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Surgery

IMAGING OF DIABETIC FOOT INFECTIONS_ REVIEW ARTICLE

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ABSTRACT **BACKGROUND:**Infection of the foot is more common in the Diabetic patients causing significant morbidity. Diabetic foot complications comprise pathologies affecting osseous, joint, muscular, tendinous and other soft tissue. Early diagnosis is crucial as it permits timely treatment (e.g. antibiotics, surgical debridement1.Optimal management is dependent on the early detection of deep-seated infections and its extent involving soft tissue and bone. Whereas Magnetic Resonance Imaging is used widely in earlier assessment of deep-seated soft tissue and bony pathology1.Application of Magnetic Resonance Imaging (MRI) in evaluating musculoskeletal pathology is expanding rapidly.

METHODOLOGY: We have taken the research literature for studies reporting use of MRI in management of Diabetic foot infections. As this study was a meta analysis based on systematic literature review, ethical approval was not required. A systematic search of the literature was conducted first in MEDLINE/PubMed and then in the Cochrane Central Register of Controlled Trials till December 2019 .The findings in diabetic foot MRI, and their management were studied

RESULTS: Based on the comparison, we have concluded that Male preponderance, duration of diabetes, vasculopathy were found to be statistically significant in majority of the studies.

KEYWORDS : Diabetic Foot Ulcer(DFU), Diabetic Foot Infection (DFI), Magnetic Resonance Imaging(MRI), Diabetic Foot Complications(DFC)

INTRODUCTION

Diabetes mellitus (DM) is a growing health problem worldwide. The global prevalence of DM was approximately 5.1% in 2012 and is projected to hit 7.7% by 2030.[1] This is contributed to by the increasingly sedentary lifestyles and evolving dietary trends associated with growing affluence, especially in developed nations. Similar to its geographical extent, DM afflicts the body in a global fashion, resulting in a myriad of complications involving multiple end-organs. In this article, we will consider diabetic foot complications, a significant cause of morbidity and mortality in diabetic patients. Diabetic foot complications comprise pathologies affecting osseous, joint, muscular, tendinous and other soft tissue structures. Infection of the soft tissue and bones is particularly common in the diabetic foot, and early diagnosis is crucial, as it permits timely treatment (e.g. antibiotics, surgical debridement). With delayed treatment and a background of impaired healing, deterioration toward a limb- and life-threatening stage is inevitable.

Almost all diabetic foot infections are due to direct spread from a skin ulcer.[2] The diabetic foot is prone to skin ulceration due to associated risk factors such as microangiopathy with peripheral neuropathy, and altered biomechanics. Unrecognised trauma, in the background of these risk factors, results in superimposed infection and restricts healing.[3,4] Another significant route of infection is related to surgery or penetrating trauma, where infectious material may be directly implanted. Haematogenous spread of infection rarely involves the foot but may be seen in the paediatric population, or with atypical organisms such as *Mycobacterium tuberculosis.*[5,6] However, in these cases, the clinical diagnosis is straightforward.

Chronic repeated unperceived traumatic injuries to the joints of the foot results in neuroarthropathy (Charcot neuro-osteoarthropathy). The diabetic patient is predisposed to this condition because of associated peripheral neuropathy and peripheral vascular disease. There is progressive arthropathy characterised by cartilage damage, bone erosions, subchondral cysts, joint deformities and new bone formation. This usually affects the tarsometatarsal joints, causing collapse of the longitudinal arch and a 'rocker-bottom' deformity that increases load-bearing on the cuboid. Both the acute and chronic forms of neuroarthropathy are recognised.

Neuroarthropathy and osteomyelitis often occur concurrently in the diabetic foot, but either of them may be more prominent. It is clinically and radiologically challenging to distinguish between these two entities. Both conditions may show marrow oedema and enhancement, joint effusion, as well as adjacent soft tissue oedema. Apart from analysing the magnetic resonance (MR) imaging features, correlation with clinical findings is also necessary in order to arrive at an accurate diagnosis.[7,8] In this pictorial review, we illustrate the MR imaging appearances of diabetic foot complications, including osteomyelitis, and also discuss the MR imaging appearance of neuroarthropathy, both with and without coexisting infection.

IMAGING MODALITIES

Radiography is the preferred initial imaging modality, since it is easily available, inexpensive, and provides superb resolution of bones. However, in the case of early osteomyelitis, the rate and accuracy of detection is at best 50%–60%, as the soft tissues are not adequately demonstrated.[9]For the assessment of soft tissue infection and osteomyelitis involving the foot, MR imaging is the modality of choice, with sensitivity and specificity of 90% and 83%, respectively.[10,11] In addition, it allows preoperative mapping of the area of infection, potentially limiting the extent of resection.[12]It has been shown that MR imaging, in combination with radiography, is the most accurate in the detection of diabetic pedal osteomyelitis (and its differentiation from neuroarthropathy).[13-17]

Bone scintigraphy and white cell scinti scans are able to demonstrate increased uptake in osteomyelitis, but they are of limited use due to their poor specificity. Ultrasonography is valuable as a widely available non-invasive imaging modality in the evaluation of soft tissue pathologies and localisation of foreign bodies. However, it has a limited role in the assessment of diabetic foot complications (particularly of the bones).[18]

MATERIALS AND METHODS:

We searched the research literature for studies reporting the use id MRI in patients with DFI. As this study was a meta analysis based on systematic literature review, ethical approval was not required. A systematic search of the literature was conducted first in MEDLINE/PubMed and then in the Cochrane Central Register of Controlled Trials till December 2019 . Our search strategies

included relevant keywords for three concepts: "diabetic foot infections", "MRI," and "diabetic Foot complications ." This search retrieved 12 most relevant articles. They were included in the review if they fulfilled the following selection criteria: (i) Theme: studies that evaluated the association between variables (clinical data or diagnostic tests results) and DFU; (ii) Type of study: cross-sectional studies;(iii) Results: Studies must conclude if there is or is not a statistically findings in MRI of the diabetic foot.

INVESTIGATIONS IN DIABETIC FOOT INFECTIONS

With a wide spectrum of clinical entity which includes cellulitis, abscess and osteomyelitis, it is challenging to diagnose and differentiate various infections, owing to different management principles. Laboratory investigations have shown not well correlating with the severity of the DFI. White cell counts (WBC), Erythrocyte Sedimentation Rate(ESR), and C-reactive protein(CRP) levels are often normal and are non-specific. Certain clinical test such as Probe to Bone(PTB) test, have been touted in the past to be highly sensitive and highly predictive of osteomyelitis in the DFI[53]. Over the recent years the PTB was found to have more negative prediction for OM and hence not used in the practise.[55]

Prompt diagnosis of the abscess and distinction between the bone and soft tissue infections in DFI are the primary goals of the imaging modalities[55]

Plain radiograph is the most easily available and low-cost radiological investigation but has got poor sensitivity and specificity[56]

Ultrasonography and Computed tomography CT are widely available non-invasive imaging modality, but their evaluation related to diabetic foot infections are limited[57].Radionuclide scans are inefficacious because of high false positive and false negative results. And they are expensive and not available in many centers. [14,58]

Magnetic resonance imaging(MRI) helps in the assessment of the extent of the infection clearly aiding the diagnosis and it has the capability to evaluate the depths of the soft tissue infections. MRI came into the investigations in the early 90's and it was not widely practiced becauseof its limited availability and cost. Now it's been used as an investigation in many conditions[59].

MECHANISM OF MRI IN EXTREMITY IMAGING

The MRI examination should be tailored to the patient and the specific clinical condition. The field of view includes the area of concern and is usually tailored to the forefoot, midfoot, or hindfoot [60]. The use of a large field view, such as the entire foot or both feet, should be avoided. Imaging should be performed in two planes to best visualize the area of interest.

T1-weighted imaging has the highest specificity for the detection of osteomyelitis. In addition, T2-weighted fat-suppressed imaging is recommended to detect changes in bone marrow and adjacent soft tissue; for these sequences, the echo time usually is fixed at 50–65 msec. Because of the curvature of the foot, fat suppression is more uniform with the use of short time inversion recovery (STIR) imaging than with T2- weighted imaging with chemical fat suppression.

Contrast enhanced imaging is useful for the evaluation of soft-tissue complications such as sinus tracts, abscesses, and necrosis, and it provides invaluable information for preoperative planning of limited limb resection. It should be performed with a turbo gradient-echo sequence because of the speed and uniformity of fat suppression that sequence provides. After turbo gradient-echo imaging, four additional views are obtained one image in each plane and an additional delayed image in the key plane. This delayed image is particularly important because the slow blood flow in diabetic patients may lead to false-negative findings due to a lack of enhancement. Caution should be exercised in patients with renal failure because of the potential for gadolinium induced nephron toxicity causing fibrosis[16–18].The American College of Radiology recommends that gadolinium-based contrast material not to be administered to patients with a severely reduced glomerular filtration rate(<30 mL/min/1.73 m^2) [61-63]

For toe ulcers, a short axis view (aligned perpendicular to the toes) provides excellent visualization of the ulcer and its relationship to underlying osseous structures. Midfoot neuropathic disease and hindfoot calcaneal ulcers are best depicted in the sagittal plane. Medial or lateral ulceration in the hindfoot is best depicted in the axial and coronal planes[63].

MR IMAGING IN OSTEOMYELITIS

The simplest method to determine whether osteomyelitis is present is to track the ulcer or sinus tract down to bone at MR imaging and evaluate the signal intensity of marrow; Noticeably low signal intensity on T1-weighted images is a primary sign of osteomyelitis[64].

There are several secondary signs, such as periosteal reaction, that may help confirm the diagnosis. At MR imaging, the calcified periosteum appears as a low signal intensity line that is separated from underlying bone by a high signal intensity layer of fluid or pus. Periosteal reaction usually is seen in the metatarsal bones and malleoli. Osteomyelitis(OM) also is likely if soft-tissue findings such as a subtending skin ulcer, sinus tract, cellulitis, abscess, or, less commonly, a foreign body are present [64].

In cases in which the bone marrow is hyperintense on T2-weighted images but is not hypointense on corresponding T1-weighted images, osteitis is more likely than osteomyelitis, even when bone marrow enhancement is present. Osteitis is a reactive change resulting from either an adjacent soft-tissue infection or a cortical (non- medullary) infection. Oedema patterns may be peculiar. In the metatarsal bones, oedema tends to spread distally, some distance from the tarsometatarsal joint, a pattern that is more common in Charcot arthropathy than in infection[65].

The criteria for diagnosing osteomyelitis at the site of amputation are the same as those for patients who have not undergone amputation [15]. However, in patients who undergo debridement instead of amputation, associated postoperative oedema may occur at the surgical site and should not be mistaken for osteomyelitis. Surprisingly, most patients who undergo amputation have little postoperative bone marrow oedema.

Magnetic resonance imaging(MRI) helps in the assessment of the extent of the infection clearly aiding the diagnosis and it has the capability to evaluate the depths of the soft tissue infections. MRI came into the investigations in the early 90's and it was not widely practiced because of its limited availability and cost. Now it is used as an investigation of choice in many conditions[59].

Diabetic foot infections are common with a prevalence of 25% causing major morbidity and mortality[6]. MR Imaging in diagnosing diabetic foot soft tissue infection is known over 20years.

Cook et al in their study of 25 patients have described plain radiography is poor at detecting foot infection because the end stage tissue destruction needs to be present before the identification can be made. MRI when compared with CT and Bone scintigraphy is better in identifying soft tissue infections and deep-seated infections[4].

CONCLUSIONS:

Hence in this review article we would like to emphasise on the importance of imaging in diabetic foot and the early decision in management of the infection. MRI is the gold standard investigation of the diabetic foot imaging.

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