RESEARCH ARTICLE

An Evaluation of Digital Imaging Studies in an Outpatient Orthopedic Setting

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Abstract

Background: Distribution of radiographic images in the outpatient setting on compact discs-recordable (CD-R) is commonplace. Opening, manipulating and interpreting these can be challenging. This study evaluated the availability and ease of use of CD-R to evaluate digital images in an outpatient orthopedic setting.

Methods: 118 CD-R containing diagnostic studies were evaluated by seven board certified orthopaedic surgeons. Surgeon age and self-perceived "tech savvy" scores were tabulated using a visual analog scale (VAS). Surgeons evaluated: ability and number of computers to open, autorun, and specific reader software. Time to load was recorded in seconds, type of study, presence of "not for diagnostic use", and if the disc required additional software. Studies were graded using a VAS for ease of opening, ability to move from image to image and/or between series, to manipulate the image, and to zoom and pan.

Results: There were 79 radiographs, 29 MRI's, and 10 CT scans. Seven (6%) had to be manually opened and four (3%) required software installation. Thirteen (11%) contained a warning that the studies should not be used for diagnostic purposes. Six (5%) of the studies could not be opened. For the opened studies, average time from disk insertion to image was 43.7 seconds overall (range 3-350), 65.3 seconds (range 21-191) for MRI and CT, and 35.2 seconds (range 5-177) for radiographs.

Conclusion: The present digital imaging systems include different software types and a variety of interfaces. Improving this would decrease time and effort necessary to open and evaluate these studies, and improve efficiency.

Level of evidence: III

Keywords: CD-R, Outpatient imaging

Introduction

With the advent of digital radiology, the distribution of radiographic images in the outpatient setting on compact discs-recordable (CD-R) has become commonplace. Most commonly, the images are stored in the digital imaging and communication in medicine (DICOM) format, and the disk typically contains a self-contained software reader package (the DICOM reader) that enables the user to view these images. While the intent of this method of image distribution is to improve efficiency and reduce

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costs, there are multiple challenges with this technology, including the ability to visualize and manipulate images, as well as increased time consumed to navigate through those images across different hardware and software platforms.

Several studies in the radiology literature have evaluated the ease and accessibility of CD-R in the transfer of digital radiographic images (1-4). In general, these studies have evaluated the applicability of CD-R in hospital and radiology settings. In the outpatient orthopedic clinic setting, surgeons frequently need to review imaging studies brought in by patients on CD-R. Opening, manipulating, navigating and viewing these studies can be a time consuming part of a patient visit, and there is a paucity of data in the orthopedic literature on the ease of use of this technology in the outpatient clinic setting. The purpose of this study is to evaluate the availability and ease of use of CD-R to evaluate digital images in an outpatient orthopedic clinical setting.

Materials and Methods

Institutional Review Board permission was obtained prior to the beginning of this study. One hundred and eighteen CD-R containing diagnostic studies were prospectively collected and evaluated by seven board certified orthopaedic surgeons. Six surgeons reviewed 17 CD-R and one 16. Studies of patients who presented for a new or follow-up visit at our outpatient surgical offices (12 different locations in a regional orthopedic practice) were included if they presented with imaging studies contained in CD-R. The CD-R's were then inserted into one of the office's standard personal computers (PC) to visualize the studies. No laptops or tablet computers were used. The computers were each embedded with a Windows standard 32-bit operating system (2010) with an Intel processor (Intel (R) Core (TM) i5-2400S CPU @ 2.50GHz), and 4.00 GB random access memory.

The age of the surgeons, time in practice, and their self-perceived "tech savvy" scores were tabulated using a visual analog scale (VAS) 1-10 (1 – not tech savvy; 10 – very tech savvy). Surgeons then evaluated each of the following parameters: ability to open the disc (yes or no), the number of computers required to open the disc, whether or not the disc opened automatically (autorun) or required manual clicks to open, and the specific DICOM reader software brand. Time to load the disc (time from disc insertion to first image on screen) was recorded in seconds, along with the type of study (plain x-ray (XR), magnetic resonance imaging (MRI), or computerized tomographic (CT) scan), whether or not the disc had a warning display indicating "not for diagnostic use", and if the disc required the installation of additional software in order to download. If after three minutes the study would not open, a second computer was used. For studies which required multiple computers to open, the time to load the disk was recorded from insertion to first image on the computer that opened the study.

After the images were successfully loaded, the studies were graded using a VAS 1-10 (1 - difficult to manipulate; 10 – easy to manipulate) by each surgeon for the following disk/image manipulation variables: ease of opening the disc, ability to move from image to image and/or between series, ability to manipulate the image brightness and contrast, and ability to zoom and pan.

Fisher's exact test for group comparisons and Pearson correlation coefficients were calculated using Microsoft Excel (Microsoft, Seattle, WA).

Results

The study group was comprised of 79 XRs, 29 MRI's, and 10 CT scans. A total of 40 different DICOM reader software brands were identified. Seven (6%) of the disks did not load the studies automatically and had to be manually opened, while four (3%) studies required software installation into the personal computer. Thirteen studies (11%) contained a warning stating the radiographic studies should not be used for diagnostic purposes.

One hundred fifteen of the studies (95%) could be opened and visualized using only one (the first) personal computer. Three (2.6%) of the studies required trying two different computers before the disk would open, and 2 (1.8%) required three different computers before the disk would open. Six (5%) of the studies could not be opened after trying three different computers, and this occurred with MR and CT more often that with XR (*P=0.015*). For the studies that could be opened, the average time from disk insertion to image visualization was 43.7 seconds (range 3-350). The average time to open the MR and CT studies was 65.3 seconds (range 21-191), while the time required to open XR studies was 35.2 seconds (range 5-177). The difference between time to open XR and advanced imaging studies was statistically significant (*P=0.002*).

The disk/image manipulation VAS scores are summarized in Table 1.

The average surgeon age was 49 years (range 35-63). The average time in practice was 17 years (range 3-31). The average self-perceived tech savvy score was 6.8 (range 5-10). There was a negative correlation between surgeon age and tech savvy score (r=-0.79, *P=0.003*). There was a positive correlation between surgeon age and the disk/image manipulation variables (r=.73, *P<0.001*). There was a weakly negative correlation

Table 1. VAS scores by evaluating surgeons

	Mean VAS score (Range)
Ease of opening the study	7.4 (2-10)
Ease of study manipulation (moving between images, series)	7.4 (1-10)
Ease of image manipulation (brightness/contrast/etc)	7.3 (2-10)
Ease of image viewing (zoom/pan/etc)	7.2 (1-10)

between the self-perceived surgeon tech savvy and the disk/image manipulation variables (r=-.032, *P<0.001*).

Discussion

Over the past several years, the replacement of hard copy with digital images has substantially changed how patients are evaluated and treated both in the inpatient and outpatient settings (5, 6). The goals of this method of image distribution are to limit cost and improve efficiency. However, several challenges remain, including the ability to visualize and manipulate images, as well as increased time consumed to navigate through those images. Given that time is at very limited resource during the average doctor-patient encounter, time lost related to information access may further strain the healthcare system (7).

While there are several studies in the radiology literature evaluating the efficiency of digital radiographic imaging for inpatients, we found only one other study evaluating the impact of this technology in the outpatient setting. Juenemann et al investigated the amount of time required for senior orthopedic residents to open up CD-R images of plain radiographs in an outpatient clinic (8). Their evaluation took place in a single clinic, and on one computer. They found that on average digital radiographs took 90 seconds to open.

Advanced imaging studies such as MRI and CT scans generally took longer to load than XR, which is intuitive given that these studies have more images to process. This increase in time is variable, however, and it is not clear that this could be accounted for in trying to optimize work-flow. Moreover, a substantial number of studies (5%) could not be visualized at all, which critically limits the goal of the provider to make a diagnosis and provide treatment, and may often lead to the rescheduling of the appointment. This problem is compounded by the large number of different DICOM readers (40 in 118 CD-R's evaluated), leading to unpredictability and lack of familiarity in both opening the study and managing the images.

The surgeons' perceived ease in opening the studies was relatively high (7.3 out of 10, 10 being easiest), as was the ease in manipulating the images. Despite the wide variety of DICOM readers and specific interfaces, most were easy to interact with. Some were very user unfriendly, however, as reflected in the range of VAS scores. In addition, the presence of a warning indicating that the images on the CD-R are "not intended for diagnostic use" was also present in a large number (11%) of the studies evaluated. This presents a dilemma for the evaluating surgeon since the images are used for precisely that purpose in the outpatient setting. We are not aware of any instances in which a surgeon was held liable for a decision made based upon review of an imaging study with this disclaimer. However, particularly in circumstances where the surgeon may disagree with the radiologist's interpretation, the implication of this statement is unclear.

The limitations of our study include that the assessment of how easy it is to open or manipulate images is a subjective measure. Given the differences in self-perceived tech saavy, participants may have had different expectations (of themselves or the technology) that would have influenced their VAS scores. However, such differences in information technology competency may be reflective of a larger cross section of a medical industry characterized by a broad range in medical provider age, background, and relative "technological prowess". There may also have been variances among computer systems used by participants that may have influenced the ease of opening the studies. We feel this is reflective, however, of the wide variety of work-stations found in clinical practice.

Digital radiographic imaging has become commonplace in the outpatient setting. The present systems, with multiple different software types, a variety of interfaces, and inconsistent compatibility, is replete with inefficiency and potential for frustration. Future efforts should focus on ways to streamline this process and improve surgeons' ability to open and interact with digital imaging with greater ease.

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