



RPI – RADIOGRAPHY

A brief history of tomography and CT

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Introduction

Today, in 1995, we live at a time when medical imaging is well established and encompasses many different modalities, each capable of giving unique anatomical and/or functional information. Several of these modalities, including magnetic resonance imaging, nuclear medicine, ultrasound and x-radiology can generate tomographic data in three-dimensions. Medical imaging has found a role in most branches of diagnostic medicine and is also the provider of images which form the basis of three-dimensional radiation therapy. It is hard to believe that, not more than forty years ago, planar x-radiographs were just about all the diagnostic radiologist had to rely on.

Almost as soon as the x-ray was discovered it was realised that planar radiographs, being two-dimensional projections of three-dimensional structures, showed the organs and structures of interest shadowed by over- and under-lying structure, thus reducing their diagnostic efficacy. Classical tomography was an attempt to overcome this difficulty and was first suggested as early as 1914. The first part of this review paints a brief picture of the development of classical tomography.

The first practical, clinical, routine computed tomography (CT) was unveiled in 1971 and rapidly became established. CT has been described as the greatest diagnostic discovery since x-rays themselves in 1895. The story of CT follows, together with a consideration of historical antecedents.

In this brief review I have tried to include as much pictorial information as possible keeping the text to a minimum. A very detailed account, together with a vast bibliography, may be found in my book: "From the Watching of Shadows: The Origins of Radiological Tomography" (1990 : Bristol, UK : IOP Publishing ISBN 0-85274-305-X)

Classical tomography

The early days of tomography are characterised by a phenomenon which in today's climate of international scientific communication and electronic information transfer would be quite impossible. At least ten people independently invented tomography over the period 1921 to 1934 with absolutely no idea that the others were working towards the same goals. When they did find out about each other's work, the sparks flew as they vied for acclaim. Thereafter there was more international awareness but the second World War still led to a lack of cooperation and communication. In particular, work in the Far East was unknown in the West and presumably vice-versa.

A Frenchman Andre Edmond Marie Bocage patented the concepts of tomography in 1921. These described how by simultaneously moving the x-ray source and detector in a synchronised motion, a blurred tomogram resulted. He never built equipment but the Dutchman Bernard Zeidses des Plantes did, writing up the work in a doctoral thesis in 1934 and some papers a year or two earlier. He had also begun his work in 1921. Zeidses des Plantes, born in 1902, lived until 1993 and provided personal comment to me on these early developments when I prepared my book of the history.

Two other Frenchman, Felix Portes and Maurice Chausse also patented tomography in 1921 and made workshop drawings of how to implement it. A German engineer Ernst Pohl patented apparatus in 1927. The French Canadian Bartelink patented in 1931 and the German Gustave Grossmann patented in 1934. Grossmann built the first commercial equipment via his company Siemens-Reiniger-Veifa GmbH and the "Grossmann tomograph" became the most widely-used, if expensive, equipment in the late 1930's. A surviving example is in the London Science Museum. Meanwhile, in Italy, Alessandro Vallebona published the tomography concept in 1931 and built apparatus.

The principles of operation of all these devices, those proposed and those constructed, was essentially the same although there were important distinguishing features concerning the orbits of motion, speed of motion etc. It is interesting to note that none of these pioneers would have called himself (and they were all men) a physicist. The first Tomography was performed in the US in 1937 by Robert Andrews), disputed by

Jean Kieffer, who claimed independent invention in the US in 1929. Tomography reached the UK in 1937 when Edward wing Twining constructed apparatus. William Watson patented axial transverse tomography in the UK in 1937 and become an important inventor of improved designs throughout the next few decades to the 1960s. During the War many field radiologists improvised equipment from systems of axles and levers, bringing tomography to the field of battle.

Tomography grew to be important and all the major manufacturers had equipment for sale. Specialist equipment for curved plane dental tomography was invented. Along came layer fluoroscopy and multiple plane tomography. Tomograms constructed with the patient horizontal were used to plan radiotherapy. Diagnostic tomography was complemented by stereoscopy. Takahashi performed pioneering work in Japan and had just published his enormous atlas of tomographic sections when CT eclipsed this giant achievement.

So why claim 1914 was the origin of tomography? Well, the Polish Radiologist Karol Mayer used the principle of movement to sharpen detail closest to the detector and blur structures further away, and though he never claimed invention, with hindsight it was realised his idea of differential motion was fundamental to tomography.

Computed Tomography

The first commercially available x-ray CT scanner was designed and built by the EMI Company and was developed in collaboration with the UK Department of Health and London's Atkinson Morley Hospital. In recognition of this outstanding achievement Sir Godfrey Hounsfield received a 1979 Nobel Prize along with Allan Cormack who had demonstrated the principles on the bench as early as 1956.

CT has recently had its 21st anniversary and is still developing, with spiral CT newest on the scene. A UK commemorative stamp highlighted the achievement.

Looking backwards in time from 1971 it is possible, with the wisdom of hindsight, to record a number of developments which worked towards clinical CT but which did not achieve practical clinical utility. The Japanese radiologist Shinji Takahashi created

sinograms in the 1940s from which he made crude section images. Gabriel Frank patented a method of creating (slightly blurred) CT images in 1940. In 1960 William Oldendorf demonstrated the principles in some historic experiments in which he translated rotating samples between a source and detector. A medical CT scanner was reputedly constructed in Kiev in 1957. In the US, David Kuhl and Roy Edwards made a CT image in 1965 by replacing one of the detectors in their Mark-2 scanner with a radiation source but took the work no further. Allan Cormack had built a laboratory scanner as early as 1956 but there was little interest from companies he approached. Many others worked on the mathematics of reconstruction from projections, the earliest theory attributed to Radon in 1917 although even this is disputed.

It is very rare in science that an invention or discovery comes "out of the blue". CT was no exception. The concept of reconstructing a cross section from projection data was understood in many fields of physics long before medical CT became a practical possibility. There was not exactly a race to achieve it. Instead a number of experimental arrangements were constructed which "nearly achieved CT", many of which, after the event, can be cited as relevant to its history. The work towards the first EMI scanner was conducted in secret, mindful of the great rewards success would bring. The team developing it certainly knew some of the history of earlier attempts but uniquely solved the practical problems to bring the device to commercial reality. This monumental achievement was unveiled at the 1972 British Institute of Radiology Congress in London, UK in April.

Conclusion

Classical tomography is now little more than an interesting historical artefact, the practice being almost abandoned. CT has taken its place. CT has made faster progress because of the availability and speed of modern computers, because of improved digital detectors and because of the sheer weight of effort invested by commercial manufacturing companies. In contrast classical tomography was the brainchild of a few lone pioneers, unsupported by industry and from an earlier less technological age.