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Monitoring Surgical Incision Sites in Orthopedic Patients Using an Online Physician-Patient Messaging Platform

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ABSTRACT

Background: Prompt identification and treatment of wound complications is essential after joint arthroplasty, but emergency department and office visits for urgent evaluation of normal incisions are a source of unnecessary cost. The purpose of this study is to evaluate the use of an online image messaging platform for remote monitoring of surgical incision sites.
Methods: We conducted a retrospective review of 1434 hip and knee arthroplasty patients who registered for an online platform in the perioperative period. We reviewed images sent by patients to evaluate potential wound abnormalities. Medical records were reviewed to determine whether assessments based on wound photographs corresponded with subsequent in-person findings and ultimate disposition.
Results: Four hundred thirty patients (42%) sent at least one text or image message to their provider. Elimination of redundant images resulted in 104 image encounters, with 76 discrete encounters in 41 patients related to the surgical wound. Most showed normal wound appearance; patients were reassured and urgent visits were avoided. At scheduled in-person follow-up, none of these patients demonstrated unrecognized wound complications. Seventeen image encounters in 7 patients showed possible wound abnormalities. These prompted in-person follow-up on average less than 1 day later for 4 issues deemed urgent (2 patients received surgical treatment) and 5 days later for issues deemed nonurgent. Photos were also used to monitor abnormal wounds over time and to send information unrelated to wounds.
Conclusion: Utilization of an online physician-patient messaging platform can prevent unnecessary visits for normal appearing wounds, while facilitating rapid in-person treatment of wound complications.

Surgical site infection (SSI) is the most common postoperative complication in surgical patients [1]. Despite perioperative education, patients are unable to consistently recognize wound complications and ensure that they are addressed in a timely manner. Removing barriers to identification and treatment of wound complications may reduce progression to SSI [2,3], which is the leading cause of unplanned, potentially preventable hospital readmission among surgical patients and linked to increased morbidity and mortality [1,4]. SSI is the most common indication for revision in total knee arthroplasty and the third most common cause of revision in total hip arthroplasty in the United States [1]. Additionally, SSI places a substantial economic burden on the healthcare system, often increasing surgical costs more than 2-fold [4–6].

Novel mobile health (mHealth) platforms allow patients to communicate remotely with their healthcare providers. Some systems facilitate online sharing of smartphone photographs in a secure and Health Insurance Portability and Accountability Act compliant manner, potentially allowing for simple and rapid postoperative wound monitoring. Studies suggest that wound imaging is a reliable way to identify SSI compared to in-person assessment, even with relatively poor image resolution [7]. Patients also seem willing to engage with this technology: surveys find that although many elderly patients do not themselves have smartphones, as many as 90% have friends or family who do and

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would be willing to send wound pictures on a regular basis [8,9]. The implementation of smartphone photography for wound follow-up has been shown to lead to fewer emergency room visits for wound checks in infants undergoing hypospadias repair [10]. To our knowledge, it has not yet been evaluated in the context of orthopedic procedures.

In this retrospective cohort study, we sought to determine the utility of wound pictures in identifying and managing wound abnormalities after hip and knee arthroplasty. We hypothesized that (1) younger patients would be more likely to use the mHealth platform, (2) patients and providers would be willing to make decisions regarding the necessity of in-person evaluation based on photographic findings, (3) normal photographic findings would reliably predict normal findings at subsequent in-person examination, and (4) remote digital wound evaluation could avoid an in-person evaluation of a normal appearing wound or prompt emergent evaluation of a wound with a concerning appearance.

Materials and Methods

This study retrospectively analyzed all patients who (1) underwent hip or knee joint arthroplasty from January 2015 to June 2017 under the care of 9 orthopedic surgeons across one health system and (2) were invited to enroll in a commercially available online medical communication and education platform, Force Therapeutics (New York, NY). This web-based and mobile platform was introduced to facilitate patient education and communication during the preoperative and postoperative period. Patients were provided with electronic care instructions, video-based rehabilitation programs, and real-time alerts to complete surveys assessing pain, function, and overall health; survey results and progress were viewable by their providers. The software was used for secure electronic text and image messaging between patients and providers, allowing patients to send wound images directly from their smartphones. Photo quality was dependent on the patient's smartphone camera. The platform application could be downloaded by any iPhone or Android device; most had at minimum an 8-megapixel camera. Members of the orthopedic care team responded to messages to reassure patients, provide advice, or schedule patients for clinic visits as appropriate. To assess and monitor joint pain and function as well as overall health, the platform asked patients to complete questionnaires, including the Veterans RAND 12 Item Health Survey and the Hip Disability and Osteoarthritis Outcome Score JR or Knee Injury and Osteoarthritis Outcome Score JR survey, before and after surgery at designated time intervals.

We retrospectively reviewed the 1476 cases for the 1434 patients who were registered for this online platform by office staff, including their demographic information as well as text (n = 4100) and image (n = 194) messages. Nine cases were duplicates and thus excluded from analysis. A total of 197 images were sent on 83 different days: 194 images by or on behalf of 58 patients and 3 by providers. Wound images were evaluated by the patients' provider in real-time for a possible wound abnormality warranting follow-up care; the provider's response to the image was recorded. No additional methodology was used to score or classify the wound images. These patients' charts were also reviewed to determine whether a follow-up clinic or hospital visit occurred as a result of the wound image and the ultimate outcome of the interaction. We also examined emergency department (ED) visit and readmission data for patients in this study who visited any hospital within the healthcare system up to 90 days after their orthopedic procedure; this time period was chosen because messages can be sent using the platform up to 90 days postsurgery.

Descriptive statistics were used to summarize patient utilization of the online platform and associated outcomes. The chi-squared test assessed differences between groups for categorical variables. Comparisons between means were evaluated using an independent sample Student's *t*-test (for normally distributed data) or the Mann-Whitney *U*-test (for non-normal data). A *P*-value of .05 or less was considered statistically significant. Statistical analyses were performed using R statistical software, version 3.4.1 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

Of the 1467 patient cases in the web-based and mobile platform, 1014 (69%) patients logged in to the platform at least once. Most patients (95%, n = 1397) were enrolled in the platform preoperatively, an average of 37 days before their scheduled surgical date; the rest were enrolled postoperatively on average 24 days postsurgery. Demographic data, such as average age (65.2 vs 65.0 years, $P = .87$) and gender (63% vs 64%, $P = .91$), and outcomes, including messages sent (2.9 vs 1.7, $P = .22$), did not differ significantly between patients who enrolled in the platform preoperatively versus postoperatively. The average age of patients enrolled was 65.2 years (SD 10.5; range 15-95 years); 63% (923) were female. Twenty-six percent (381) of patients had Medicare as their primary insurance. The majority of patients received a primary knee replacement (924, 63%) or primary hip replacement (480, 33%); a small number of patients had a revision knee replacement (55, 4%) or a revision hip replacement (8, 0.5%).

Only 1206 (82%) patients had an existing e-mail address associated with their account and thus could receive e-mail notifications from the platform, which may have limited utilization. Six hundred twenty-one (42%) patients selected to receive notification reminders via text message (SMS). Two hundred ninety-three (20%) patients downloaded the mobile application to an iOS (178, 12%) or Android (115, 8%) device.

The 1014 patients who logged in to the platform at least once averaged 6.1 (SD 8.2, range 0-91) log-ins presurgery and 8.3 (SD 12.3, range 0-82) log-ins postsurgery. Compared to patients who did not use the platform, patients who logged in at least once were on average younger (64.3 vs 67.2 years, range 15-95 vs 21-93, $P < .01$), but the magnitude of the difference was small. There was no significant difference in gender (62% vs 64%, $P = .60$) or Medicare insurance status (25% vs 27%, $P = .45$) between patients who logged into the platform and those who did not. Indeed, 67% of the 381 Medicare patients enrolled did use the platform, so age, gender, and insurance status may not be particularly important factors in determining overall use of mHealth platforms. Of the patients who logged in, 430 (42%) patients sent at least 1 message; patients who sent messages averaged 9.5 (SD 15.4, range 1-150) messages for a total of 4100 messages sent by all patients. The top 20 utilizers of the messaging service accounted for 30% (1248) of the total messages sent, whereas 23% (100) of patients who logged in sent 1 message.

Fifty-eight patients utilized the platform to send or receive a total of 197 images. Ninety-one (46%) of these images were duplicates or very similar photos sent by the same patient within a 10-minute interval, which were removed from the analysis. Two images were sent by patients accidentally and excluded. A total of 104 discrete image encounters were observed on 80 different days. The majority of those were wound images (72%, n = 76), but the messaging service was also used to send pictures unrelated to wounds.

Forty-one patients sent 76 images directly related to their surgical incision on 62 different days. Pictures were sent on average 26 days (SD 33.8, range 2-165) postsurgery, with 55% (42) of the images sent within the first 2 weeks. Among the patients who sent

images, 54% (22) were female and 46% (19) were male. Sixty-six percent (27) of these patients underwent a knee replacement or revision (3% of all knee arthroplasty patients) and 34% (14) underwent a hip replacement or revision (3% of all hip arthroplasty patients); a similar proportion is reflected in the study demographics. Patients initiated contact out of concern for a variety of reasons. Common complaints included redness or discoloration (17 cases), drainage (12 cases), rashes (6 cases), swelling (4 cases), and dry or peeling skin (3 cases). Seven messages were initiated due to concerns with the patient's dressing—4 patients were provided with reassurance that their dressing looked normal and did not need to be removed (although 1 patient was later referred to the ED by her primary care provider; she was told in the ED that her dressing and wound looked normal), 1 patient was given self-care instructions to secure the dressing, and in 2 cases, the patient was seen in the office after his dressing fell off for wound vacuum application. Three cases were related to concerns regarding sutures and these patients were seen in the office for suture removal or evaluation of a suture reaction. Providers validated the patients' concerns and provided appropriate reassurance, self-care instructions, or in-person follow-up. In 22 cases, the patient did not report a complaint, but sent a wound image to their provider as a progress update.

A total of 59 image encounters sent by or on behalf of 38 patients demonstrated a normal wound appearance at the time of the message; these patients were reassured by their provider that their wound was healing appropriately and all but 1 patient attended their standard postoperative follow-up visit on average 17 days (SD 25.5, range 2-158) after their message. The in-person visits corroborated the normal photographic findings in all cases. In 1 case, an in-person wound check performed 1 day after reviewing a wound photograph revealed no evidence of complication. Two weeks later the patient developed new abnormal findings that were not previously evident on photography or in-person. At that time, the patient was promptly diagnosed with a deep infection and underwent removal of the implant with placement of an antibiotic spacer. In some cases of a normal appearing wound, the provider not only gave reassurance, but also provided instructions for self-care regarding nonurgent issues. For example, patients with questions regarding a loosening dressing were told to tape or use an elastic bandage to secure the dressing. Three images showed a rash near the incision site and patients were advised to apply a hydrocortisone cream or take an oral antihistamine.

Seven patients sent 17 images that showed a possible new wound abnormality. Four of these patients were determined to warrant urgent evaluation, whereas 3 were deemed appropriate for nonurgent follow-up care. For the 4 patients with potentially urgent wound issues, the images resulted in an office visit on average less than 1 day after the wound picture was sent due to concern for a serious complication related to their wound. Two of the 4 patients underwent an incision and drainage procedure with polyethylene exchange. One patient had suture material removed from a 1-cm area of superficial dehiscence and was prescribed antibiotics, and another had blisters at the distal aspect of his incision unroofed. The other 3 cases of abnormal wound pictures were associated with a finding perceived not to be urgent; patients were seen in-person on average 5 days (SD 1.9, range 2-9) after their image was sent. One patient underwent removal of suture material. The wound images from another patient prompted an office visit, and an in-person assessment led to placement of a closed-incision vacuum-assisted wound treatment dressing. A week later, this patient sent an abnormal wound picture that led to a joint aspiration and hospital admission for management of a draining wound. Finally, 1 patient was prescribed antibiotics for worsening redness and swelling.

In addition to allowing providers to identify wound abnormalities, the application was also used as a monitoring tool. After seeing the initial normal 5 wound images from 5 patients, providers gave remote reassurance but decided to continue to monitor the surgical incision by asking these patients to send additional wound pictures; 6 follow-up pictures were sent over the next several days. The monitoring resulted in 2 patients coming in for an in-person evaluation following an abnormal, worsening wound photo. The 3 other patients were monitored through image and text messages until their next postoperative follow-up appointment, which showed no wound complications. In addition, 4 patients sent 4 wound images to follow-up on a wound issue previously diagnosed at their last in-person visit. Reassurance was provided in 3 cases. In the other case, the provider prescribed antibiotics without an office visit; this patient presented for an incision check 8 days later, which showed the incision was healing appropriately with no further intervention warranted.

Ninety patient cases in the study cohort were linked to a total of 104 ED visits and hospitalizations related to the patients' orthopedic procedure in the first 90 days postsurgery. Over half (57%) of the visits occurred during the first 3 weeks. There were no substantial differences in platform log-in rate between patients who went to the hospital and who did not (68% vs 69%, $P = .87$). However, patients who went to the hospital had fewer total log-ins compared to those who did not (9.8 vs 10.0, $P = 0.49$). Despite having fewer log-ins, these patients who went to the hospital ultimately sent more messages using the platform (7.3 vs 2.5, $P = .34$) and were more likely to send wound photos (8% vs 3%, $P < .01$). Five patients, as described above, sent a wound picture prior to presenting to the hospital and 2 sent follow-up wound pictures after their ED visit. Patients went to the ED in 23 instances for signs of an SSI, including fever and wound drainage and erythema. Almost half (43%) of patients who presented for signs of an SSI ultimately were diagnosed with a complication at the surgical site and underwent a procedure in the operating room; 3 patients had a superficial incision and drainage procedure, 5 patients underwent an incision and drainage with polyethylene exchange, 1 patient had exchange of the tibial component and placement of antibiotic beads, and the remaining patient underwent explanation and placement of an antibiotic spacer. Other reasons patients presented to the hospital were for joint pain (19%, 20 cases), joint dislocation after a hip replacement (9%, 9 cases), or a revision procedure for instability, component loosening, or other reasons (13%, 7 cases).

Although the messaging feature was originally intended for sending wound images, 20 patients sent 28 pictures that were not directly related to their surgical incision. Six patients sent a total of 7 images of their swollen lower extremities. Although 2 patients were given reassurance and instructions to ice and elevate their legs, 2 patients were seen in office for an in-person evaluation and 2 underwent an ultrasound examination that was negative for a deep vein thrombosis (DVT). Indeed, patients presented to the hospital in 18 different cases with signs of a DVT or pulmonary embolism including leg swelling, chest pain, or shortness of breath; in 6 cases (33%), the work-up for a DVT or pulmonary embolism was positive. Sixteen patients sent 21 images regarding nonorthopedic medical issues, including a swollen tongue, gout symptoms, insurance cards, test results, medication lists, medical equipment, and patient forms. A provider sent 2 patients a total of 3 images that contained referrals to physical therapists and nonorthopedic specialists.

Discussion

To our knowledge, this is the first study to evaluate the use of an online physician-patient messaging platform for monitoring incision sites in an orthopedic patient population. Our study shows that

older adult patients are willing to and can successfully use mHealth applications. However, more work can be done to improve patient engagement, especially with older patients. Although age was a statistically significant predictor of utilization, there were no statistically significant differences in utilization based on gender and Medicare insurance. Of the patients who successfully logged into the application, less than half of patients used the available messaging services and a very small portion sent images. Opportunities exist to encourage patients to actively use the tool.

We demonstrate that an mHealth platform can be an effective tool for providers to identify and communicate with patients regarding potential wound issues in a real-time manner. For patients with a wound abnormality, this may enable more rapid evaluation and management at the appropriate level of care. Patients who sent abnormal wound photos that prompted urgent follow-up were evaluated in-person on average 1 day later and underwent a change in management, including referral to the hospital for additional work-up or treatment. An interesting finding of the study was that the patients who went to the hospital in the study cohort were more likely to send messages and images via the platform. This demonstrates that patients with serious complications or issues are in general more likely to reach out to their provider and seek care in every way possible. On the other hand, patients with normal appearing wounds appeared satisfied with the reassurance provided by their provider remotely. Although these patients were given the option to come into the office for an in-person wound check, patients seemed to forgo this option to wait until their next standard postoperative visit. Avoiding unnecessary clinic visits may ultimately lead to cost-savings and increased patient satisfaction. If the 38 patients who sent images seeking evaluation of normal appearing surgical wounds on 59 occasions might have sought in-person care each time they sent a wound image, the availability of image messaging may have spared up to 59 unnecessary visits. That translates to roughly 4 visits for every hundred patients enrolled in the online platform by office staff and 14 visits for every hundred patients who actually utilized the messaging service.

This technology also helps circumvent the inefficiencies associated with multiple office visits through its ability to monitor the progression of a wound's appearance in the case of a previously diagnosed issue or when the need for an in-person visit is unclear. Barriers to care are also reduced as mHealth eliminates the need for patients to travel for follow-up care that can be addressed through the online platform. A variety of pictures unrelated to wounds were also sent, demonstrating the versatility of image messaging to promote communication between the patient and the provider.

We acknowledge the financial cost and resources needed to implement such a platform as well as the staff required to enroll patients and respond to their questions and concerns. Further research is necessary to demonstrate whether the magnitude of any improvement in access and efficiency justifies the investment of resources and whether patient experience or outcomes are demonstrably improved. These upfront costs may or may not be offset by downstream cost savings. Although we were unable to show that users of the platform had fewer emergency room visits and readmissions, more research is needed to evaluate the impact of platform usage on subsequent hospital and care utilization. Regardless, granting patients real-time access to their surgical team may result in more prompt management of wound problems that helps prevent development of additional complications requiring reoperation and additional costly hospitalizations. Although this study could not quantify all the variables contributing to potential cost savings, we believe that a tool of this kind may prove to be a valuable asset to orthopedic practices, especially as participation in alternative reimbursement models, such as bundled payments, demand coordination of care to improve value and quality.

This study was retrospective, descriptive, and observational. Due to the lack of a control group, we were not able to compare abnormal wound identification and follow-up rates with a patient cohort that was not enrolled in the application. Thus, we could not explicitly determine how many potential clinic visits for wound check were avoided due to remote reassurance, nor demonstrate that wound photographs hastened the evaluation or management of patients with wound complications. Nevertheless, the intention of this retrospective review was to serve as a proof-of-concept for the use of an online messaging platform in monitoring wounds.

Our data clearly show that (1) many patients were willing to engage with mHealth platforms, regardless of patient age, (2) providers and patients were willing to base treatment decisions on photographic findings, (3) photographic findings predicted subsequent in-person findings, and (4) many patients who were concerned enough to send a wound picture were remotely reassured without the cost and inconvenience of an in-person evaluation for a normal appearing wound and no patient with a wound complication evident on in-person examination on average 2 weeks later was falsely reassured based on photographic findings.

Conclusion

This study demonstrates that electronic text and photographic messaging can be an effective way for orthopedic patients to communicate with their surgeons and care teams regarding their surgical incision site as well as other issues. The sharing of abnormal wound images online between patients and their providers can prompt rapid evaluation and management of wound issues. It remains to be seen whether this will reduce infectious complications associated with delayed diagnosis and treatment of delayed wound healing. In the case of normal appearing wounds, remote reassurance can help patients avoid unnecessary clinic and hospital visits for wound checks.

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