DOI: 10.7860/JCDR/2017/25902.10154

Original Article

Orthopaedics Section

Diagnostic Accuracy and Surgical Utility of MRI in Complicated Diabetic Foot

MAYANK MAHENDRA[1], RAHUL SINGH[2]

ABSTRACT

Introduction: Diabetic foot complications pose a significant public health hazard and have negative effect on life quality. These complications are associated with increased risk of amputations and premature death. So focus is increasing on early treatment of complicated diabetic foot.

Aim: To assess the diagnostic accuracy and surgical utility of MRI in complicated diabetic foot.

Materials and Methods: Thirty four complicated diabetic patients were evaluated prospectively. Initially X-ray was done and a provisional management plan was formulated. Later T1W, T2W and FSat sequences of the affected foot and ankle was carried out. The soft tissue, tendons and osseous apparatus were evaluated and subsequently compared with histopathological examination. Before and after MRI, change in management plan was marked. Previously operated cases with persistent ulcer of affected foot were excluded from the study.

Results: Twenty two males and 12 females with mean age of 52±8.8 years were analysed. The sensitivity of MRI for tenosynovitis and osteomyelitis was 88% and 100% respectively. The specificity for the same was 100% and 90%. Of all 34 cases, MRI reshapes surgical planning in 23.5% cases (8 patients). The difference between MRI and histopathological findings was evaluated statistically using Fisher-Z test and the proportion of difference between these two groups was not significant as values for tenosynovitis was Z=0.50 (p-value >0.05) and for osteomyelitis Z= 0.54 (p-value>0.05).

Conclusion: The result indicates that MRI is a sensitive and accurate imaging modality for evaluation of diabetic foot and for planning proper treatment and the MRI correlates significantly with the surgical finding.

Keywords: Accurate imaging, Diabetic foot complications, Health hazard

INTRODUCTION

Diabetic foot is prone to skin ulceration because of associated risk factors such as microangiopathies, peripheral neuropathies and also altered biomechanics. In diabetic foot with ulceration, infection is fairly common and is main reason for hospital admission [1]. Infection in diabetic foot is usually caused by direct spread from skin ulcer which leads to various pathologies affecting musculoskeletal structure. Overall, lifetime risk for complicated diabetic foot in diabetic patients may be upto 25% [2]. Complicated diabetic foot poses significant public health hazards considering their correlation with increased chance of amputation and also early death [3,4]. With high costs and a high prevalence, there should be increased focus on the treatment of the diabetic foot in health-care systems, as it shall be less expensive to prevent complications than to manage their consequences [5].

Prompt diagnosis of abscess and distinction between bone and soft tissue infection are the prime goal of imaging modalities [6]. Plain radiography is most common choice of radiological investigation owing to its low cost and wide availability but has got poor sensitivity and specificity rate [7]. Ultrasonography and computed tomography are widely available and noninvasive imaging modality, although there role in the evaluation of diabetes related foot complications is limited [8]. Also, radionuclide scans are inefficacious because of high false-positive and false-negative results [9]. Magnetic Resonance Imaging (MRI) is the modality of choice for evaluation of pedal osteomyelitis and soft tissue infection (ACR Appropriateness Criteria rating 9) [8]. MRI has the capability to evaluate the depths of the infected diabetic foot within the span of one hour [10]. A recent meta-analysis evaluating the usefulness of MR imaging in diagnosing diabetic pedal osteomyelitis demonstrated a sensitivity of 90% and a specificity of 83% [11].

The present study was designed to assess the diagnostic accuracy of MRI in complicated diabetic foot (with ulceration) by comparing MRI and histopathological finding as well as surgical utility in a view of change in surgical plan post MRI.

MATERIALS AND METHODS

This prospective study included 34 patients (male-22, female-12, mean age- 52.3±8.8 years) with complicated (with ulceration) diabetic foot presenting to LLR Hospital, Kanpur, Uttar Pradesh, India, between June 2013 to August 2015 after Ethical Committee and Departmental Review Board approval. After obtaining consent, all complicated diabetic feet patients during study time were included except previously operated cases with persistent ulcer. Patients in whom MRI was contraindicated like with pacemakers, implants etc., were also excluded.

Pre MRI included complicated diabetic foot patients were evaluated clinicoradiologically (using X-ray) and a presumptive management plan was formulated by a senior physician based upon above assessment. All patients were re-evaluated based on MRI findings and change in management plan by the same physician was noted. MRI evaluation of all diabetic feet and ankle was done with 1.5 Tesla MRI machine. Sequences used were T1, T2, and FSat sequence with intra-venous gadolinium contrast (Omniscan) whenever feasible. The images were primarily done in sagittal, coronal and axial planes. To diagnose bone and tendon infection we used signs as mentioned by previous authors [12,13]. All included patients underwent histopathological examination tenosynovium and bone

tissue of adjacent area of ulcer to assess the diagnostic accuracy of MRI.

STATISTICAL ANALYSIS

Appropriate statistical evaluation was done using the Fisher-Z test (software- SPSS version 10.0).

RESULTS

Most skin ulcer on diabetic foot occurred in the forefoot (62%) which was distributed mainly among metatarsal heads (27%) and tip of toes (23%) [Table/Fig-1].

Radiographical Analysis

X-rays revealed no osseous abnormality in 30 patients (88%) [Table/Fig-2]. Osteomyelitic signs were seen in only four patients (12%). Out of these four patients, one patient had pathological fracture.

Imaging Analysis

MRI evaluation of 34 diabetic feet was done with 1.5 Tesla MRI using T1, T2, FSat sequences.

Tenosynovitis

MRI showed a sensitivity of 88% and specificity of 100% for tenosynovitis. MRI was able to diagnose tenosynovitis in 15 out of 17 histopathologically confirmed cases. MRI failed to diagnose tenosynovitis in two cases, one each of Wagner grades four and five [Table/Fig-2]. Of the 17 cases of tenosynovitis, majority were flexor group (83%) involving one or more tendons of planter of foot as compared to extensor group (17%).

The difference between MRI and surgical findings was evaluated statistically using Fisher-Z test. Z-value for tenosynovitis is 0.50 (p-value> 0.50) which signifies the difference between MRI and surgical findings is non-significant.

Osteomyelitis

MRI reported two false positive cases as osteomyelitis but, on surgery and histopathology they did not reveal features suggestive of osteomyelitis [Table/Fig-2]. Both of these false positive cases were in Wagner two as osteomyelitis based on signal changes of marrow. Overall sensitivity and specificity of MRI was 100% and 90% respectively. The difference between MRI and surgically confirmed osteomyelitis was found to be non-significant. (Z value=0.54, p-value >0.05).

Type of Treatment

In Wagner one and two, all 16 patients were evaluated clinicoradiologically and planned for debridement but MRI helped in detecting tenosynovitis and abscess in six cases (two and four cases in Wagner one and two respectively) which were not suspected clinicoradiologically which subsequently underwent incision and drainage of abscess and tenosynovitis [Table/Fig-3,4].

In Wagner three, two patients (50%) underwent debridement of ulcer, along with the excision of involved tendons only. While clinically, we had a doubt about the involvement of underlying bone in these patients but MRI as well as histopathology did not show any signs suggestive of osteomyelitis. Since these patients had good skin coverage, they were benefitted by mere debridement. MRI helped in defining the extent of infection and salvaging the toes. The other two patients (50%) showed signs of osteomyelitis

Sl. No.	Site of ulcer	No. of cases (percentage)
1	Tip of toes	8 (23%)
2	Metatarsal head (planter)	9 (27%)
3	Dorsum	4 (12%)
4	Heel	4 (12%)
5	Tendon achilles	3 (8%)
6	Around malleolus	3 (8%)
7	Whole of foot	2 (6%)
8	Sole	1 (3%)

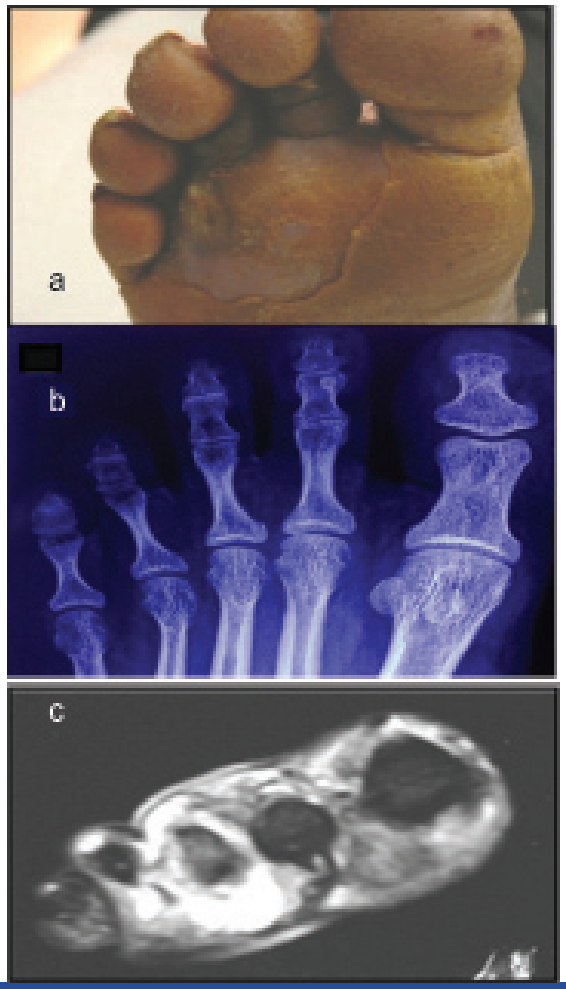
[Table/Fig-1]: Distribution sites of diabetic ulcers on the foot.

Wagner grade	Total no. of patients	No. of patient with X-ray changes	Tenosynovitis		Osteomyelitis	
			MRI	HPE* confirmed	MRI	HPE* confirmed
1	5	0	2	2	0	0
2	11	0	2	2	2	0
3	4	0	3	3	2	2
4	10	1	6	7	5	5
5	4	3	2	3	3	3
Total	34	4	15	17	12	10

[Table/Fig-2]: Diagnostic accuracy of MRI.
*Histopathological examination

Wagner grade	No. of patients	Pre MRI Plan	No. of patients with change in plan (post MRI)
1	5	Debridement/ Conservative	2
2	11	Debridement	4
3	4	Amputation	2
4	10	Amputation	0
5	4	Amputation	0
Total	34		8

[Table/Fig-3]: Surgical utility of MRI.



[Table/Fig-4]: a) Wagner grade 1 ulcer present over planter surface of foot; b) X-ray showing no bony or soft tissue abnormality. Initially was thought to be managed conservatively; c) MRI shows the presence of abscess in planter surface of third toe which surgically proven to be correct.

[Table/Fig-5]: a) A 29-year-old lady with Wagner grade 3 ulcer over the dorsum of great toe; b) AP radiograph of foot showing soft tissue swelling; c) Sagittal post contrast MRI section shows cortical disruption of the distal and proximal phalanx, but no involvement of the metatarsophalangeal joint or first metatarsal. As a result, only first ray amputation was done.

clinically which was further proved correct by MRI signal changes and histopathology. Subsequently, these patients underwent toe amputation [Table/Fig-5].

In Wagner four and five, although only eight patients (57%) out of total of 14 showed signs suggestive of osteomyelitis on MRI, all 14 patients underwent amputation due to poor cutaneous circulation, showing gangrenous changes. All the patients in Wagner four and five underwent amputation (nine cases below knee amputation, five patients ray amputation) and had good stump healing and were walking with prosthesis after three months. MRI also helps in deciding the level of amputation in Wagner three,four and five grade patients. Overall in total, management plan was improved in eight cases (two in Wagner one, four in Wagner two, two in Wagner three) post MRI [Table/Fig-3].

DISCUSSION

MRI gives information about any deep seated abscess, the condition of surrounding tendons as well as defining the anatomy of pathologies which also play an important part in the pathogenesis of complicated diabetic foot. Skin ulcers usually occur in the areas of highest pressure during ambulation and frequently involves the plantar surface of metatarsophalengeal joints, mainly the first and fifth rays, the first toe, and the heel [14,15]. Plantar ulceration is due to weight bearing where as ulcers on dorsum and borders of foot are usually caused by pressure of shoes.

Fluid within a tendon sheath can be a normal finding or it can be seen in other non infective pathologies such as neoplastic, mechanical or post-traumatic conditions but, if fluid is in the anterior tendon sheath, it is neither normal nor by mechanical conditions [13]. Tenosynovitis typically occurs next to an ulcer or sinus tract due to direct extension of infection. In the forefoot, two-third tenosynovitis occur in flexor tendon as a consequence of planter skin ulcers, and most of the cases in hind foot, tenosynovitis occurs in peroneal and the Achilles tendon as they are adjacent to lateral malleolus and calcaneal skin ulceration respectively. In our study, MRI failed to diagnose tenosynovitis in two cases, one each of Wagner grades four and five. Possible causes for this discrepancy could be signal intensity changes suggestive of tenosynovitis being masked by surrounding cellulitis, which also shows bright signal on T2 images or infected tendon sheath slits open in later stages, causing gadolinium contrast to spill out [16]. Al-Khawari et al., in 2005 reported four cases of tenosynovitis in 29 diabetic feet which underwent MRI evaluation. There tendon sheaths were split open subsequently. However, their study did not divide diabetic feet under Wagner grading [17].

Tenosynovitis is commonly associated with osteomyelitis, likely because both pathologies are most commonly seen with fairly advance infection and the easiest way to detect osteomyelitis in MR imaging is to follow the path of skin ulcer and sinus tract to the bone and assess the marrow signal intensity [18].

Location is a governing factor to distinguish osteomyelitis from neuroarthropathy as neuroarthropathy is primarily joint pathology involving tarsometatarsal and metatarsophalangeal joint mainly while osteomyelitis is a bony pathology commonly involves calcaneum, malleolus and bones distal to tarsometatarsal joint [18]. Also, the soft tissue feature that helps in differentiating neuroarthropathy with superimposed infection from uncomplicated neuroarthropathy includes a loss of fat signal intensity in adjacent subcutaneous tissue and presence of larger neighbouring fluid collection compare to uncomplicated neuroarthropathy [18]. Additionally, 'ghost sign' helps in differentiating these two entities. The ghost sign refers to bones that 'disappear' on T1W sequences and 'reappear' (become better delineated) on T2W or post contrast sequences [13]. The presence of the ghost sign signifies superimposed infection.

MRI helps to take decision regarding surgical planning and extent of surgery. Proper surgical management in diabetic foot osteomyelitis yields good results in terms of recurrence and new episode of osteomyelitis [19]. In present study, MRI showed two false positive results regarding osteomyelitis. Both of these false positive cases belonged to Wagner grade 2. MRI also revealed osteomyelitis in two out of four cases in Wagner three which was confirmed on surgery, although osteomyelitis was suspected clinically in all four cases. MRI narrowed down our suspicion to only two cases, which was confirmed surgically. Al-Khawaris et al., reported 14 cases of osteomyelitis in 29 diabetic feet. Of these 14 cases, three cases were proven of not having osteomyelitis surgically. They concluded as MRI having sensitivity of 100% and specificity of 63%. MRI helped in limb saving procedures in six of their cases [17].

Although we had put our best effort, the study has certain limitations as small number of cases. We wish to accumulate more number of cases and long term follow up for better evaluation and detailed analysis in future.

CONCLUSION

MRI offers distinct advantages as in Wagner one and two, MR allows for the differentiation of cellulitis from actual organized abscess pockets. It helps in pin-point localization of abscess, assists surgeon in most direct and least injurious approach. It also helps in identifying the involvement of tendon present at the base of ulcer. In Wagner three, MRI helps in detection of the involvement of underlying bone assisting in decision making with respect to debridement or amputation and lastly in Wagner four and five, MRI helps in detecting the extent of infection along the tendons, so that the proximal most extent of tendon can be excised and hence the level for amputation could be chosen. The clinical significance of MRI is its sensitivity and also since it has an extremely low false negative rate which may justify its use in early diagnosis to prevent amputation. MRI finding correlate significantly with surgical findings.

REFERENCES

[1] Zgonis T, Stapleton JJ, Roukis TS. A stepwise approach to the surgical management of severe diabetic foot infections. Foot Ankle Spec. 2008;1(1):46-53.
[2] Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. JAMA. 2005;293(2):217-28.

[3] Armstrong DG, Lavery LA, Wrobel JS, Vileikyte L. Quality of life in healing diabetic wounds: does the end justify the means? J Foot Ankle Surg. 2008,47:278-82.
[4] Moulik PK, Mtonga R, Gill GV. Amputation and mortality in new-onset diabetic foot ulcers stratified by etiology. Diabetes Care. 2003;26:491-94.
[5] Ortegon MM, Redekop WK, Niessen LW. Cost-effectiveness of prevention and treatment of the diabetic foot: a Markov analysis. Diabetic Care. 2004;27:901-07.
[6] Loredo RA, Garcia G, Chhaya S. Medical imaging of the diabetic foot. Clin Podiatr Med Surg. 2007;24:397424.
[7] Dinh MT, Abad CL, Safdar N. Diagnostic accuracy of the physical examination and imaging tests for osteomyelitis underlying diabetic foot ulcers: meta-analysis. Clin Infect Dis. 2008;47(4):519-27.
[8] Schweitzer ME, Daffner RH, Weissman BN, Bennett DL, Blebea JS, Jacobson JA, et al. ACR Appropriateness criteria on suspected osteomyelitis in patients with diabetes mellitus. J Am Coll Radiology. 2008;5:881-86.
[9] Donovan A, Schweitzer ME. Current concepts in imaging diabetic pedal osteomyelitis. Radiology Clin N Am. 2008;46:1105-24.
[10] Durham JR, Lukens ML, Campanini DS, Wright JG, Smead WL. Impact of MRI on the management of diabetic foot infections. Am J Surg. 1991;162(2):150-53.
[11] Kapoor A, Page S, Lavalley M, Gale DR, Felson DT. Magnetic resonance imaging for diagnosing foot osteomyelitis: a meta analysis. Arch Intern Med. 2007;167(2):125-32.
[12] Morrison WB, Schweitzer ME, Wapner KL, Hecht PJ, Gannon FH, Behm WR. Osteomyelitis in feet of diabetics: clinical accuracy, surgical utility, and cost-effectiveness of MR imaging. Radiology. 1995;196:557-64.
[13] Dangman BC, Hoffer FA, Rand FF, O'Rourke EJ. Osteomyelitis in children: gadoliniumenhancedMR imaging. Radiology. 1992;182:743–47.
[14] Yavuz M, Erdemir A, Botek G, Hirschman GB, Bardsley L, Davis BL. Peak plantar pressure and shear locations, Relevance to diabetic patients: Diabetes Care. 2007;30(10):2643-45.
[15] Gibbons GW, Habershaw GM. Diabetic foot infections: anatomy and surgery. Infectious Disease Clin North Am. 1995;9:131-142.
[16] Ledermann PH, Morrison WB, Schweitzer ME, Raikin SM. Tendon involvement in pedal infection:MR analysis of frequency, distribution, and spread of infection. AJR Am J Roentgenol. 2002;179:939–47.
[17] Al-Khawari, Al-Saeed OM, Jumaa TH, Chishti F. Evaluating diabetic foot infection with magnetic resonance imaging: Kuwait experience. Med Princ Pract. 2005;14;165-72.
[18] Low KTA, Wilfred CG. Magnetic resonance imaging of diabetic foot complications: Singapore Med J. 2015;56(1):23-34.
[19] Aragon-Sánchez J, Lazaro-Martínez JL, Hernandez-Herrero C, Campillo-Vilorio N, Quintana-Marrero Y, Garcia-Morales E et al. Does osteomyelitis in the feet of patients with diabetes really recur after surgical treatment? Natural history of a surgical series. Diabet Med. 2012;29(6):813-18.

PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Orthopaedics, King George Medical University, Lucknow, Uttar Pradesh, India.
2. Assistant Professor, Department of Orthopaedics, Mayo Institute of Medical Sciences, Barabanki, Uttar Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Mayank Mahendra,
301-A, Fortuna Apartment, Jopling Road, Lucknow-221006, Uttar Pradesh, India.
E-mail: mahendra_mayank@rediffmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Dec 03, 2016**
Date of Peer Review: **Mar 04, 2017**
Date of Acceptance: **Apr 27, 2017**
Date of Publishing: **Jul 01, 2017**