Effect of Home Monitoring via Mobile App on the Number of In-Person Visits Following Ambulatory Surgery
A Randomized Clinical Trial

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**Importance**
In the age of information and patient-centered care, new methods of delivering postoperative care must be developed and evaluated.

**Objective**
To determine whether follow-up care delivered via a mobile app can be used to avert in-person follow-up care visits compared with conventional, in-person follow-up care in the first 30 days following ambulatory surgery.

**Design, Setting, and Participants**
A randomized clinical trial was conducted from February 1 to August 31, 2015, among ambulatory patients undergoing breast reconstruction at an academic ambulatory care hospital. Patients were randomly assigned to receive follow-up care via a mobile app or at an in-person visit during the first 30 days after the operation. Analysis was intention-to-treat.

**Main Outcomes and Measures**
The primary endpoint was the number of in-person follow-up visits during the first 30 days after the operation. Secondary endpoints were the number of telephone calls and emails to health care professionals, patient-reported convenience and satisfaction scores, and rates of complications.

**Results**
Of the 65 women in the study (mean [SD] age, 47.7 [13.4] years), 32 (49%) were in the mobile app group, and 33 (51%) were in the in-person follow-up care group. Those in the mobile app group attended a mean of 0.66 in-person visits, vs 1.64 in-person visits in the in-person follow-up care group, for a difference of 0.40 times fewer in-person visits (95% CI, 0.24-0.66; \( P < .001 \)) and sent more emails to their health care professionals during the first 30 days after the operation (mean, 0.65 vs 0.15; incidence rate ratio, 4.13; 95% CI, 1.55-10.99; \( P = .005 \)) than did patients in the in-person follow-up care group. This statistically significant difference was maintained at 3 months postoperatively. The mobile app group reported higher convenience scores than the in-person follow-up care group (incidence rate ratio, 1.39; 95% CI, 1.09-1.77; \( P = .008 \)). There was no difference between groups in the number of telephone communications, satisfaction scores, or complication rates.

**Conclusions and Relevance**
Patients undergoing ambulatory breast reconstruction can use follow-up care via a mobile app to avert in-person follow-up visits during the first 30 days after the operation. Mobile app follow-up care affects neither complication rates nor patient-reported satisfaction scores, but it improves patient-reported convenience scores.

**Trial Registration**
clinicaltrials.gov Identifier: NCT02318953

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In the age of patient-centric care, delivery models must evolve to become more convenient for patients and cost-effective to the health system, while also maintaining a high degree of patient satisfaction and convenience. Many centers are now substituting in-person follow-up care with care delivered via telephone or a mobile app. Studies show that these remote modes of follow-up are safe and that patients are as equally satisfied with them as they are with in-person follow-up care.

Women's College Hospital in Toronto, Ontario, Canada, offers specialized surgical procedures, including breast reconstruction typically following mastectomy for breast cancer. The goal of surgery is to restore a breast mound and improve the quality of life of cancer survivors. These procedures are performed on an ambulatory basis; all patients go home on the day of or the day after surgery. Patients often travel significant distances to receive this care. Traveling for surgery is not unique to patients who undergo breast reconstruction; surgical care programs have become regionalized to ensure higher volumes in specific centers of excellence, which means that more patients travel to receive that care.

In general, the morbidity and mortality rates following ambulatory surgery are very low. Complication rates in this subset of patients undergoing breast reconstruction are approximately 5% to 7.5%, making most follow-up visits perfunctory.

The QoC Health Inc mobile app allows patients to submit photographs and answers to a validated quality of recovery questionnaire and a pain visual analog scale using a mobile device for the first 30 days after the operation. Surgeons are able to follow patient reports on a web portal. This technology has been used for patients who have undergone ambulatory breast reconstruction. Our study builds on preexisting data by determining whether receiving follow-up via the mobile app can avert the need for in-person follow-up care.

Methods

This pragmatic, single-center, open, controlled, 2-arm parallel-group superiority randomized clinical trial was conducted from February 1 to August 31, 2015, to compare follow-up care delivered via mobile app vs in person during the first 30 days following ambulatory breast reconstruction. Permutated-block randomization was conducted by blocks of 4 to 6 using the program RALLOC in Stata statistical software (StataCorp). The complete research protocol is available in the Supplement. This study complies with the standards outlined in the Tri-Council Policy Statement and was approved by the Women's College Hospital Research Ethics Board. During a 5-month period, eligible patients were consecutively approached by a senior author not directly involved in patient care (K.A.A.) during their preoperative visits, and written informed consent was obtained.

All ambulatory patients undergoing elective breast reconstruction at Women's College Hospital were included in this study. Patients had to be able to use a mobile device and communicate in English. All patients were nonsmokers with a body mass index of 30 or less (calculated as weight in kilograms divided by height in meters squared) because these are requirements for ambulatory breast reconstruction. Patients were excluded if they experienced chronic pain, were taking narcotic (morphine-like) medication for pain on a regular basis, or had an allergy to local anesthetics or morphine-like medications. Pain ratings captured in the pain visual analog scale and quality of recovery 9-item questionnaire are important for judging the quality of postoperative recovery.

Procedures were performed by 3 surgeons (M.B., B.B., and J.L.S.), with more than 90% of cases being performed by 2 surgeons within this group of surgeons. Randomization was performed by an outside statistician and occurred in equal proportions (1:1) between those using the mobile app and those receiving in-person follow-up care. After a patient agreed to participate in the study, she was provided a sequentially numbered envelope containing her group assignment by the enrolling senior author. All patients received what is currently the standard of care in this hospital. Patients in the conventional follow-up group had planned clinic follow-up at approximately 1 week and 4 weeks after the operation. This is the follow-up schedule currently used by all surgeons.

The mobile app follow-up group had no planned in-person follow-up at 1 week and 4 weeks after the operation. However, these visits were replaced with an examination of the surgical site via photographs submitted through the mobile app, as well as monitoring of the results of the pain visual analog scale, and quality of recovery 9-item questionnaire. Patient reporting began after discharge from the recovery room. Since 75% of complications occur within the first 2 weeks of discharge,12 we used daily monitoring for 2 weeks and then weekly monitoring for the remaining 2 weeks (totaling 30 days of monitoring). Patients were reminded by email to complete regular reporting if a submission was not received. The data entered through the mobile app reached a double-encrypted server. The surgeon used a wireless interface to access those data and monitor the patient's condition (not in real time). High pain scores were flagged in the database for quick viewing. Any red flags (abnormally high pain scores or abnormally low quality of recovery 9-item questionnaire scores) prompted in-person follow-up. Physicians

Key Points

<table>
<thead>
<tr>
<th>Question</th>
<th>For patients undergoing ambulatory surgery, can follow-up care via a mobile app avert in-person visits compared with conventional, in-person follow-up care during the first 30 days after the operation?</th>
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<tr>
<td>Findings</td>
<td>In this randomized clinical trial of 65 patients, those who used the mobile app attended fewer in-person visits for follow-up care during the first 30 days after the operation than patients in the in-person follow-up care group. This difference was statistically significant.</td>
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<tr>
<td>Meaning</td>
<td>Follow-up care delivered via a mobile app can be used to avert in-person visits following ambulatory surgery.</td>
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summarized the clinical findings recorded by the mobile app using the prototypical subjective, objective, assessment, and plan note at 1 or more time points during the 30-day monitoring period.

Outcome Measures
The main outcome was the total number of follow-up visits (including specialists, family physician, and emergency department) associated with the surgery. These data were captured at 30 days after the surgery by patient survey and confirmed via review of the medical record.

The secondary outcomes included the total number of telephone calls and emails to the health care team associated with the surgery, satisfaction and convenience scores, and postoperative complications. All secondary outcome data were captured by telephone survey 30 days after the surgery. Patient-reported satisfaction and convenience scores were recorded using a 5-point Likert scale. Complications were defined as adverse events that were attributed to the surgery and required a medical or surgical intervention.

Statistical Analysis
Descriptive statistics (frequencies and mean [SD] values) were calculated for all clinical and outcome variables. All data obtained in this study were entered into Excel and analyzed using Stata version 13 (StataCorp LP).

We used person-level Poisson regression to determine if there was a statistically significant difference between patients using the mobile app and those receiving in-person follow-up care in count data including the number of in-person follow-up visits attended, the number of telephone calls and emails to health care professionals, and the 5-point patient-reported satisfaction and convenience scores. The goodness of fit of all Poisson regression models was confirmed with the χ² test. Complications were recorded as a binary variable. A 2-sample test to the known variability in the rates of complication reported in the literature.

Results

Demographic and Surgical Data
A total of 77 eligible patients were approached consecutively during the 5-month study period. Figure 1 demonstrates the flow scheme of all study patients. A total of 65 patients were enrolled in the study: 33 completed in-person follow-up care and 32 completed mobile app follow-up care. No patients were lost to follow-up. There were no missing data. The trial was completed 30 days after the final patient had surgery. See the Table for patient demographics. Major surgery was defined as a bilateral mastectomy and immediate reconstruction or a delayed pedicled autologous breast reconstruction based largely on the length and complexity of the procedures. Using a stringent P value of .10, we found that prior radiotherapy (8 [24%] vs 15 [47%]) and mean distance from the hospital to the patient’s home (120 vs 53 km) were unbalanced between the in-person and mobile app groups. All other variables were well balanced (Table).

Total Number of In-Person Follow-up Visits During the First 30 Days
The in-person group attended a mean 1.64 in-person visits during the first 30 days after surgery (median, 2 visits; range, 0-4 visits). This mean includes 3 patients who visited the emergency department. The mobile app group attended a mean 0.66 in-person visits during the first 30 days after surgery (median, 1 visit; range, 0-3 visits). No patients in the mobile app group visited the emergency department. The mobile app group was 0.40 times less likely to attend in-person follow-up care during the first 30 days after surgery compared with the in-person group (95% CI, 0.24-0.66; P < .001). This difference was maintained at 3 months postoperatively (incidence rate ratio [IRR], 0.66; 95% CI, 0.46-0.95; P = .03).

The number of patients who underwent prior radiotherapy and the distance from the patient’s home to the hospital remained unbalanced between the 2 groups after randomization. It is reasonable to anticipate that patients who underwent prior radiotherapy may require more follow-up
because of a higher potential of delayed wound healing and other complications. It is also reasonable to anticipate that patients who live further from the hospital may attend fewer in-person follow-up visits. After adjustment for these covariates, the significant difference in the number of in-person follow-ups during the first 30 days after surgery was robust between the in-person group and the mobile app group (prior radiotherapy: IRR, 0.42; 95% CI, 0.25-0.70; \( P = .001 \); and distance from home to the hospital: IRR, 0.38; 95% CI, 0.23-0.64; \( P < .001 \)).

**Total Number of Emails and Telephone Calls During the First 30 Days**

The group receiving in-person follow-up care made a mean 0.30 telephone calls to their health care professionals during the first 30 days after surgery (median, 0 telephone calls; range, 0-2 telephone calls). The group using the mobile app made a mean of 0.31 telephone calls during the first 30 days after surgery (median, 0 telephone calls; range, 0-2 telephone calls). There was no statistically significant difference between groups (IRR, 1.03; 95% CI, 0.43-2.48; \( P = .95 \)). However, the group using the mobile app did send more emails than did the in-person group during the first 30 days after surgery (IRR, 4.13; 95% CI, 1.55-10.99; \( P = .005 \)). The group using the mobile app sent a mean of 0.65 emails (median, 0.5 emails; range, 0-3 emails) and the in-person group sent a mean of 0.15 emails (median, 0 emails; range, 0-1 emails). These findings were robust after adjustment for the unbalanced covariates of prior radiotherapy and distance from the patient’s home to the hospital (IRR, 4.38; 95% CI, 1.62-11.84; \( P = .004 \) and IRR, 4.84; 95% CI, 1.69-13.84; \( P = .003 \), respectively).

**Complications**

Four patients in the in-person group developed a postoperative complication. Two patients developed superficial infections at the incisional surgical site requiring oral antibiotics, 1 patient...
developed a seroma requiring drainage with a percutaneous needle, and 1 patient developed a deep incisional infection at the surgical site requiring removal of the implant and administration of intravenous antibiotics for 10 days. Two patients in the mobile app group developed a postoperative complication. One patient developed a superficial infection at the incisional surgical site requiring oral antibiotics, and 1 patient developed a deep incisional infection at the surgical site requiring removal of the implant and oral antibiotics. There was no statistically significant difference detected in the rates of complications (P = .42). The overall rate of reoperation was 3% (2 of 65 patients). There were no complications among the 8 patients who underwent a major surgery.

Discussion

Follow-up via a mobile app can be used to eliminate in-person follow-up visits during the first 30 days following ambulatory breast reconstruction surgery. Patients using the mobile app attended 0.40 times fewer in-person visits for follow-up care and sent more emails to their health care professionals during the first 30 days after surgery than did patients in the in-person follow-up group. This finding is important because a common criticism of telemedicine or virtual communication between patients and health care professionals is whether it truly replaces in-person care. There was no statistically significant difference between groups in satisfaction scores; however, patients using the mobile app were more likely to agree or strongly agree that the type of follow-up care they received was convenient. Improving patient convenience without compromising satisfaction is another critical finding as we look for ways to build a patient-centric health care system that supports quicker recovery and resumption of normal daily living. There was no statistically significant difference between groups in the rate of postoperative complications.

Previous prospective and retrospective cohort studies have been performed in a variety of ambulatory patient populations and have shown similar results. Hwa and Wren found that surveys conducted by physician assistants could be safely used as a substitute for in-person follow-up among patients who underwent open hemiorthopaxy and laparoscopic cholecystectomy, with a high degree of patient satisfaction. Jones et al found that telephone interviews and standardized postoperative questionnaires pose no additional risk to pediatric patients undergoing tonsillectomy and/or adenoidectomy compared with their previous experience with scheduled postsurgical clinic follow-ups. Our study is unique in that it is the first randomized clinical trial, to our knowledge, to examine the effect of replacing in-person follow-up care with follow-up care delivered via a mobile app. It is also the first time, to our knowledge, that a mobile app has been used as the platform for collecting patient-reported outcomes or survey data. All previous studies have relied on telephone interviews.

A growing number of procedures, including complex operations such as autologous breast reconstruction, are offered in an ambulatory setting. Patients using the mobile app require approximately 2 minutes to input the quality of recovery, pain visual analog scale, and photographs of the surgical site. This ease of use allows patients to submit data frequently (ie, daily or weekly), providing a continuous, richer inflow of information than could ever be achieved by telephone or in-person follow-up care. As we look for ways to improve clinical care, the granular data collected via the mobile app could be used to augment the National Surgical Quality Improvement Programs occurring across the country.

Limitations

The limitations of this trial include the single ambulatory patient population. These findings are likely generalizable to other ambulatory patient populations, given the similar findings already discussed, but are not generalizable to individuals receiving inpatient breast reconstruction. In addition, we were unable to conduct the study in a blinded fashion owing to the nature of the intervention. We did not power our study to detect a significant difference in the number of emergency department visits between groups. This is an unexpected and important finding that should be investigated in the future.

Conclusions

Mobile app follow-up care is suitably targeted to low-risk postoperative ambulatory patients. Patients using the mobile app attended 0.40 times fewer in-person visits for follow-up care and sent more emails to their health care professionals during the first 30 days after surgery than did patients in the in-person follow-up group. The mobile app group was more likely than the in-person group to agree or strongly agree that their type of follow-up care was convenient. Complication rates and patient satisfaction scores were comparable between the groups. These are important findings given the current demands on the health care system and the push toward patient-centric care. In the future, we will report on the cost-effective nature of this solution.
Monitoring via Mobile App and In-Person Visits After Ambulatory Surgery

Original Investigation Research

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REFERENCES


