Clinical Applications of OsiriX for Orthopaedic and Musculoskeletal Imaging

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Abstract
OsiriX is an ‘open source’ multimodality medical imaging software that has gained huge popularity in areas of medicine where advanced image processing and visualisation are needed. An increasing number of surgeons, particularly orthopaedic surgeons, are adopting this software platform for better assessment of musculoskeletal images from different imaging modalities such as magnetic resonance imaging (MRI), computed tomography (CT), or even hybrid positron emission tomography (PET)-CT. The ability to easily generate 3D and 4D images in real-time, with a convenient and user-friendly interface for interactive navigation, through large sets of image data allows for better diagnostic interpretation and treatment planning.

Keywords
OsiriX, imaging software, 3D and 4D images, real-time

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OsiriX Software
The OsiriX program is an image display and visualisation software for multimodality and multidimensional medical images. It is designed to allow physicians with limited expertise in computer handling to easily navigate through large data sets of images. It provides a variety of 3D rendering techniques applicable to static and dynamic images acquired on any imaging modality. It also handles different measurement tools and the program architecture allows for specialised ‘plug-in’ modules to be added for specific applications. The OsiriX platform was also designed to support peer-to-peer communication between users in response to the increasing requirements for wider access to images across medical enterprises. It is particularly suitable for large hospitals and academic environments where clinical conferences, interdisciplinary discussions and successive sessions of image processing are often part of the complex workflow of patient management and decision-making.

OsiriX is distributed free of charge under open source licence where the program source code is also available for free, allowing users and developers to add further features or modify the program if needed. The current version runs on Apple Macintosh hardware only and takes full advantage of the Macintosh platform for features such as video-conferencing and facilitated image transfer through seamless integration of iPod devices. The program and supporting documents can be downloaded from www.osirix-viewer.com

Musculoskeletal Imaging
The diagnosis and clinical management of osteo-articular conditions relies extensively on imaging techniques, and being designed for degenerative, traumatic or tumoral diseases, musculoskeletal imaging procedures represent more than 40% of the total number of procedures of a general radiology department. Recent developments in medical imaging have improved the ability to determine, with a high degree of accuracy, the diagnostic nature and extent of a given condition, leading to better treatment planning and patient management. Treatment of most musculoskeletal conditions cannot be properly undertaken without imaging and, in most situations, imaging procedures are an integral part of the treatment and follow-up process.

Investigation of the musculoskeletal system utilises a variety of imaging modalities, from conventional X-ray to ultrasound, computed tomography (CT), magnetic resonance imaging (MRI) and more recent imaging techniques such as positron emission tomography (PET), as well as multimodal techniques such as PET-CT. Recent developments allow the acquisition, storage and transmission of these images in a digital format. While in many institutions images are still being printed on film, there is a rapid move towards ‘film-less’ images with radiology departments relying on picture archiving and communication systems (PACS). In most modern radiology departments these images are accessible on diagnostic workstations together with additional image processing and analysis software platforms that are usually provided with the imaging equipment or as high-end extensions of PACS. Unfortunately, access to these images in digital format is often limited outside the radiology department and may be restricted to simple web-based applications. The high cost of specialised image processing and rendering workstations limits their deployment in clinical departments. There is increasing demand from specialists and referring physicians to access and process these images themselves. This is even more applicable in the case of surgeons, who often have
Clinical Applications of OsiriX for Orthopaedic and Musculoskeletal Imaging

There is a need for the display and visualisation of anatomical findings prior to surgical interventions. This is particularly true for orthopaedic surgeons, who can benefit from 3D visualisation of musculoskeletal images for treatment planning prior to surgery. The integration of 3D models of prosthetic material and implants provides an additional capability for more accurate surgical planning.

Clinicians are often confronted with the challenge of reviewing images provided to them by patients bringing CDs or DVDs in place of films. Digital images on those discs can be reviewed by simple imaging software usually provided on the disc itself. These programs are limited in their features and in most cases allow browsing through sets of images only, without any tools for advanced 3D rendering and navigation. Discs from different manufacturers often carry different software programs, thus requiring the referring physician to learn how to use and manipulate each individual program.

Access to more generic software programs, capable of reading images from any imaging modality from any manufacturer, is not usual and only available on a high-end expensive commercial workstation. The cost and complexity of these workstations limits their use in general clinical settings outside of specialised imaging departments. OsiriX provides an attractive solution for clinicians and specialists who need to access digital images. Even inside large academic institutions that benefit from PACS infrastructure, convenient access to images by referring physicians anywhere in a hospital remains a problem. OsiriX was designed to provide a convenient solution and adapt to any environment and digital image communication infrastructure. It supports standard DICOM communication protocols, which are almost universal in the medical imaging industry. It also supports a variety of other communication protocols, allowing for the fast and easy exchange of image data between users. Finally, OsiriX gained its reputation by allowing users to use their iPods to carry their image data from one workstation to another, exactly as they would do with their music. OsiriX automatically detects when an iPod is connected and, if image data are stored, it will automatically list them on the main list of studies, which can be opened by a simple click on the main window of the OsiriX database window.

With the rapid increase in the performance of recent generations of personal computers and in particular with the adoption of high-performance multicore multiprocessor architecture on the latest models of Apple computers, users can benefit from an unprecedented performance for complex visualisation and 3D rendering of large volumes of high-definition image data. Standard consumer market models offer processing performance that was only available on high-end professional workstations a few years ago. This allows clinicians to generate and manipulate 3D rendered images in realtime on a low-cost hardware platform and laptop computers. OsiriX takes full advantage of the optimised high-speed graphic capabilities of Macintosh hardware and also utilises the 64-bit memory addressing capability of the recent generation of machines to load and manipulate very large sets of images. This supports high-resolution scans of several thousands of slices.

**OsiriX Adapts to the Needs of Orthopaedic Surgeons**

Advances in surgical techniques have led to a growing number of complex musculoskeletal conditions that can benefit from more efficient and less traumatic surgical treatments. Surgeons – in particular surgeons involved in osteo-articular diseases – rely on imaging for the planning of their surgical procedures. The precise knowledge of the nature, location, dimension and tri-dimensional orientation of the lesion is essential for the choice of surgical approach, size and design of implants to be used.

The surgeon him- or herself only masters the technical expertise and in-depth knowledge of the surgical techniques, the specifications of mechanical implants and the innovative minimally
invasive surgical techniques. The surgeon is the only one who can define the way in which images should be presented and manipulated for optimal treatment planning. Image representations and rendering performed by radiologists for diagnostic purposes are often inadequate for the surgeon, who needs a completely different view of complex anatomical structures. This explains the growing need for surgeons to have their own visualisation and image processing tools, allowing them to benefit from the extraordinary wealth of precise anatomical information provided by advanced imaging technologies. This is where OsiriX has made its major impact. With an extremely powerful ability to reconstruct objects in 3D and realtime from CT or MRI data through a simple and intuitive interactive user interface, it does not require complex training to use. Varieties of multidimensional image rendering techniques are provided, with standard shaded surface rendering that is suitable for skeletal imaging. More advanced volume rendering techniques also provide better 3D views of soft tissue, vessels, muscles and organs surrounding the bones in realistic views. OsiriX supports advanced colour management and rendering techniques using complex transparency, shaded colours and blending techniques that provide much better perception of the real anatomy and the topology and relationship of soft tissue and organs such as vessels, muscles, tendons, ligaments and bone. Using simple tools, the user can also isolate, remove and segment different parts of the image to better visualise areas of interest.

With the high performance of image rendering that OsiriX provides, users can move, rotate and manipulate 3D images at will in realtime. By offering a large range of colour transparency and blending techniques (it supports full 16-bit colour management), it is possible to generate new and innovative views of the anatomical structures that are more suitable for specific surgical applications. In orthopaedic surgery, some surgeons prefer to use different colours and transparency settings, allowing for better separation of metal implants from bone structures in semi-transparent 3D views (see Figures 1–4). A simple interactive tool allows users to define their own colour tables and rendering methods and to save these settings as preferred rendering methods. This flexibility in the customisation of 3D rendering and user preferences is not available on other more conventional medical imaging platforms. In modern orthopaedic surgery, great care is devoted to the preservation of integrity and minimising damage to surrounding local anatomical structures and organs through limiting the extent of surgical exposure. In trauma cases, minimally invasive procedures cannot be safely performed if prior to the surgery the surgeon does not know the exact tri-dimensional anatomy of a fracture or a lesion. The tri-dimensional capabilities provided by OsiriX allow the surgeon to analyse and visualise the lesions in 3D, reducing the need to perform unnecessary surgical exposure. This is also a tremendous advantage in complex degenerative situations such as hip dysplasia, as well as in articular trauma, where the complex nature of acetabular fractures becomes more obvious through tri-dimensional reconstruction. These tools greatly enhance the success of such surgical procedures.

The surgical treatment of degenerative joint diseases often relies on the use of surgical implants such as arthroplastic devices. The variety in shape, destination and size of these articular implants is enormous. Pre-operative planning and careful selection of the appropriate implant is a prerequisite for a successful surgical procedure. Surgeons currently use a pencil, transparent templates of the devices, a piece of paper, a light box and plain films to perform this pre-operative planning. With the replacement of films by digital images, the need for more accurate and convenient ways to perform these planning tasks is necessary. OsiriX allows for the performance of standard measurements and the drawing of graphic overlays on top of images. A set of specialised tools was also developed as ‘plug-ins’ for specific advanced-planning tasks. A software ‘plug-in’ for arthroplasty planning has recently been developed to allow for the digital models of surgical implants of a given manufacturer to be easily manipulated and super-imposed on images, allowing surgeons to easily prepare and select the appropriate implant for a given patient. This new development will allow for ‘film-less’ arthroplasty templating and surgical planning within the OsiriX application itself.

Conclusion

Over 20,000 radiologists, physicians and surgeons in academic and non-academic settings around the world have adopted OsiriX software as their primary tool for image analysis and treatment planning. The feedback from users and the rapid response from developers, who continue to improve and expand the software capability on a daily basis, ensures the growth and rapid evolution of the product compared with more traditional commercial systems. The medical imaging software industry is evolving rapidly and there is no doubt that increasingly powerful or more user-friendly solutions will continue to appear in the future. OsiriX is clearly ‘leading the pack’ in the field of open source medical imaging platforms, allowing for the powerful and accessible analysis of most medical imaging data available. It compares favourably with other commercial systems available today. It is, in many aspects, as powerful, requires less computing hardware resources and is more easily accessible to users without extensive skills in computer handling. Its distribution as a free open source software package ensures its wide adoption and future expansion by a large number of users and developers around the world, who will continue to improve and expand its capabilities.

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