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THE EVOLUTION OF E-HEALTH – MOBILE TECHNOLOGY AND mHEALTH

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Medicine has always been an information intensive field from the first days of practice, when pearls of wisdom were passed along the generations as word of mouth. Throughout history, informatics has been an integral part of medicine, facilitating the storage and accession of vast amounts of data. This has come to the culmination of present day medical practice, which is built on the foundations of Electronic-Health (E-Health). New information is rapidly disseminated through electronic access to medical journals and other relevant sources of information. Patient data is increasingly stored electronically, and reference information including textbooks are stored electronically in websites. The E-Health revolution digitized the world, and medicine has benefited immensely. Whilst having this information available electronically has numerous benefits, the delivery of this information to medical staff has been less than ideal, requiring doctors to be tied down to devices such as immobile desktop computers. The next stage in digital informatics is to gain rapid access in both storing and creating material in a convenient manner; and smartphones have been an instrumental tool in this evolution.

Smartphones have a number of characteristics which give them an advantage over other technologies, such as portability, constant internet connectivity, enough computing power to run complex applications and the simple fact that the majority of doctors have one in their pocket. In June 2011, the penetration of wireless devices amongst the US population was recorded at 102%, meaning that there were more wireless devices than the total population.1 Whilst smartphones do not account for all wireless devices, it is estimated over 75% of medical staff use a smartphone.2 Varied clinical uses of smartphones are being increasingly documented in the medical literature. The assessment of wounds by picture messaging has become ubiquitous amongst plastic surgeons, and studies have found promising results.3 Communication between medical staff and hospitals has also been facilitated greatly with the use of ‘push email’ and notifications; in addition to certain hospitals integrating paging systems with smartphone notifications.4,5 With the advent of custom designed applications, smartphone use has rapidly expanded and a number of specialties are producing innovative applications relevant to their own specialty, such as orthopaedic decision support applications,6 offsite radiology access,7 anaesthetic techniques8 or infectious disease physicians tracking epidemics9 to name a few. With continued innovation, medical applications will continue to be developed at an exponential rate. Storage of reference materials is another area which has become popularized, with many a medical student’s heavy textbooks being traded for electronic textbooks accessible in the palm of their hand.10

Whilst the smartphone has been the catalyst for the transition of E-health to mobile health (mHealth), various other mobile technologies have been introduced to the market which show promise. Tablets are now becoming mainstream with the advent of the Apple iPad, which finally took tablets from a specialist item, to something that many people find essential. Medical uses of iPads are rapidly expanding, with examples such as patient education material, reference material storage, medical education,11 and even use in research projects (as exemplified in a case report in this issue of our journal). Advances in technology have allowed specialized devices to be produced which are either mobile equivalents of large cumbersome pieces of equipment, such as ultrasound scanners, devices for deep venous thrombosis (DVT) prophylaxis,12 or devices which interface with smartphones, such as blood sugar level (BSL) monitors which can monitor and transmit results to physicians.13

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Whilst all of these developments amongst mobile technology show great promise, it is of utmost importance that the rigors of evidence based medicine are applied. Without a strong evidence base to support a product or application, one needs to be cautious about its use. New pharmaceutical products undergo demanding testing, and their efficacy needs to be proved through appropriate studies. Similarly, new technologies should also be tested through the scientific process, and their value needs to be carefully documented. Currently, there exists a gap in the literature, and no medical journals focus on documenting developments in the field of mobile technology. The launch of the Journal of Mobile Technology in Medicine represents an opportunity for doctors to be kept up to date with quality peer reviewed research articles, and provides an avenue for researchers to publish articles which will shape the field of mobile technology and its application to medicine.

References


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THE NEED FOR AN EVIDENCE-BASE IN MOBILE TECHNOLOGY IN MEDICINE

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Modern medical practice is undergoing a transformation in the way it communicates and provides healthcare. The evolution in medicine has been advanced by the human desire to provide and receive a high standard of affordable medical care within an appropriate time. A significant contribution to this has been facilitated by advances in modern technology and telemedicine. Whilst a tsunami of easily accessible technology has engaged the attention of the medical community and improved access to medical care, particularly in remote areas, there is always an element of concern regarding safety, reliability, reproducibility and accuracy of telemedicine methods.

The strength of western medical practice is the establishment of evidence-based principles and guidelines. The concept of evidence-based medicine (EBM) is to merge clinical experience and patient values with the best available research.1 The purpose of this is not to create a rigid, automated framework that eliminates the clinician’s judgement, but rather a logical framework that facilitates decision making that can be applied to the care of the individual patient. This concept of EBM is now entrenched in medical school curricula, such that junior doctors are taught to think in a more rigorous scientific framework while practicing the art of medicine.

Whilst the advent of telemedicine has the potential to improve access to patient assessment, treatment and monitoring, until such methods are validated and proven to be effective there is likely to be a degree of reluctance on the part of medical fraternity to adopt these technologies in routine practice. In 2009, Thomas et al published a study of the use of off-site display of patient parameters in several intensive care units (ICU), whereby clinicians located away from ICU were able to view patient parameters and make treatment decisions.2 At the conclusion of the study there was no significant difference in mortality and length of stay trends between the conventional and “trial” off-site telemedicine practice. Chen’s article in the New York Times portrayed the polarized sentiment of doctors on this issue.3 Clearly some may feel the emergence of telemedicine alters the clinician-patient relationship and raises concerns over patient safety. Conversely, another school of thought relates to practical considerations whereby remote access technology may facilitate timely care or referral for patients. In a vast continent such as Australia, the advent of radio communication was a critical milestone for the success of the Royal Flying Doctor Service (RFDS) in providing medical care to remote communities. At present, telemedicine accounts for one third of the 277,000 RDFS patient contacts per annum.4 These figures vindicate that modern medicine must adopt the principles of evidence based medicine in keeping up with the rising demand in order to assess what modalities of telemedicine are best suited to different environments.

The advances in technology and affordability of hand-held devices have ensured that telemedicine and mobile technology will be an integral part of medical practice in the near future. In May 2011, the Manhattan Research Group survey of medical practitioners in the United States demonstrated that 75 per cent of physicians have purchased an Apple® Inc. mobile device such as iPad, iPhone, iPod.5 Prior research by the same group concluded that almost 30 per cent of doctors were using iPads to access patient records, radiology investigations, and communicating with their patients electronically. These trends reflect the rapidly growing demand for fast, readily accessible information in order to facilitate clinical decisions in a more efficient and timely manner. A search of the Apple “Appstore” reveals over 5300 medical, health and fitness applications. These range from medical reference resources for patients and clinicians, to medical calculators, examination instruments, and information storage programs across
a spectrum of medical disciplines. Yet as the market for such “apps” increases exponentially, one must be cautious regarding the quality and utility of these applications. This is particularly relevant to software that can be readily installed onto a mobile phone with the promise of converting it into an examination instrument, for example a chart to test colour vision. It can be argued that a natural process of censorship may occur as these applications can be rated for satisfaction by consumers. However, this merely equates to level five evidence. Thus, before such applications are adopted into routine practice clearly there needs to be rigorous scientific study of their validity.

The integration of accessible and affordable health technology is one of the six pillars of an effective health system as defined by the World Health Organisation. Mobile technology is arguably one of the most dynamic fields in medicine with the greatest potential to change clinical practice for the better. In order for it to be successfully integrated into practice, healthcare workers and patients need to be assured of its scientific validity. It is therefore imperative while we transition to the use of mobile technology, we do not compromise on the principles of evidence-based medicine when caring for our patients.

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The use of mobile technology in medicine is not limited to the tablet computer or the use of the ever-popular Apple® iPhone. As semi-conductors become smaller, various devices are being redeveloped and transformed into portable miniature versions of their old previously large and cumbersome counterparts. In particular, we have seen the advancement and miniaturisation of piezoelectric transducers in the recent decade, leading to the development of portable ultrasound machines that can be utilised virtually anywhere and in settings of dire need. The most tragic and recent of those events was the Haitian earthquake in 2010, where 230,000 people lost their lives with many more injured in a background of crucial infrastructural destruction that was seemingly endless to the naked eye. Notably, one of the devices that had shaped the humanitarian effort to save lives, was (and still is) the humble portable ultrasound. (Refer to Figure 1). Are clinicians ready for the next diagnostic tool, some branding it as the next ‘pocket stethoscope’?

The use of the portable ultrasound has played an instrumental role in the humanitarian effort in Haiti. Dr. Sachita Shah, an emergency physician of Rhode Island Hospital and one of the key players in the rescue effort, states the use of portable ultrasound in “mass casualty settings” as well as rapid triaging of patients for subsequent surgical or medical management. Their team used the Sonosite Micromaxx™ device to rapidly diagnose intraperitoneal and intrathoracic haemorrhage as well as various other uses from pregnancy assessment to ultrasound guided regional anaesthesia. Studies originating from the war in Iraq have also seen the use of portable ultrasound in austere medical environments specifically demonstrating the utility of FAST (Focused Assessment with Sonography in Trauma) scanning. One large study from a mobile combat support hospital scanned 400 patients within their first 6 months of operations with a hand-held portable device. Their study noted that the use of portable ultrasound improved their diagnostic accuracy as well as prevented unnecessary transfer of soldiers to tertiary medical centres for further management. Closer to home, the FASTER (Focused Assessment with Sonography in Trauma during Emergency Retrieval) trial, a collaboration by South and Western Australian hospitals established that it was feasible for emergency physicians to conduct in-flight FAST scans using portable ultrasounds on critically ill patients en-route to definitive care, thus preventing further delays in diagnosis.

What is the role of portable ultrasounds in the ward hospital environment? Moving to a very different clinical setting, a current cross sectional study by Liebo et al. comparing echocardiograms taken by a ‘pocket mobile device’ (VScan GE® Healthcare, Milwaukee) (Figure 2) and a standard trans-thoracic echocardiogram (TTE) demonstrated highly correlative findings in most cardiac function measurements. Within the constraints of a single centre study, they found that pocket mobile echocardiography (PME) yielded accurate assessments of ejection fraction and cardiac function, however there was a variance in accuracy with mitral valve abnormalities and inferior vena cava size. Interestingly, a similar comparison study using a
different pocket echocardiograph (Acuson P10, Siemens®, Mountain View, CA) showed that there was a good correlation with standard TTE to quantify ejection fraction.6 Both studies demonstrate a stronger association between PME and TTE for the experienced echocardiographer.

The aforementioned studies and many more demonstrate the nascent capabilities of portable ultrasound in the clinical setting. Nevertheless, what is lacking are large multi-centre comparative studies identifying validity in comparison to the gold-standard, but also comparative costs, operator-reliability and a cost-benefit analysis with standard machines. The Vscan GE device mentioned above costs US$7,900, which is a small margin in comparison to the standard machines that would cost in excess of US$30,000. This, at first, may appear to be a substantial cost-saving however one must consider the cost of training physicians to an appropriate skill level that would screen examined patients and reduce the need for unnecessary trans-thoracic echocardiograms. Training doctors in mobile bedside echocardiography may not only reduce the workload for dedicated trans-thoracic echocardiogram services in public hospital, but facilitate earlier diagnosis, and thereby ensure timely management decisions. There is also the issue of the willingness of junior medical officers as well as senior doctors alike to learn a new skill and accepting it as part of the routine physical examination of a patient.

Figure 2: Pocket mobile echocardiography device. Image courtesy of VScan GE® Healthcare, Milwaukee.

Perhaps a way of introducing portable ultrasound to junior doctors would be to embed its use in the learning of anatomical sciences. Ivanusic and others investigated perceptions of undergraduate students in the use of ultrasonography for the study of ‘living anatomy’. Ninety percent of medical students strongly agreed that utilising trans-thoracic echocardiography to reinforce cardiac anatomy was an ‘effective’ teaching method as well as a sound reinforcer of the material learned.7

After discussing the economics, utilisers and politics of the use of portable ultrasound, one should also consider the technical and hardware viability especially to survive the ‘elements’ in severe environments. There have been case reports of portable ultrasounds deployed in extreme conditions from the Amazonian jungle to the International Space Station – the salient issues in regards to usage were the weight of the device and battery power.8 We were unable to obtain the operative limits in terms of environmental conditions however an unexpected degradation in battery life was noted in high temperature environments. Moreover, batteries being the only means of power in the absence of electricity was especially important in high-altitude environments demonstrated in Himalayan missions.9 10

In summary, to rationalise the use of portable ultrasound in mass casualty situations such as environmental disasters is strengthened by the fact that it aids in prompt triaging of patients as well as its role in anaesthesia. Still in contention however, is its practicability in the modern, resource-full clinical setting to aid in the bedside examination of patients. The introduction of its use in tertiary hospitals must be balanced with the cost in its initial purchase, the education of medical staff, its potential cost-savings in reducing the workload of the echocardiography department, and not to mention its propensity to optimise patient management in the ward-setting. By the ‘sound’ of things to come, it may be inevitable that the pocket ultrasound will be part of the clinician’s armamentarium alongside the humble stethoscope.

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The reliability of mobile multimedia messaging (MMS) for decision making in distal radius fractures: an effective alternative

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Background: Assessment of radiology is an integral part of fracture management in orthopaedic surgery. Mobile multimedia messaging (MMS) can be utilised in the referral process of patients with fractures. However, the reliability of using MMS in making management decisions in distal radius fractures has not been assessed.

Methods: Radiographs of 20 consecutive cases of distal radius fractures managed with closed reduction and plaster, and 20 cases managed with open reduction and internal fixation (ORIF) were analysed retrospectively by two blinded orthopaedic surgeons on a computer and an Apple iPhone 3GS. The inter- and intra-rater agreements were assessed.

Results: Inter-rater agreement between the MMS group and the picture archiving and communication system (PACS) group were consistent among the surgeons (K -0.55, 0.80, p<0.001). However, the management decisions were different in seven cases (8.75%) in the study group.

Conclusion: MMS x-ray pictures can be useful in formulating management plans for patients with distal radius fractures. With advancing technology smartphones will likely play a larger role in the communication process in delivering orthopaedic care.

Introduction
Smartphones are rapidly becoming an integral part of modern society, revolutionising the portability of information with functionalities such as high quality phone cameras, internet access and access to third party services. They also have the potential to positively impact healthcare with easier access to telemedicine.

Fracture management in orthopaedics relies on accurate diagnosis with relevant history, clinical examination, and evaluating imaging modalities such as x-rays. In busy trauma units quick ascertainment of accurate information is vital for care. Relevant history taking, and to some extent clinical examination can be directed when receiving a referral from an emergency department. However, adequate assessment of radiographs via a verbal description can be highly variable and inaccurate. This is dependent on the referrer, with variability based on experience, knowledge, language skills and the quality of the images. Picture archiving and communication systems (PACS) have revolutionised fracture care by providing easy access to orthopaedic surgeons and registrars to imaging findings. However, access to a PACS system may not always be available especially
when receiving referrals at night or from other health networks.

In these instances multimedia messaging service (MMS) can be utilized to transmit a picture of the radiological images to the specialist staff.\textsuperscript{3,4} Smartphones with cameras are readily available among doctors, and especially among junior doctors who are usually in the forefront of an emergency department. It is relatively easy to take a picture of a radiological image on a screen or film with a smartphone and to send it via MMS to the specialist staff.

Studies have evaluated the use of MMS in different aspects of surgery including plastics, neurosurgery and orthopaedics.\textsuperscript{6,7,8,9} A recent study evaluated the reliability of MMS in classifying wrist fractures, and found similar agreement rates between observers viewing mobile phone images and x-rays.\textsuperscript{10} However, classification systems of wrist fractures are cumbersome and are rarely used in clinical practice. Furthermore, there is poor inter and intra-observer reliability among distal radius classification systems.\textsuperscript{11,12} A more relevant clinical outcome is whether the management following reviewing an image via MMS is reliable when compared to viewing the images via a PACS system. To that end, a retrospective study was designed to assess whether MMS was reliable in predicting the recommended management when compared to PACS.

**Methods**

Forty consecutive distal radius fractures were identified between October 2010 and January 2011. The study inclusion criteria were patients between the ages of 20 and 70 years who sustained distal radius fractures that had presented to the emergency department. Twenty consecutive cases that were managed conservatively with closed reduction and plaster, and twenty consecutive cases that required open reduction and internal fixation were selected. Pre-operative x-rays were obtained through the hospital PACS network. Through a random number generator, three random sequences of the forty cases were created.

Two of the random sequences were used for x-ray images for the computer component of the study, where the blinded pre-operative antero-posterior (AP) and lateral images of each fracture were included in a computer presentation. The computer component was the control group, where the x-ray images of the forty cases were viewed on a standard computer monitor. The third sequence was used for the study group, which involved obtaining digital photographs of the AP and lateral images of each fracture via a smartphone camera. The study utilized the iPhone 3GS (Apple Inc, California), which is popular with doctors in Australia and is readily available. The iPhone 3GS has a 3.2 mega-pixel camera with autofocus capabilities and the images were transmitted in medium quality format via MMS on a 3G network. Analysing the x-ray images on the iPhone 3GS by viewing the MMS pictures (screen resolution 480x320, 163ppi) comprised the study group.

The study recruited two consultant orthopaedic surgeons, who are routinely involved in trauma orthopaedics with similar levels of experience at our institution. Both surgeons were not part of the orthopaedic service during the period when the forty patients were selected, and hence were not involved in their care or decision making process at presentation. Each surgeon was provided with a universal serial bus (USB) flash-drive with the two computer presentations and an Apple® iPhone 3GS with the MMS images available in the random sequence. Both surgeons were blinded to the management that the patients had received originally.

Each surgeon was requested to complete a questionnaire where they were asked to select whether the patients should undergo closed reduction and plaster, or open reduction and internal fixation (ORIF) for their fractures. The decision was asked to be purely based on the imaging provided, however, an assumption was made that each fracture involved the non-dominant hand in an otherwise healthy patient. All injuries were assumed to have been closed and the patients were neurovascularly intact. If a decision was unable to be made from the images available they were allowed to select ‘unsure’ as an option. The surgeons completed the questionnaires for each part of the study on different days.

The data was collected and was analysed through the computer statistical software, MedCalc® (Version 12, MedCalc Software, Belgium). Inter-rater and intra-rater agreement was calculated using kappa (K) values, and average measures interclass correlation coefficients (ICC) were used to assess intra-rater reliability. A post hoc power analysis was performed to analyse the adequacy of the sample size.

The K values were interpreted as per table 1.\textsuperscript{13}
### Table 1: Interpretation of $K$ values

<table>
<thead>
<tr>
<th>Value of $K$</th>
<th>Strength of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.20</td>
<td>Poor</td>
</tr>
<tr>
<td>0.21-0.40</td>
<td>Fair</td>
</tr>
<tr>
<td>0.41-0.60</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.61-0.80</td>
<td>Good</td>
</tr>
<tr>
<td>0.81-1.00</td>
<td>Very Good</td>
</tr>
</tbody>
</table>

### Figure 1: AP and Lateral views of distal radius fractures obtained from PACS

### Results

The twenty patients managed conservatively (mean age: 51 years (SD 14.5), range: 21-69) were comparable with the twenty patients managed operatively (mean age: 46 years (SD 14.7), range: 25-69). The inter- and intra-rater agreement values are shown in Tables 2 and 3.

### Table 2: Inter-rater agreement

<table>
<thead>
<tr>
<th></th>
<th>Surgeon A</th>
<th>Surgeon B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(K-value)</td>
<td>(K-value)</td>
<td></td>
</tr>
<tr>
<td>Computer 1 vs Computer 2</td>
<td>0.899</td>
<td>0.914</td>
</tr>
<tr>
<td>Computer 1 vs MMS</td>
<td>0.795</td>
<td>0.552</td>
</tr>
<tr>
<td>Computer 2 vs MMS</td>
<td>0.798</td>
<td>0.552</td>
</tr>
</tbody>
</table>

Inter-rater agreement was excellent within the control groups, where the images were assessed on a standard computer screen via the PACS images by both surgeons (K- 0.90, 0.91; p<0.0001). The inter-rater agreement between the study group and the control groups were consistent among the surgeons (K- 0.55, 0.80 respectively, p<0.001). However, the intra-rater agreement was varied in the study group between the two surgeons (K- 0.69, p<0.0001), whereas the control groups had very good intra-rater agreement (K- 0.91, 0.82, p<0.0001).
Table 3: Intra-rater agreement

<table>
<thead>
<tr>
<th>Surgeon</th>
<th>Computer 1</th>
<th>Computer 2</th>
<th>MMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>0.82</td>
<td>-</td>
</tr>
<tr>
<td>X</td>
<td>-</td>
<td>-</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Between the study and control groups, MMS led to different management decisions in seven patients (8.8%, n= 80). Three (3.75%) patients were assigned to conservative management, where reviewing the PACS images deemed that they required surgery, and four (5%) patients were opted for surgery instead of conservative management. Three (3.8%) cases were selected as being 'unsure' in the MMS group compared to two (2.5%) in the computer group. Only surgeon B had selected the 'unsure' option, and when these five patients were excluded in a sensitivity analysis, the inter-observer reliability improved to $K$ of 1.00 for PACS images, and 0.72 for MMS. Interestingly, when comparing the management that the patients had received and the study recommendations, both the MMS and the computer groups were similar (ICC0.83 vs. 0.88 respectively, $p<0.0001$).

A post hoc power analysis was performed with the worse-case scenario results: correlation of 0.55, alpha value of 0.05 and beta of 0.20. A sample size of 23 would have been sufficient to reach significance.

**Discussion**

Distal radius fractures are one of the commonest fractures faced by orthopaedic surgeons. Careful attention to detail when reviewing radiology is perhaps more important in making management decisions for these fractures compared to other common limb fractures. Surgery is commonly recommended in the presence of radiological findings such as shortening, angulation and articular defects. As such, distal radius fractures were used as the focus of this study. The number of cases where a management decision was unable to be made was similar between the study and control groups (n= 3 versus 2 respectively), which suggests that the clarity of MMS images is sufficient.

The use of smartphones is spreading, especially among the new generation of doctors. Eighty-five per cent of ACGME trainees in the United States owned a smartphone, where the iPhone was the most popular at 56%. The study utilized the iPhone 3GS, however, the newer version, iPhone 4GS has better camera capabilities and superior screen resolution. Other smartphones in the market also encompass excellent camera functionality and screen resolutions. It would be an interesting focus of research to assess whether improved technology leads to more consistent decision making or not. Initial limitations to telemedicine, especially the cost of setup are being dissolved by the widespread availability of these devices, their ease of use and advanced functionality. Smartphones will likely change the availability and access to specialist healthcare especially in rural and remote communities.

The quality of the radiology is dependent on the quality of the images obtained. In orthopaedics, plasters can routinely affect the picture quality. The current study did not evaluate the quality of the initial images and whether this had an impact on the photographs taken by the camera phone. It is unclear whether taking a digital photograph of an already poor quality image will further reduce its ability to be interpreted. Future research is required to address this issue.

The variability between the initial treatment received by the patients and the current treatment recommendation in the study may be due to surgeon preference. The surgeons involved in the study were younger consultants, who may perhaps have a stronger inclination towards surgical management of distal radius fractures. Furthermore, patient factors are an important determinant of management decisions that were not considered in the study.

The major strength of the current study is that the endpoint was assessing management decisions, rather than accuracy of fracture classification. This is a more clinically relevant endpoint. It’s retrospective nature (although neither surgeon was involved in the initial management of the patients) and recall bias are potential weaknesses. Other common fractures such as ankle fractures or neck of femur fractures should also be the focus of future research to assess the extent to which the findings can be generalised.

**Conclusion**

MMS with smartphones is a useful tool in assessing radiology images to formulate management plans in distal radius fractures. It can positively impact the communication of information from emergency...
department staff to orthopaedic surgeons to make effective treatment decisions.

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Orthopaedic surgical technique guides: are they readily available in an electronic format?

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Background: New developments in mobile technology have had a profound effect on medical care worldwide.¹ In orthopaedic surgery a variety of implants and devices are used, and knowledge about their designs, specific features and surgical techniques is essential. The purpose of this study was to assess whether orthopaedic surgical technique guides are readily available in an electronic format.

Methods: A list of thirty-two orthopaedic device companies currently trading in Australia was generated through a structured internet search and by reviewing a tertiary hospital database. The Apple store was searched for iPhone or iPad surgical technique applications for each company. Company websites were searched for downloadable surgical technique guides. Companies without downloadable surgical technique guides or iPhone applications were contacted via email or telephone to ask whether such products were in development.

Results: Of the thirty-two orthopaedic device companies studied, twenty-two (68.8%) had surgical technique guides available for download on their websites. Four (12.5%) companies had an iPhone or iPad application available in the Apple store.

Conclusion: Although many orthopaedic device companies have downloadable surgical technique guides on their websites, only a few had iPhone or iPad applications for their products. Further development of such products may be beneficial for orthopaedic surgeons.

Introduction

New developments in mobile technology have had a profound effect on medical care worldwide.¹ Smartphones have been the latest revolution in telecommunication.²,³ The United Kingdom’s National Statistics report growth in mobile phone ownership from 65% in 2001 to 81% in 2009.² Due to their powerful computing capability, sizable memory, large screens and effective operating systems, the latest generation of smartphones are commonly viewed as handheld computers rather than telephones.²,³ With thousands of medical applications available in Apple’s App Store, physicians use the Apple ® iPhone and iPad as portable medical libraries.⁴ These new modalities of information access provide new opportunities for orthopaedic surgeons, allowing them to integrate technology into clinical practice.²,³ A database search revealed that iPhone and Android platforms have applications specifically created for orthopaedic surgery.⁵ In the United States, 84% of orthopaedic health professionals currently use a
smartphone, and 53% use applications in their clinical practice.\(^5\) Ninety-six per cent of respondents stated they would like to see more applications available.\(^5\)

In orthopaedic surgery a variety of implants and devices are used, and knowledge about their designs, specific features and surgical techniques is essential. This information is generally provided by orthopaedic device companies in booklet form and via their company representatives. The development and distribution of mobile applications, with their portability, updatability, speed and simplicity, make them an ideal tool for quick reference, especially in the operating theatre.

The purpose of this study was to assess whether orthopaedic surgical technique guides are readily available in an electronic format.

**Materials and Methods**

A list of thirty-two orthopaedic device companies currently trading in Australia was generated through a structured internet search and by reviewing a tertiary hospital database. The review was conducted by a single investigator. All company’s websites were searched for downloadable surgical technique guides for their products. If a username and password was required to download such material, this was recorded. The Apple store was searched for iPhone or iPad surgical technique applications for each company. Companies without downloadable surgical technique guides or iPhone applications were contacted via email or telephone. They were asked whether they planned to release such information on their website or to develop an iPhone application.

**Results**

Of the thirty-two orthopaedic device companies studied, twenty-two (68.8%) had surgical technique guides available for download on their websites. The other ten (31.3%) companies had some product information available but surgical technique guides were not provided. Six of the twenty-two (27.3%) companies with downloadable surgical technique guides required a username and password to access these documents.

Four (12.5%) companies (Synthes®, Stryker®, Depuy®, and Acumen®) had an iPhone or iPad application available in the Apple store, while two (6.3%) had declared they had applications in development. An example of an iPhone application is demonstrated in Figure 1. Twenty-six (81.3%) companies did not have an iPhone application.

![Synthes® iPhone application screenshot.](image)

**Discussion**

The use of smartphones and applications is prevalent among orthopaedic residents, fellows and consultants, and most surgeons with smartphones use applications in their medical practice.\(^2,5-7\)

Multiple iPhone and iPad applications are available for use in different medical disciplines including neurosurgery, paediatrics and anaesthetics, and for different audiences from medical students to consultants.\(^8-11\)

New applications are released regularly, many free of charge. There are a number of applications that are designed for the iPhone that can be used on the iPad.\(^12\)

Our study showed that only a few orthopaedic device companies provided an iPhone or iPad application for surgeons to use. There may be a number of reasons for this. Firstly, the need for these applications may not be appreciated by device companies, who may feel that currently available resources suffice. Secondly, the companies that currently have applications for iPhone or iPad are the largest providers of orthopaedic equipment and devices, so perhaps the number of products provided by smaller device companies does not warrant investment in applications for smartphones or tablets. Thirdly, device companies may be concerned that patients, and possibly other companies, have access to their product information.
An additional consideration is that this study only reviewed the Apple “App” Store as these are the predominant devices in use at present. However, the Android® application market is growing and needs to be evaluated in future studies.

A recent report revealed that the health-care market has been slow to integrate into the information superhighway because of concerns with regard to patient security, confidentiality, physician liability, and reliability of information. This may be one reason that orthopaedic device companies are reluctant to release product information in an electronic format.

Another important point is that currently available applications are sponsored by private companies which may not be required to adhere to any standard for medical content or accuracy. If this trend toward the use of privately funded educational material continues, regulations may need to be established to ensure that the information provided is accurate, honest, supported by peer-reviewed literature, and is free from conflict of interest.

Conclusion
The majority of orthopaedic companies provided surgical technique guidelines in an electronic format. Only a minority of companies provided iPhone/iPad applications with this information. Further development of such products may be of benefit to orthopaedic surgeons.

References

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USE OF A SMARTPHONE FOR MONITORING DERMATOLOGICAL LESIONS COMPARED TO CLINICAL PHOTOGRAPHY

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Background: To compare the use of a personal device such as an Apple iPhone 4 against formal clinical photography in monitoring skin lesions.

Methods: Clinical photography was used to photograph 10 skin lesions and these images were compared to photographs taken by an iPhone. These images were then reviewed by 5 different dermatologists to determine whether a discernible difference in image quality was apparent, and if sufficient detail was present to use the images taken from the iPhone in the clinical setting.

Results: All 5 dermatologists correctly identified all 10 skin lesions taken by clinical photography and those which were taken by the iPhone. Forty seven of the 50 dermatologist responses indicated both photographs provided enough detail to be clinically useful, although only 9 of the 50 responses indicated the same detail was seen in both images.

Conclusion: Although the quality of images produced using clinical photography is superior to those produced by the iPhone, pictures taken by an iPhone may provide sufficient detail for clinical assessment of skin lesions.

Introduction
Clinical photography is used in the medical profession to monitor and record various anatomical structures, wounds and lesions.¹ While providing a useful clinical tool, costs and access can limit its use. With technological advances in portable devices such as personal cameras or smartphones with built in cameras, the ability to record and send information quickly and simple would have clear advantages over clinical photography, if image quality did not lead to a compromise in patient care.² For certain lesions such as moles, clinical photography needs to be accurate and of high quality to monitor the subtle changes that occur over time. In this area, patients with multiple moles being screened for a lengthy period of time can accrue hundreds of photos, all of which require storage and come at considerable cost. Our project tests whether a picture taken on a patient’s own smartphone could be used as a cheap alternative to clinical photography, allowing patients to track and keep their own lesions.

Methods
A single subject was used to clinically document 10 skin lesions using clinical photography and an Apple iPhone 4. All lesions were first were photographed by clinical photography, with the same 10 lesions then being photographed using an iPhone.

Clinical photography uses a Nikon® D700, 105 mm macro lens, (4256x2832 pixels) and studio flash lighting. All photographs were taken following standardised views and magnifications.

Using the iPhone, we aimed to replicate similar conditions to what patients and general practitioners would be able to capture images with a well-lit room. The Apple iPhone 4 uses a 5 megapixel camera (2,592
x 1,936 pixels) and also uses a built-in high dynamic range imaging (HDR) effect, which captures three photos – one underexposed, one overexposed and one neutral – and then combines them to create an image with better dynamic range.\(^3\)

Each lesion was photographed using the Nikon D700 and the Apple iPhone 4. All images were subsequently printed to a standardised dimension of 10x15cm on photo quality paper by the same printer. An example of both images are presented in Figures 1 and 2. The pair of images were then presented to the dermatologists who were blinded to the method in which the image was taken. They were then asked the following questions:

1) Which image was the best quality?
2) Did both images have adequate detail to make a clinical decision?

Results
A total of 10 skin lesions were photographed with both cameras. Five dermatologists provided opinions on all 20 images. All five dermatologists found clinical photography images to be of superior quality in every skin lesion image. Forty-seven of the 50 dermatologist responses indicated both photographs provided enough detail to be clinically useful (Figure 3).

Discussion
Current literature indicates dermatologists are able to provide a more specific diagnosis with the aid of clinical photographs, in particular with regard to evaluation of inflammatory skin diseases and pigmented lesions.\(^4\) It has also been shown that dermatologists can make a correct diagnosis from an image without history,\(^2\) and this is true even when the lesion is not in the centre of the picture\(^6\) or the image has low resolution.\(^5\)\(^6\) This study has highlighted that although the quality of images produced using clinical photography is superior to those produced by an iPhone, this technology can still provide useful clinical information. The Apple iPhone 4, using a 5-megapixel camera can produce images that are of higher quality than standard resolution images of less than 3 megapixels, which have previously been deemed sufficient to monitor dermatological conditions.\(^6\) A personal device such as an iPhone allows images to be kept by a patient to show to the various professionals involved in care, and images can be uploaded or sent from the device. Furthermore it offers a relatively inexpensive alternative to clinical photography, which may not be practical in certain situations such as rural and remote practice.

Further studies are needed to ascertain the ability of smartphones in monitoring lesions that are subtle and clinically challenging.

Conclusion
Smartphone cameras have progressed to an extent they are able to provide image quality, which is of sufficient detail for clinical use in dermatological practice. It must however be noted that the image quality from clinical photography is currently superior to that of an Apple iPhone 4.
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Original Article

QUALITATIVE STUDY ON THE APPLICATIONS OF SMARTPHONES IN MEDICAL RESEARCH

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Background: Mobile technology advancements have bought many benefits to professionals across all industries, particularly an increase in productivity. There is a paucity of information regarding the use of smartphone applications in medical research, particularly within the laboratory has not been examined.

Method: We performed a qualitative study on the use of smartphones in the laboratory. Medical researchers were surveyed regarding use of their smartphones in the laboratory, as well as the use of apps, or “applications”. We also performed analysis on available applications and current standing of smartphone integration with laboratory equipment.

Results: Survey responses indicated researchers to be more productive as a result of owning smartphones, however most did not utilise applications, and none utilised field-specific applications in the laboratory. Several issues preventing researchers from using their smartphones and applications in the laboratory were identified. These included occupational health and safety reasons, security, potential for distraction, absence of wireless connectivity, and a lack of awareness. Analysis of iPhone applications demonstrated availability of a range of reference and functional applications performing essential laboratory tasks.

Conclusion: This study demonstrates that smartphones are currently not used to their full potential within the laboratory, and there are hurdles to overcome before wider use in the field of medical research. However as time and technology progresses further, and with increasing integration of smartphone technology with current laboratory equipment, researchers will embrace the smartphone as a cost-effective and timesaving device.

Introduction

Smartphones have proven to be powerful tools in the workplace, increasing connectivity and productivity. Some of the benefits in the workplace are seen as negative as the smartphone can be complex and distracting. The prospect of being able to be contacted at anytime is often seen as an invasion of personal time. Despite this, smartphones have a function in all aspects of life, and their use is increasing dramatically.

The smartphone is considered different to other mobile phones due to the presence of advanced computing systems, notably with high-speed internet access via wi-fi and mobile broadband. With constantly evolving features, such as large touch screens, QWERTY keyboards, web browsers, inbuilt cameras, Global positioning systems (GPS) and voice command, smartphones have become powerful and essential tools. In addition, smartphones have available to them a vast range of applications which can be downloaded onto the smartphone from the
internet. A global study in 2011 conducted by Google®
1 demonstrates 37% of Australians utilise smartphones; they have an average of 25 applications
on their smartphone, including 8 paid applications. Much of the growth in smartphone use is attributed to
the Apple® iPhone, which is used by 46% of surveyed smartphone users globally.

Organisations and individuals have developed applications, which allow people to be more efficient
and flexible; to perform tasks on-the-go where they would normally require a computer. The smartphone’s
ability to handle complex programming has allowed the generation of applications which perform highly
specific functions for a range of professionals. Within the medical field, an ample quantity of applications
exist, including diagnostic protocols, guidelines, and drug reference applications for clinicians across all
disciplines of medicine. Applications also exist which allow patient monitoring, where patients are able to
log in data or symptoms online. For example, the Apple iPhone accelerometer allows measurement and
monitoring of tremors for patients with Parkinson’s disease from any location2, arguably more accurately
than previous methods within the doctors office.

There are many applications available for medical researchers in the laboratory. They provide access to a
wide range of information ranging from reference guides for molecules, chemicals, medical journals and
databases, to laboratory technique guides and calculators. However, the use of the smartphone
specifically by medical researchers in the laboratory has never been examined.

Therefore, the aim of this study was to investigate the utilisation of smartphones in the field of medical
research by performing a qualitative survey. To the best of our knowledge this study is the first to
examine issues encountered with smartphone use in the laboratory, and applications usage. In addition, we
discuss the availability of applications for the Apple iPhone for use in the laboratory.

Methods
An online survey was generated consisting of 10
questions, with a combination of multi choice and
discussion responses required. Being a qualitative
study, a total of five surveys were completed
anonymously. In conjunction with the survey, three
researchers were interviewed. Researchers consisted
of research assistants, post doctoral and postgraduate
(PhD in Medicine) staff covering a range of skills and
experience in non-clinical medical research at
Monash University, Clayton, Australia. The survey
questions were structured to include individuals that
did not use smartphones, as well as those that may
use applications. Responses were analysed and key
issues were extracted and discussed. Interviewed
researchers were asked to elaborate on their issues
with smartphones in the laboratory and what they
would consider a useful application.

Information on available applications for the Apple
iPhone, the predominant smartphone used by
surveyed staff as well as in Australia, was gathered by
searching scientific forums and websites, and by
entering a range of key words in the Apple iTunes
Application store, including laboratory techniques
and field-specific words. Several applications were
downloaded and used on an iPhone 4S, including
multiple applications performing similar tasks, and
their functions and usability were compared.

Results
All surveyed and interviewed researchers owned
smartphones; with the leading smartphone being the
Apple iPhone. Researchers classified themselves as
more productive as a result of owning a smartphone.
Specifically, researchers indicate that accessing
email, calendars and to-do lists, contacting colleagues
and transferring data were the ways in which the
smartphone was most beneficial to them at work.
Only 2 of the 5 surveyed researchers utilised
applications; none of which were field-specific. These
applications simply consisted of a timer and basic
calculator. Further, these functions were utilised
during experimental planning, but only occasionally
within the laboratory.

Limitations for smartphone use in the laboratory
Scientists surveyed sometimes, rarely or never carry
their smartphone into the laboratory. Survey
responses regarding reasons why researchers do not
carry their smartphone into the laboratory or use
applications were analysed and themes were evident.

Occupational health and safety
Concern for occupational health and safety was a
major issue for most researchers. Laboratory work
involving bio-hazardous substances such as human or
animal fluids and tissues, and corrosive chemicals do
not allow a safe environment for any personal
belongings. Survey responses indicated that the
removal of gloves and protective gear to access a
phone can be troublesome and disruptive during
experiments.

Security
Some researchers claimed that their laboratory space
is not secure enough to leave personal belongings;
and often not having pockets on clothing means the phone cannot be carried personally.

Distractions
Researchers also state that having their smartphone in the laboratory with them can be distracting. This includes distractions with phone calls, text messages and email notifications as well as social networking sites and games.

Absence of wireless network within the laboratory
The particular building in which surveyed researcher’s laboratories were located did not provide a wireless network. An intranet system containing staff contact details was suggested by one researcher to be a potentially convenient function to increase connectivity within the workplace.

Lack of awareness
One issue faced when searching for applications for this study, was the difficulty in finding themes the correct key words had to be used. Some researchers suggested the need for applications within the survey, which unaware to them, already existed. For example, one researcher stated:

“If there was something particularly unique that I couldn’t use other equipment for when I’m in the laboratory.”

A few researchers stated that they were happy with their current methods and did not think that an application would be beneficial to them.

Discussion
While researchers state that their smartphones have made them more productive in the workplace by making them more organised, this is independent of applications. From this study, it appears that the benefits of smartphones and applications do not necessarily outweigh the negatives for researchers.

The limitations discussed may have solutions to overcome them. Upon examining the issues stated by researchers, it became apparent that research institutes and workplaces need to adapt to the increasing use of smartphones by their researchers. Surveyed researchers were unaware of available applications, indicating workplace involvement to increase awareness of field-relevant applications is required. Promoting increased security within the laboratory, such as restricting access to laboratories via card-only access or personal lockable drawers or lockers and increasing awareness for occupational health and safety rules regarding safe areas for personal belongings could allow researchers to carry their smartphones into the laboratory more often. Waterproof protective casing for smartphones or lanyard attachment would allow researchers to use their phones and comply with experimental conditions. A recent editorial mentioned the possibility of a removable skin. Furthermore, providing information on how to manage settings on smartphones to restrict notifications for emails and phone calls and social networking sites may reduce distractions in the laboratory.

Wireless internet connections allow access to parts of buildings such as basements in which service provider broadband networks are not accessible. Particularly where smartphone plans or contracts are not covered by employers, researchers may be reluctant to access the internet for work purposes. Further, an intranet network for staff to access useful links such as journals, reference guides, calculators relevant to their field of research and staff contacts may be beneficial for all smartphone researchers.

Many people who own smartphones are not necessarily technically knowledgeable; and with smartphones now being more affordable, many people own smartphones with little interest in most of
its functions. Some researchers indicated that they were satisfied with their current techniques. For some, the complexity of the smartphone is daunting. However, as time and technology advance, many will “fall behind” and miss out on the many advantages of owning a smartphone, and therefore may benefit from some encouragement from employers and colleagues.

A range of applications are available for researchers covering everyday laboratory tasks. Here we discuss some applications found available for the iPhone. Life Technologies have developed a free application providing all the essential calculators- molarity, dilutions and unit conversions. Celeromics® Cell Count application allows continuous counting of squares, viability percentages and nice large easy-to-tap buttons on screen. Several laboratory timer applications are available, ranging from no cost to a few dollars. Major biotechnology company Sigma – Aldrich® have produced a slightly cumbersome 6-timer application, in contrast much simpler timers exist providing quick access buttons ideal for hectic experiments. Applications covering more specific laboratory techniques are covered, including Real time- Polymerase Chain Reaction (PCR). Bio-Rad® real-Time PCR is an easy to use interactive guide to the technique. BioLegend® have developed a range of reference applications, including a cytokine and chemokine guide for both mouse and human. They have also developed a flow cytometry guide application, which includes a fluorochrome guide, as well as a timer and antibody calculator.

Reference guides are available in the form of applications, useful both inside and outside the laboratory. Particularly useful is the MSDS (Material Safety Data Sheets) available in the Chemical Safety Data Sheets application; this application in conjunction with a text recognition system would be highly convenient. Genetic code contains nucleic acid and amino acid properties. Many scientific and medical journals have released applications intended for medical professionals, including The New England Journal of Medicine, Nature Publishing Group and databases such as Science-Direct, particularly useful with an institution subscription allowing access to any journal or book.

A new aspect of research dedicated to combining the functions of laboratory equipment with the convenience of the mobile phone is now well underway. The replacement of with the camera phone is now a possibility, with a study utilising the phone camera function to detect Enzyme linked immunosorbent assay (ELISA) results. A large range of studies exist examining the combination of microscopy components with the mobile phone, including fluorescence microscopy. Hardware attachments to the phone allowing flow cytometry functions have also been explore. Using the smartphone to store and transfer data is also a useful function in the laboratory, including those located in remote areas, where microscopic images can be sent for analysis or diagnosis immediately.

Upon analysis of the above applications available for the medical researcher, it is clear that applications can provide many benefits for a researcher particularly regarding time management and productivity both inside and outside the laboratory. The primary advantage is that multiple functions are conveniently available in one device. Most of the analysed applications were free of charge, and the most expensive applications were less than five dollars (Australian currency). For the more sophisticated functions, significant benefits exist to the laboratory. Complex machines such as spectrometers, flow cytometers and microscopes with their associated computer systems are a large financial burden on laboratories. The prospect of smartphone applications or hardware attachments would save money and space, and be particularly beneficial to lower income laboratories.

Conclusion
This study demonstrates that while researchers believe that smartphones have the capability to increase productivity at work. However, some limitations apply in the laboratory. Upon analysis of survey responses it appears that researchers have the potential to be even more productive with a smartphone. However, there needs to be increased involvement with employers and a heightened awareness of its potential. With the emphasis on the ‘hands free’ utilisation of smartphones, and the plethora of novel research examining the integration of complex laboratory equipment components, the future of smartphone usage in the laboratory is indeed promising.

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Case Report

Standardised operational procedures are important in randomised controlled trials as these help to minimize unwanted sources of variability. Standardisation procedures may be used to orient and train participants as well as research staff with respect to study protocols. In interventional trials involving task performance, use of a standardisation procedure helps ensure that participants have an adequate understanding of the intervention and are able to perform this correctly and consistently prior to formal assessment. This report describes the use of a video displayed on a tablet device to enhance the standardisation procedures of a recently conducted randomised controlled trial. Participants received uniform exposure to instructions. The process was successful and was found to be acceptable.

Introduction

Standardisation is an important tool used by investigators to enhance the likelihood of detecting an intervention effect if one in fact exists. Variability may be introduced at the level of the intervention or at the level of outcome assessment. In the setting of a randomised controlled trial, standardisation procedures may be used to ensure that the intervention and/or outcome ascertainment is performed consistently and as outlined in the study protocol. Hence, when conducting clinical and non-clinical research, it is important to ensure that study operating procedures are standardised to minimize potential sources of variability apart from the intervention of interest. Variability is not the same as bias, as bias refers to systematic deviation from the “truth”. Data may be accurate but not precise (variability) or precise but inaccurate (bias). Both are problematic from a research perspective: bias risks over or underestimation of treatment effects; while imprecision negatively affects study power and increases the risk of a type II error.

The need for clearly defined interventions is reinforced in the most recent CONSORT Guidelines. The corollary to this is the requirement for investigators to ensure that these well-defined interventions are applied with rigour and consistency across all participants in the study. This report describes the use of a tablet device as part of study standardisation procedures in a recently conducted randomised controlled trial.

The trial referred to in this article was approved by the Hamilton Health Sciences/Faculty of Health Sciences Research Ethics Board, and is registered at ClinicalTrials.gov (NCT01494116). The study was conducted in accordance with the Tri-council Policy Statement on the ethical conduct for research involving human subjects.

Methods

Forty-eight participants were enrolled in this trial and were tested from October to December 2011. As part of the study protocol, each participant completed the standardisation procedure prior to formal assessment. Testing involved participants performing an intervention on a resuscitation model with the primary
outcome of interest being the amount of time that it took to perform the procedure. As such, it was important to ensure that each participant clearly understood the procedure to be performed and had an opportunity to practice prior to formal testing.

Standardisation procedures can take various forms including printed instructions, explanation using a scripted text, demonstration by a Research Assistant, and/or the requirement to travel to an expert training centre. In order to allow timely transmission of both visual and auditory information to participants, a standardisation video was used in this study. The decision to use a video to explain study procedures, including a demonstration of the intervention, facilitated the complete standardisation of the standardisation procedure itself across our study population. Each participant heard the same instructions and saw the same demonstration delivered in the exact same way. Participants then had a brief opportunity to practice in order to reduce variability attributable to the training or learning phase.

The standardisation video was created with use of a Canon VIXIA HF R20 HD camcorder. Video data was then transferred to an Apple iMac computer (model iMac12.2) for review and video editing using iMovie ’11. Once the standardisation video was finalized, it was then uploaded to iTunes 10 to enable transfer onto an iPad 2 tablet device, trademark of Apple Inc. (32 GB with Wi-Fi, Apple model A1395). As is required for all data files, transfer of the video file from iTunes onto the iPad was achieved through synchronization of the iPad with the iMac computer. The standardisation video could then be easily launched from the iPad using the touch pad screen, which also served as the video display. (Refer to Figure 1).

The standardisation video used in this study was 3 minutes, 20 seconds in length. The video included an explanation of the study premise, an orientation to testing equipment and the model, and a demonstration of the procedure to be performed. A single Research Assistant was responsible for coordinating participant testing, including administering the standardisation procedure through use of the iPad. Minimal training was needed to orient the Research Assistant to the iPad, which she had not used previously.

Discussion

The process results in each participant viewing the same instructions and demonstrations in a consistent manner. The Research Assistant did not encounter any technical difficulties using the iPad during the course of the study and in fact spoke highly of its ease of portability and ease of use. Many of the participants who participated in this study also offered spontaneous positive comments regarding their experience viewing the standardisation video using the iPad.

Use of a tablet device as part of study standardisation procedures is not without its potential limitations. To achieve the intended purpose, the Principal Investigator must ensure that standardisation videos are clear and accurately reflect the study protocol. Specific instructions should be provided to any staff tasked with creating a standardisation video. The video narrator should use simple language and avoid the use of any unnecessary technical terms. Demonstrations should be filmed in a well-lit environment, and walk the viewer through the procedure or technique in question in a stepwise manner. Researchers may opt to show the standardisation video to individuals not participating in the study to ensure clarity prior to use with study participants. Additionally, while an iPad was used in this study, alternative tablet devices could be used for similar purposes. These devices may make it easier to transfer video to the tablet.
Conclusion
This report describes the successful use of an iPad to administer a standardisation procedure in the setting of a randomised controlled trial. It is easy to envision how tablets could be used to facilitate other aspects of standardisation in the context of research studies, including training modules for research assistants and laboratory technicians.

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Both Ms. Manan and Dr. Harvey have consented to being acknowledged in this article.

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