Review Article

Mobile messaging and smartphone apps for patient communication and engagement in spine surgery

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Abstract: Mobile health (mHealth) applications are rapidly becoming increasingly available to patients. These interventions utilize simple mobile messaging (SMS) and software applications on mobile devices for a variety of purposes. In the surgical population mHealth applications have shown promise in increasing medication and protocol adherence, monitoring patients after surgery, and helping modify behaviors associated with poor surgical outcomes. There is a paucity of spine specific applications at this time. Further development and study of efficacy of spine specific mHealth applications is needed.

Keywords: Mobile health (mHealth); telemedicine; spine surgery; texting; mobile messaging; patient communication

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Introduction

Mobile phones are nearly ubiquitous in the United States. An estimated 96% of people in the U.S. own a cellular phone, and 81% own a smartphone (1). The number of cell phone owners has almost tripled from 35% in 2011. Orthopaedic patients have a similar cell phone utilization, with 77% of patients in a large urban academic center report owning a smartphone (2). Due to the rapid growth of smartphone use, mobile health (mHealth) applications have become increasingly common; over 165,000 mHealth applications are currently available for purchase (3-5).

The World Health Organization defines mobile health or "mHealth" broadly as "medical and public health practice supported by mobile devices" (6). There are a number of different types of mHealth applications; these include mobile access to clinical records, communication between healthcare team and patients, patient monitoring, telemedicine/remote delivery of care, wearable devices, emergency services, patient education/counseling, appointment reminders, outcomes/surveys collection, and provider decision support. According to the WHO, the most common types of mHealth initiates are health call centers, emergency toll-free telephone services, mobile tools to manage large scale emergencies and disasters, and mobile telemedicine. The great majority of these programs are in the pilot or informal stages.

While the number of mHealth applications is growing, and a few have been studied in surgical patients, there is a limited number of applications that are specific to spine surgery patients. The review below outlines mHealth applications that have been studied in a variety of setting, many of which can be applied to spine surgery patients but have not been formally studied in that population.

Behavioral modification

There has been a ground swell of research into the effectiveness of behavior modification with the use of mHealth applications. The majority of research to date has focused modification of secondary risk factors for cardiovascular disease. Studied risk factors include cigarette use, weight loss, diet modification, and medication compliance (7,8). The success of smoking cessation

interventions has been shown to benefit from patient engagement (9-11). A number of mHealth applications have been developed aimed at cigarette smoking cessation (12-14). Heminger *et al.* reports on an automated text messaging system with messages centered around a user-set quit date. Messages are designed to promote engagement, track cigarette use, and administer timed surveys. The application was shown to be effective in generating user engagement and higher smoking cessation rates compared to controls (15).

Chow *et al.* performed a large randomized controlled trial (RCT) of patients with coronary heart disease randomized to an SMS cohort receiving 4 texts per week for 6 months versus standard care and found that the intervention group demonstrated increased physical activity, better improvement in low-density lipoprotein (LDL) cholesterol, blood pressure control, and BMI relative to controls (16). Other mHealth initiatives have also demonstrated similar effectiveness in improving physical activity in patients with cardiovascular disease (17-19). A review of mHealth and SMS applications for secondary prevention of cardiovascular disease found that higher frequency of text messages, personalized content, two-way communication, and use of multiple modalities were consistently associated with success of behavior modification (20).

Substance use disorders is another area where mHealth interventions have been studied in their effectiveness to modify behavior. Computer based and computer assisted cognitive behavioral therapy as well as community reinforcement approach (CRA) programs have been shown to lead to similar success in treatment of alcohol, marijuana and cocaine dependence compared to in-person therapist-based approaches (21-23). While the above studies do not directly apply to the spine surgery population, a number of conditions studied such as cigarette use, obesity, substance abuse have been linked to negative outcomes after spine surgery and represent areas where mHealth interventions could optimize outcomes (24,25). There remains a paucity of data on behavior modification and pre-operative patient optimization using mHealth tools in the spine population.

Protocol/medication adherence

mHealth applications have been studied in the surgical setting for impact on patient adherence to discharge instructions/postoperative protocols as well as improving adherence to medication regimens. Miloh *et al.* studied medication adherence in pediatric patients with orthotopic liver transplants and demonstrated improved adherence to antirejection medications with automated SMS based reminders sent to primary medication administrator relative to control (26). Improvement in adherence to postoperative protocols and discharge instructions has been shown in patients undergoing endoscopic retrograde cholangiopancreatography (ERCP) (27). Mobile application reminders for preoperative instruction have also shown promise in improving adherence to preoperative instructions leading to decreased day of surgery cancellations in a group of neurosurgery patients (28).

Park *et al.* studied the impact of post-discharge counseling via phone versus SMS on patient satisfaction, activities of daily living, and knee function in patients that have under gone a total knee arthroplasty (29). The authors found that phone and SMS counseling have the same effect on the studied outcomes. This suggests that automated SMS texts can play a role in optimizing resource utilization of orthopaedic clinic staff. Day *et al.* found that an automated SMS texts program increased patient satisfaction measures after total joint arthroplasty (TJA) (30). The positive impact of mHealth on medication adherence has been studied in surgical and non-surgical settings (31).

A Cochrane Collaboration review and meta-analysis found that mobile phone text messaging programs were effective in improving medication compliance amongst patients with HIV (32). The review also notes that the frequency of messaging appears to be important, with weekly text messages associated with lower rates of nonadherence compared to daily messages. Multiple other studies have suggested the benefit of mHealth intervention to medication adherence in this population (33-36). Foreman *et al.* found that SMS medication reminders improved adherence by about 10% in a non-randomized cohort study of patients with a broad range of chronic conditions beyond HIV (37).

Patient monitoring

The average length of stay for various spine surgeries has been gradually decreasing, and outpatient surgeries are becoming more common. As patients leave the hospital earlier, remote patient monitoring has been a growing area of interest to ensure patient safety and well-being after discharge. Debono *et al.* studied an application based patient monitoring system in patients that underwent ambulatory microdiscectomy (38). Patients were queried daily regarding their symptoms. The system triggered

alerts to the neurosurgery treatment team based on symptom severity as well as nonresponse. Thirty-two percent of patients triggered an alarm, with 94% of alarms handled over the phone without the need for in person evaluation (38).

Remote wound monitoring with pictures sent to the surgical team via mobile devices has been studied in plastic surgery, orthopaedic surgery, and general surgery patients (39,40). There is a lack of studies that directly compare postoperative ER visits with versus without remote monitoring. A number of studies using surrogate measures suggest that postoperative ER and clinic visits may be decreased with mHealth interventions (39-41). Martínez-Ramos *et al.* found that 55% of patients undergoing remote wound monitoring after ambulatory surgery stated that they would have returned to the hospital to seek further care if not for the remote wound monitoring application (39).

Barriers to adoption

The field of mHealth is currently in its early stages. Prior to wide adoption, a number of challenges need to be overcome. The WHO in their analysis of the mHealth global market has highlighted poor evidence, uncertain regulation, and data safety concerns as key barriers to broad adoption (6). While there is a rapidly growing number of new applications being developed, very few have been studied in a rigorous manner. The majority of the research on mHealth interventions is comprised of low quality prospective, nonrandomized studies. Due to the increasing pressures on health systems to deliver efficient, high-quality care, cost-effectiveness of various mobile interventions will have to be studied in a scientifically sound manner.

The regulatory landscape of mHealth is another area of uncertainty. As mHealth applications become more sophisticated, many offer functionality that can aid in the diagnosis of health conditions. In the United States, the practice of medicine is regulated by state law, and the practice of medicine without a license is illegal. Mobile applications that provide medical tools to individuals that can aid in diagnosis fall under a poorly defined category. While providing health related information is not considered medical practice, providing medical advice does fall under the category of medical practice. The definition of medical advice varies from state to state and needs to be considered for future mHealth application development and regulation.

Currently mHealth applications are not regulated by the Food and Drug Administration (FDA). The FDA is responsible for the regulation of, among other things, medical devices (3). According to the FDA, a medical device is "any implement, machine, or apparatus intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease" (42). As such, many mHealth applications would qualify as medical devices. The FDA issued a guidance document in 2015 that lists 28 categories of mobile medical applications that may quality as medical devices but the FDA elected to not actively regulate. Broadly, the 28 categories can be grouped into (I) General Health and Wellness applications; (II) illness prevention/management applications; (III) tracking, logging, and trending applications; and (IV) symptom-disease association applications (43).

Conclusions

A growing number of mHealth applications are available to the public. Orthopaedic and spine patients have demonstrated that the great majority own smartphones, have internet access, and are willing to use mobile applications for medical purposes. While the majority of early research has pertained to non-spine patients, early reports are promising in the utility of mHealth applications for behavior modification, patient monitoring, and protocol adherence. Development of spine specific applications and further study of the effectiveness of mHealth applications in spine is needed.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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