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ORIGINAL ARTICLE

Does Engagement in an Electronic Patient Rehabilitation Application Predict Outcomes After Total Joint Arthroplasty?

Daniel B. Buchalter[1], MD; William E. Carpenter[1], MD; Jonathan A. Gabor[1], BS; Daniel P. Waren[1], MSPH; Morteza Meftah[1], MD; William J. Long[1], MD FRCSC; Ran Schwarzkopf[1], MD MSc; Writing Committee*

1 Department of Orthopedic Surgery, NYU Langone Orthopedic Hospital, NYU Langone Health, 301 E 17th St., New York, NY, United States.

* Writing Committee: Craig Capeci MD, Roy Davidovitch MD, Justin Lamont MD, William Macaulay MD, Ivan Fernandez-Madrid MD, Scott Marwin MD, Patrick Meere MD, James Slover MD, Thomas Youm MD, Joseph Zuckerman MD.

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Correspondence to: Ran Schwarzkopf, Department of Orthopedic Surgery, NYU Langone Orthopedic Hospital, 301 E 17th St., New York, NY, United States.
Email: schwarzk@gmail.com
Telephone: +1-(212) 598-6000

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ABSTRACT

BACKGROUND: Electronic patient rehabilitation applications (EPRA) may both decrease cost and standardize postoperative rehabilitation after total joint arthroplasty (TJA). We hypothesize that increased engagement with EPRA leads to higher patient reported outcome measures (PROMs).

METHODS: Prospective data from an orthopedic hospital were reviewed for primary total hip arthroplasty (THA) and total knee arthroplasty (TKA) patients between November 2016 and May 2019. Hip Disability and Osteoarthritis Outcome Score for Joint Replacement (HOOS, JR.) and Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS, JR.) were collected at 1 month prior to surgery, 6 weeks, 12 weeks, and 1 year postoperatively. Patients were compared based on how many days within the first 10 postoperative days they utilized EPRA.

RESULTS: 1,865 patients undergoing THA and 875 patients undergoing TKA were registered for EPRA. THA patients who logged in to EPRA 6 or more of the first 10 postoperative days reported significantly better HOOS, JR. scores at 12 weeks compared to those who did not log in or logged in only 1-5 days ($p = 0.033$ and $p = 0.030$, respectively). TKA patients who logged in to EPRA 6 or more of the first 10 postoperative days trended towards better KOOS, JR. scores at all postoperative timepoints, but these findings did not reach significance.

CONCLUSION: Our data suggests that patients who engage early and frequently with EPRA may have increased PROMs after TJA. These findings support EPRA as a value-based tool for TJA rehabilitation and emphasize the importance of preoperative patient education for maximizing postoperative PROMs.

Key Words: Total joint arthroplasty; Electronic patient rehabilitation; Engagement; Patient reported outcomes; Preoperative education; Value-based care

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Abbreviations

Electronic patient rehabilitation applications (EPRA), home health services (HHS), patient reported outcome measures (PROMs), total hip arthroplasty (THA), total knee arthroplasty (TKA), total joint arthroplasty (TJA), hip disability and osteoarthritis outcome score for joint replacement (HOOS, JR.), knee injury and osteoarthritis outcome score for joint replacement (KOOS, JR.), minimal clinically important difference (MCID).

INTRODUCTION

Total hip and total knee arthroplasty have been proven to alleviate pain, restore function, and improve quality of life for patients with degenerative joint disease[1,2]. Recent developments such as modern pain control modalities, minimally invasive surgery, and advanced rehabilitation protocols are being utilized with increasing frequency to reduce the need for ancillary services and improve care in the value-based era[3-8]. Currently, many total joint arthroplasty patients who are discharged home receive home health services (HHS), including visiting nurses and physical therapy. Alternatively, remote means of patient engagement have shown promise and may be a way to supplement or even supplant traditional HHS[9]. New developments in telemedicine are providing additional opportunities to decrease the need for these ancillary services, standardize the perioperative management of total joint arthroplasty, and decrease costs[10,11].

Even in its early stages, electronic medical services, namely electronic patient rehabilitation applications (EPRA), have already shown to be effective at rehabilitating most primary total hip and knee arthroplasty patients[12-15]. These services are intended to improve patient compliance, reinforce patient-centered decision making, facilitate earlier patient independence, and increase patient and provider satisfaction. EPRA allows patients to adhere to pre- and post-operative standardized protocols without the need for in person monitoring. Additionally, it provides physicians the opportunity to immediately identify patients who require closer monitoring or adjustments to their rehabilitation protocol. Thus, EPRA may allow patients to receive both standardized and customizable perioperative rehabilitation, all without the need for expensive ancillary services[16,17].

While it has been reported that EPRA can lead to similar post-operative outcomes compared to patients who receive traditional HHS after total hip and knee arthroplasty[12-15], to our knowledge, no study has evaluated whether patients who use EPRA more frequently have better patient reported outcomes. The purpose of our study is to evaluate whether total joint arthroplasty patients who use EPRA more often postoperatively have better outcomes as measured by patient reported outcome measures (PROMs). If this relationship exists, patients may be even more inclined to participate in EPRA as an alternative to HHS, thus leading to earlier patient independence and significant healthcare savings. We hypothesize that total joint arthroplasty patients who engage more with their EPRA will have higher PROMs compared to patients who engage less.

MATERIAL AND METHODS

Prospectively collected data was retrospectively reviewed from a single urban, academic, tertiary orthopedic hospital. Patients who underwent total hip arthroplasty (THA) and total knee arthroplasty (TKA) between November 2016 and May 2019 were registered for the EPRA. Those who completed at least the preoperative PROM survey were included in this study. Patients were excluded if they underwent bilateral or revision total joint arthroplasty. As part of our institutional quality improvement program, the present study was exempted from human-subjects review by our Institutional Review Board.

EPRA

Consistent with our institution's standard of care, all total joint arthroplasty patients were preoperatively registered for the EPRA (Force Therapeutics, New York, NY) at the time of surgical scheduling. Outcome surveys were pushed to the patient at predefined time intervals (1-month prior to surgery, and 6 weeks, 12 weeks, and 1 year postoperatively) via mobile and web-based methods. PROMs collected through the EPRA included the Hip Disability and Osteoarthritis Outcome Score for Joint Replacement (HOOS, JR.) and Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS, JR.). HOOS, JR. and KOOS, JR. Scores are measured on a 100-point scale, with higher scores representing superior joint function. Both KOOS, JR. and HOOS, JR. have been validated as patient-relevant and efficient[18,19]. The minimal clinically important differences (MCID) for the HOOS JR. and KOOS, JR. are estimated to be between 7 and 36 points for both PROMs[20].

Study Cohort

In total, 1,865 patients undergoing THA and 875 patients undergoing TKA at our institution were registered for the EPRA during the study period. The average age of the THA cohort was 64.3 ± 10.8 years (range 15 to 93 years), and the average age of the TKA cohort was 65.5 ± 9.2 years (range 26 to 100 years). Patients were divided into three cohorts based on how many of the first 10 postoperative days they logged into the EPRA; no days, 1-5 days, or 6-10 days. We will refer to these groups as the no login cohort, 1-5 login-day cohort, and 6-10 login-day cohort, respectively moving forwards.

Statistical Analysis

All statistical analyses were performed by a statistician using STATA version 15.1 (StataCorp. 2017. College Station, TX). Descriptive statistics were run on all patient entries and included averages and standard deviations. One-way ANOVA tests and pairwise comparisons were performed to evaluate for significance between PROMs at each pre and postoperative time point for each frequency of logins. A regression analysis was performed to determine the rate of change in PROMs over time, controlling for the number of logins.

RESULTS

In total, 1,865 patients undergoing THA and 875 patients undergoing TKA were included in this study. Surgeries were performed by thirteen surgeons at our institution. Of the THA patients, 352 (18.9%) did not log in to the EPRA during the first 10 postoperative days, 158 (8.5%) logged in for 1-5 of the first 10 postoperative days, and 1,355 (72.7%) logged in for 6-10 of the first 10 postoperative days. Of the TKA patients, 352 (39.0%) did not log in to the EPRA during the first 10 postoperative days, 128 (14.6%) logged in for 1-5 of the first 10 postoperative days, and 406 (46.4%) logged in for 6-10 of the first 10 postoperative days.

On average, THA patients in the 6-10 login-day cohort were significantly younger (61.8 years ± 10.2) than those in the no login or 1-5 login-day cohort (66.1 years ± 11.4, 65.8 years ± 10.7, respectively; $p = 0.001$). Similarly, TKA patients who used EPRA more often were significantly younger (no login: 67.2 ± 10.5 vs. 1-5 login-days: 66.6 ± 9.3 vs. 6-10 login-days: 64.7 ± 8.4; $p = 0.013$).

Tests for significance revealed that for THA patients, as engagement increased, HOOS, JR. scores were significantly higher both preoperatively (no login: 50.0 ± 14.6 vs. 1-5 login-days: 51.9 ± 14.9 vs. 6-10 login-days: 52.1 ± 13.1; $p = 0.033$) and at 12 weeks postoperatively (no login: 78.2 ± 15.6 vs. 1-5 login-days: 80.7 ± 14.2 vs. 6-10 login-days: 81.8 ± 13.7; $p = 0.030$). Pairwise

comparisons showed that significantly higher HOOS, JR. scores were achieved by the 6-10 login-day cohort compared to the no login cohort both preoperatively and at 12 weeks postoperatively ($p \leqslant 0.01$). Differences in HOOS, JR. scores between the login frequency cohorts at the 6 week interval approached but did not reach significance ($p = 0.059$). Similarly, when comparing magnitude of improvement in HOOS, JR. scores from preoperative to 12 week postoperative timepoints, while there was a trend towards larger magnitude of improvement in the 6-10 login-frequency cohort (29.4, $n = 1076$) compared to the no login cohort (27.3, $n = 106$), this finding did not reach significance ($p = 0.221$).

Similar to the HOOS, JR. scores at 6 weeks, KOOS, JR. scores appeared to improve as login frequency improved, but these scores did not reach statistical significance preoperatively, at 6 weeks, or at 12 weeks postoperatively ($p = 0.291$, $p = 0.736$, $p = 0.207$, respectively). Additionally, there did not appear to be a significant difference between the increases in HOOS, JR. or KOOS, JR. at any time point for any of the login frequency cohorts. PROMs for each of these login frequency cohorts at the pre and postoperative time points are shown in Tables 1 and 2.

The relationship between HOOS, JR. scores and EPRA engagement was further explored in a multivariable regression analysis that controlled for time and the number of days logged in (Table 3 and Figure 1). Postoperative scores were found to significantly improve over preoperative scores at 6 weeks, 12 weeks, and 1 year (beta coefficient 20.5, 27.7, 35.2, respectively; $p < 0.001$ for each time point). Additionally, patients in the 6-10 login-day cohort had significant improvements in HOOS, JR. scores over time compared to the no login reference cohort (beta coefficient 2.1; $p = 0.009$). While the 1-5 login-day cohort appeared to have improved HOOS, JR. scores over time compared to the no login reference cohort, this trend did not reach significance (beta coefficient 1.9; $p = 0.153$). When looking at the interaction between time and EPRA engagement, the improvement scores at 6 weeks approached significance for those in the 6-10 login-day cohort ($p = 0.070$), although true significance was not demonstrated for any time-login frequency interaction explored.

DISCUSSION

Achieving value-based care is one of the most important strategies in reducing healthcare costs and increasing patient satisfaction. Adult reconstructive orthopedic surgeons are attempting to improve their use of healthcare resources by shifting perioperative services out of the hospital and into the patients' home. In order to achieve this, significant resources are being directed towards optimizing patients in the perioperative period, improving multimodal pain regimens, advancing anesthesia modalities, and developing less traumatic surgical techniques[3-8]. Traditionally, patients would receive HHS after discharge home from the hospital, which has been challenging to coordinate, non-uniform in application, and expensive, costing Medicare over $648 million USD a year[21]. Newer data suggests that HHS may not be necessary for all patients after primary total hip and knee replacements, and that value-based alternatives such as unsupervised home rehabilitation programs and EPRA exist, with savings potentials of over $400,000 USD per year noted at one institution[12,17,22].

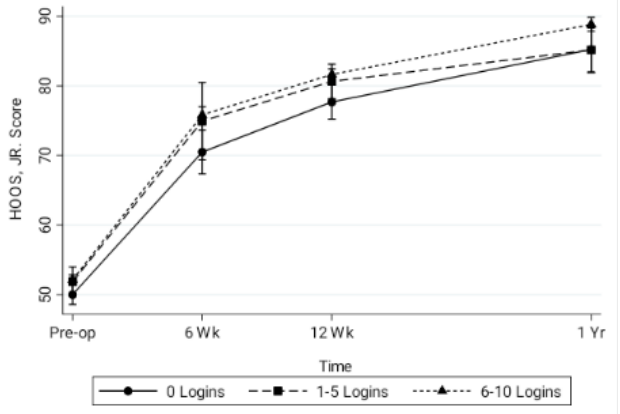

Figure 1 HOOS, JR. scores over time by number of days within the first 10 postoperative days with an EPRA login.

Total Hip Arthroplasty

Our data suggests that for patients who undergo THA, those who engage most frequently with EPRA have significantly better outcomes as measured by HOOS, JR. scores (Table 1). These better outcomes were seen for the most engaged patients both preoperatively ($p = 0.033$) and at 12 weeks postoperatively ($p = 0.030$). At 6 weeks, more engaged patients had higher HOOS, JR. scores, but this finding did not reach significance ($p = 0.059$). The

Table 1 Association of HOOS, JR. scores and logins, mean (± SD).

	No Logins ($n = 352$)	1-5 Logins ($n = 158$)	6-10 Logins ($n = 1355$)	p-value*
Pre-Op	50.0 (±14.6)	51.9 (±14.9)	52.1 (±13.1)	0.033
6 Week	71.6 (±14.6)	69.1 (±10.8)	74.7 (±13.4)	0.059
12 Week	78.2 (±15.6)	80.7 (±14.2)	81.8 (±13.7)	0.03

* results from ANOVA, pairwise comparisons suggest significance between those with no logins in the first 10 days and those with 6-10 logins within the first 10 days with p-value < 0.01 for HOOS, JR. Pre-Op and HOOS, JR. 12 week. All other pairwise comparisons were non-significant.

Table 2 Association of KOOS, JR. scores and logins, mean (± SD).

	No Logins ($n = 341$)	1-5 Days ($n = 128$)	6-10 Days ($n = 406$)	p-value*
Pre-Op	45.4 (±13.9)	45.6 (±14.5)	46.9 (±13.7)	0.291
6 Week	61.8 (±12.2)	61.4 (±11.8)	62.3 (±10.8)	0.736
12 Week	64.4 (±13.1)	64.7 (±13.0)	66.5 (±12.8)	0.207

* results from ANOVA, pairwise comparisons were also non-significant.

Table 3 Regression of HOOS, JR. score over time predicted by logins

	β Coefficient (95% CI)	p-value
Time		
Pre-Op (ref)	---	
6 Wk	20.5 (17.2, 23.7)	< 0.001
12 Wk	27.7 (25.1, 30.2)	< 0.001
1 Yr	35.2 (31.8, 38.6)	< 0.001
Logins		
0 (ref)	---	
1-5	1.9 (-0.7, 4.4)	0.153
6-10	2.1 (0.5, 3.7)	0.009
Time-Login Interaction		
Pre-Op by 0 logins (ref)	---	
6 Wk by 1-5 logins	2.6 (-4.0, 9.1)	0.441
6 Wk by 6-10 logins	3.2 (-0.3, 6.7)	0.07
12 Wk by 1-5 logins	1.1 (-2.7, 4.9)	0.568
12 Wk by 6-10 logins	1.8 (-0.9, 4.6)	0.186
1 Yr by 1-5 logins	-1.9 (-6.7, 2.9)	0.43
1 Yr by 6-10 logins	1.5 (-2.1, 5.1)	0.417

inability to identify significance at the 6 week time point for the most engaged patients is likely a beta error given that the 6 week timepoint had fewer subjects than the preoperative and 12 week time points (n = 522 vs. n = 1865 vs. n = 1292, respectively).

Importantly, despite the suggestion that increased EPRA engagement leads to improved HOOS, JR. scores, while there was a trend, there was no significant difference in the magnitude of improvement in HOOS, JR. score from the preoperative to 12 week timepoint for the no login cohort compared to the 6-10 login-day cohort (p = 0.221). This suggests that despite having higher average HOOS, JR. scores in the most engaged cohort, the magnitude of improvement in HOOS, JR. scores may be equivalent regardless of login frequency. However, this comparison also appeared to be underpowered (no login cohort, n = 106 vs. 6-10 login-day cohort, n = 1076), and may require more patients in order to detect a significant difference.

One reason that more engaged patients have better outcomes may be because these patients are younger (p = 0.001). Younger age, which independently has been associated with more engagement in EPRA[23], is also suggested by some to be independently associated with better outcomes after THA[24-26]. Despite this, while younger patients are generally less disabled and have less comorbidities at baseline[24,26-28], all patients who take a more active role in optimizing their perioperative health have better pain relief and higher satisfaction after total joint arthroplasty[29]. Further, while both the higher average and the larger magnitude of improvement in HOOS, JR. scores for the 6-10 login-day cohort compared to the no login cohort may appear to be explained by the significantly younger age of the 6-10 login-day cohort, recent data suggests that as people age, HOOS, JR. scores only decrease about 0.1 a year[30]. Thus, the maximum HOOS, JR. score difference due to cohort age would only be about 0.5 points (6-10 login-day, 61.8 years vs. no login cohort, 66.1 years). In actuality, the higher average and larger magnitude of improvement in HOOS, JR. scores for the 6-10 login-day cohort compared to the no login cohort is far greater than 0.5, suggesting that all THA patients, regardless of age, may realize early postoperative benefits from increased engagement with EPRA.

Total Knee Arthroplasty

Similar to the 6 week timepoint for THA patients, for TKA patients, our data suggests but does not confirm that more interaction with EPRA leads to better KOOS, JR. scores (Table 2). As engagement increased, KOOS, JR. scores increased at each timepoint, though these improvements did not reach significance. Our inability to reject the null hypothesis may similarly be due to a sample size error, as the TKA cohort was less than half the size of the THA cohort (875 vs. 1,865). Further, engagement numbers at each of the three TKA timepoints had a similar number of engagements to the THA 6 week cohort, which also failed to reject the null hypothesis but closely approached significance. Using a post-hoc power analysis, it appears that the TKA cohort achieved at most 60% power (12 week timepoint), and as low as 10% power (6 week timepoint). Future analyses with a larger sample size are required to determine if increased engagement with EPRA leads to significant improvement in PROMs for TKA patients.

Further support for this comes from Fleischman *et al*, who found that in select TKA patients, unsupervised home exercises, both by EPRA or using a printed paper manual, can lead to noninferior outcomes when compared to outpatient physical therapy[22]. Importantly, compared to the study by Fleischman *et al*, our protocol was not as selective in enrolling patients for EPRA, which may explain why our TKA cohort may have been too underpowered to detect significance. Any patients who would have otherwise been excluded by Fleishman *et al*, and even Klement *et al* who found that most but not all TKA patients may be appropriate for EPRA[15], may have confounded any dose-dependent effect of EPRA. Future studies should either be more selective in enrolling patients or have a larger sample size to detect significance.

Another possible explanation for our inability to find significantly improved PROMs with increased engagement in the TKA cohort was that there was less overall engagement in the TKA cohort compared to the THA cohort. Specifically, 39.0% of TKA patients were in the no login cohort and thus did not engage with EPRA, while only 18.9% of THA patients were in the no login cohort. Given that THAs are more often outpatient procedures at our institution compared to TKAs, our THA patients may have a more robust emphasis on EPRA engagement and perioperative optimization compared to our TKA patients. Future studies would optimally account for this surgeon bias and make sure all patients undergo the same perioperative counseling.

Lastly, like the THA cohort, the TKA patients in the 6-10 login-day cohort were significantly younger compared to patients in the less engaged cohorts. While this may partially account for the trend in PROM improvement seen between the login frequency cohorts, the maximum KOOS, JR. difference due to cohort age would only be about 0.3 (6-10 login-day, 64.7 years vs. no login cohort, 67.2 years). Again, the higher average KOOS, JR. scores for the no login and 6-10 login-day cohorts is far greater than 0.3, suggesting that all TKA patients, regardless of age, may realize early postoperative benefits from increased engagement with EPRA.

Limitations

There are several limitations to this study. Most importantly, despite the significant improvements in HOOS, JR. scores, and trend towards improvement in KOOS, JR. scores for the most engaged cohorts, the improvements in PROMs may not be clinically apparent to patients and providers. The minimal clinically important difference for HOOS, JR. or KOOS, JR. scores of 7 to 36 points was not achieved in our study[20]. Despite this, it is important to note that clinically significant improvements in outcome do not occur in isolation and are a combination of multiple modalities that together lead to clinically significant improvements in PROMs. Additionally, while maybe not clinically significantly better, EPRA can still act as a non-inferior, better-value alternative to traditional HHS for the appropriate total joint arthroplasty patient. As discussed, another limitation of this study is that the TKA cohort and the 6 week THA cohort appeared to be underpowered, and will require future analyses with larger cohorts to detect any true significance. Lastly, while our large consortium of surgeons allowed for a wider, more generalizable applicability of our findings, it did introduce variability into our patients' perioperative education and encouragement to participate in EPRA. This may explain why our TKA cohort had lower engagement compared to our THA cohort. With this information, we are placing more emphasis on preoperative education, encouraging maximum and frequent engagement with this simple tool to improve value in total joint arthroplasty.

CONCLUSIONS

With each successive supportive publication, EPRA is quickly gaining acceptance within the orthopedic community for

postoperative rehabilitation after total joint arthroplasty. Unlike with outpatient physical therapy, increased engagement with EPRA does not lead to increased healthcare costs, or significant patient inconvenience. Our study suggests that early, frequent engagement with EPRA leads to improved PROMs for THA patients, and that increased EPRA engagement may also benefit TKA patients. While more work is needed to define the clinical advantages and disadvantages of EPRA, EPRA is quickly proving to be a valuable tool in helping orthopedists achieve value-based care.

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