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PRACTICAL DERMATOLOGY

Digital Photograph Storage Systems in Clinical Dermatology

R. Taberner[a,*] and T. Contestí[b]

[a]*Servicio de Dermatología, Hospital Son Llàtzer, Palma de Mallorca, Spain*
[b]*Departamento de Informática, Hospital Son Llàtzer, Palma de Mallorca, Spain*

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Abstract
In recent years, digital photography has consolidated its role in clinical dermatology. In view of the quality and low cost of current equipment and the simplicity of digital storage, almost all dermatologists now use digital photography, which is also extremely versatile and readily applicable to teaching.
However, to maximize its full potential, image retrieval must be available at any time and with the patient present. This requires a suitable storage system that may vary according to the characteristics of each center. Dermatologists must also find time to maintain and organize the digital archives.
The present article describes current options in digital image storage and retrieval, ranging from multidepartmental picture archiving and communication systems at one end to image management freeware at the other, and also including dedicated dermatology software.

PALABRAS CLAVE
Fotografía digital;
Sistemas de información;
PACS

Sistemas de almacenamiento en fotografía clínica dermatológica

Resumen
En los últimos años la fotografía digital se ha afianzado definitivamente en la consulta dermatológica. La calidad de los equipos actuales, sus bajos precios y la facilidad de almacenamiento en soporte digital hacen que hoy en día la práctica totalidad de los dermatólogos utilicen la fotografía digital debido a su gran versatilidad y a sus aplicaciones académicas. Sin embargo, para poder aprovechar todas sus posibilidades tenemos que asegurar la recuperación de las imágenes en cualquier momento y en presencia del paciente. Para ello es necesario un sistema de almacenamiento adecuado que variará en función de las características de cada centro, así como la inversión de parte de nuestro tiempo en mantener organizado el archivo de imágenes.

*Corresponding author.
E-mail address: rtaberner@ono.com (R. Taberner).

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En el presente artículo se describen las diferentes posibilidades existentes a día de hoy para almacenar y recuperar las imágenes digitales, desde la utilización de un *Picture Archiving and Communication Systems* multidepartamental o el empleo de *software* gratuito de gestión de imágenes, pasando por el uso de programas específicos para Dermatología.

Introduction

The last decade has witnessed the steady changeover from archiving images in the form of slides to digital format, now that doubts concerning their quality for use in daily medical practice have been resolved.[1-3] Thus, in 2001, between 56% and 71% of dermatology departments in the UK had access to digital cameras (depending on whether they were university or general hospitals), whereas the percentage is now close to 100%.[4]

Digital format offers a host of advantages. Apart from considerable savings in physical space, the images are immediately available, they can be retrieved at any time and viewed with the patient present. This also facilitates their use for teaching purposes, and teledermatology and e-Health projects (Table 1).

However, to take full advantage of their potential, image retrieval must be guaranteed and this implies having an effective storage system and investing time in file maintenance and organization. What is the point of accumulating thousands of clinical photographs of our patients if we cannot find them when they are needed?

A Dermatologist Survey

Recently, members of the Spanish Academy of Dermatology and Venereology were surveyed to find out how dermatologists organized their image files (data presented at the Informatics and Teledermatology Seminar of the 37th National Congress of Dermatology and Venereology, Madrid, June 2009). In total, 93% of the 61 physicians

Table 1 Glossary of Terms

PACS	*Picture Archiving and Communication System*. Computerized system for archiving digital medical image files and transferring them to workstations through a computer network
DICOM	*Digital Imaging and Communications in Medicine*. Internationally recognized standard for transmitting medical images
MIO	*Medical Image Organizer*. DICOMization software for images and other medical parameters
CIT	*Communication and Information Technologies*. A set of techniques, developments, and advanced devices that integrate data storage, processing, and transmission functions
e-Health	The application of CIT to healthcare practice
Web 2.0	A second-generation Web technology based on user groups, and that offers a special range of services, such as social networks, *blogs*, or *wikis* that facilitate collaboration and the exchange of information between users. Also called the social Web
JPEG	*Joint Photographic Experts Group*. The most common digital image format that uses a lossy compression algorithm
BMP	Windows *bitmap* (a map of bits). A format used by the Microsoft Paint application offering lossless compression
TIFF	*Tagged Image File Format*. Image file format that uses tags, with or without compression
RAW	Image file format that contains image data as acquired by the digital camera sensor. Applies lossless compression
Exif	*Exchangeable image file format*. Specification for the image file format used by digital cameras and that adds metadata to the image file
Tag	A label. A nonhierarchical keyword assigned to a datum (such as a digital image), that describes it and enables retrieval, usually assigned informally and personally by the user
EPR	*Electronic Patient Record*. Electronic medical record in digital format
RIS	*Radiology Information System*. Database used in radiology departments to store radiologic data, integrated within the hospital's information system
HIS	*Hospital Information System*
HL7	*Health Level 7*. Set of standards for the electronic exchange of medical information
CIM 2.0	*Clinical Image Manager* (Sargonet). Application for medical image management specifically designed for dermatology
Freeware	Software that is freely available for immediate and permanent use
LOPD	Personal Data Protection Law 1999

who responded said they used a system to organize their digital images. However, the system most frequently used was Windows folders (52.5%). Only 3.3% used in-house applications (developed in the hospital itself) and 11.5% used dedicated dermatology image software. Only 10% of the respondents (all of whom worked in the same health center) used electronic medical records and the hospital's Picture Archiving and Communication System (PACS) for storing clinical images. Only 16.4% expressed satisfaction with their image storage system.

The present article describes the different options for digital image storage, taking into account the possibilities of each dermatologist according to where they work.

Beyond PACS: Global Storage of Nonradiologic Images

The term "medical image" is a general concept that includes images acquired from radiology, magnetic resonance imaging, computed tomography, ultrasonography, endoscopy, ophthalmology, otorhinolaryngology, dermatology, pathology, and so on, but has been recently widened to include recordings of biomedical parameters that can be represented graphically (electrocardiograms, electroencephalograms, perimetry tests, Holter monitoring, exercise tests, etc).[5,6] This generates a great deal of information that has to be acquired, analyzed, transferred, stored, and retrieved.

The introduction of digital medical imaging in the 1970s and the use of computers for post-acquisition processing led the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) to form a joint committee to create a standard method for transferring medical images and their associated information. This committee was formed in 1983 and published the ACR-NEMA standard in 1985. Version 3.0 was launched with the new name Digital Imaging Communications in Medicine (DICOM) and numerous improvements were added to standardize communication.[7]

DICOM is not only a format for medical images; in fact, it aims to be a complete standard that meets all the needs of a PACS: storage, transmission, communications, and printing. Thus, it integrates all the machines that form a PACS, from those used for image acquisition to those used to view them.

The DICOM standard provides interconnectivity for medical imaging equipment and currently forms the core of a hospital's entire information system.

DICOM files consist of 2 parts:

1. A header with a large number of standard fields (DICOM tags) that specify administrative fields (patient details, hospital, physician, type of procedure, etc) and information about the image.
2. The image itself which can be compressed using different standards (JPEG, TIFF, RAW, etc).

The current DICOM standard is version 3.0 and is maintained by members of the DICOM Standards Committee which is formed by organizations, PACS hardware and software representatives, and other groups.

The PACS is a computer system that stores, transfers, and displays the medical image and that replaces physical storage systems (Figure 1). The PACS is connected to other computer applications in the hospital, such as the Hospital Information System (HIS) and electronic medical records.[5,6,8]

Only DICOM images are accepted for storage in a PACS, but most medical devices generate images and videos in non-DICOM formats. The current situation is that a PACS only stores radiologic images; large companies provide robust tools that function perfectly in the context of radiology, but are barely adaptable to other environments. The solution is to use DICOMization tools of sufficient power and flexibility that enable integration with the PACS.

DICOMization software tools integrate the medical images from all departments into a single storage system, increasing the value of the patient's electronic medical record by providing it with nonradiologic images and videos.

The Hospital Son Llàtzer in Palma de Mallorca, Spain, has solved the integration problem by using the Medical Images Organizer (MIO) application, an automatic DICOMization tool for the silent upload of images to the PACS in an unlimited number of modalities within corporate environments. Any medical image produced in the hospital is centralized and automatically converted to DICOM, and silently uploaded to the PACS without user involvement.

Thus, once the images have been transferred from the memory card to the personal computer, the dermatologist transfers them from the medical workstation to the PACS using MIO (Figure 2), differentiating clinical images from dermoscopic images. In addition, the location and diagnosis can be included following the short version of ICD-9 modified for dermatology.[9]

Subsequently, the web-based viewer Centricity PACS (GE Healthcare, Little Chalfont, UK) (Figure 3) can be used to retrieve the images from the patient's electronic medical record or through a web application that enables searches based on multiple parameters (patient data, type of test, physician, date, diagnosis, etc). Furthermore, images taken at different times can be compared to monitor progress.

Figure 1 Model of a multidepartmental Picture Archiving and Communication System.

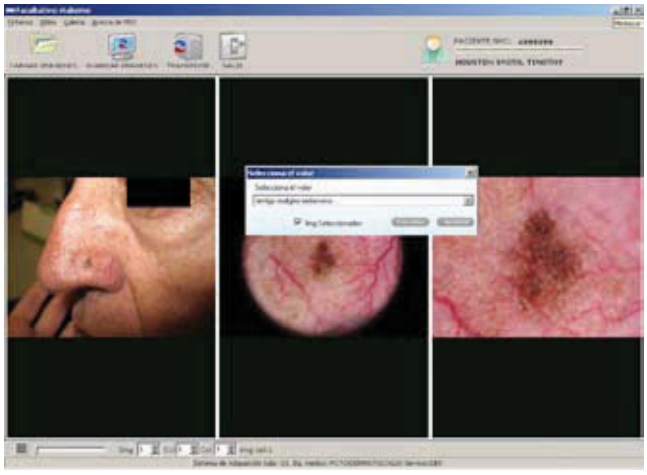

Figure 2 Using *Medical* Image *Organizer* to transfer clinical and dermoscopic images to the *Picture Archiving and Communication System.*

Figure 3 Retrieval of dermatological images taken at different times of a single patient from the *Picture Archiving and Communication System* using *Centricity Web.*

A PACS offers many advantages as a storage system for dermatological images (Table 2). First, image information loss is kept to the minimum. We can also immediately access images at any time and from any hospital computer. Searches can be based on multiple variables, including diagnosis, making it simple to prepare clinical sessions and teaching applications.

Finally, it helps us to take full advantage of "e-Health", which is defined as the application of communication and information technologies (CIT) to aspects of healthcare, from diagnosis to follow-up, and the management of organizations involved in these activities.[10]

The main drawback of this system is reluctance among professionals to place all their dermatological images in a PACS and that all those images are then available to any professional with access privileges (physicians of the regional public health system in the case of the Balearic Islands), especially when the images are of the genital area, pediatric cases, or cases which are likely to be published. The Hospital Son Llàtzer is solving this "problem" by encrypting specific images selected by the dermatologist when uploading them to the PACS, so they can only be retrieved using the physician's password.

Table 2 Advantages of a *Multidepartmental Picture Archiving and Communication System*

Information loss is minimized
Immediate access from any computer
Image search based on multiple variables
Enables teledermatology
Facilitates e-Health
Educational applications (presentations, teaching, etc)

Standards and Information Systems Used for Integrating Nonradiologic Images Into the Hospital Network

The standard most frequently used to work with nonradiologic images is that of the Joint Photographic Experts Group (JPEG). It is a commonly used compression method for photographic images, and is also considered a file format.[11]

The degree of compression can be adjusted, which makes it possible to strike a balance between the size and quality of the image. The compression ratio normally achieved is 10:1, with little perceptible loss of image quality. JPEG/Exchangeable Image File Format (Exif) is the most commonly used format for digital cameras and other image acquisition devices, together with JPEG/JPEG File Interchange Format (JFIF), which is another format for storing and transferring photographic images over the world wide web (www). These variations are rarely distinguished from each other and all of them are usually referred to as JPEG. JPEG is named after the commission that created the standard in 1992, and that was approved as ISO 10918-1 in 1994. It is the standard most dermatologists use to acquire clinical and dermoscopic images.

Windows BITMAP (BMP) is the format used by the Microsoft Paint application and is bundled with the Windows operating system. It can store 24-bit images (16.7 million colors), 8-bit images (256 colors), or images with even fewer bits. These files can undergo lossless compression (run-length encoding [RLE] compression).

A very large number of departmental applications use the BMP format in the healthcare setting. However, this standard is used on a routine basis for screen capture by pressing Prt-Scr and pasting the image into Microsoft Paint or another image editor.

The Tagged Image File Format (TIFF) contains, apart from image data, tags which provide information on the

image and that are used for subsequent processing. More than one image can be stored in a single file and it can optionally use Lempel-Ziv-Welch (LZW) compression. The format was developed by the now defunct company Aldus and Microsoft, and is currently the property of Adobe Systems. Although some digital cameras can record images in this format, in the healthcare setting it is particularly used in ophthalmology (retinal tomography, perimetry).

RAW is a digital image file format that contains all the information acquired by the digital image sensor. It is a lossless compression format. It has been called a "digital negative" since it is a "read only" file and can only be generated by the camera. It is not a universal format, since each manufacturer has its own format, and requires postprocessing with dedicated software. Although the RAW format is the one used by professional photographers, in daily clinical practice it is seldom used for the above reason.

Information systems in healthcare settings are based on 3 factors: globalization, accessibility, and integration. The concept of integration is crucial in a setting in which there a vast number of applications that require the exchange of information. Nonradiologic images are integrated via different information networks, particularly between the Electronic Patient Record (EPR), the Radiological Information System (RIS) and the DICOMization software. Normally, information is exchanged using messages in Extensible Markup Language (XML) format or Health Level Seven format (HL7) format as defined by the RIS provider.

Dedicated Software for Dermatology

Currently, most hospitals have a Radiology PACS available and computerized medical records. As mentioned, the ideal situation would be one in which there was multidepartmental use of the integrated PACS, but this is not always feasible.

An alternative to this would be the creation of a database hosted on the hospital's central server and linked to the electronic medical record.[12] Dedicated software can be developed with this aim in hospitals with computer-based systems.

In Spain, dedicated image management software has recently been developed for use in dermatology. The Clinical Image Manager 2.0 (CIM, Sargonet; http://www.sargonet.com) is an application for use in hospitals that includes network installation and connection to the hospital computer system for patient data acquisition (Figure 4). This software was developed using Java and can be installed on any relational database (Oracle, MySQL, SQLServer, etc) in the hospital or can be used as a standalone application. The software has its own file manager and does not require a PACS for its operation. There is no limit to the number of photographs that can be filed. Although this depends on the available hardware, a 1-terabyte hard disk can store at least 300 000 to 400 000 photographs, which would be the number expected for a large department over the course of 15 years or so. The software has an ICD-9 coding tool (in the version adapted for dermatology[9]) for managing pending diagnoses. In addition to making backup copies, this application can be used to search for images based on different variables, either individually or in combination (patient data, location, diagnosis, etc). Furthermore, users can define their own variables to include other types of specific information. Finally, images can be automatically inserted into presentations for teaching purposes.

Image Management Software

In clinical settings, the use of digital cameras leads to the accumulation of thousands of images in little time, and it is crucial to be able to access these rapidly and at any moment. Classifying them into Windows folders aids in their organization up to a point, but it can become very complicated if we have to search through several thousand images to find what we want. It is striking that 90% of the dermatologists surveyed only used Windows as a clinical photograph management tool. At best, the images can be chronologically classified into subfolders and the files can be renamed using the medical record number of the patient, and so we can only use the variables time and patient when searching.

There are a great number of image management and archiving tools available that can help to optimize file organization. There is an almost unlimited number of applications on the market. Some of these require payment, others are bundled with the digital camera, and yet others are free — and powerful — and can be downloaded from the Internet.

The most popular free applications are as follows: Picasa 3, XnView 1.96.2, iPhoto 09 (this requires a license, but is bundled with the Mac OS), IrfanView 4.25, Pictomio 1.2.29, and FastStone Image Viewer 3.9, among others (Table 3). In

Figure 4 Example of using CIM 2.0 for dermatological images. Patient data can be imported from the hospital's computer system.

Table 3 TImage Management Software

Application	Logotype	Operating System	License	Spanish Version
Picasa 3			Free	Yes
XnView 1.96.2			Free	Yes
iPhoto 09			Bundled with Apple computers	Yes
IrfanView 4.25			Free	No
Pictomio 1.2.29			Free	Yes
Fast Stone Image Viewer 3.9			Free	No
ACDSee			50 US dollars	Yes

addition to having a variety of tools for image organization, most image managers are also provided with editing and viewing tools.

In this section, we focus on Picasa 3 due to its popularity of use. After downloading and installing the software, users should set it up according to their preferences. The Picasa 3 image viewer can be installed for Windows, since it is faster than the one provided with the Windows operating system.

The files organized with Picasa appear in the general list, but organization can be improved by creating personalized albums in which to store images (Figure 5). These albums are an excellent way to organize general categories ("pediatric dermatology", "surgery", "laser", "biological", "cases pending diagnosis", etc), but if we want to classify the images individually, then they should be tagged (diagnosis, location, etc) (Figure 6). Furthermore, tags can contain several words in the latest version of Picasa. Also, we can change the name of the file using the number of the medical record, and flag specific photographs by assigning them a title (rare diagnoses or peculiar cases).

Finally, it can be very useful to highlight specific images, which will appear in a separate category in the search bar (photographs for presentations or publications), by flagging them as "favorites" (marked with a yellow star in the thumbnail version).

Once the images have been correctly classified, the search and view functions can be fully exploited. Of note,

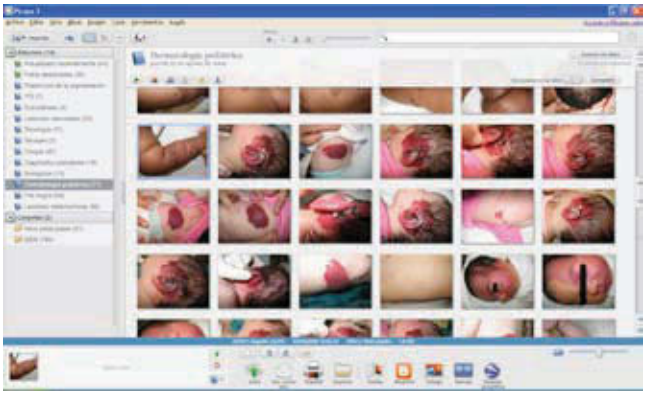

Figure 5 Organization of dermatological images in Picasa 3 using albums and folders.

Picasa 3 also enables a complete backup copy to be made for subsequent restoration. These can be saved to disc or to a backup file which can be stored on any medium.

Whatever the filing system used, it should be obvious that to be able to exploit all its advantages we should invest some time in uploading and classifying the images. In an increasingly bureaucratized workplace this could seem to involve an excessive use of time, but this is completely offset by the savings gained when searching for specific images, which is an almost impossible task if Windows

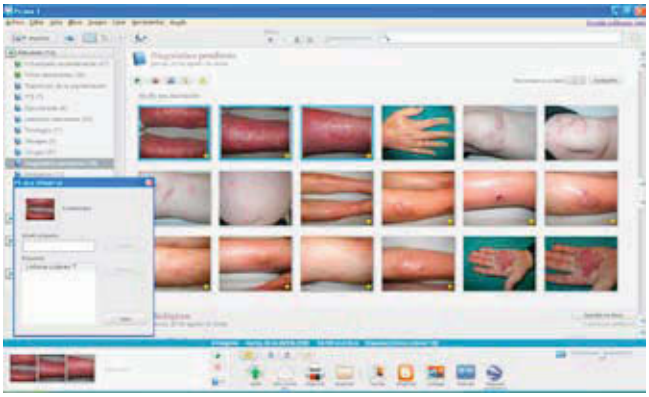

Figure 6 Tagging dermatological images according to diagnosis using Picasa 3.

folders alone are used. Furthermore, for those who remain skeptical of the digital world, it suffices to recall what was involved in the past working with an analog file supported by physical slides: record the name of the patient, number of the medical record, and suspected diagnosis in a notebook, develop the film, identify the slides, note the date and the number of the medical record on the slide frame, and establish the definitive diagnosis by reviewing the medical record on paper and then recording this on the slide to be filed in the correct folder in an archive that filled an entire room.

However, our file is organized from the very moment we press the button on the camera. Of course, given that we take photographs of several patients during the working day, and that in some cases the camera is shared between several people from the same department, it is essential to keep some type of record of the images. When dermatologists work with their own camera several options are available to organize the images, from recording the photographs in a notebook or creating an Excel file to making a photograph of the patient data (from the list of patients or of the screen itself).[13] When the camera is shared between several colleagues the latter option is the most effective one due to its simplicity, although this takes up more memory on the card.

In any case, it is important to set the date and time on the digital camera, since this is how it records when the photographs were acquired and enables future searches by using the Exif data (data associated with the image and the camera embedded in the same file). Table 4 presents some basic recommendations.

In a consumer society such as ours, photographic equipment is being offered with ever greater resolution. This "megapixel race" does not always result in better photographs (this is determined mainly by other features of the camera and the photographer's abilities), and, in any case, accumulating thousands of images has an impact on the storage capacity of the system. The dermatology department of our hospital was set up in 2002 with a team of 2 dermatologists. There are currently 5 dermatologists and our photographic archive now contains more than 26 000 images that occupy more than 23 Gb on the server. Thus, it is recommended that resolution should be no more than 5 megapixels and that compression should be set to the minimum when acquiring images in JPEG (*Fine*) format to maintain image quality.[14] Finally, it is essential to frequently backup the entire system to avoid losing information.

Legal Implications

In recent years, CIT has substantially changed the physician-patient relationship, passing from one based on paternalism to another embodying the principle of autonomy, in which the patient assumes responsibility for decisions regarding their disease. Paper-based medical records ensured that this relationship was free from disclosure to third parties due to the simple fact that doctors have a duty to preserve confidentiality, but the new storage techniques for medical information (including clinical images) have the potential danger of putting patient privacy at risk.[15]

Health professionals who work in hospitals with computer-based systems and that have available a PACS for nonradiologic image storage or dedicated software for image management, are obliged to use systems that guarantee confidentiality under Spanish law (Royal Decree 994/1999, June 11; Organic Law 15/1999, December 13; Law 41/2002, November 14). However, dermatologists in private practice and private health centers must also manage confidential patient data according to current legislation.

Conclusions

The wide availability of the new CIT in healthcare settings implies that the main objective of dermatology departments in hospitals with computer-based systems is having access to a multidepartmental PACS, with the aim of integrating clinical and dermoscopic images in the patient's electronic medical record.

However, the current situation is very different in most dermatology departments. Although PACS are increasingly available in hospitals, access to them by specialties other than radiology is difficult due to technical and management issues.

Although we believe it unnecessary to abandon storing images in a PACS, for the reasons mentioned above we have to find alternative solutions to ensure that our image file is as practical as possible, especially when locating the images of a specific patient, while always guaranteeing compliance with the Data Protection Laws.

Table 4 General Recommendations

Limit image resolution (to 5 megapixels)
Use low compression *(Fine)*
Adjust date/hour of the digital camera
Keep a record of all photographs
Upload the images daily
Make backup copies frequently

In order to resolve this issue, some departments which use electronic medical records have created a backup image database, interconnected by the number of the patient's medical record, and which is hosted on the central servers of the informatics department.[12] Other hospitals use dedicated dermatological image management applications, such as CIM 2.0, which can be connected to the hospital's computer system.

Finally, given that most dermatologists restrict themselves to accessing images which have been simply stored in the operating system folders, we believe that there are easy to use, reliable and above all cost-effective alternatives which can enhance performance in these cases. This is provided by simple and intuitive freeware, such as Picasa 3, which can classify our images based on multiple variables and organize them in albums and files for their subsequent and instant retrieval.

Conflicts of Interest

The authors declare no conflicts of interest.

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