Editorial

THE COMPUTER, EDUCATION AND CLINICAL PRACTICE

Traditionally, an orthopaedic surgeon has only needed to integrate the skills of talking, reading, clinical examination and operating to perform at the highest level. However, for today's surgeon the electronic era, arising from advances in digital technology, can no longer be ignored. The ability to turn on a computer, navigate a website, use a search engine, communicate by e-mail and assemble and carry out a PowerPoint presentation has become essential. Mastery of these will result in an easier acquisition of knowledge and enable the surgeon to become a more efficient and effective communicator. Most surgeons acquire their skills by experimentation or one-to-one exchanges, with the result that their education is usually incomplete.

In recognition of these needs, the Journal will publish occasional articles on topics describing the application of

this new technology to clinical practice. The first of these review articles on digital photography follows (pp 1 to 4), which will also be available to download from a new electronic section on our website (jbjs.org.uk). Other information, which will include techniques and advice about electronic issues, an interactive section as well as useful website addresses, will be posted there. We also hope to allow our subscribers to carry out personal continuing professional development assessment after reading articles in the Journal and to personalise their own webpage.

We wish to provide electronic information which will be of educational value for our readers and would welcome feedback on this venture, as well as suggestions for future topics. We encourage readers with particular expertise in the field of electronic communication to submit instructional articles for possible future publication.

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©2004 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.86B1.14966 \$2.00
J Bone Joint Surg [Br] 2004;86-B:1.

Annotation

DIGITAL PHOTOGRAPHY AND COMPUTERISATION IN ORTHOPAEDICS

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Accurate clinical documentation is an important part of a surgeon's work. Dermatology and plastic surgery have a long tradition of using photographic documentation,^{1,2} but

very few papers have described its application to orthopaedic surgery.^{3,4} Digital photography is particularly suitable in specialised areas such as the hand or foot because of the discrete regional anatomy and radiology.

For many years 35 mm negative and slide photography have been the standard means for photographic records. This is a familiar technique, producing high-quality images. The disadvantages are the higher costs of films and slides, the time lag between photography and development of the film, significant wastage of film in achieving the best exposure, the labour and time needed to sort slides, the space required for storage, and, most importantly, the deterioration in the quality of the images with time.

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doi:10.1302/0301-620X.86B1.13387 \$2.00
J Bone Joint Surg [Br] 2004;86-B:1-4.

In the early 1980s the first digital camera was introduced and there have since been rapid advances in the technology of digital imaging. The reduced cost of digital cameras, computers and software has allowed the acquisition of clinical material in the form of electronic media to become an affordable and convenient alternative to conventional 35 mm photography.^{1,5} The application of digital technology for filmless radiology using a PACS (Picture Archiving and Communication Systems) is already beginning to influence the practice of orthopaedic surgery in some hospitals.¹

This article describes the co-ordinated use of digital photography, computer and database software for clinical documentation, audit, information sharing and research in orthopaedics.

Digital imaging

In digital photography the image is captured using charge coupled sensor devices (CCD) that record light. The range of CCD light sensitivities as opposed to film is enormous and particularly well suited for the challenging environment of X-ray and intra-operative photography. The image is converted into a binary digital code and can be viewed on the camera's liquid crystal display (LCD) screen immediately. The number of digital picture elements (pixels) is proportional to the image resolution and picture quality. The resolution of a standard digital camera is 2.1 to 3.3 megapixels, which has been shown to be satisfactory for clinical and research purposes.^{2,5,6}

Most digital images are stored using image compression which makes the files more manageable with minimal loss of picture quality. Image compression formats which are commonly used include Joint Photography Expert Group (JPEG) and Graphic Interchange Format (GIF). For clinical purposes JPEG is preferred since GIF gives significantly bigger files, requires more memory space and is slower to process. Tagged Image File Format (TIFF) is an uncompressed file which is even slower to process and occupies more memory space. The phenomenon of slight diminution of the quality of the image, when JPEG pictures are opened, and closed, should encourage the maintenance of an unedited picture as the archive/back-up copy.

The advantages of digital photography in clinical practice are:

- instant preview of the image on the LCD display of the camera allows pictorial editing of composition, brightness and clarity of the images;
- the images are immediately available for the purpose of surgical planning or case discussion;
- the images can be stored and organised directly into a computer database, facilitating easy retrieval and integration;
- incorporation of digital images into the patient's case file (e.g. a floppy disc and a re-writable CD) provides legal documentation of the nature and severity of injury, as well as assisting surgical management;

- in the absence of the original x-rays, pre-captured images can provide information for peri-operative management;

- transmission of the images via electronic mail or direct phone line (ISDN) is useful in a medical emergency, such as a motor vehicle accident,⁷ or to facilitate specialist clinical opinion in long-distant consultation;⁸

- diagnosis may be improved when clinical digital images are sent with pathology specimens;⁹

- it facilitates teleconference or internet conference with experts;

- educational and academic presentations are facilitated by incorporating digital images in commonly used computer presentation software, such as Microsoft PowerPoint™ (Microsoft Corp; www.microsoft.com).

Choice of equipment for digital photography

Digital cameras. There are many digital cameras available on the market and their resolution, storage capacity and optical stabilisation are improving all the time. The following features are the minimum requirements in clinical practice for individual surgeons:

- Resolution of 2.1 to 3.2 megapixels will usually be adequate. With software enhancement it may be possible to enlarge an image to more than 8 inches x 10 inches with minimal loss of clarity. The more expensive cameras with 4.3 to 5.5 megapixels are not usually needed and their higher resolution will demand a larger storage capacity;

- a macro lens, either built in or external, is essential for close-up photography;

- an optical stabilizer is needed to prevent camera shake;

- an image magnification or zoom facilities may be either optical or digital. Optical zoom is identical to the performance of zoom lenses used in 35 mm film cameras. Digital zoom is created by enlarging the image off the CCD sensor. It is similar to enlarging from a negative and may lose image quality;

- rechargeable batteries are more economical. Having a fully charged spare battery is essential for clinical work as digital cameras consume battery power rapidly, especially in the viewing mode;

- size and robustness are important considerations. A bulky camera is more stable but less portable, whereas a camera which is too light may cause 'camera shakes'. Irrespective of size, the camera must be robust enough to sustain minor accidents;

- some newer cameras have the capability of a short video capture, usually up to 30 seconds. The resolution is acceptable in cameras which use a larger memory storage medium, such as a memory stick, but it is generally poor in those using floppy discs.

Storage medium. A digital camera processes the image which is altered and compressed prior to storage. The 'film' for the digital camera is its storage medium. The most commonly available types include:

- floppy diskettes which store up to 1.3 megabytes (MB), e.g. Sony FDMavica (www.sony.com);

- removable memory type devices which are available in sizes from 8 to 512 MB are used in the majority of compact digital cameras;

- - CompactFlash™ (www.compactflash.org) is the oldest, most robust, and widely used type of memory and is effectively a cut-down PC card with the largest cards storing 512 MB of memory;

- - SmartMedia™ (www.smartmedia.com) cards are a similar size to CompactFlash, but thinner and less robust with a maximum capacity of 256 MB;

- - MemoryStick™ (www.memorystick.org) is a proprietary storage card used only in Sony cameras and their other products. It is smaller, but only half as fast as CompactFlash with capacities from 16 to 128 MB;

- rewritable 8 cm CD (CD-RW). This has a storage capacity of 156 MB, but can only be used with the Sony CDMavica™ camera.

The authors have chosen a digital camera which uses floppy discs rather than memory cards for the following reasons:

- sorting the images stored on memory cards is time consuming and inefficient, similar to processing rolls of clinical film. The larger the memory capacity of the card, the longer it takes to sort out;

- pre-operative, intra-operative and post-operative images captured on a floppy disc may be easily kept within the patient's file or record until the completion of treatment before being archived to a dedicated computer;

- an 8 cm CD-RW is significantly more expensive than a floppy disc and requires computers which can read the small CDs. The cost of the cameras using 8 cm CD-RW is also much higher.

The limitation of the floppy disc is the file size. This may be managed by adjusting the image resolution with a low resolution for the patient's identity label and a higher resolution for the detailed anatomy. Most clinical images may be captured on 640 x 480 pixels file size. At this resolution a floppy disc can store between 24 and 40 images.

Image size. The size of the image is measured in pixels. The trend is for newer cameras to capture pictures with large file sizes (megabytes), requiring a storage medium of increasingly larger capacity. A larger file size ensures picture clarity and allows pictures to be printed on A3 size prints without compromising definition. However, this is usually unnecessary in clinical practice, as smaller file sizes in kilobytes (e.g. 640 x 480 pixels and 1024 x 768 pixels) are quite satisfactory for presentation and publication, since the subject matter is usually singular, such as a hand, and not multiple as in group family shots. Occasionally there may be a need for a more detailed picture requiring more than one megapixel, but this is rare in clinical practice. Larger file sizes also demand larger storage space in the computer.

Scanners. A dedicated slide scanner is preferable for scanning large numbers of analogue 35 mm slides and negatives

into digital data. High-resolution 4000 dots per inch (dpi) type scanners allow digital images to be enlarged to A3 size with excellent resolution. Slide holders for automated serial multiple slide scanning of up to 50 slides are helpful where all the slides to be scanned are of uniform colour and contrast.

In situations where a patient record may involve clinical pictures, X-rays and macroscopic pathology, automated serial multiple slide scanning may yield a sub-optimal result due to variation in brightness, colour definition and contrast. Scanning with manual adjustment of the contrast and brightness is preferable. Most slide scanners have built-in software to automatically restore colour balance and to remove dust spots and scratches during the scanning process. In so doing, the software blurs the whole image creating a softer looking picture.

A flat bed scanner is useful for archiving prints and documents. Radiographs may be more conveniently captured with a digital camera set against a standard viewing box. There is no need to use the transparency adapter which comes with some scanners to scan 35 mm slides or negatives, as this is best done using a dedicated slide scanner which is faster and yields more accurate colour reproduction. The use of a transparency adapter is only recommended for surgeons who archive digital images very occasionally. In general there is no major difference between scanners, except that USB or FireWire connections will allow faster data transfer, FireWire being the fastest.

Computer. The computer is necessary for the processing, storage, archiving and retrieval of the digital images. Use of either a PC (IBM™ compatible computer) or a Macintosh (Apple™ computer) is a matter of personal preference. The size of the hard drive, the speed of the computer processor and the Random Access Memory (RAM) are more fundamental. As the computer hardware is often outdated by the time it is purchased, it is important to acquire a system that has the maximal RAM and the fastest hard drive (Pentium III or IV in PC or G3 or G4 in Macintosh) which is affordable, flexible and easily upgradeable. Laptop computers are more suitable as a portable back-up system, but are not as reliable as a primary, dedicated computer to store all the digital data, given the higher risk of theft and accidental damage.

If using a PC system, it is essential that the software operating system is Windows 98 or a later version, to allow the facility to store and manipulate images. The earlier versions of Windows 3xx and 95 will not support this function.

CD burner/writer. For more permanent data storage and backup, a CD writer is essential for transferring or 'burning' data onto a CD-ROM. The CD-ROM has the advantage of being a relatively stable storage medium compared with floppy, zip or jaz disks. Each CD can store up to 650 MB of data and is relatively cheap. Whether a CD-Read (CD-R) or CD-Re-Write (CD-RW) disc is used, it is advisable to make at least one extra back-up copy of the stored data. The newer, more powerful, storage medium will be the DVD

disk, although, as yet, the industry standard has not finally been agreed.

Image editing software. Computer software is required for editing, cataloguing, retrieval and presentation of digital images. The images may be viewed directly on a computer screen using a standard picture viewing software program. The time and effort spent on creating an efficient catalogue system that suits individual needs is necessary. Examples of commercial software programmes currently available for filing digital photography include:

- FotoStation™ (FotoWare; www.fotoware.com);
- Photosuite™ (MGI Software Corp; www.roxio.com);
- Microsoft Access™ (Microsoft Corp; www.microsoft.com), - although not ideal for image databases as the files get too large;
- FileMaker Pro™ (Filemaker Inc; www.filemaker.com);
- Photo Explorer™ (www.ulead.com);
- ACDsee™ (www.acdsystems.com).

For those with more limited budgets, a number of good Shareware and Freeware programmes, such as Power Albums (www.webattack.com) are available to download from the Web. The fundamental considerations of any data-based digital photography filing programme include ease of use so that it may be tailored to specific purposes, and flexibility to make it suitable and interchangeable for both PC and Macintosh computers. 'Crash resistance' is an essential built-in safety feature with an 'auto save' function in case of accidental computer 'shut down'. It must be affordable. We have found Filemaker Pro™ (www.filemaker.com) adequate for clinical use, although it does require some basic programming skill.

Commercially available image editing programs include Paint Shop Pro™ (Jasc Software; www.jasc.com) and Adobe Photoshop™ (Adobe Systems; www.adobe.com), but these are expensive and designed for the professional user. Limited editions of these programs, such as Adobe Photoshop Elements™ are often packaged with the computer or digital camera. They will generally suffice as a basic editing tool, for manipulating colour and contrast, or to resize an image file before importing it into a presentation program like PowerPoint™ (Microsoft Corp; www.microsoft.com). Similarly, images imported from other sources, such as the internet, may need to be rescaled or reformatted.

Technique of digital photography

To put the subject in perspective, a 'global overview' shot is advisable before a 'close-up' shot. Flash and theatre lights

are generally not necessary with digital cameras and, indeed, can often cause over-exposure and colour distortion. It is important to confine the picture to one type of subject in order to avoid distraction, and a simple blue or green background is suitable for focusing. When photographing radiographs, it is important to use 'black and white' settings on the digital camera to avoid 'colour fringe' effects from the lighting source.

It is essential to obtain informed consent for all aspects of digital photography in a clinical setting. Similarly, protecting the confidentiality of patients by avoiding images that could identify the individual must be standard practice. This is particularly important when images are to be used for publication, research, teaching, or case discussion. Data protection is another important consideration. This may be achieved using commercially available data protection software programs to prevent unauthorised access and data transfer, either manually or electronically.

Digital photography has revolutionised the way we document and store clinical information. It allows important clinical material, especially images, to be documented, archived and retrieved with ease. A reliable filing program and a fast computer are preferable. The initial costs are unavoidable but will be set against the savings on film- or slide-processing charges, as well as minimising wastage. The information, once stored and archived, will be preserved indefinitely, to be used for teaching, audit and potential research purposes.

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