arthritis was suggested and joint aspiration was done. In addition, in two of the cases, a small area of abnormal signal was found in the acetabulum bone marrow suspicious for juxta-articular osteomyelitis (Fig. 10a,b).

In the cases with prolonged symptoms (all cases), cartilage damage and superimposed degenerative changes was developed (Fig. 10c).

Results

The average dose of prednisolone equivalent steroid our patients received was 1695.2 mg (1375–2010 mg). The time period of onset of hip symptoms in our cases from the beginning of the COVID-19 infection was 56 days in the first case, 43 days in the second case, 30 days in the third case, 29 days in the fourth case and 50 days in the last case, with an average time of 41.6 days. All patients underwent surgery depending on the extent of articular cartilage damage by direct anterior approach and their clinical and laboratory symptoms improved significantly. The mean visual analogue pain score of the patients decreased from 9.4 (9–10) before surgery to 2.8 (1–4) after one week of operation. All of our cases experienced more severe pain than other cases of hip joint inflammation in other studies (AVN, rheumatoid arthritis, viral arthritis, reactive arthritis) before surgery. Table 1 lists the demographic characteristics of the patients as well as other factors influencing the study.

Table 1
Specifications of the cases reported in the study

	Sex	Age	The onset of hip symptoms (days from covid infection)	Pre-op ESR(mm/hr)	Pre-op CRP (mg/l)	Hip involved	Culture	Medication used in addition to corticosteroid	Dose of corticosteroids (mg of prednisolone)	AB used	Pre-op VASIS score
Case 1	M	34	56	110	140	Left	Negative	Remdesevir	1384.5	Imipenem + Vancomycin	10
Case 2	F	14	43	64	90	Bilateral	Non-typhoid salmonella	Remdesevir	2009.5	Ceftriaxone	9
Case 3	F	52	30	40	69	Right	Negative	Azithromycin	2010	imipenem + Vancomycin	9
Case 4	F	54	29	59	65	Bilateral	serratia marcescens	Azithromycin, hydroxychloroquine	1697	imipenem + Vancomycin	10
Case 5	M	38	50	112	145	Bilateral	Coagulase negative staphylococci	Remdesevir, Actemra	1375	Targocid	9

Discussion

Joint symptoms have been seen in a number of patients with COVID-19 infection during the recent pandemic event. These joint involvements can have different etiologies and occur in different joints. For example, drugs used to treat COVID-19 infectious disease such as CS can have side effects on the hip joints and several cases of femoral head AVN following treatment of COVID-19 disease have been reported in individuals treated with CS. Agarwala and colleagues reported three cases of AVN of femoral head following recovery from COVID-19 disease in May 2021; all of them were treated conservatively and their joint symptoms improved significantly(1). These reports indicate the onset of AVN of femoral head in COVID-19 patients was associated with lower doses and shorter duration of CS administration compared to other patients with avascular necrosis of femoral head who did not have COVID-19 disease(11, 12). In addition, endothelial markers were found to have elevated in the blood of critically ill patients with covid-19(13). The autopsy of many of these patients confirmed endothelial dysfunction(14). This endothelial destruction can trigger the pro-inflammatory and pro-coagulant pathways(15) and can lead to generalized microcirculatory dysfunction and related microthrombi (14) Which could potentially be one of the causes of femoral head avascular necrosis in patients with covid-19 infection.

Reactive arthritis is another form of joint complication after different caused by different type of infections, which can be related to mucosal infections in different areas of body such as urogenital (chlamydia) and gastrointestinal (campylobacter, salmonella, shigella, clostridium difficile, Yersinia) and respiratory pathogens (chlamydia pneumonia)(2, 16, 17). It's incidence is reported to be 1-1.5% in gastrointestinal infections and 4–8% after urogenital tract infections(16). People with HLA-B27 allele or family history of spondyloarthropathies are more at risk of developing reactive arthritis(16). Most cases of this kind of arthritis are seen in the lower extremities and this is considered as a diagnostic major criteria for the diagnosis of reactive arthritis(17). The prognosis is favorable in most cases and spontaneous improvement is seen in most cases within 6–12 months(16). Cases of reactive arthritis associated with COVID-19 disease have been reported in lower limbs such as knees, ankle, metatarsophalangeal and interphalangeal joints, recently(2, 7, 9, 10). A case of reactive arthritis following COVID-19 disease in the wrist and shoulder has also been reported(2).

Another cause of joint inflammation is viral arthritis which sometimes difficult to detect. It is considered in patients with acute onset poly-articular symptoms. A wide range of viral infections such as parvovirus-B19, hepatitis B, HCV, HIV, alphaviruses, HTLV-1, arboviruses, flaviviruses can cause arthritis(18). It is specially considered in patients who have a history of traveling to certain areas.

Reactive arthritis in different from viral related arthritis, however in the cases of COVID-19 infection recognizing these differences and naming them requires further studies. It should be noted that bacterial infections of body organs, immunological and genetic factors including HLA-B27 play an essential role in the

development of reactive arthritis(19). Accurate viral diagnostic tests as well as low-titers autoantibodies such as rheumatoid factor and antinuclear antibody can help differentiate viral arthritis from a reactive one(18). However, both treatments are supportive and anti-inflammatory medications should be considered as treatment.

However, the most destructive type of arthritis is infectious arthritis, the early diagnosis of which, is very important. Joint function is irreversibly lost in 25–50% of cases of infectious arthritis(20). Despite advances in antibiotics and surgical procedures the case fatality rate of septic arthritis in the past 25 years has not changed, ranging from 5–15%(21, 22). The incidence of SA varies from two to ten per 100000 population to 30–70 per 100000 people with rheumatoid arthritis or prosthetic implants(21).

Bacteria that most often cause SA include: staphylococcus aureus, all types of streptococci, all gram negative bacilli, nisseria gonorrhoea and anaerobes(21, 22) and the most common risk factor underlying that are: rheumatoid arthritis or osteoarthritis, joint prosthesis, low socioeconomic status, intravenous drug abuse, alcoholism, diabetes, previous intra-articular CS injection and cutaneous ulcers(22).

Diagnosis of SA is based on physical examination of the patient as well as laboratory markers and radiological evidences. Joint fluid aspiration is helpful in 50–67% of cases(23). Fever, redness, swollen and very painful joint movement are common symptoms and raised WBC and erythrocyte sedimentation(ESR) and C-reactive protein(CRP) in peripheral blood are other diagnostic factors, but these tests are very non-specific. Radiological evidences including joint effusion and adjacent lymphadenopathy as well as juxta-articular osteoporosis and bone erosions and osteomyelitis is helpful in prolonged cases. Finally, destruction of articular cartilage on X-rays and MRI is evidence of prolonged joint infection(21–23). Differential diagnoses of SA include gout and pseudo-gout, reactive arthritis, rheumatoid arthritis, Lyme disease and viral arthritis, which can be greatly differentiated by accurate history and complete examination as well as various laboratory tests(21).

The most appropriate treatment for septic arthritis is joint drainage and administration of appropriate antibiotics based on the culture results and anti-biogram(21, 22). Complete removal of necrotic and infectious material is mandatory. Joint drainage methods include closed drainage, arthroscopic drainage and open drainage specially in hip joints(22). Appropriateness and adequacy of antibiotic type and dose and duration is determined in the literature and it should cover the most common pathogens (staphylococcus aureus and streptococcus). In patients with the history of recent inpatient, intensive care unit and other risk factors for MRSA, antibiotic regimen should consist of vancomycin with or without second or third generation cephalosporin and in patient with high risk of gram-negative sepsis (elderly, UTI, catheters) it must include second and third generation cephalosporin with or without fluoroquinolones(21, 22). Consultation with infectious disease specialist is strongly recommended.

According to our knowledge, in this study the first cases of septic arthritis in the field of COVID-19 infection and its treatment are reported and given the current pandemic we expect more in the future.

In any patient with the history of COVID-19 infection specially those who have been treated with corticosteroid as one of the medications prescribed during the disease, any joint symptom specially in the hips should draw our attention to the joint infection and take the necessary measures in this regard.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. The methodology and ethics were reviewed and approved of by the institutional review board of Tehran University of Medical Sciences.

Consent to participate All the patients were contacted and asked to give their informed written consent to be a part of study and their medico-surgical data be used for research purpose.

Consent for publication The patients also were asked to give their informed written consent regarding the publication of their data in a scientific journal.

Competing interests The authors declare that they have no relevant financial or non-financial interests to report.

References

1. Agarwala SR, Vijayvargiya M, Pandey P (2021) Avascular necrosis as a part of 'long COVID-19'. *BMJ Case Reports* 14(7):e242101
2. Hønge BL, Hermansen M-LF, Storgaard M (2021) Reactive arthritis after COVID-19. *BMJ Case Reports* CP 14(3):e241375
3. Edler C, Schröder AS, Aepfelbacher M, Fitzek A, Heinemann A, Heinrich F, et al (2020) Dying with SARS-CoV-2 infection—an autopsy study of the first consecutive 80 cases in Hamburg, Germany. *International journal of legal medicine* 134(4):1275–84
4. Fahmy OH, Daas FM, Salunkhe V, Petrey JL, Cosar EF, Ramirez J, et al (2021) Is microthrombosis the main pathology in coronavirus disease 2019 severity?—a systematic review of the postmortem pathologic findings. *Critical Care Explorations* 3(5)
5. Wichmann D, Sperhake J-P, Lütgehetmann M, Steurer S, Edler C, Heinemann A, et al (2020) Autopsy findings and venous thromboembolism in patients with COVID-19: a prospective cohort study. *Annals of internal medicine* 173(4):268–77
6. Leung T, Chan A, Chan E, Chan V, Chui C, Cowling B, et al (2020) Short-and potential long-term adverse health outcomes of COVID-19: a rapid review. *Emerging microbes & infections* 9(1):2190–9
7. Liew IY, Mak TM, Cui L, Vasoo S, Lim XR (2020) A case of reactive arthritis secondary to coronavirus disease 2019 infection. *Journal of Clinical Rheumatology*
8. Mahase E (2020) Covid-19: What do we know about “long covid”? *bmj* 370

9. Saricaoglu EM, Hasanoglu I, Guner R (2020) The first reactive arthritis case associated with COVID-19. *Journal of Medical Virology*
10. Yokogawa N, Minematsu N, Katano H, Suzuki T (2021) Case of acute arthritis following SARS-CoV-2 infection. *Annals of the rheumatic diseases* 80(6):e101-e
11. Powell C, Chang C, Naguwa SM, Cheema G, Gershwin ME (2010) Steroid induced osteonecrosis: an analysis of steroid dosing risk. *Autoimmunity reviews* 9(11):721–43
12. Zhang S, Wang C, Shi L, Xue Q (2021) Beware of Steroid-Induced Avascular Necrosis of the Femoral Head in the Treatment of COVID-19—Experience and Lessons from the SARS Epidemic. *Drug Design, Development and Therapy* 15:983
13. Meizlish ML, Pine AB, Goshua G, Chang C-H, Zhang H, Bishai J, et al (2020) Circulating markers of angiogenesis and endotheliopathy in COVID-19. medRxiv
14. Varga Z, Flammer AJ, Steiger P, Haberecker M, Andermatt R, Zinkernagel AS, et al (2020) Endothelial cell infection and endotheliitis in COVID-19. *The Lancet* 395(10234):1417–8
15. Bonetti PO, Lerman LO, Lerman A (2003) Endothelial dysfunction: a marker of atherosclerotic risk. *Arteriosclerosis, thrombosis, and vascular biology* 23(2):168–75
16. Schmitt SK (2017) Reactive arthritis. *Infectious Disease Clinics* 31(2):265–77
17. Wendling D, Prati C, Chouk M, Verhoeven F (2020) Reactive arthritis: treatment challenges and future perspectives. *Current Rheumatology Reports* 22:1–7
18. Marks M, Marks JL (2016) Viral arthritis. *Clinical medicine* 16(2):129
19. Kobayashi S, Taniguchi Y, Kida I, Tamura N (2021) SARS-CoV2-triggered acute arthritis: Viral arthritis rather than reactive arthritis. *Journal of Medical Virology*
20. Gupta M, Sturrock R, Field M (2001) A prospective 2-year study of 75 patients with adult-onset septic arthritis. *Rheumatology* 40(1):24–30
21. Goldenberg DL (1998) Septic arthritis. *The lancet* 351(9097):197–202
22. Mathews CJ, Weston VC, Jones A, Field M, Coakley G (2010) Bacterial septic arthritis in adults. *The Lancet* 375(9717):846–55
23. Weston V, Jones A, Bradbury N, Fawthrop F, Doherty M (1999) Clinical features and outcome of septic arthritis in a single UK Health District 1982–1991. *Annals of the Rheumatic Diseases* 58(4):214–9

Figures

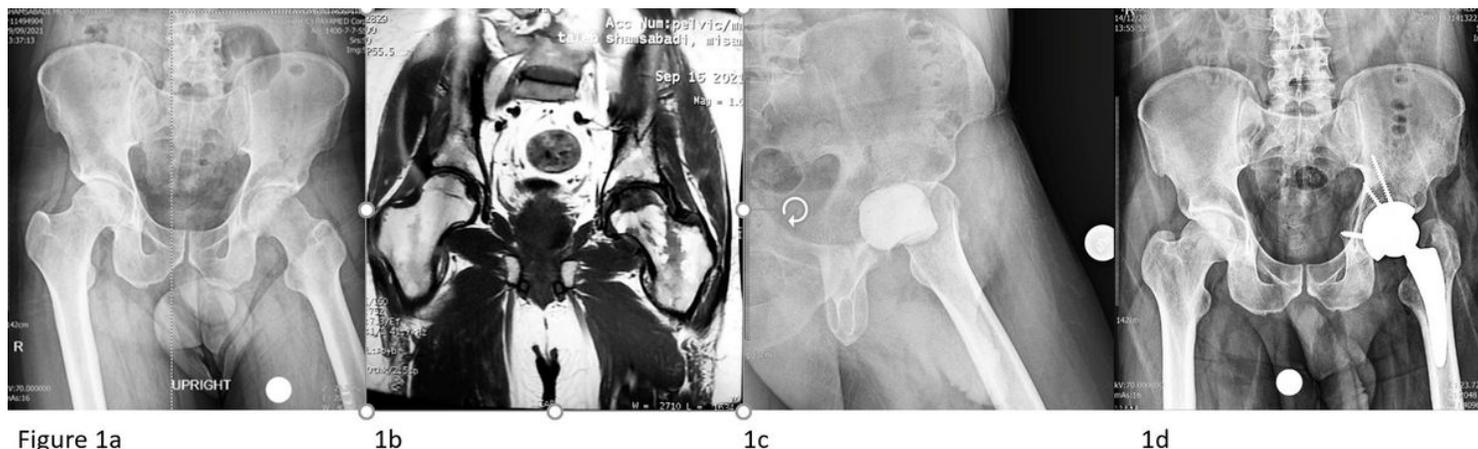


Figure 1

a) case one, pre-operative X-ray, left hip involvement. B) MRI of the hips shows left side inflammation and cartilage destruction. C) early post op after first stage of arthroplasty d) post-op radiography, after 2nd stage



Figure 2a

2b

2c

Figure 2

a) case two, pre-operative X-ray, bilateral involvement. B) MRI of both hips shows cartilage destruction on right side and acute inflammation on left side. C) post-op radiography after first stage of THA for right side and arthroscopy and irrigation and debridement for left side



Figure 3a

3b

3c

Figure 3

a) case three, pre-operative X-ray, right side involvement. B) MRI of the hips showing right side joint destruction. C) post-op radiography after first stage of arthroplasty



Figure 4a

4b

4c

Figure 4

a) case four, pre-operative X-ray, both sides involvement. B) MRI of the hips showing bilateral joint destruction and cartilage loss. C) post-op radiography after first stage of THA for both sides

Figure 5

a) case five, pre-operative X-ray, both sides involvement. B) MRI of the hips shows right side cartilage destruction and less involvement of the left side. C) post-op radiography after first stage of right side and arthrotomy and irrigation and debridement of left side.

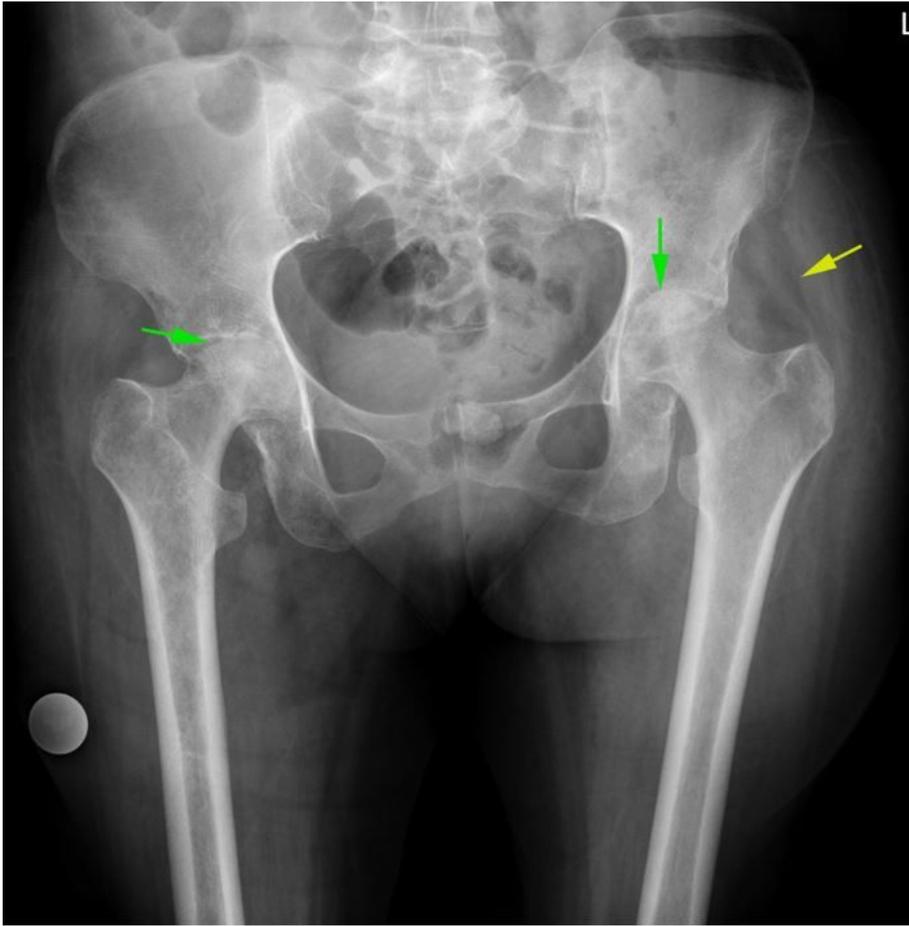


Figure 6

Figure 6

AP view pelvic X-ray shows sclerosis and collapse of bilateral femoral head in favor of femoral head AVN (Green arrow). Soft tissue edema and displaced gluteal fat planes is in favor of joint fluid and possible inflammatory process (Yellow arrow).



Figure 7

Figure 7

coronal T1 non-fat sat MRI shows low signal serpiginous lines of femoral head compatible with femoral head AVN(Yellow arrow).



Figure 8a

8b

8c

Figure 8

a) Coronal PD fat sat images show femoral AVN in association with joint effusion and synovial thickening (Small red arrow). There is also edema in the adductor muscle group (Large green arrow). B) Coronal T1 fat sat images in the same patient as (a) shows synovial thickening and enhancement after contrast injection(Red arrow). C) Axial oblique PD fat sat images in another patient shows edema in the pectineus muscle and also inferior capsule of the hip joint (Green arrow).

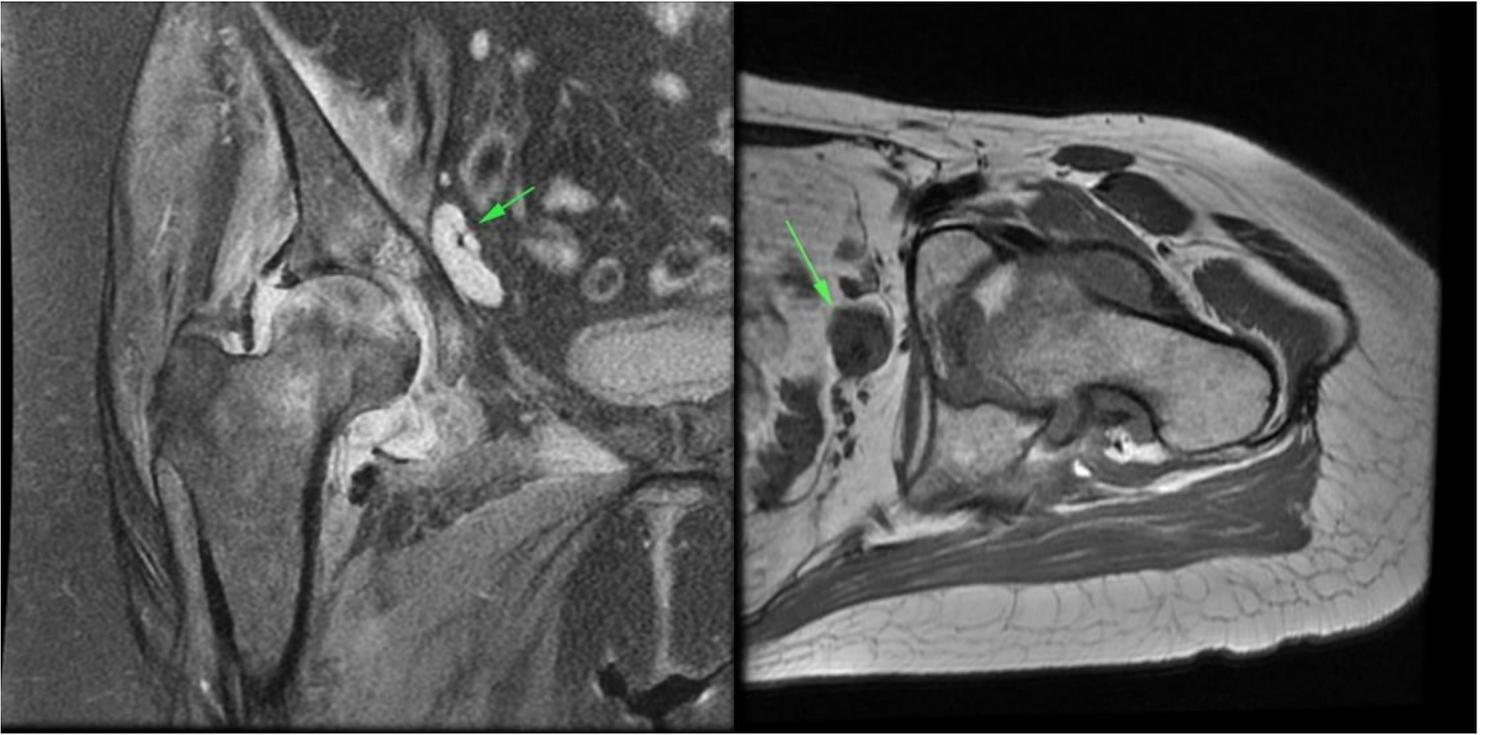


Figure 9a

9b

Figure 9
a) Coronal PD fat sat and b) axial T1 non-fat sat images show two different patients with enlarged lymphadenopathy in the external iliac chain (Green arrow).

Figure 10
a,b) coronal PD fat sat image shows a focus of bone marrow edema in acetabulum which has low signal in coronal non-fat sat T1 images with signal intensity darker than adjacent muscle (Yellow arrow) which was suspicious for presence of osteomyelitis c) Coronal PD fat sat image shows joint space narrowing and full thickness cartilage loss in the weight-bearing surface (Blue arrow).