Development of a Magnetic Resonance Imaging Atlas for the Classification of Osteoarthritis of the First Metatarsophalangeal Joint

Shannon E. Munteanu, Karl B. Landorf, Jade M. Tan, Maria Auhl, Jamie J. Allan, Andrew K. Buldt, Hylton B. Menz

La Trobe University, Australia

Background and purpose

Osteoarthritis (OA) of the first metatarsophalangeal joint (1st MTPJ) of the foot is the most common form of foot OA. The condition is typically evaluated using plain film radiographs, however magnetic resonance imaging (MRI) may provide more detailed insights into the disease process and responses to treatment. The purpose of this study was to develop a standardised atlas of MRI features of 1st MTPJ OA and assess its reliability.

Methods

We developed a semi-quantitative atlas after selecting representative MR images covering the spectrum of OA severity from a database of 1st MTPJ OA for the following features: osteophytes (dorsal and plantar metatarsal head and dorsal proximal phalanx), joint space narrowing (1st MTPJ and 1st metatarsal-sesamoid joint), bone marrow lesions (1st metatarsal, proximal phalanx and sesamoids), cysts (1st metatarsal and proximal phalanx), effusion (dorsal and plantar), capsular thickening (dorsal and plantar) and cartilage loss. See Figure.

Thirty cases were then independently scored with the atlas by two raters (SEM and HBM) to determine inter-rater reliability. Statistical analysis was conducted using Gwet's AC1 modification of the weighted kappa statistic (κ_w). An a priori decision was made to exclude any observations with κ_w <0.40 from the atlas. Reliability of a combined score summing all observations was also assessed using the intra-class correlation coefficient (ICC).

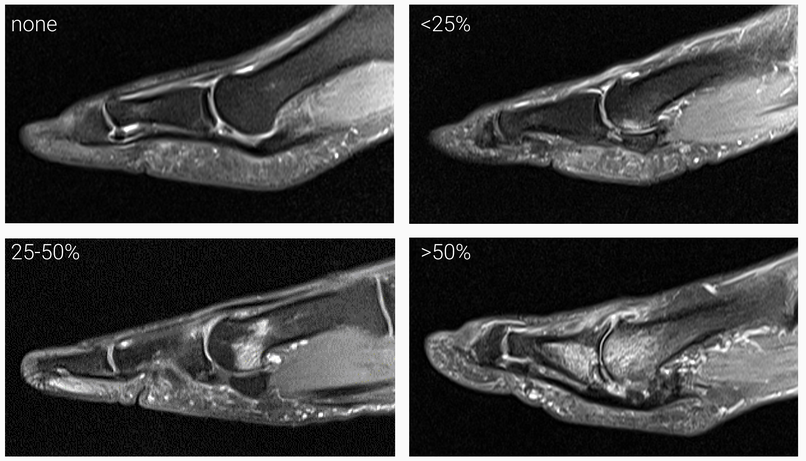

Figure. Atlas images for bone marrow lesions of the first metatarsal.

Results

Intra- and inter-tester reliability results are shown in the table. Intra-tester κ_w scores ranged from 0.42 to 0.98 and inter-tester κ_w scores ranged from 0.13 to 0.91. Of the 15 features documented with the atlas, 14 (93%) demonstrated acceptable reliability. Only plantar capsular thickening did not reach the reliability threshold, with an inter-tester κ_w of 0.13.

The intra-tester ICCs for the combined scores were 0.94 (0.89 – 0.97) for tester 1 and 0.93 (0.86 – 0.97) for tester 2. After excluding plantar capsular thickening, these scores were 0.94 (0.88 – 0.97) and 0.94 (0.87 – 0.97), respectively. Inter-tester ICC for the combined score was 0.89 (95% CI 0.78 – 0.95), and after excluding plantar capsular thickening, the ICC was 0.90 (95% CI 0.80 – 0.95).

Table. Intra-tester and inter-tester reliability of 1st MTPJ OA MRI atlas (Gwet's AC1 weighted kappa).

Variable	Intra-tester 1	Intra-tester 2	Inter-tester
Osteophytes, dorsal metatarsal head[1]	0.81 (0.65 – 0.97)	0.88 (0.74 – 1.00)	0.72 (0.53 – 0.91)
Osteophytes, plantar metatarsal head[1]	0.84 (0.72 – 0.97)	0.94 (0.88 – 0.99)	0.81 (0.68 – 0.94)
Osteophytes, dorsal proximal phalanx[1]	0.85 (0.73 – 0.96)	0.81 (0.69 – 0.93)	0.54 (0.24 – 0.84)
Joint space narrowing, 1st MTPJ[1]	0.95 (0.90 – 0.99)	0.91 (0.85 – 0.96)	0.88 (0.82 – 0.94)
Joint space narrowing, 1st metatarsal-sesamoid[2]	0.73 (0.48 – 0.99)	0.61 (0.30 – 0.91)	0.60 (0.30 – 0.91)
Bone marrow lesions, metatarsal[3]	0.94 (0.89 – 0.99)	0.80 (0.68 – 0.92)	0.87 (0.80 – 0.94)
Bone marrow lesions, proximal phalanx[3]	0.98 (0.95 – 1.00)	0.86 (0.74 – 0.98)	0.87 (0.76 – 0.98)
Bone marrow lesions, sesamoids[2]	0.82 (0.60 – 1.00)	0.38 (0.01 – 0.74)	0.40 (0.03 – 0.77)
Cysts, metatarsal[2]	0.88 (0.69 – 1.00)	0.81 (0.58 – 1.00)	0.81 (0.58 – 1.00)
Cysts, proximal phalanx[2]	0.91 (0.78 – 1.00)	0.91 (0.77 – 1.00)	0.91 (0.78 – 1.00)
Effusion – dorsal[2]	0.90 (0.76 – 1.00)	0.87 (0.72 – 1.00)	0.76 (0.53 – 0.99)
Effusion – plantar[2]	0.94 (0.83 – 1.00)	0.69 (0.43 – 0.95)	0.67 (0.39 – 0.95)
Thickening – dorsal[2]	0.67 (0.39 – 0.95)	0.63 (0.33 – 0.93)	0.40 (0.05 – 0.75)
Thickening – plantar[2]	0.73 (0.48 – 0.99)	0.42 (0.06 – 0.77)	0.13 (-0.24 – 0.51)
Cartilage loss[2]	0.73 (0.47 – 1.00)	0.88 (0.74 – 1.00)	0.60 (0.29 – 0.91)

[1] scored as none, mild, moderate or severe, [2] scored as present or absent, [3] scored as none, <25%, 25-50%, >50%.

Conclusion

With the exception of plantar capsular thickening, MRI features of 1st MTPJ OA can be reliably documented using our standardised atlas. The use of this atlas will assist in documenting the severity of 1st MTPJ OA for epidemiological studies and for evaluating the effects of treatment in clinical trials.