Smartphones for Mobile Teleradiology in Paediatric Imaging: Evaluation of Diagnostic Accuracy

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Abstract

Teleradiology is a useful practice to provide remote consultation from specialists or senior staff, when no staff is available "on-site", and a quick consultation or a second opinion is necessary. Recently smartphones with high quality display have been marketed. The aim of our study was to determine if these devices could be used for paediatric radiologic remote consultation without loss of diagnostic information. Ninety-three paediatric exams were evaluated. CT and MRI examinations were randomly chosen among performed exams and sent to two different smartphones (Apple iPhone and Nexus One -Android OS-) using a VPN encrypted connection. Two independent radiologists evaluated the images prospectively. Results were collected in a database and compared with the gold standard result (PACS system, EBIT Aet DICOMed Review v.4.1, and monitors officially certified for radiologic interpretation). Concordance between diagnostic interpretation using smartphones and the golden standard was 97.52%. Values of specificity and sensitivity were respectively 100% and 96.3%, with a PPV of 100% and a NPV of 93.0%. Missing findings were only minor ones, while the overall diagnostic interpretation was essentially the same. These preliminary results show that diagnostic accuracy of radiologic paediatric interpretation using smartphones is overall acceptable. Although such system is not suitable for long consultation sessions, they can be used for quick remote consultation on single cases.

Keywords: *Teleradiology, Smartphones, Pediatric Radiology, Medical Imaging*

1. Introduction

There is a general lack of specialised radiologists, and subspecialists such as paediatric radiologists are more and more difficult to find [1-2-3]. Our hospital is a research center, and a third level referral center for Maternal and Child Health. Since 2006, radiologists from the institute started using teleradiology from home to attend "on call" service. The team of radiologists of the institute is constantly confronted with an increasing number of calls not only for exams but also for consultations from junior radiologists or from general radiologists facing paediatric cases. We also provide external radiologic consultation via teleradiology to a children hospital in Luanda, Angola. For these reasons evaluating more flexible methods to provide remote consultation had become necessary. Recently smartphones with high quality display have been marketed [4-5]. In the same time, diffuse coverage of high-speed Internet connection allows large data flow from and to different sites outside the hospital (**Fig 1**). However, it is unclear if image quality on these devices is adequate for radiologic diagnosis. Moreover, there is a lack of data on paediatric radiologic interpretation using such devices [6-7]. The objective of this research was to evaluate if smartphones can be used for "remote" paediatric radiologic consultation without loosing diagnostic information, when compared to the standard method for radiologic interpretation [8].

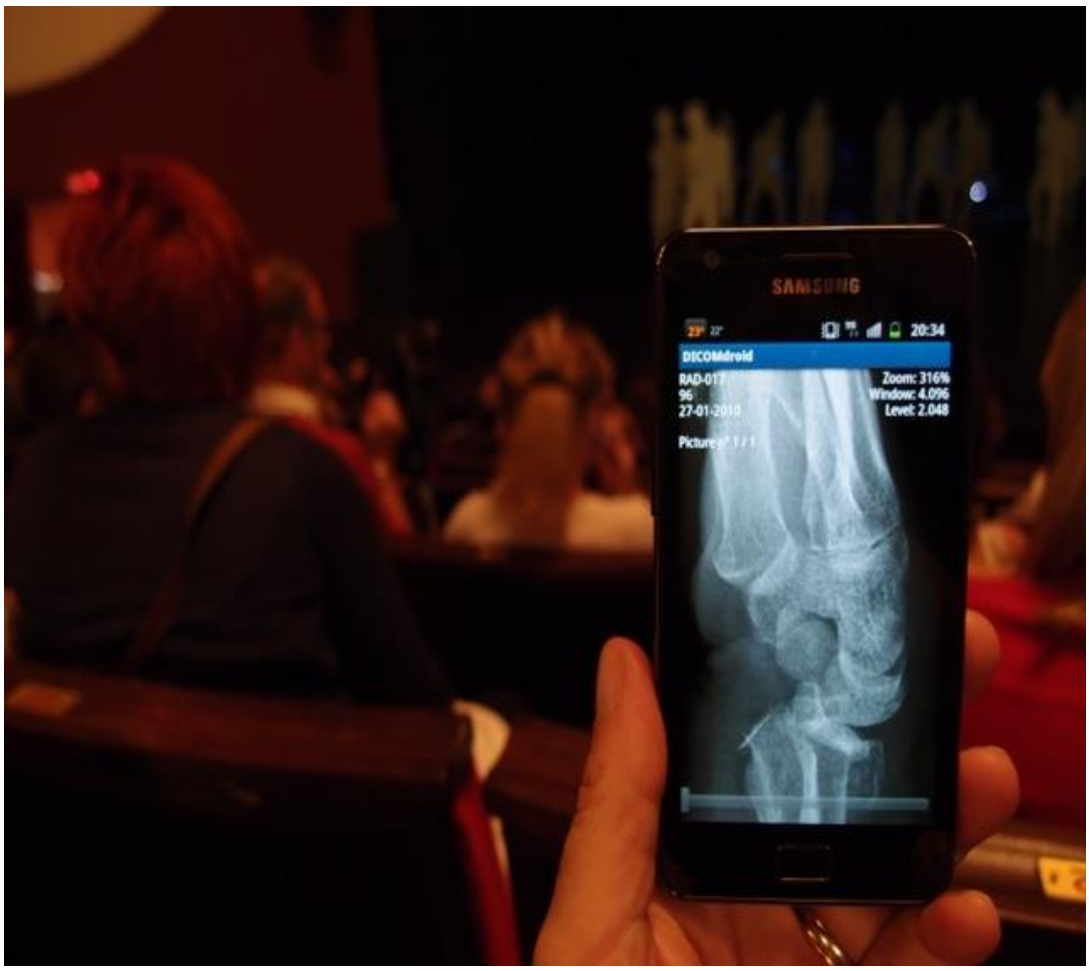

Figure 1. Example of remote radiologic consultation via smarthphone (Android using DicomDroid), from a congress site.

2. Methods

The study was carried out at the IRCCS Burlo Garofolo, a third level referral center for Maternal and Child Health, from April to May 2010. We tested two different smartphones, using two different operating systems: Apple iPhone (Apple IOS) and Nexus One (Android OS). iPhone 4 has a retina display screen, with a resolution of 960 x 640 pixels [9]. Nexus One has an AMOLED screen with a resolution of 600 x 480 pixels. Both have a 3.7 inch screen. Images were sent as DICOM files. Two image processing softwares dedicated to DICOM images were used: OsiriX v.2 was used on Apple iPhone 4, while DicomDroid beta v. 0.9 was used on Nexus One.

Both softwares are fully compliant with the DICOM standard for image communication and image file formats. Both softwares are able to receive images transferred by DICOM communication protocol from any PACS or imaging modality including the open-source dcm4chee server. They query and retrieve images from/to a PACS workstation.

Anonymous exams stored in dedicated mini-PACS were sent to smartphones using an encrypted connection based on a point-to-point secured VPN (Virtual Private Network) to ensure safe data transfer in line with European privacy regulations and IT security guidelines. The exams were interpreted prospectively by two senior radiologists. CT and MRI images were chosen because of their low matrix, usually less than a smartphone display matrix. An evaluation of the smartphones' display properties was also conducted using AAPM TG18 luminance and quality protocols and Dicom GSDF (Grayscale Diplay Function) standards, obtaining valuable results on CT and MRI images [10]. CT and MRI examinations were randomly chosen among exams performed at the Radiologic Department of the IRCCS Burlo during the two years from the beginning of the study. One slice for each CT or MRI examination was randomly chosen from each case. All findings from the radiologic evaluation were transcribed in a database built using Filemaker Bento**.** These findings were compared "in blind" with the findings resulting from the evaluation of the image using the gold standard method. The gold standard was the PACS system, routinely used in paediatric radiology department, using the EBIT Aet DICOMed Review, v.4.1 software, and monitors officially certified for radiologic interpretation, with an image resolution of 2 MB. To evaluate diagnostic accuracy, sensitivity, specificity, positive predicative value (PPV) and negative predicted value (NPV) of the findings from the image interpretation on smartphones and the gold standard (PACS system) were calculated. Furthermore, the percentage of correct classified images ((correct classified positive + correct classified negative/total population enrolled)*100) was calculated. [10]

3. Results

Ninety-three paediatric images were evaluated (24 CT and 69 MRI exams) prospectively. Examples of smartphone screen images are provided in **Fig 2**. The percentage of correct classified images was 97.52% (**tab 1**). Values of specificity and sensitivity were respectively 100% and 96.3%, with a PPV of 100% and a NPV of 93.0%. Missing findings were only minor ones, while the overall diagnostic interpretation was essentially the same. All missing findings were detected without any difficulty on a second check. There were no major differences in findings between the two smartphones. Radiologists reported a subjective sensation of fatigue after long sessions (> 0.5 hour) of image interpretation using smartphones.

Table 1. Results of image interpretation in smartphones compared to the golden standard

		GOLDEN STANDARD		
		Positive	Negative	
SMARTPHONES	Positive	78	0	78
	Negative	3	40	43
	TOT	81	40	121

Note: each image could contribute with more than one pathologic findings.

Figure 2. Comparison between OsiriX and Dicomdroid . Screenshots of iPhone (left) and Android (right) layout, showing a spine MRI using respectively OsiriX and DicomDroid software.

4. Discussion

Our study evaluated the use of two smartphones for radiologic paediatric consultation, including an evaluation of the display properties according to international standards, and the respect of IT security guidelines. Results from this pilot study confirm that there is no significant loss of diagnostic information in CT and MRI exams when smartphones are used for radiologic interpretation. However, the fact that radiologists reported a subjective sensation of fatigue after about thirty minutes of diagnostic sessions confirmed that the system is suitable for short consultation, but not for routine interpretation. The market of new products that can be used for remote consultation is evolving very rapidly, with new high quality, low-cost devices which are becoming available nearly on a daily basis. More studies are already evaluating new products, such as Tablet PC for remote consultation in paediatric imaging [11]. So far, our study has a value in showing than even basic and now "relatively old" smarthphones perform well, and have high diagnostic accuracy in paediatric radiologic interpretation.

5. Conclusions

Preliminary results confirm that there is no significant loss of diagnostic information in CT and MRI exams reported using smartphones. Radiologists have shown eye fatigue after long sessions, which confirm that the system is suitable for consultation, not for routinary interpretation.

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