ESSR Blog: Artificial Intelligence – the musculoskeletal radiologist’s avatar?

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Key-messages

- Computer-assisted diagnosis (CAD) has been used in musculoskeletal imaging since 1963 with DXA to be regarded the most important application for computer-assisted quantitative imaging.
- Machine learning as part of artificial intelligence (AI) is an important technological driving force causing changes rapid, but not abrupt changes in MSK imaging research.
- The way, in which AI will influence the future of MSK imaging depends on its integration in the radiological workflow with eventually a meaningful, actionable and timely available report.

A patient is referred by his orthopaedic surgeon for radiography of his hips and the radiologist reports osteoarthritis. The referring physician, however, knows this already, he just needs the image for planning endoprosthetic surgery with a fully automated digital templating software, which is usually not done by radiologists. This example illustrates that computer-aided image analysis and decision support is shaking the foundations of musculoskeletal (MSK) imaging. This process of “intelligent” self-directed positioning of the templet of a prosthesis, however, did not start abruptly but was a stepwise development since orthopaedic surgeons could not draw any more their surgical sketches with paper and pencil on roentgen films.

Artificial intelligence (AI) is currently a strong technological driving force. MSK imaging is – besides cardiovascular radiology – more prone to it than other subdisciplines because of the broader spectrum of applications, a longer research tradition and the high complexity of MSK diseases. In 1963, a software for the pattern analysis of osteolytic bone lesions was perhaps the first application of computer-assisted diagnosis (CAD) [1]. With the next advance, quantitative computed tomography (qCT) and later Dual-energy-X-ray-Absorptiometry (DXA), the x-ray image was in part replaced by the T- and the Z-score and other quantitative parameters of bone density, architecture and body composition. High-resolution peripheral quantitative computed tomography (HRpqCT) and micro-CT, are used for an even more detailed automated analysis of bone structure in the form of a “virtual biopsy”. With new so-called machine learning (ML), several other computer-assisted techniques may be brought into clinical practice, namely biochemical imaging, vertebral and other fracture assessment, quantification of synovitis, and skeletal age assessment [2].

Deep learning is a form of machine learning and, with its potential to develop rapid and scalable systems, is very useful for radiological applications. It is in fact not learning, just a training on predefined data sets and is far away from a real learning process with educational impact. In its traditional form, like artificial neural networks (ANN), the machine is trained to analyse features and patterns from training sets. With deep learning, most often with convolutional neural networks (CNNs), unsupervised learning without cumbersome training on training sets is possible [4]. In such a way new applications can be programmed with much higher speed. Nevertheless, the quality of ML always depends on the ground truth, i. e. well-annotated large sets of data provided for the continuous learning process. If they are incomplete, erroneous or misleading, it will become difficult to interpret subtle differences between disease states or other observations [3]. Google, Facebook, Dr. Watson and a couple of medical start-ups are assembling big data collections for that purpose.

In which way AI will influence the future of MSK imaging depends on how these techniques will be integrated in the radiological workflow and eventually result in a meaningful, actionable and timely available report. Despite deep learning systems can match or even surpass the human's decision, errorless CAD does not exist, so they need approval in the form of a signed report. An important issue is how the communication paths will be designed, especially the alerting of urgent or other relevant findings. AI systems which directly alert the clinician about a fracture or a joint instability by bypassing the radiologist will cause turf battles among the involved disciplines.

AI should be regarded rather as a technical add-on like a new MR sequence and not as the radiologist's avatar. At least in the near and middle future, it will replace the radiologist's job description and not himself, whose atout is his ability of diagnostic reasoning. Radiologists will not dictate or write but edit the digitally designed draft report. This has already been realized with DXA report generators and with advanced voice recognition dictation system [5, 6]. Such way of reporting leads to a reduction of variability, amelioration of errors and improvement of clarity [7]. Multimedia reports, as already recommended in new guidelines, contain a graphic display of the abnormalities, disease classifications, risk estimates and trending [8, 9]. In this way, AI will support us in overcoming the documentation burden and providing more personalized medicine. Recent trends show that the report content will be designed according to clinical needs, which means that from the full report in some situations the urgent information will be sent as Twitter-like short message, complex information in graphical form, and explanations for patients as transcription in simple language.

Another increasing demand on the radiologic service is quantitative imaging and the continuous adoption of new knowledge. Roentgen signs will be replaced by clearly defined imaging biomarkers. In musculoskeletal imaging, only joint space narrowing and the slowing of progression of arthritis as surrogate imaging biomarker has been accepted by the U. S: Food and Drug Administration (FDA) and the European Medicines Agency (EMA). Another biomarker is the finding of osteoporotic fractures which has been approved by the FDA. Machine learning offers the great chance to stimulate the cumbersome research of defining more biomarkers as surrogates of bone and joint diseases.

In conclusion, the demands on MSK radiology will constantly increase with a higher number of investigations, more complex protocols and a more detailed quantification of findings. The reporting radiologist will not be able to oversee all recent advances that have to be included in his or her report and the necessary academic work, research and education, will become so time-consuming and expensive that we will reach the limits of our resources. Gustav Mahler, the composer and conductor, mentioned that tradition is sloppiness. We should reflect our traditions and working habits. Under these circumstances, AI is our chance to bring more relevant knowledge efficiently to the point-of-care and to provide a profound error-management with cross-checks to other healthcare documents and data sets. Diagnostic reasoning is defined as a combination of systematic analysis and intuition which, by following Albert Einstein, is driven by “Learning is experience. Everything else is just information.” The thorough understanding of disease processes cannot be replaced by computers, but the border between systematic, computer-assisted analysis and intuition will move from the latter to a more structured reasoning. With such an efficient and effective handling of the huge and steadily growing amount of information, the quality of our work will improve enormously. If AI is integrated in the diagnostic and communication process by following the ground-rules of clinical reasoning, MSK radiology can face a bright future.

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