



FORTH
INSTITUTE OF COMPUTER SCIENCE
COMPUTATIONAL BIOMEDICINE LABORATORY

Artificial Intelligence



MRI-based applications on Musculoskeletal Disease

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Disclosures

- Board Member



EuSoMI

- Trainee Editorial Board Member





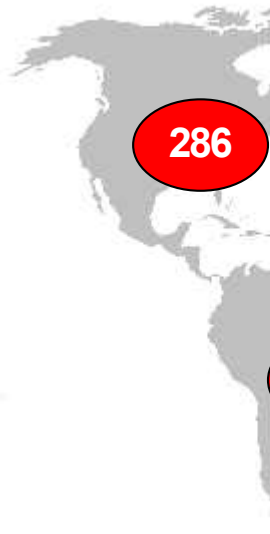
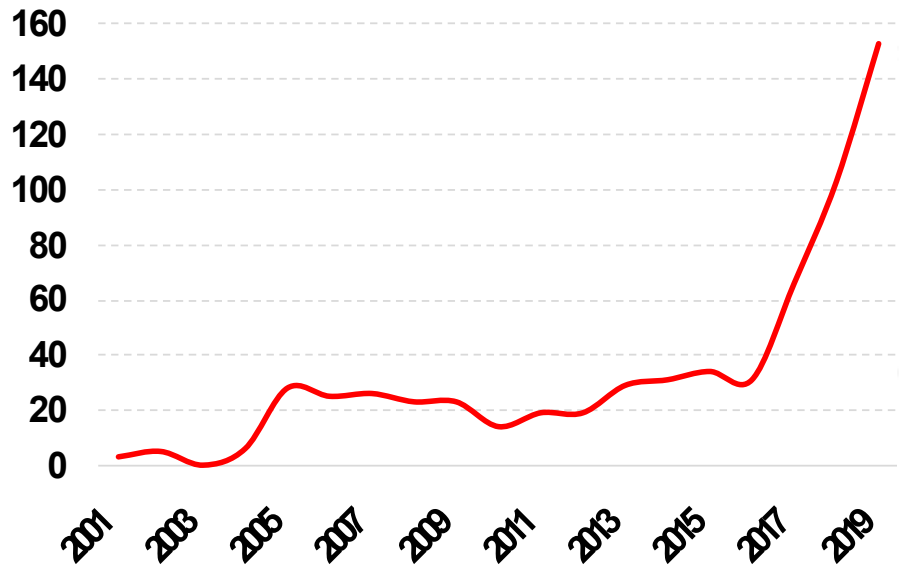
Lecture outline

- AI basics for radiologists
- Applications on MSK imaging with the use of MRI
- Conclusions



AI in MSK imaging: publication frenzy

AI publications on MSK imaging



NIH National Library of Medicine
National Center for Biotechnology Information

PubMed.gov

("artificial intelligence")
Advanced Create alert

Save Email

MY NCBI FILTERS

RESULTS BY YEAR

2,064 results

Editorial for Based Upon
1
Cite Ellmann S, Bäuer
J Magn Reson Im
Share PMID: 34936152

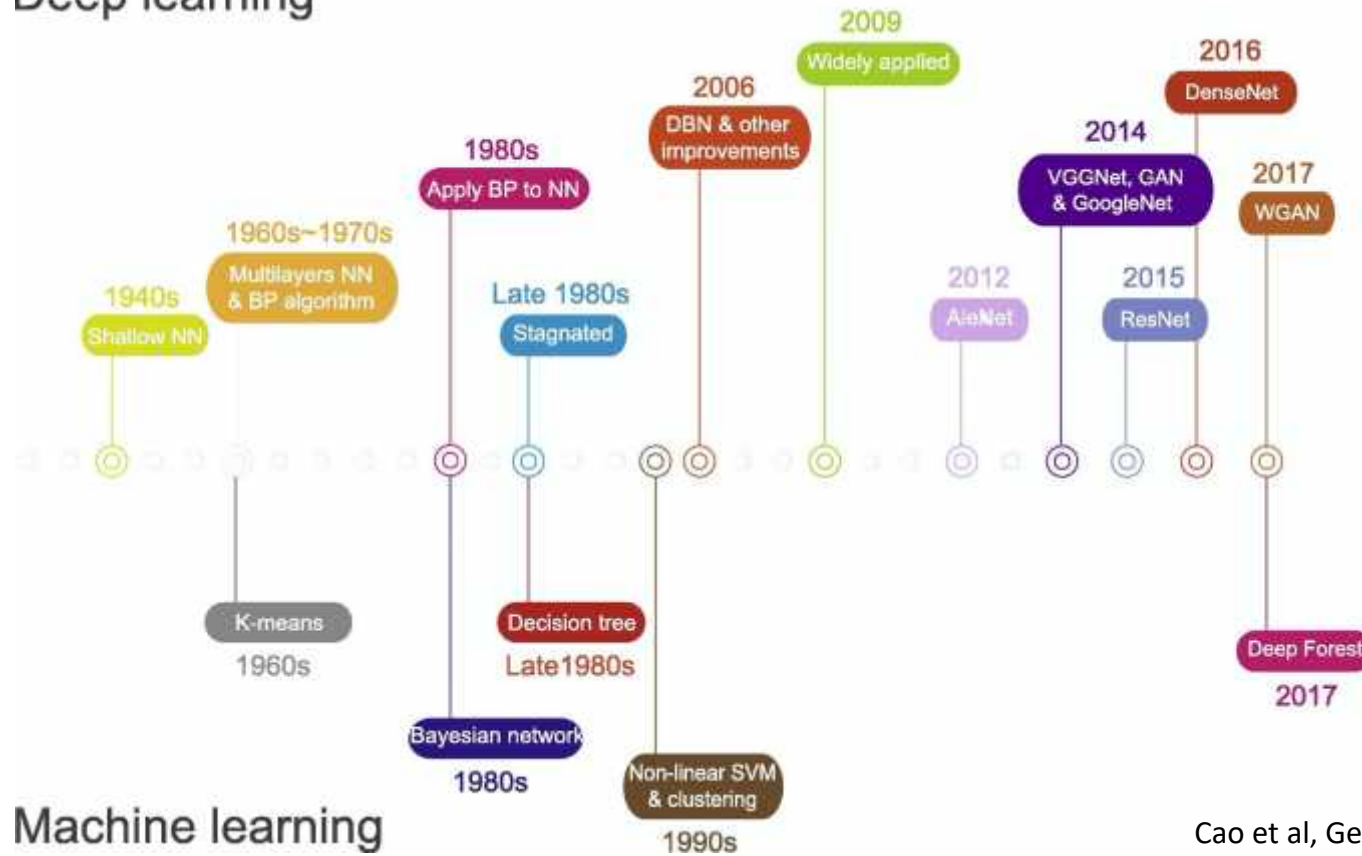
Deep Learning
2
Contract Fok

20



Is AI new?

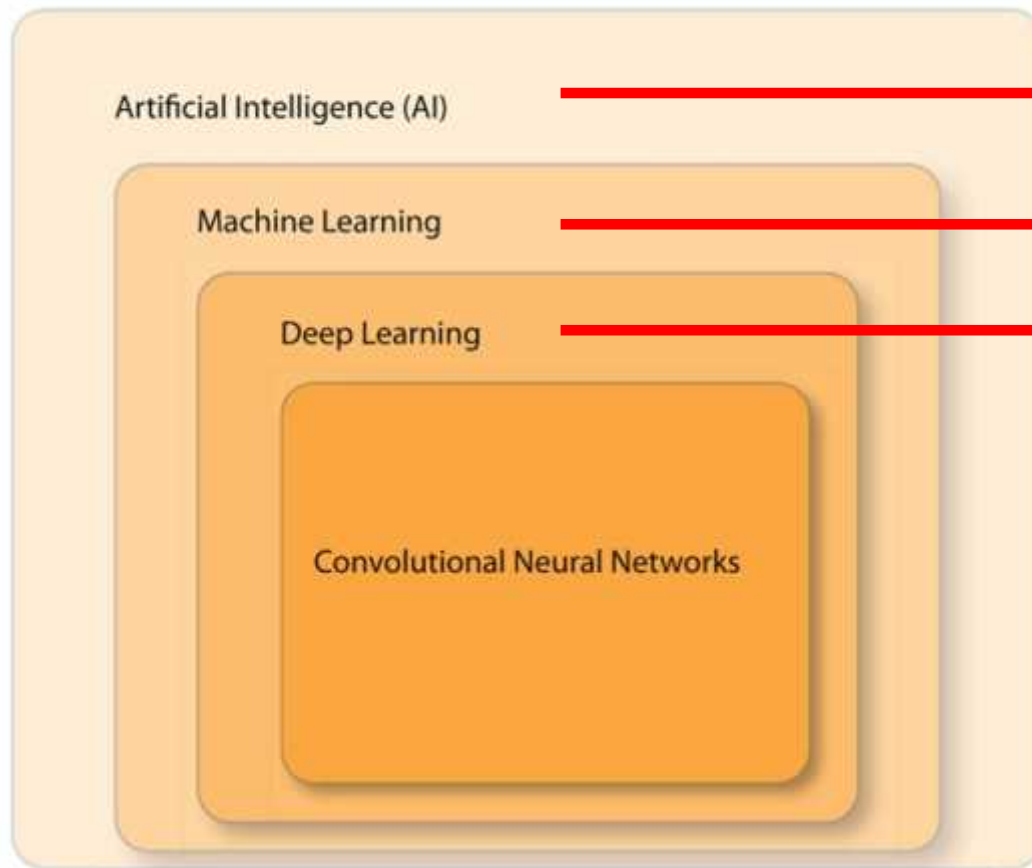
Deep learning



Cao et al, Genomics Proteomics Bioinformatics 2018



Nomenclature



Any technique that enables computers to imitate humans

Computers "learn" without being programmed
Arthur Samuel 1959

Subset of machine learning studying neural networks



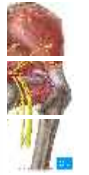
Chea & Mandell, Skeletal Radiol 2020

Image acquisition - Preparation

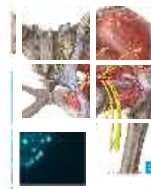


- 1 Prioritisation
- 2 Protocol selection
- 3 Artifact reduction
- 4 Quality enhancement

AI in MSK Radiology



**Model
input types**



Let's dance with radiomics



Machine Learning

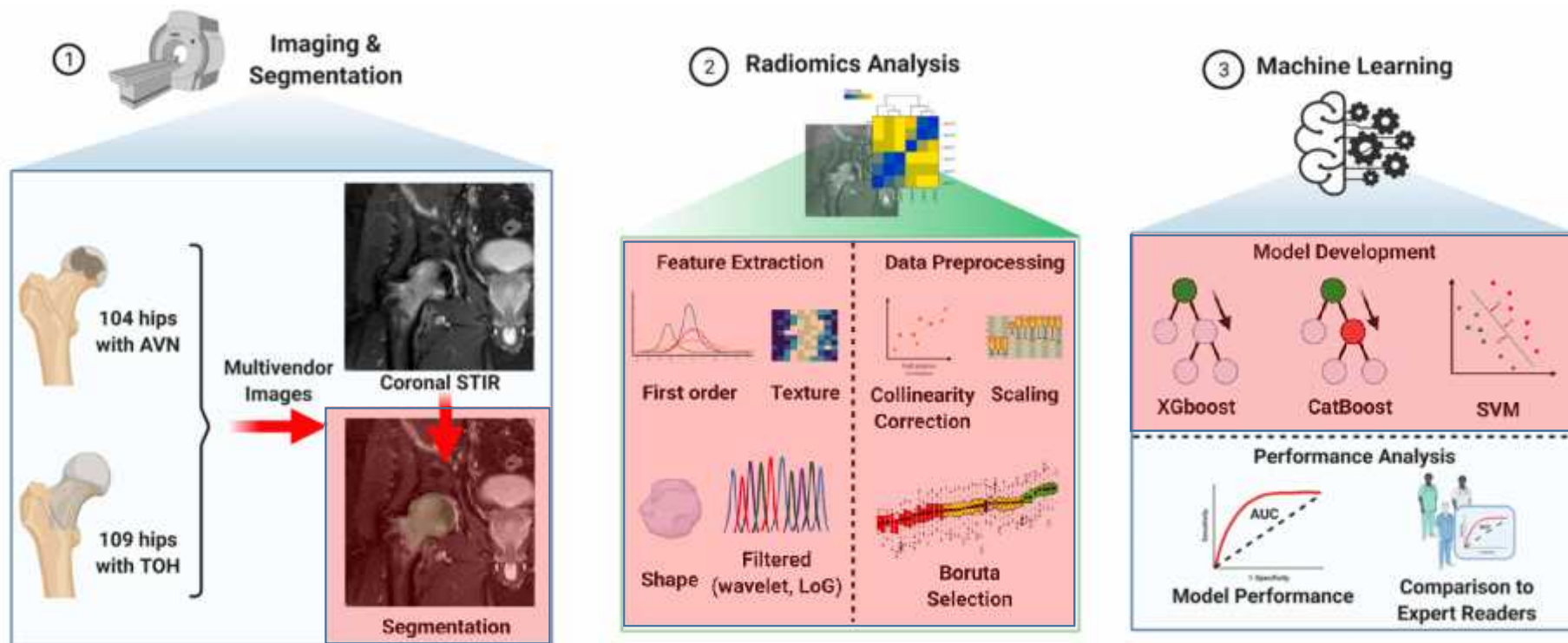


Radiomics





AI for radiomics data



Klontzas M, ..., Karantanas AH, Diagnostics 2021; 11(9), 1686

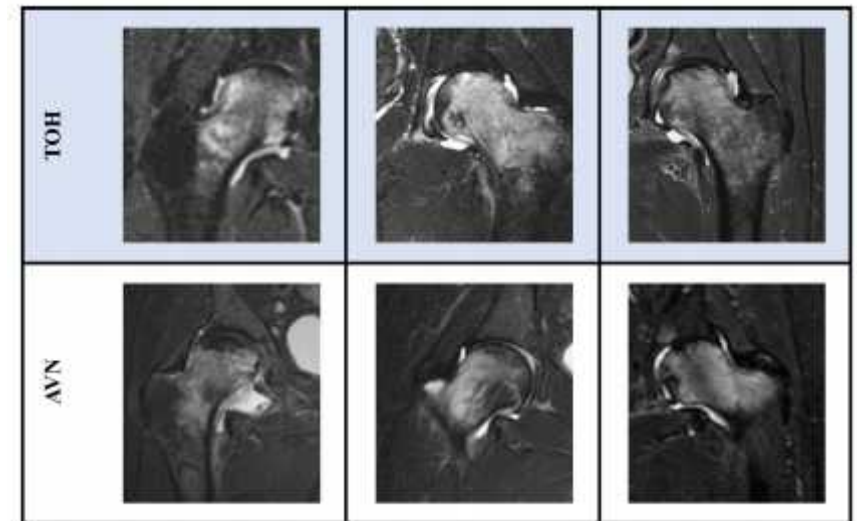


Conservative or surgical treatment?

Non-reversible, surgery?

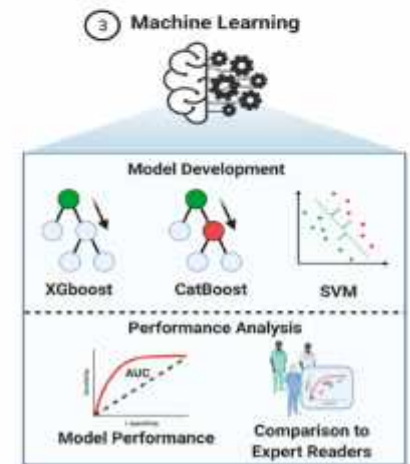
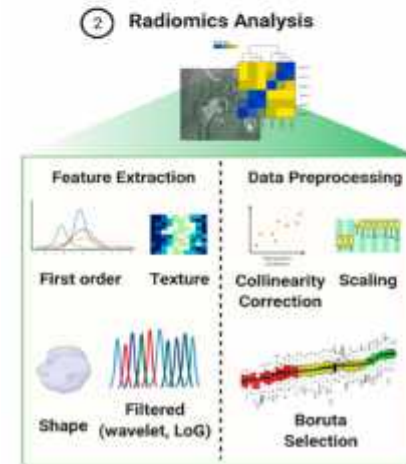
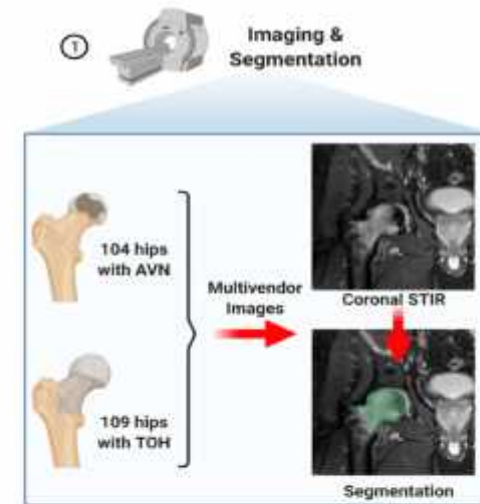
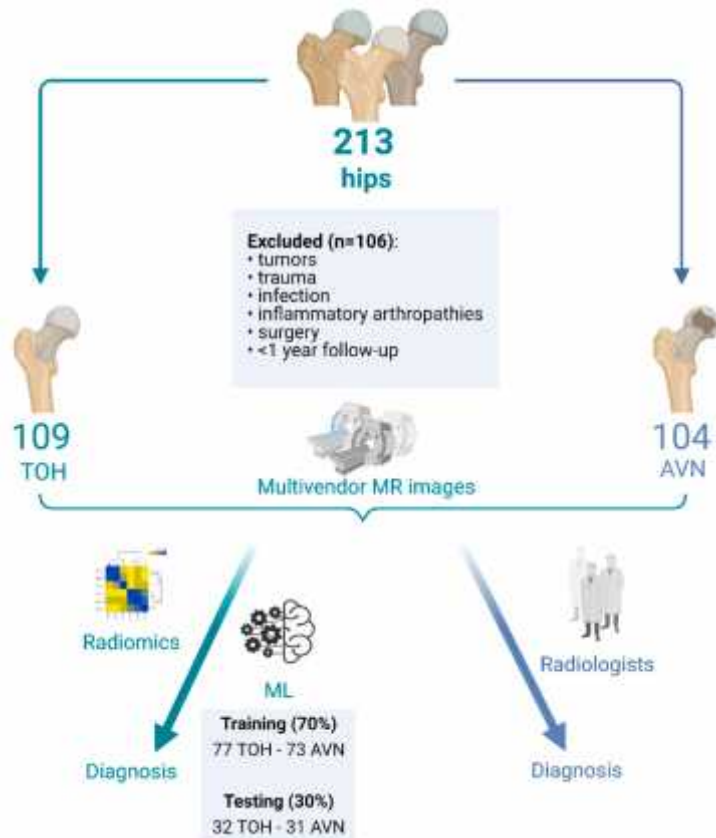
- Avascular necrosis of the hip
- Transient osteoporosis

Reversible, conservative?



Klontzas M, ..., Karantanas AH, Diagnostics 2021; 11(9), 1686

TOH vs AVN

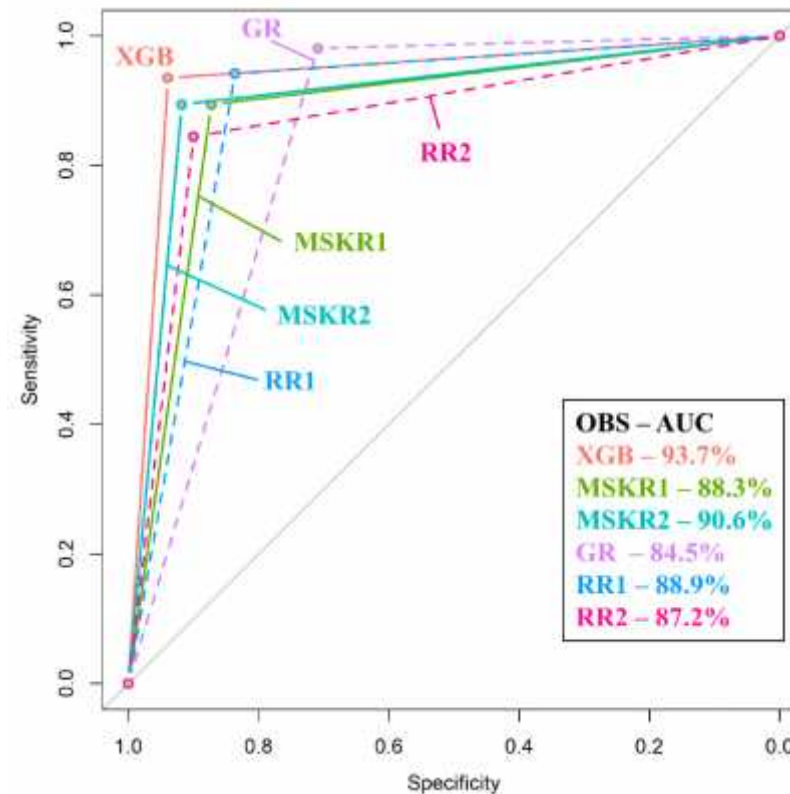


Klontzas M, ..., Karantanas AH, Diagnostics 2021; 11(9), 1686



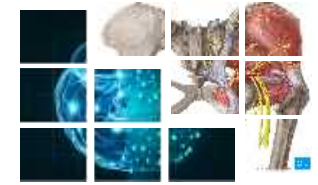
TOH vs AVN

- **MSK radiologists**
 - AUC of 90.6% (86.7% to 94.5%) and 88.3% (84% to 92.7%)
- **General radiologist**
 - AUC 84.5% (80% to 89%)
 - <XGboost (p = 0.017)
- **Rad residents (MSK oriented)**
 - Similar to MSK rad



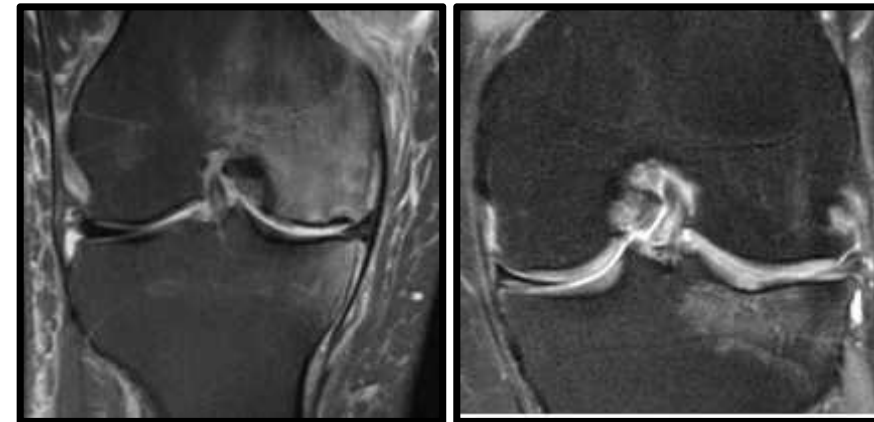
Klontzas M, ..., Karantanas AH, Diagnostics 2021; 11(9), 1686

To reverse or not to reverse?



Advanced OA of the knee – non reversible = total knee replacement
Subchondral Insufficiency Fracture (SIF) – reversible

- Both bone marrow edema
- Expertise is required



- Can AI differentiate between the two?



To reverse or not to reverse?

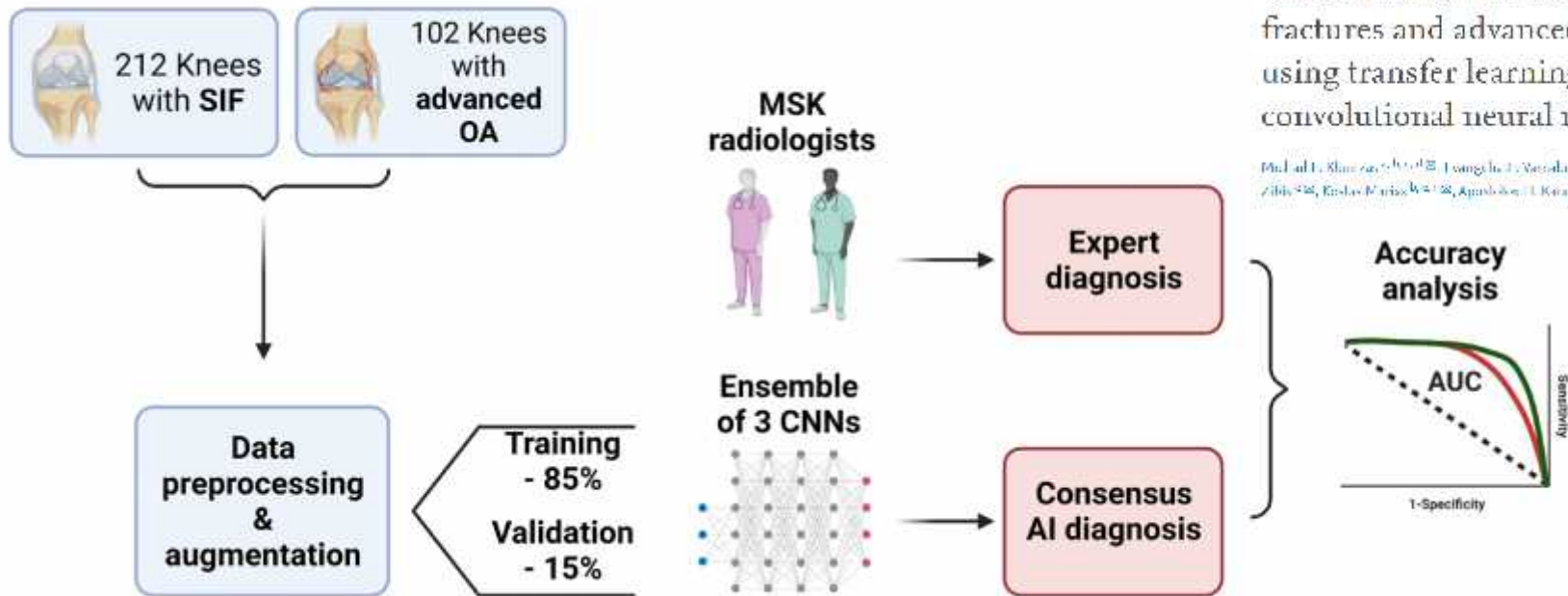


Injury
Available online 6 March 2022
In Press, Corrected Proof



Differentiation between subchondral insufficiency fractures and advanced osteoarthritis of the knee using transfer learning and an ensemble of convolutional neural networks

Mohammed Alsharif^{1,2,3*}, Li Wang^{1,2,3}, Yueshan Li^{1,2,3}, George A. Baker^{1,2,3}, Ravulakrishna Suresh^{1,2,3}, Anandha Zilber^{1,2,3}, Krishna Murthy^{1,2,3}, Ajaykumar L. Kulkarni^{1,2,3,4}





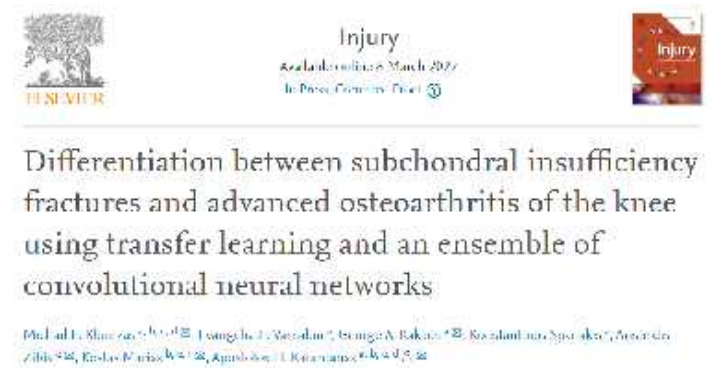
To reverse or not to reverse?

InceptionV3 AUC 93.68%

Inception-ResNet-V2 AUC 92.53%

VGG-16 AUC 82.18%

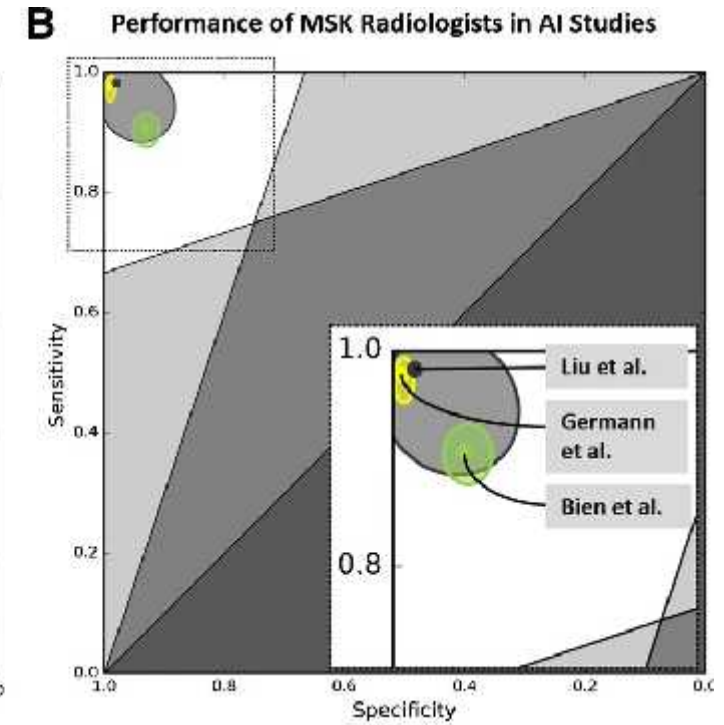
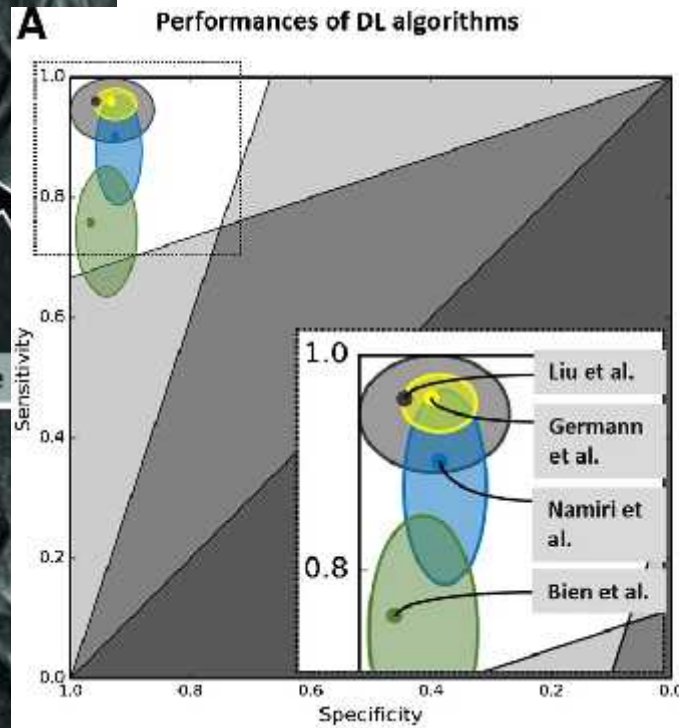
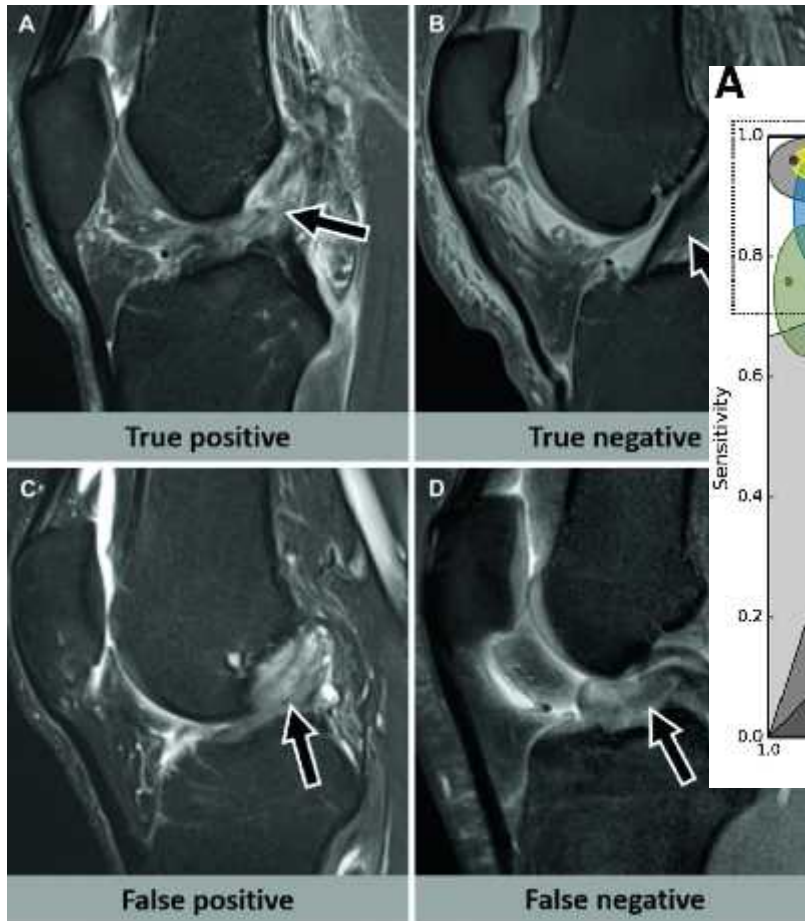
CNN ensemble AUC 95.97%



Compared to two experienced MSK radiologists

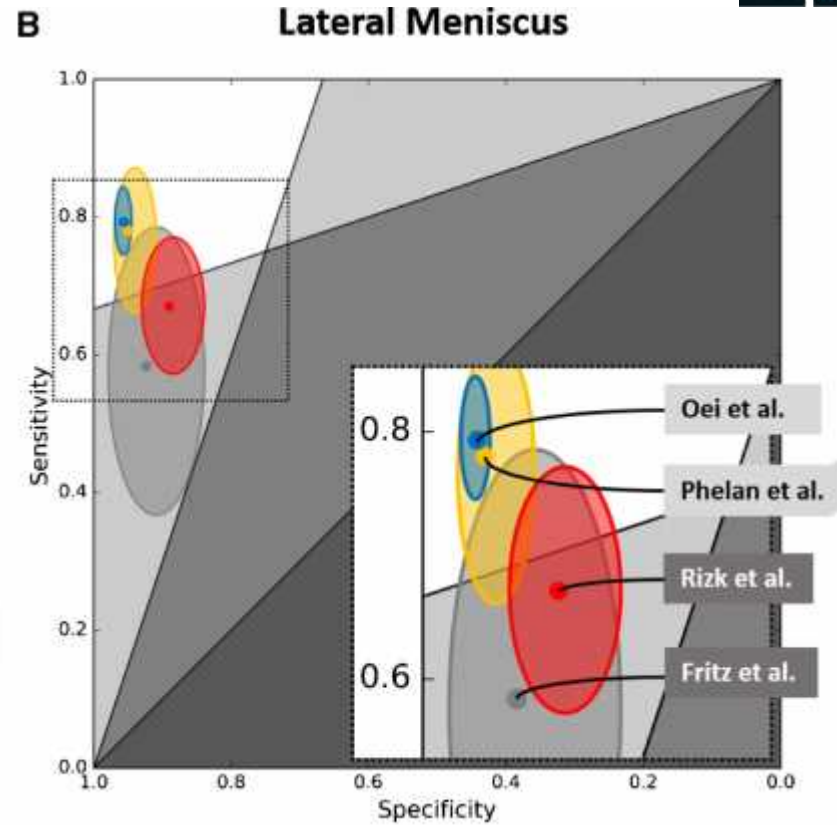
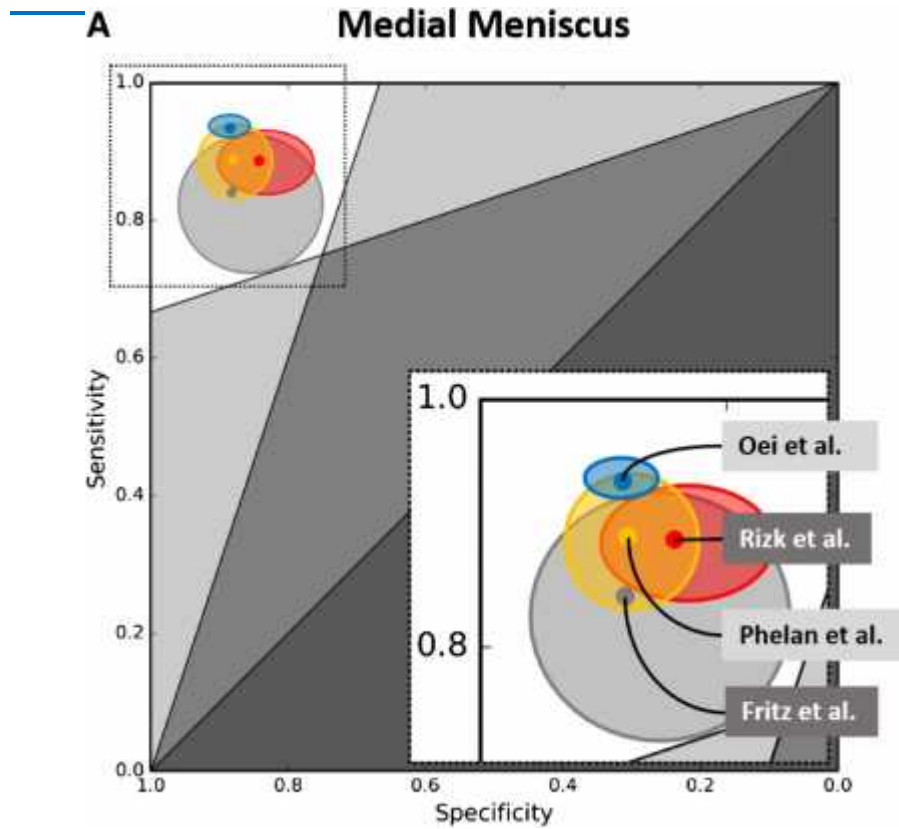
- **Ensemble vs MSKrad-1 (AUC 91.95%, P>0.05)**
- **Ensemble vs MSKrad-2 (AUC 82.76%, P<0.001)**

ACL tears



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Meniscal tears

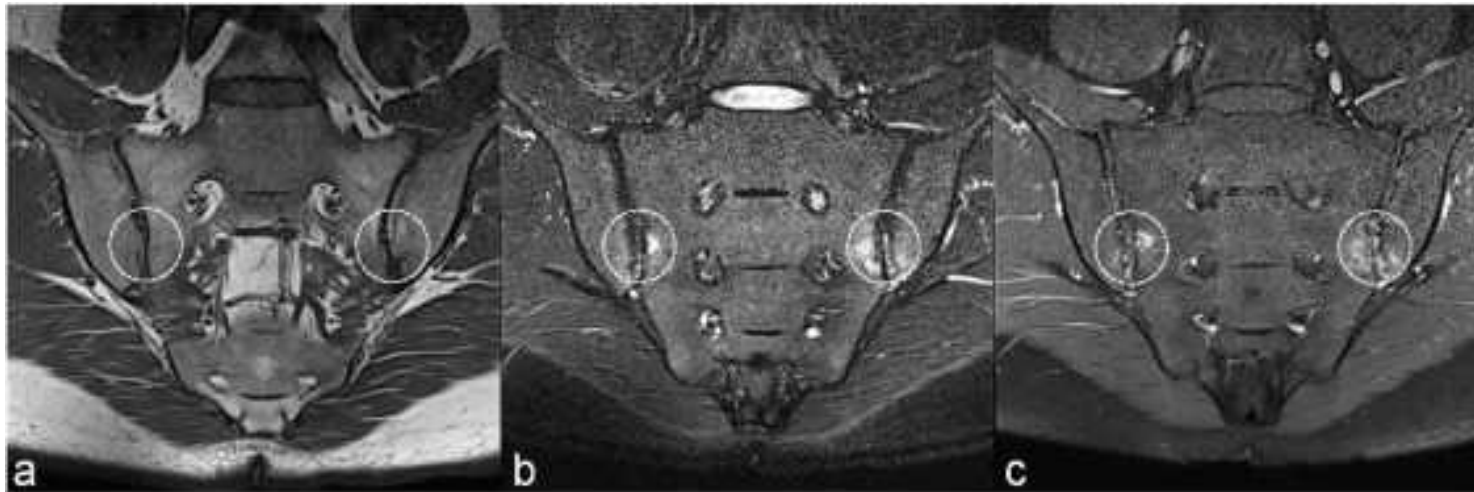


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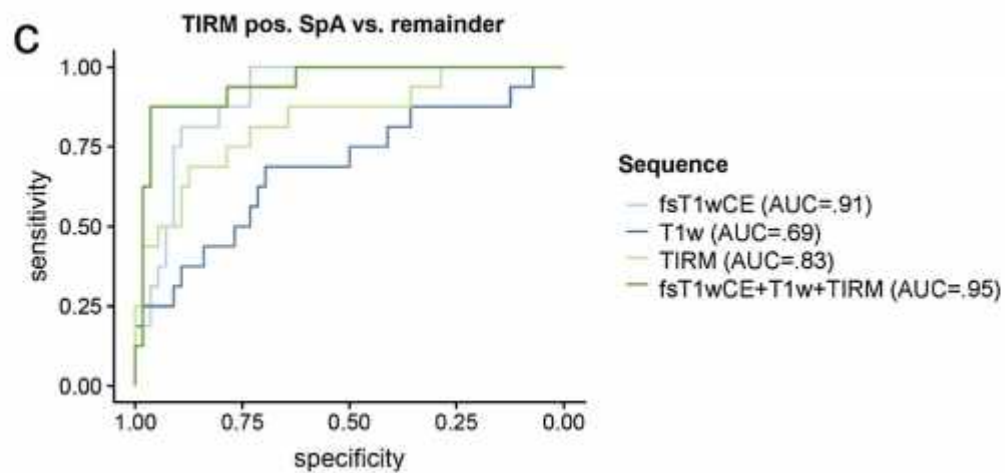
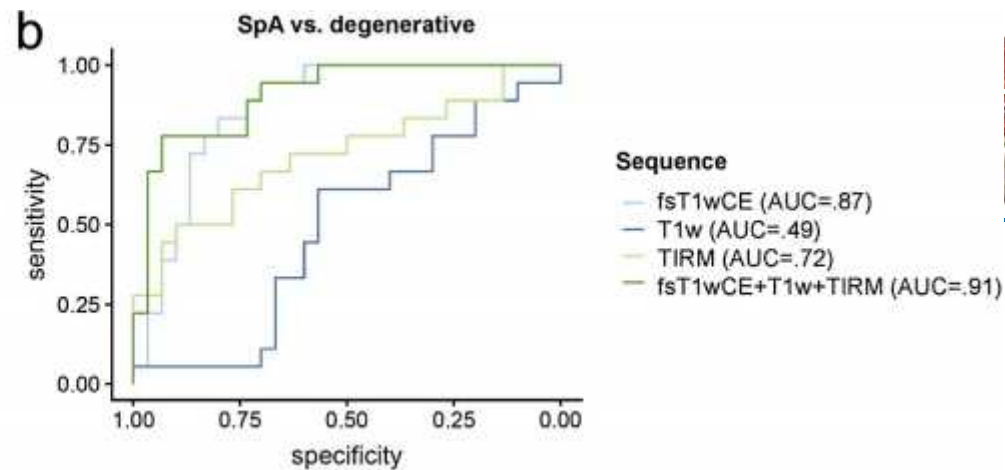
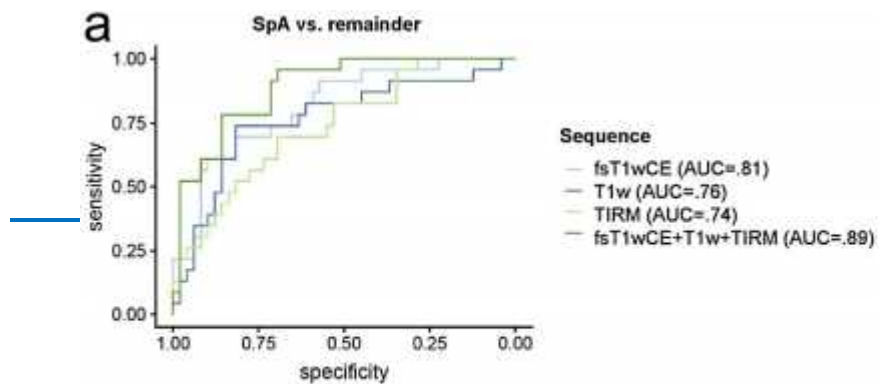


Ankylosing spondylitis or degeneration?

- Texture analysis – machine learning
- Degenerative vs inflammatory vs no changes



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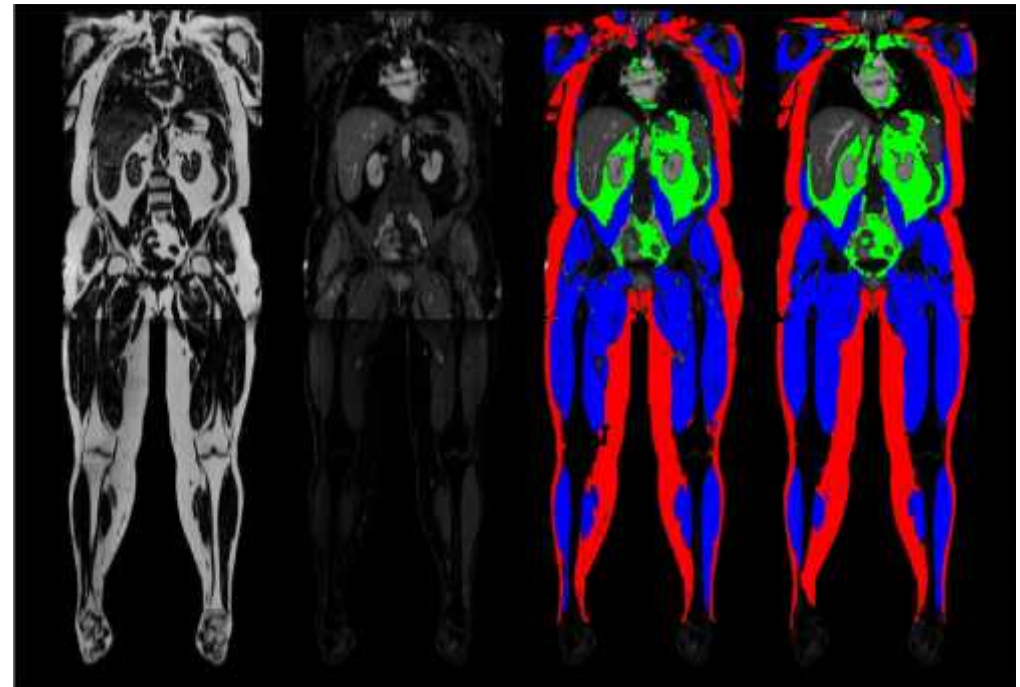


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Body composition analysis

- Fat & muscle segmentation
- Sarcopenia assessment
- 3D U-Net architectures
- Automated whole body muscle & fat quantification



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Miscellaneous applications

- Machine learning has been used to automate everyday tasks in MSK imaging
 - **Necessity of IV contrast enhancement** in MRI protocols
 - **Reconstructing high quality images** from fast acquisition protocols
 - Prediction of follow-up **no-shows**

Trivedi et al. J Digit Imaging 2018

Hammernik et al. Magn Reson Med 2018

Harvey et al. J Am Coll Radiol 2017



Lecture outline

- Background – the advent of AI ✓
- AI basics for radiologists ✓
- Applications on MSK imaging ✓

Thank you!!!

