Smartphones in orthopaedics: a decade of innovation

ABSTRACT

Smartphones have become a mainstream feature in medicine since the introduction of the Apple iPhone in 2007. Over the last decade they have taken on increasing prominence with multiple uses in daily practice. They have long been used for group messaging and accessing patient's electronic records while mobile. More recently, however, smartphones have allowed clinicians to improve patient assessment in clinic and manage follow-up appointments remotely. Furthermore they have been used to aid procedural tasks in surgery and provide a medium for simulation training for junior doctors. The role of smartphones in the future is predicted to increase exponentially and there will no doubt be countless further roles for them in the ever-expanding field of orthopaedics.

Although smartphones have been used since the 1990s, they were popularised in 2007 with the introduction of the first-generation Apple iPhone. The following year, Google introduced the Android operating system, which they allowed third party manufacturers to use, helping Google gain 85% of the market share as of 2018 (IDC, 2018). As the two main platforms have grown, so have the number of applications which are available on their respective systems, with as many as 1000 new applications developed per month (Wong et al, 2015).

An article in 2015 found that about 99% of doctors own smartphones, with almost 90% of them stating they find them useful for clinical practice (Mobasheri et al, 2015). In 2012, a review of the use of smartphones in orthopaedic surgery described innovative roles for smartphones in the medical sector (Al-Hadithy et al, 2012). However, there has since been a rapid growth and development of applications and uses. Furthermore, there has been increasing research into the efficacy of these new applications and whether clinical benefits have been realized. This review discusses the new uses of smartphones for the orthopaedic surgeon.

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Communication

A rising number of orthopaedic teams use group-texting applications, with WhatsApp being the most common. These carry the advantages of rapid decision making from a pooled group, easier delegation of tasks and mass dissemination of information. They also act as a forum where interesting or educational learning points could be shared. The main disadvantage is the potentially serious breach in information governance as no individual is legally responsible for the data (Donati-Bourne and Cooke, 2017). This becomes more important given the recent General Data Protection Regulation which provides a legal framework for data protection for all individuals within the European Union.

Patient's electronic records

There has been increasing political pressure for the NHS to move to electronic patient record systems. The Department of Health has been pushing this to NHS trusts as there is increasing evidence that electronic patient records can improve health care, reduce frontline staffing requirements, and help with clinical coding and remuneration (Hillestad et al, 2005; Donati-Bourne and Cooke, 2017). An example of an electronic patient record accessible via smartphones is EPIC Haiku (*Figure 1*), which allows doctors to access clinic schedules, hospital patient lists, health summaries, test results and notes. It also allows clinicians to capture images and upload them directly into the patient's notes (Ai et al, 2017).

Orthopaedic assessment tools

As smartphones have developed, so has the technology they contain, with newer phones having the ability to sense acceleration and inclination. This has enabled smartphones to be used as goniometers to assess range of motion in the elbow (Behnoush et al, 2016), knee (Ferriero et al, 2013) and first metatarsophalangeal joints (Otter et al, 2015) (*Figure 2*), with several studies demonstrating higher reliability than traditional hand-held goniometers (Ferriero et al, 2013; Otter et al, 2015). Furthermore, they allow direct transfer from measurement to an electronic format.

Several authors have used the camera and accelerometer to determine the inclination angle during total hip arthroplasty. Peters et al (2012) placed an iPhone into a sterilised sealed plastic bag and held it parallel to the acetabular cup introducer. This determined the inclination angle correctly to within 1° of the desired angle, all within the safe zone as described by Lewinnek et al (1978).

Figure 1. EPIC patient record (https://play.google.com/store/apps/details?id=com.epic.haiku.android&hl=en).

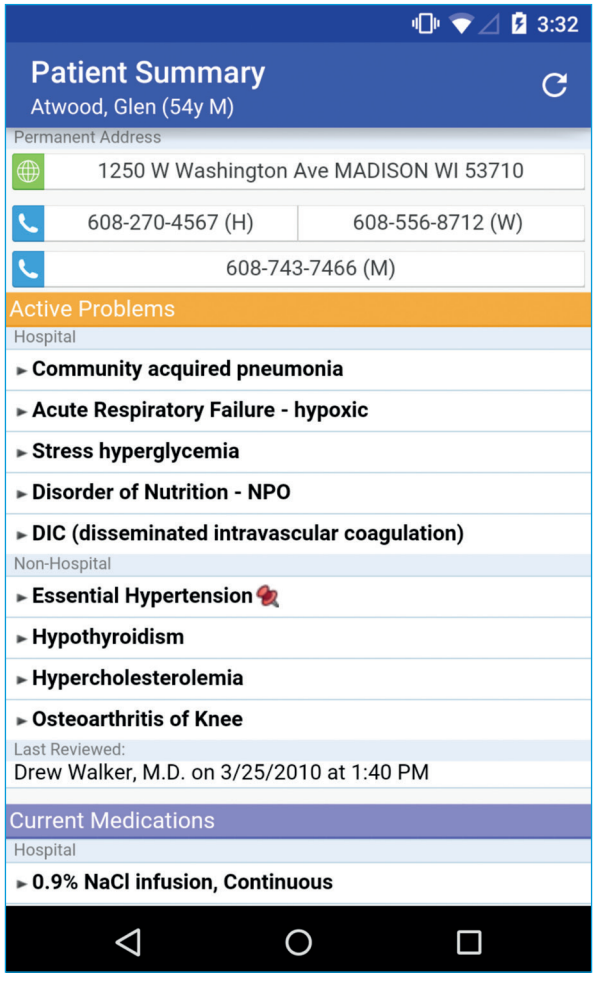
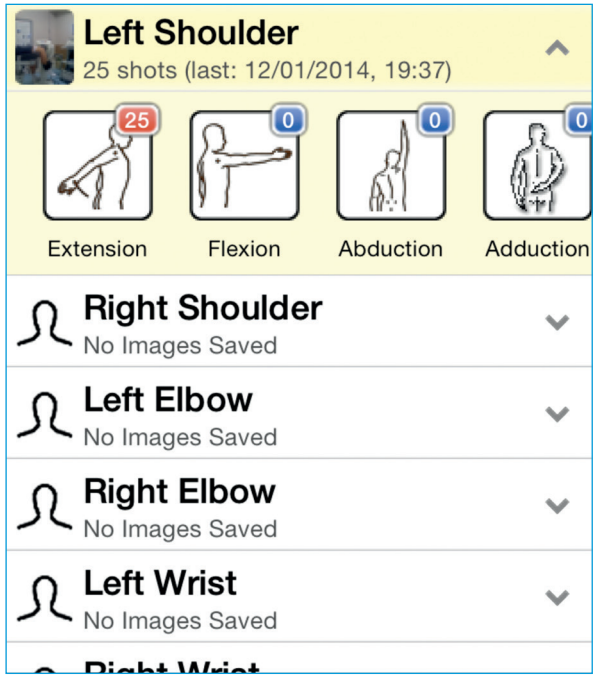


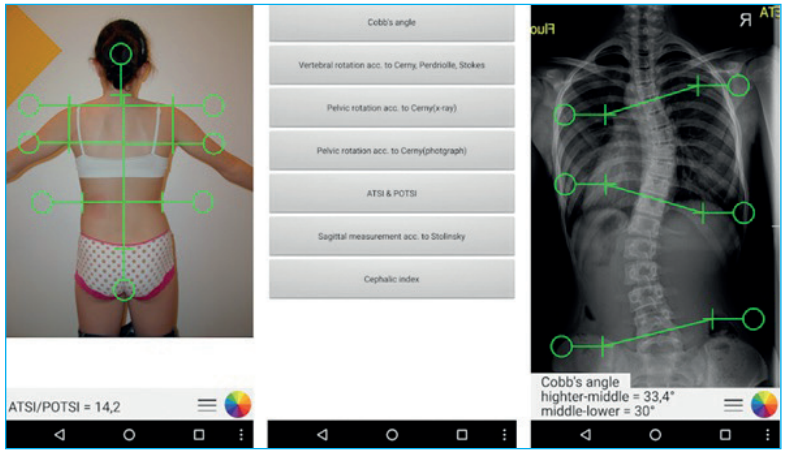
Figure 2. Dr Goniometer interface (http://www.drgoniometer.com).



CobbMeter (*Figure 3*) and Scodiac (*Figure 4*) are applications that were designed to help with the measurement of Cobb angle, on the iPhone and Android respectively. Scodiac also allows measurement of vertebral and pelvic rotation as well as sagittal profiles. Qiao et al (2012) compared the CobbMeter with standard manual measurement and found similar measurements (29.3°

Figure 3. CobbMeter interface (https://itunes.apple.com/gb/app/cobbmeter-ce/id832462914?mt=8).

Figure 4. Scodiac interface (https://www.apkmonk.com/app/com.xamarin.scodiac/).



> Smartphone applications have been used to deliver rehabilitation services remotely and collect outcomes in real time.

vs 29.1°), but there was better intra- and interobserver variability and a significantly (P<0.05) reduced mean time to perform the measurements in the smartphone group (13.7s *vs* 37.9s).

Appointments and postoperative care

In recent years there has been a rapid increase in teleconsultations (Deldar et al 2016), particularly in general practice. Babylon allows patients to have a video consultation with a GP in minutes. Although there is increasing uptake of these appointments in primary care, this has not been seen in orthopaedics, partly because of the need for specific physical examinations and radiological investigations. However, there has been an increased focus on assessing chronic pain and postoperative outcomes. Smartphone applications have been used to deliver rehabilitation services remotely and collect outcomes in real time (Chhabra et al, 2018). The Snapcare app monitors the patient's activity levels and his/her pain profile. These data will feed into and produce patient-reported outcome measures which can help guide the surgeon on further treatment.

Other authors have developed their own applications to assess clinical outcomes postoperatively. Tofte et al (2018) developed their own application with interactive video instruction to enable patients to change their dressings, remove sutures, document median nerve function and capture videos of their finger range of motion post-carpal tunnel decompression. They found excellent correlation between software-reported and clinical assessment. Higgins et al (2017) used their application to assess and collect real-time indicators of postoperative recovery after anterior cruciate ligament reconstruction. In their series of 32 patients, they found that the majority of patients did not need follow-up appointments at 2 and 6 weeks, with 83% of patients reporting their satisfaction with the smartphone application as excellent or good.

Education

Simulation training has become increasingly popular in orthopaedic training and has helped develop cognitive competencies before performing surgical procedures (Sugand et al, 2015). A commonly used application is Touch Surgery (Kinosis Limited, London, UK) (*Figure 5*) which allows rehearsal of more than 60 orthopaedic operations and approaches. Tulipan et al (2018) found improved performance in their study participants (hand surgeons, residents and medical students) after completing the carpal tunnel release module, and a correlation between increasing use and performance. Other authors have found similar outcomes in lag screw fixation (Levin et al, 2018) and femoral nailing (Sugand et al, 2015).

One of the most widely used applications among orthopaedic surgeons is the AO Surgery Reference (*Figure 6*), which describes the complete surgical management of conditions from diagnosis to aftercare for all fractures. It has been expanded to include paediatric trauma conditions.

Logbook

Traditionally, surgeons have taken copies of their theatre lists and inputted them onto their desktop computers at a later date. Elogbook is an application which synchronizes operations entered on the user's smartphone with the Royal College of Surgeons elogbook and can be used offline if there is not adequate reception.

Conclusions

Smartphones have a wide range of uses for orthopaedic surgeons and these are increasing. They not only facilitate traditional roles such as multimedia messaging but are now used to aid patient assessment and surgery. They are also

Figure 5. Touch Surgery app demonstrating carpal tunnel release (https://play.google.com/store/apps/details?id=com.touchsurgery&hl=en_GB).

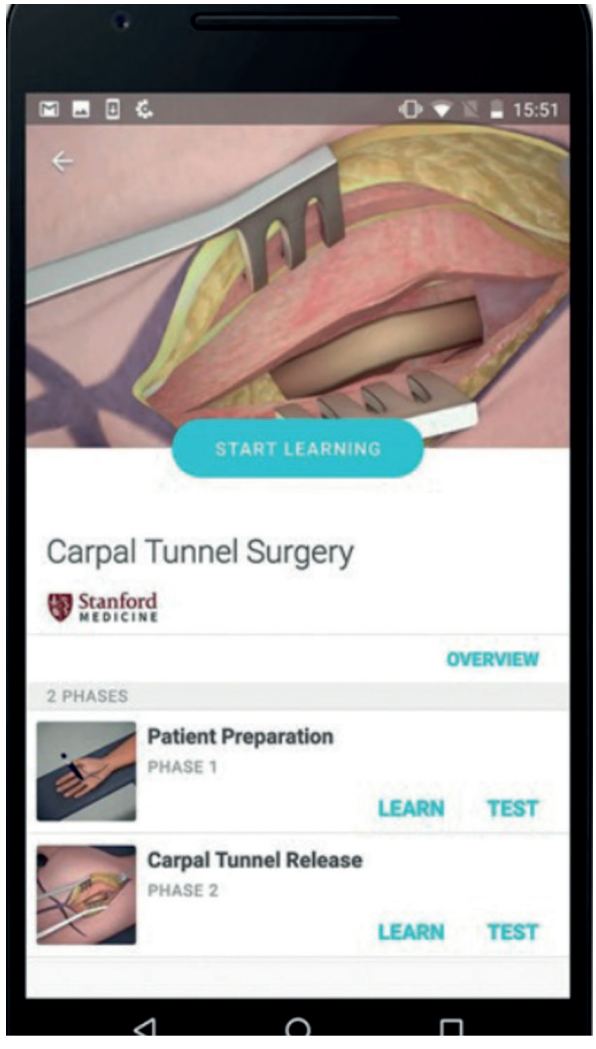
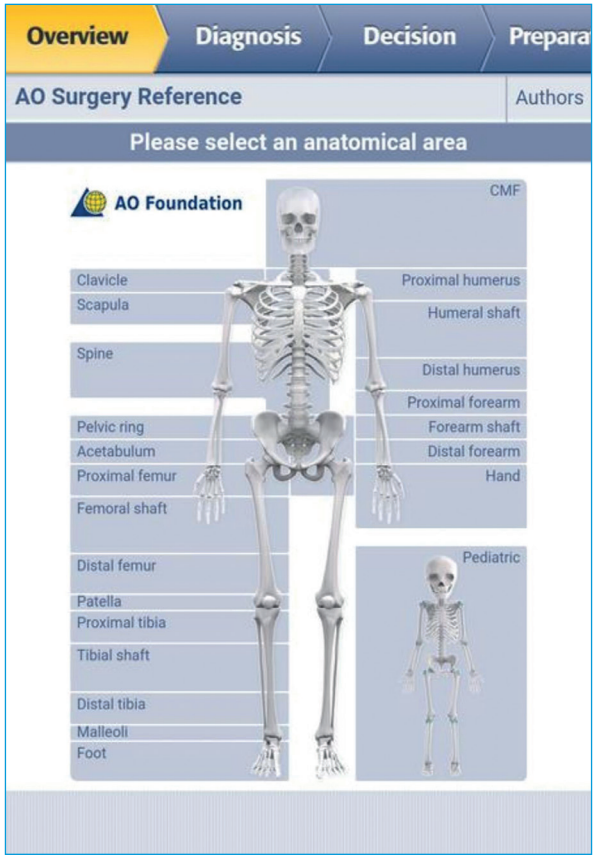


Figure 6. AO Surgery Reference application (https://apkpure.com/ao-surgery-reference/af.org.aofoundation.AOSR).



used as a training tool via applications aiming to provide simulation training and a data collection option for the surgical logbook. Clinicians may also conduct remote follow-up appointments and manage patients via their smartphones. These innovations have rapidly developed over the last decade and further advances should be expected over the next 10 years. **BJHM**

Conflict of interest: none.

KEY POINTS

- Smartphones have had an expanding role in orthopaedics since the introduction of the first-generation Apple iPhone in 2007.
- Traditionally in health care, smartphones have been used as a communication tool and a platform to access electronic health records.
- More recently, applications have been developed to aid clinical assessment and serve as intraoperative guides.
- The use of smartphones in teleconsultation and postoperative rehabilitation is perhaps the biggest area for growth in the near future.
- Over the next 10 years, smartphones and their applications are likely to further improve the capabilities of orthopaedic surgeons.

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