Twenty years ago, when Dicom had not gained global recognition as a medical image standard, each radiology machine vendor used their own proprietary flavour of image format to store and display their images. Thus we had a number of proprietary display workstations – CT workstation, MR workstation, CR workstation, NM workstation etc. The vendors then bolted on some extra storage to these workstations, resulting in a CT miniPACS, CR miniPACS, MR miniPACS etc (figure 1). Perhaps vendors thought this was a good commercial strategy of encouraging customers to buy all their machines from the same supplier. Intelligent customers wanted the best of breed when it came to machines, resulting in a fragmented digital images record lying in multiple MiniPACS systems. Thus despite creating digital images, customers continued to print images to film (figure 2) as this was the only way of getting an integrated radiology record from multi-vendor machines.

Then along came Dicom – an open standard – standardising medical images produced in any vendor’s machine, to be stored and displayed in any vendor’s PACS system. Machine vendors soon realised that unless they adopt Dicom as the medical image format, they would soon lose a significant market share as educated customers insisted on Dicom send and Dicom Modality worklist capabilities from a machine vendor. This was the revolution in the medical world of digital imaging, and we see the ubiquitous adoption of PACS globally today. This resulted in all digital images produced in multiple vendors machines to be stored and displayed together – popularly called PACS. Most hospitals were able to move to becoming filmless with adoption of PACS.

In 2002, England embarked on the ambitious National Programme of IT-NPFIT, with nationally procured IT systems. The aim was to digitise the NHS requiring all existing NHS IT systems to be replaced. It was a rip and replace strategy from Connecting for Health – CHF (responsible for delivering NPFIT). By about 2005, as the NPFT was making little headway for a complete electronic patient record, their attention turned to radiology PACS (which had already established itself as an off-the-shelf deliverable product, due to vendor neutral standard of Dicom). CHF saw PACS as a quick win to save their reputation by delivering something fairly easily to NHS hospitals. What was different about PACS was that it was not a rip and replace strategy, due to the existing standard of Dicom, it was a connect-all strategy. We could retain our CT, MRI, US machines, etc and just make them Dicom compliant (for old machines Dicom adaptors were available) and connect to an off-the-shelf PACS (figure 3).

The National Programme for IT had made the following assumptions:

1. Assumption 1 – Central contracts would bring about economies of scale and thus lower the cost of IT systems bought by the NHS as a whole. In the years that followed, this assumption proved to be wrong, as many organisations later realised that the cost of PACS was more expensive through central procurement, than if they had bought it themselves as central procurement had removed the competitive market that was key to driving down costs. However, trusts had little choice in the matter at the time due to the political drive of NPFIT.

2. Assumption 2 – Another wrong assumption by CHF was that NHS hospitals did not share patient information with other hospitals. At the core of the design of CHF/NPFIT PACS were the central data stores. It was assumed that if images were stored in a central store, then a clinician reviewing a patient’s images would have access to the entire patient image record, irrespective of which hospital it was acquired. Thus all NHS hospitals would be forced to share patients images in a patient centric manner. NHS and CHF came in for a shock when they realised that the central data stores were unable to store data in a patient centric manner due to poor specification of unique ID for the patient in the PACS systems. Thus millions of pounds spent on central stores did not actually provide any additional benefit. In hindsight there would be more benefit if the data was stored locally in hospitals.

Both assumptions of cost benefit and sharing benefit through central PACS contracts through CHF proved to be wrong as time went on. It is part of the business of NHS hospitals to share images with neighbouring hospitals for clinical purposes; for neuro-surgical patients, centralisation of cancer services requires a number of patients to have shared care between DGH and cancer centres. Previously films were sent via taxis. NHS hospitals once again turned their attention to Dicom, as the vendor neutral interoperability standard. It was possible to create direct Dicom push links between hospitals with different PACS systems (figure 4). This allowed for images to be shared electronically between hospitals within minutes of a request being made.

As CHF was getting a bad reputation for inability to share images through their expensive central data stores, they invested in a intermediary Dicom router called Image Exchange Protocol-IEP for a hub and spoke mechanism for sharing images between NHS hospitals. The IEP was based on the global Dicom standard and created a mechanism for every NHS hospital to create a single connection with IEP. With all NHS hospitals connected to IEP, it would simply route images using standard Dicom to the destination hospital. As this used Dicom standards for transfer, it was technically easy to establish and soon became the most commonly used methodology for NHS trusts to send images from one trust to another (figure 5).

What this has clearly demonstrated over the years is that to enable image sharing, just having images stored in a single physical location on computer discs (like the CDS of CHF) is not sufficient – specification, understanding and insisting on global standards is key. Just having financial clout (which is what CHF had in those days) does not necessarily make things happen. The knowledge, understanding and power of global standards are hugely important.
So this is where we are today. All NHS trusts in England have a PACS for radiology images and are filmless. They share images largely through IEP. Central data stores are on their way out. There are plans to bring back storage locally into the trusts.

However, I do not think we have got to where we need to be. Radiology images and PACS are creating a radiology data silo within each hospital. They are separate from the patient’s clinical record, which is held in the patient’s paper notes today. It is important that radiology images become part of a patient’s electronic clinical record. This is where adoption of another standard called XDS comes in – Cross Enterprise Document Sharing. PACS systems in future must be able to index to an XDS registry, so that when a doctor is reviewing a patient’s blood results or referral letter he/she is able to see radiology images alongside other clinical information (figures 6 and 7). For this to happen it needs educated customers in NHS to insist on the PACS replacement projects to have XDS-I complaint PACS. Most major PACS vendors already support XDS-I, but we all know that customers only get what they ask for.

The next step is about access to patient information beyond organisation boundaries. Push mechanisms like Dicom push works well IF you are aware that scans exist in another hospital. How does a radiologist get to know about previous relevant scans done in another hospital? Another global standard appearing in the horizon is XCA – Cross Community Access (figures 8 and 9). This is prior knowledge of patient centric information in a secure way across organisational boundaries. This standard also enables the concept of a patient portal (figure 10) with a patient having access to information about him/her held in multiple organisations and GP surgeries.

Over the last few years what has been achieved is an integrated digital radiology image record with the adoption of Dicom. Through use of Dicom and IEP we are also able to share images between NHS hospitals. However, adoption of the XDS standard is important to make radiology images become part of an Electronic Patient Record (figure 11). XCA Standard is the future of patient centric health information sharing beyond organisational boundaries (figure 12).