

Medical illustration in the 21st century and beyond

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Abstract

This paper provides an overview of contemporary medical illustration; the role of the modern medical illustrator is examined, including who they are likely to work for and with, as well as the range of media and technology employed. The various applications of medical illustration are described with a focus on looking at how these are likely to change and develop in the near future.

The modern medical illustrator

"As art reflects culture, scientific illustration reflects the findings of science and technology. Science illustrators are artists in the service of science. They use scientifically informed observation, combined with technical and aesthetic skills to accurately portray a subject. Accuracy and communication are essential."

Guild Handbook of Science Illustration,
©GNSI 1989, 2003

It is the role of the medical illustrator to communicate often complex scientific information and concepts to a broad range of audiences through visual media. To this end, the modern medical illustrator should be educated to an advanced level in both anatomy and visual communication. While some train first as artists and illustrators, others come from backgrounds in science and medicine, with each typically learning the other when they go on to specialise in medical illustration. While there is no legal requirement in the UK or elsewhere to undertake specialist or accredited programmes, it is generally regarded as best practice. In the UK, medical illustrators are encouraged to join the Academy for Healthcare Science (AHCS) Medical Illustrator Register, which requires the completion of an accredited degree programme. Similarly, in the US, the Commission on Accreditation of Allied Health Education Programs (CAAHEP) accredits a number of medical illustration programmes in North America.

It should be noted that in the UK, medical illustration is an umbrella term for both medical photography and artistic illustration, which is also referred to as medical art. For the purposes of this article, the terms medical illustration and medical illustrator will be used in place of art and artist.

There are several professional bodies that medical illustrators can join, such as the Association of Medical Illustrators (AMI) in the US and the Institute of Medical Illustrators (IMI) and Medical Artists Association (MAA) in the UK. There are many advantages to joining a professional organisation, including the sense of community and networking that comes about through conferences and regional meetings. Such face-to-face events also provide opportunities for

continuing professional development (CPD), which is essential to those wishing to join a register such as that held by the AHCS. The registration of medical illustrators has been welcomed within the profession as it recognises and promotes the specialist skills required and thus helps to raise professional standards. In addition, such registers help to safeguard the public by allowing anyone to search them and check that practitioners are registered and meet the required standards. It is also possible for concerns to be raised against a registrant and ultimately for actions and sanctions to be taken where necessary. Most professional bodies also produce guidelines in terms of professional practice and ethics. The IMI, for example, provides a large number of guidelines to their membership on topics as diverse as; patient confidentiality, working with transgender patients, cultural diversity, and the ethical use of social media (to name just a few). These are of utmost importance as this is a profession whose members often have direct access to patients and/or their data. An understanding of the responsibilities and laws around subjects such as data protection and anatomy legislation are therefore essential.

Medical illustrators work for a variety of employers including organisations such as various governmental health services, private hospitals, medical schools, research institutions, publishers, as well as specialised medical illustration companies. More recently, medical illustrators are also being employed by e-learning companies, software and app developers, and even VR developers. In addition, a sizeable proportion of the profession is self-employed, working with clients such as medical professionals and publishers directly.



Media and technology

Traditional media

Despite the proliferation of digital media, many medical illustrators still incorporate traditional media into their work. Those who use traditional media for all or a part of their work, often cite a preference for it because of the tactile feedback it can provide along with certain effects that can be difficult if not impossible to replicate with digital media. In addition, using a medium such as watercolours can be beneficial when depicting particularly graphic or sensitive material as it can “soften” the image and make it less disturbing, especially for a lay or patient audience. Medical illustrator Joanna Culley frequently uses both watercolour and pencil media in addition to digital. Figure 1 shows an example where the client requested the illustration be created in pencil so it could be used within an animation to “reflect a softer look and ‘feel’ to the illustrations... Graphite pencil was the preferred choice to depict the properties of the intrauterine birth control device and the insertion procedure along with the female anatomy so that it would seem more appealing to the patients watching the animation.”¹

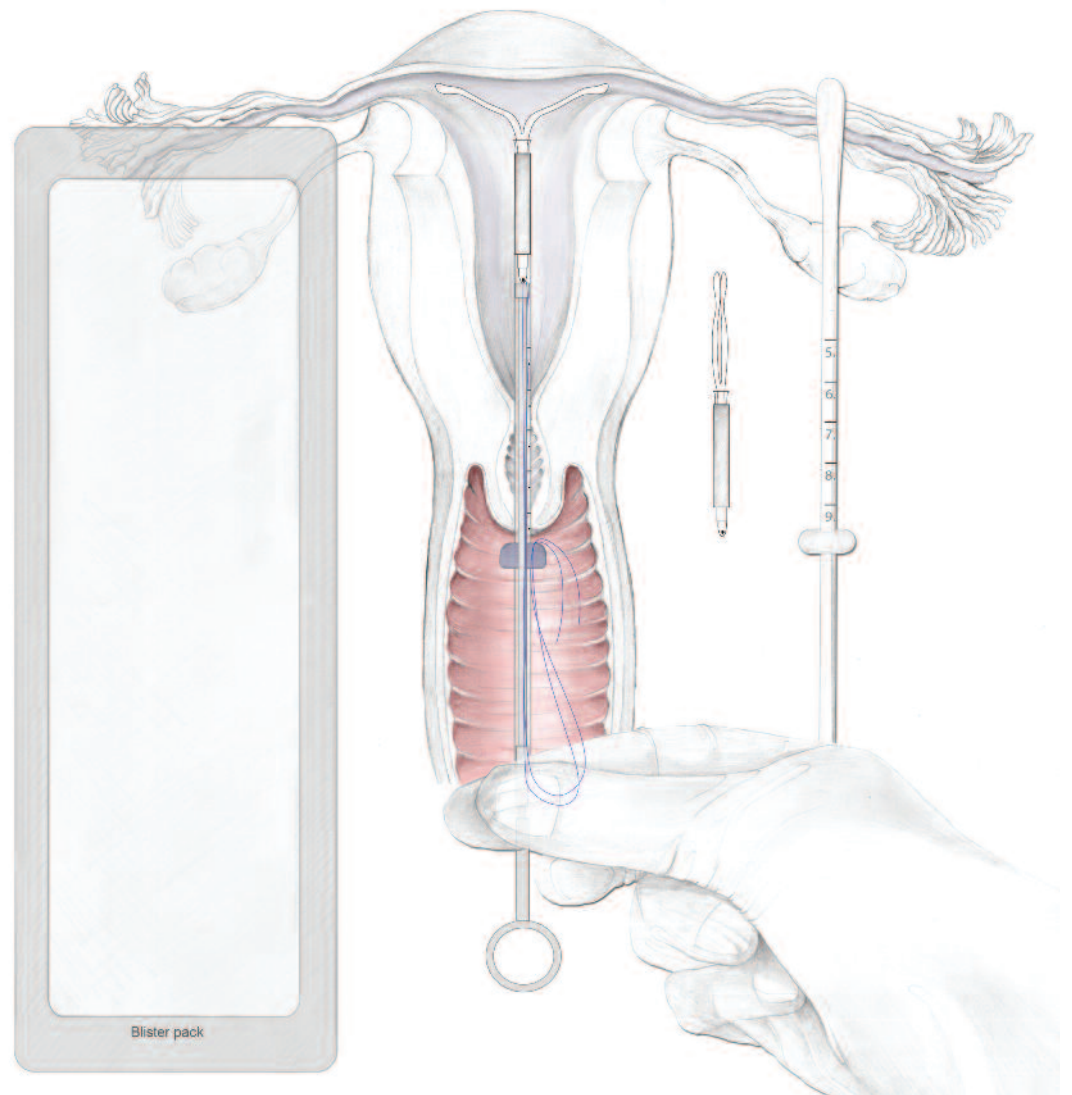


Figure 1. Illustration by Joanna Culley, demonstrating the use of graphite pencil to depict the IUD and its insertion procedure along with the female anatomy in a style that would be more appealing to patients watching the animation

2D digital illustration and animation

Two-dimensional digital illustrations are the staple work for many medical illustrators. They can be produced in a variety of styles and at different levels of realism for various target audiences. They can range from simple black and white line illustrations to full-colour realistic depictions, or even cartoons and “graphic medicine” comics.²

In addition to 2D illustrations, 2D animations are also useful for conveying information that does not require 3D spatial relationships, or for conveying complex concepts in a simpler manner. Animations (both 2D and 3D) are best combined with a voice-over (as opposed to subtitles) as this can help guide the narrative and

aid in highlighting important features.

3D digital modelling and animation

Over the past two decades, there has been a proliferation of 3D software enabling the creation of complex 3D models and animations. 3D models can either be based on scan data, such as magnetic resonance imaging (MRI), computed tomography (CT), and surface scans or created from scratch within the software itself. 3D digital models have a range of uses; they can be embedded as interactive models (that allow the user to rotate, zoom, and read annotations) in webpages, virtual learning environments,

e-books and iBooks, as well as in interactive PDF documents. In addition, they can be used as ‘assets’ (i.e., individual components that can be re-purposed) when creating animations or educational games and applications. They can be viewed and interacted within virtual reality (VR) and even 3D printed.

3D animations are very popular and, when done well, have the potential to convey a large amount of information in a short space of time. They are particularly useful for topics that require an understanding of 3D spatial relationships and for which a narrative or a sequence of events is important.

Applications of medical illustration

Medical and anatomical education

Medical and anatomical education is one of the primary applications of medical illustrations. Traditionally, medical illustrations have featured prominently in anatomy and medical textbooks. It could even be argued that some of these books (such as Vesalius's *De humani corporis fabrica*) are known more for their artwork than for the accompanying text. Such textbooks are still a mainstay of medical education, featuring modern (usually digital) 2D illustrations. However, there is a new wave of educational resources being developed, aimed at engaging students who are used to seeking information online and via apps. These include commercially available software programmes, mobile apps, e and eBooks, and websites, as well as bespoke resources made in house. Such resources tend to be more engaging for the user, often featuring 3D interactive models and animations in place of or in addition to 2D illustrations. These can be combined with touch-screen technology, "gamification" principles,³ and self-testing. E-learning is a growing field as it can provide students with access to approved learning resources remotely. As such, some medical schools now employ e-learning technologists along with medical illustrators to create visual learning resources for use online; Figure 2 is an example created by the author for the University of Dundee. It is important to note, that when creating such

resources, medical illustrators work closely with subject area specialists in order to understand the key learning objectives that need to be communicated. Medical illustrators working in medical education should also have a good understanding of the research surrounding learning styles and theories in order to apply these to their work.

New technologies such as virtual and augmented reality have also made their way into medical education. These are discussed in more detail below.

Patient information

The other primary application of medical illustration is patient information. Traditionally, this has largely consisted of illustrations and designs for 2D posters and leaflets. While these are still used, as with medical education, there is a growing demand for information to be accessible in digital formats and online. It is well documented that patients often search their symptoms or conditions in order to find out more information without the need for a doctor's appointment.⁴ The results of such activities can be varied, largely because of the differing quality of information available online. However, research by Briggs et al. demonstrated that when patients were provided with access to high-quality digital resources (in this case, a series of three eBooks containing written information along with interactive diagrams, 3D animations, and interactive 3D models), they no longer felt the need to seek further information from external sources, such as the internet.⁵ This demonstrates the importance of good quality and readily accessible patient information. For this reason, many organisations such as the NHS and medical charities have their own webpages where they can guarantee the quality and accuracy of the information provided. Illustrations, animations, and 3D models can enhance these online resources making them easier to understand and more accessible to a range of audiences.

When considering the best format (paper leaflet, interactive PDF, e-books and eBooks,

website, etc.) to use for patient information, the medical illustrator needs to consider who the target audience is, i.e., adults, children, the elderly, visually impaired, etc., since this may affect both the format and style chosen, as well as the level of detail provided.⁶

In terms of what the future holds for medical illustration, one of the major drivers will be recent and ongoing developments in technology.

Other applications

In addition to the two primary applications described above, other types of applications also use medical illustration.

Medico-legal exhibits, such as Illustrations, 3D models and animations, can all be used to clarify often complex information for both

judges and juries. Such exhibits often take the form of 'body mapping' where the injuries sustained are mapped onto a digital model, both to prevent distress to the jury as well as helping them to focus on the cause and impact of the injury rather than the traumatic image. In addition, radiographs and medical scans can be enhanced with the addition of colour or the creation of an illustrated interpretation.

Pharmaceutical and medical device companies utilise medical illustrations in their brochures, websites and promotional materials for trade shows, etc. These tend to demonstrate, often to a specialised medical audience, what the drug or device is capable of as well as how to use it.

Peer to peer science communication can take many forms but typically includes illustrations, 3D models, and animations for illustrating scientific reports, journal articles, and conference presentations. In addition, visualisations can be useful when trying to engage the public in medical and life science research.

The future of medical illustration and visualisation

Technology

In terms of what the future holds for medical illustration, one of the major drivers will be recent and ongoing developments in technology. Imaging technologies such as medical and 3D surface scanners can capture higher resolutions of detail than ever before; likewise, modern 3D modelling software packages (such as Pixologic Zbrush, Autodesk Maya, Cinema 4D, etc.) are able to handle ever more complex models and





Opponens Pollicis

Nerve: Recurrent branch of the median nerve

Actions: Flexion of the thumb's metacarpal at the first carpometacarpal joint, which aids in opposition of the thumb

Figure 2. An example of a 3D interactive model (of the muscles of the hand), created by the author for use in e-learning, hosted online at Sketchfab.com (<https://skfb.ly/6GWXx>)

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render objects with highly realistic material properties. Developments in image capture and creation technologies are already being combined with new and evolving forms of media (some of which have been described above), including e and iBooks, interactive PDFs, online 3D models, and mobile apps.

In addition to these, virtual and augmented reality technologies are being investigated by a number of medical schools as a means of further engaging students with virtual models.⁷⁻¹¹ VR refers to a fully immersive experience using a head-mounted display (HMD) where the user can interact with a digital object or environment. One of the benefits of viewing models in VR is that they are truly 3D, i.e., the user can move around them in space as

Virtual and augmented reality technologies demonstrate great promise for the future of medical and anatomical education in particular and may even find their way into other applications such as patient information and medico-legal exhibits.

opposed to viewing them on a 2D screen. Models can be displayed as life-size replicas or blown up to 100x their normal size, which can be particularly useful when exploring small structures such as those of the inner ear. In addition, not only can objects be viewed from an external perspective, but users can view a model, such as a beating heart, from within. The term augmented reality (AR) is used to describe a range of experiences, including the use of QR codes to trigger the launch of additional web-based information, such as images and models, usually on mobile devices, as well as HMDs such as the Microsoft HoloLens. Unlike the HMDs used for VR, AR HMDs show the virtual scene overlaid with reality. This has the benefit of allowing the user to interact with both

the digital and real world simultaneously.

Both technologies demonstrate great promise for the future of medical and anatomical education in particular and may even find their way into other applications such as patient information and medico-legal exhibits. Currently, however, most students don't have access to good quality VR and AR HMDs at home. This may change in the coming years as more affordable, standalone VR headsets (such as the recently released Oculus Quest) become more readily available.

Representation

Finally, it is worth saying something about representation in medical illustration. Parker et al.¹² in their 2017 paper "A visual analysis of gender bias in contemporary anatomy textbooks" explored the ratio of female and male representation in contemporary anatomy textbooks and found that out of the 17 textbooks examined (consisting of a total of 6,004 images), only 36%



of the images with an identifiable sex were female. In addition, other forms of bias were also found, including: “the visualization of stereotypical gendered emotions, roles and settings; the lack of ethnic, age, and body type diversity; and in the almost complete adherence to a sex/gender binary”. This is a major problem considering that these textbooks are used to educate our future healthcare workers. Rather, medical students (along with nurses and other allied health professionals) need to be prepared for the diverse range of patients they are likely to encounter in their working lives. It is the responsibility of everyone associated with the production of such material, including medical illustrators, to consider how to address this issue in the future.

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Conflicts of interest

The author declares no conflicts of interest.

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