Effect of Preoperative Electronic Patient Engagement on Patient Reported Outcomes following Total Hip Arthroplasty

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Introduction

Electronic patient rehabilitation applications (EPRAs) are widely used to provide remote, cost-effective perioperative care. The clinical utility of EPRAs have previously been assessed in the context of post-operative use. The aim of this study was to examine the effect of preoperative EPRA engagement on patient-reported outcomes (PRO) following primary total hip arthroplasty (THA).

Methods

We conducted a single-center, retrospective review of patients at an urban, academic medical center who received primary total hip arthroplasty and EPRA between 2016 and 2019. Patients were separated into groups depending on preoperative login totals: [0-3], [4-7] and [8+]. Patient-reported outcome scores (Hip injury and Osteoarthritis Outcome Score, Joint Replacement [HOOS, JR], Veterans RAND-12 Physical and Mental Components [VR-12 PCS, MCS]) were collected at baseline and 12 weeks. Kruskal-Wallis testing was used to assess differences in mean scores between subgroups.

Results:

Of the 2,289 patients included, 897 had 0-3 preoperative logins, 792 had 4-7 logins, and 600 had over 8 logins. There was no difference in baseline VR12 PCS and MCS scores. A small difference in baseline HOOS, JR scores was observed (51.27 vs 53.14 vs 52.24, $p=0.028$). Mean scores at 12 weeks were higher for patients with preoperative login counts greater than 3, (HOOS, JR: [0-3] 77.68 vs [4-7] 79.79 vs [8+] 81.35, $p<0.001$, VR-12 PCS: [0-3] 43.49 vs [4-7] 44.07 vs [8+] 44.9, $p<0.05$; VR-12 MCS: [0-3] 53.93 vs [4-7] 54.42 vs [8+] 55.42, $p<0.05$).

Conclusion:

Preoperative EPRA engagement measured by the frequency of patient log-ins is associated with statistically significant higher postoperative PRO scores. However, the differences were not clinically significant. Further study is needed to determine if increased participation in pre-operative exercise can improve outcome scores after total hip arthroplasty further.

Keywords: total hip arthroplasty, outcomes, preoperative, electronic patient rehabilitation

Introduction

The success of total hip arthroplasty (THA) has been ubiquitously studied in the context of improved quality of life, pain alleviation, and functional rehabilitation. Outcomes following THA have continued to improve the past several decades. This progress can be attributable to many factors such as improved perioperative protocols as well as advances in postoperative rehabilitation[1–3]. Preoperative rehabilitation has recently demonstrated improvement in postoperative outcomes and has thus come to the forefront in the investigation of perioperative management and optimization[4,5].

Preoperative health status has long been considered a predictor of postoperative outcomes following joint replacement, with greater physical function and strength associated with better outcomes[6–8]. Several studies have shown an association between preoperative exercise programs and reduced disability[9], improved strength, and faster return to function in the immediate postoperative period[10–12]. Reductions in financial burden have also been associated with preoperative rehabilitation; Rooks et al. found patients who participated in preoperative exercise programs were more likely to be discharged home rather than to inpatient rehabilitation[13]. In contrast, reduced preoperative function has been associated with increased length of stay and need for more intensive rehabilitation, thus increasing financial burden on the health system[14].

Simultaneously, the utilization of smartphone applications to provide exercise instruction to patients have allowed easier active patient participation in their care[15,16]. The use of application-based rehabilitation platforms offers the convenience of accessibility and real-time monitoring, leading to improved patient compliance and emphasizing patient-centered care and minimization of economic burden related to care[15]. Although many studies have explored the benefits of traditional in-person prehabilitation exercise programs, it is currently unknown if electronic patient rehabilitation applications (EPRAs) used for prehabilitation have a similar effect on postoperative outcomes of total joint arthroplasty patients. This study looks to discover the relationship between participation in EPRAs in the preoperative period and postoperative patient reported outcomes after THA. We hypothesize there will be a direct correlation between greater preoperative EPRA engagement and improved PRO scores in the immediate postoperative period.

Materials & Methods

Study Design

A retrospective analysis of patient data was performed at an urban academic medical center following approval by the institutional review board. Patients who received elective primary total hip arthroplasty between 2016 and 2019 were identified for inclusion. A report containing baseline demographics was generated using the institution's electronic health records (EHR) system. Patient variables included in the demographic report included age, sex, race, BMI, ASA, and smoking status. Preoperative login counts were collected from the EPRA platform as a proxy for preoperative EPRA engagement. Outcomes of interest included the Hip injury and Osteoarthritis Outcome Score, Joint Replacement (HOOS, JR) and the Veterans RAND-12 Physical and Mental Components (VR-12 PCS, MCS). All patient reported outcome (PRO) scores were collected at baseline and 12 weeks postoperatively via an online survey integrated into the EPRA. Patients who did not have a corresponding baseline PRO score were excluded

The EPRA platform used in this study was Force (Force Therapeutics, New York, NY), an electronic application focused on rehabilitation following lower extremity joint arthroplasty. The application allows THA candidates to preoperatively watch surgeon-specific videos in preparation for their procedure. In addition to providing educational videos focused on post-operative care (e.g. wound management and rehabilitation), the application provides access to instructional videos recommended by the surgeon for pre-operative exercises (i.e. prehabilitation). Furthermore, the application includes encrypted chat functionality for patients to directly communicate with their care providers. 2,289 patients were categorized into three groups based on their preoperative login counts (0-3, 4-7, and 8+) to the EPRA, which were used as a proxy for preoperative patient engagement.

Statistical Analysis

Statistical analysis was conducted using R Studio (version 1.3.959, Boston, MA). All patient variables reported were assessed using descriptive statistics. Comparative analyses of mean PRO scores between cohorts were conducted using Kruskal-Wallis testing, with a value of $p < 0.05$ considered statistically significant.

Results

In total, 2,289 patients underwent elective primary THA and participated in the FORCE application within the study period. Of these, 2,160 (94.4%) had complete PRO records for HOOS, JR, with scores

acquired at baseline and 12 weeks. All patients completed the VR12 PCS and MCS surveys at baseline and 12 weeks.

Within the HOOS, JR cohort, 848 patients preoperatively logged in between 0 and 3 times, 739 logged in between 4 and 7 times, and 573 logged in over 8 times. Within the VR12 cohort, 897 patients logged in between 0 and 3 times [0-3], 792 logged in between 4 and 7 times [4-7], and 600 logged in over 8 times [8+]. No clinically significant difference in mean PRO scores between the three groups was observed at baseline for HOOS, JR, VR12 PCS, and VR12 MCS. Statistically significant differences were found in mean PRO scores at 12 weeks, with patients logging in greater than 8 times preoperatively reporting the highest mean PRO scores for all three PROs included (Table 2). Mean HOOS, JR scores at 12 weeks for the [0-3], [4-7], and [8+] groups were 77.68, 79.79, and 81.35, respectively ($p<0.001$). Similarly, mean VR12 PCS scores at 12 weeks were 43.49, 44.07, and 44.91 ($p=0.023$) and mean VR12 MCS scores at 12 weeks were 53.93, 54.42, and 55.42 ($p=0.011$). For all PROs studied, patients in the [8+] group showed the greatest difference in mean PRO scores from baseline to 12 weeks (Table 2).

Discussion

Prehabilitation in preparation for total joint arthroplasty has the potential to improve preoperative strength[11], postoperative outcomes[4], reduce hospital length of stays[17], and decrease the total cost per episode of care[17]. The goal of this study was to evaluate the relationship between patient involvement in EPRAs during the immediate preoperative period prior to total hip arthroplasty and postoperative outcome scores in the first three months after surgery. Pre-operative patient engagement was measured by the number of patient log-ins to the EPRA app. This study demonstrated a statistically significant, increase in HOOS JR, VR12 PCS, and VR12 MCS outcome scores between cohorts based on the number of “logins” to the EPRA. The data suggests that greater preoperative involvement in EPRAs was associated with improved patient reported outcomes scores, but the differences were not clinically significant. This is the first study to explore the relationship between preoperative usage of EPRAs and their association with postoperative patient reported outcomes.

Electronic rehabilitation after total joint arthroplasty is not a new concept. Klement et al.[18] performed a single institution, multi-surgeon retrospective study of 941 patients who underwent unilateral primary THA comparing those who were enrolled in a web-based self directed physical therapy (SDPT) program to another group who were enrolled in formal outpatient physical therapy (OPPT) as well as SDPT. Patients were

prescribed OPPT after their 4 week follow up appointment if they were felt to have a perceived need. The study demonstrated that those patients who underwent only SDPT had a statistically significant higher HOOS JR vs the cohort that was enrolled in both SDPT and OPPT suggesting that web based SDPTs can be a safe and effective protocol for some patients.

While this is the first study to examine the usage of EPRAs in prehabilitation, there are an abundance of studies examining the effects of prehabilitation programs on postoperative outcomes following total joint arthroplasty. In 2009, Topp et al performed a randomized controlled trial comparing the effect of preoperative leg exercises three times per week on postoperative pain, quadriceps strength, and leg strength asymmetry. The group performing preoperative leg exercises demonstrated a maintained increase in operative leg strength with lower leg strength asymmetry compared to the control group which demonstrated greater lower extremity strength asymmetry[12]. Brown et al compared a preoperative exercise group undergoing total knee arthroplasty to a non-exercise control group with a SF-36 questionnaire at 3 months following surgery. The prehabilitation group demonstrated statistically significant increases the physical functioning sub-scale compared to the control group[19]. Moyer et al performed a meta-analysis of the value of preoperative exercise and education on patients undergoing total joint arthroplasty. This meta-analysis evaluated 35 studies involving 2,956 patients. Those patients undergoing total hip arthroplasty participating in prehabilitation demonstrated statistically significant improvements in postoperative pain as well as postoperative function. Additionally, significant improvements were noted in quadriceps strength in the prehabilitation group compared to control group after TKA[5]. Chughtai et al looked at the impact of a prehabilitation program focused on exercises, nutritional advice, education, and pain management after surgery compared to a control group who did not utilize the program. The prehabilitation group demonstrated shorter length of acute care stays (2.0 vs 2.7 days, $p<0.001$) as well as 77% disposition to home versus 42.8% in the control group ($p<0.001$). Finally, the prehabilitation group demonstrated fewer discharges to a SNF (1.8%) versus the control group (21.8%, $p<0.0001$)[20]. Therefore, efforts to increase patient participation in prehablitation exercises are warranted, and may have a positive impact on patient outcomes for some patients.

The introduction of BPCI and CJR, with fixed payments per episode of care for performing total joint arthroplasty has forced healthcare systems, hospitals, and surgeons to become better financial stewards of our patients care. Utilization of EPRAs instead of formal OPPT in the postoperative period has been demonstrated

to be a safe alternative to formal OPPT in a majority of patients[18]. In addition, Zachwieja et al. performed a retrospective review of 701 patients who were enrolled in both a web-based physical therapy (WBPT) as well as OPPT[21]. The patients were examined preoperatively and followed for 6 months postoperatively with the rate of manipulation under anesthesia, operative knee range of motion, and cost of physical therapy recorded. Approximately half of all patients participated in only WBPT, a third in WBPT and OPPT, and the remainder in neither program. Interestingly, in those patients that participated in both WBPT and OPPT, subgroup analysis demonstrated a decrease in the number and cost of PT visits as the number of WBPT logins increased. Given the success of EPRA applications with post-operative rehabilitation, it is worthwhile to explore their use for prehabilitation exercises as well.

Encouraging patient involvement can be a difficult task for surgeons and their staff. While there is clear evidence that those patients who frequently logged into the EPRA prior to the surgery had a statistically significant effect on PROs, this did not reach clinical significance. Participation in EPRA may be as much of an indicator for individual patient motivation as it is an indicator of the positive effect of the preoperative exercises. Despite this, knowing the amount of preoperative EPRA participation is still valuable information. A surgeon or care coordinator can use the number of “log-ins” to stratify those patients that may need extra help in the perioperative period to achieve greater postoperative outcomes while allowing those motivated patients to perform home therapy with confidence. Further research needs to be performed to delineate if those engaged patients would do well without any formal OPPT while those unengaged patients may need more formal instruction to secure improved outcomes.

Limitations of this study include its lack of granularity with the data reporting from the EPRA application. The data harvested only demonstrates how many “log-ins” a patient had prior to the surgical date. It does not specify how long they were logged in for, what preoperative videos they watched if any, how long they used the application, and what other activities they performed in the application. This study assumes that preoperative log-in into the EPRA application was used to perform preoperative exercises in preparation for surgery, but this may not be the case for all patients. Additionally, this study is subject to a volunteer bias as it requires patients to voluntarily log into FORCE and complete the patient reported outcome surveys. This is also a retrospective study that by its nature can only demonstrate an association between participation in preoperative EPRAs and statistically significant improvement in postoperative outcomes.

Conclusion

Preoperative EPRA engagement can be a valuable tool for the arthroplasty surgeon and their staff to help improve postoperative outcomes. Given their success for some patients in supporting post-operative rehabilitation as well as additional data supporting prehabilitation, exploring the use of EPRAs prior to hip or knee arthroplasty as a cost-effective adjuvant is important. Further study is needed to determine the optimal EPRA application and program for each patient, and if increased participation in pre-operative exercise can improve outcome scores after total hip arthroplasty further.

References

1. Auyong DB, Allen CJ, Pahang JA, Clabeaux JJ, MacDonald KM, Hanson NA. Reduced Length of Hospitalization in Primary Total Knee Arthroplasty Patients Using an Updated Enhanced Recovery After Orthopedic Surgery (ERAS) Pathway. *The Journal of Arthroplasty*. 2015;30(10):1705-1709. doi:10.1016/j.arth.2015.05.007

2. Van Horne A, Van Horne J. Presurgical optimization and opioid-minimizing enhanced recovery pathway for ambulatory knee and hip arthroplasty: postsurgical opioid use and clinical outcomes. *Arthroplasty Today*. 2020;6(1):71-76. doi:10.1016/j.artd.2019.08.010

3. Ranawat AS, Ranawat CS. Pain Management and Accelerated Rehabilitation for Total Hip and Total Knee Arthroplasty. *The Journal of Arthroplasty*. 2007;22(7):12-15. doi:10.1016/j.arth.2007.05.040

4. Cavill S, McKenzie K, Munro A, et al. The effect of prehabilitation on the range of motion and functional outcomes in patients following the total knee or hip arthroplasty: A pilot randomized trial. *Physiotherapy Theory and Practice*. 2016;32(4):262-270. doi:10.3109/09593985.2016.1138174

5. Moyer R, Ikert K, Long K, Marsh J. The Value of Preoperative Exercise and Education for Patients Undergoing Total Hip and Knee Arthroplasty: A Systematic Review and Meta-Analysis. *JBJS Rev*. 2017;5(12):e2-e2. doi:10.2106/JBJS.RVW.17.00015

6. Fortin PR, Clarke AE, Joseph L, et al. Outcomes of total hip and knee replacement: preoperative functional status predicts outcomes at six months after surgery. *Arthritis Rheum*. 1999;42(8):1722-1728. doi:10.1002/1529-0131(199908)42:8<1722::AID-ANR22>3.0.CO;2-R

7. Ethgen O, Bruyère O, Richy F, Dardennes C, Reginster J-Y. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. *J Bone Joint Surg Am*. 2004;86(5):963-974. doi:10.2106/00004623-200405000-00012

8. Mizner RL, Petterson SC, Stevens JE, Axe MJ, Snyder-Mackler L. Preoperative quadriceps strength predicts functional ability one year after total knee arthroplasty. *J Rheumatol*. 2005;32(8):1533-1539.

9. Gill SD, McBurney H, Schulz DL. Land-Based Versus Pool-Based Exercise for People Awaiting Joint Replacement Surgery of the Hip or Knee: Results of a Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*. 2009;90(3):388-394. doi:10.1016/j.apmr.2008.09.561

10. Evgeniadis G, Beneka A, Malliou P, Mavromoustakos S, Godolias G. Effects of pre- or postoperative therapeutic exercise on the quality of life, before and after total knee arthroplasty for osteoarthritis. *BMR*. 2008;21(3):161-169. doi:10.3233/BMR-2008-21303

11. Swank AM, Kachelman JB, Bibeau W, et al. Prehabilitation Before Total Knee Arthroplasty Increases Strength and Function in Older Adults With Severe Osteoarthritis: *Journal of Strength and Conditioning Research*. 2011;25(2):318-325. doi:10.1519/JSC.0b013e318202e431

12. Topp R, Swank AM, Quesada PM, Nyland J, Malkani A. The Effect of Prehabilitation Exercise on Strength and Functioning After Total Knee Arthroplasty. *PM&R*. 2009;1(8):729-735. doi:10.1016/j.pmrj.2009.06.003

13. Rooks DS, Huang J, Bierbaum BE, et al. Effect of preoperative exercise on measures of functional status in men and women undergoing total hip and knee arthroplasty. *Arthritis Rheum*. 2006;55(5):700-708. doi:10.1002/art.22223

14. Fielden JM, Cumming JM, Horne JG, Devane PA, Slack A, Gallagher LM. Waiting for Hip Arthroplasty. *The Journal of Arthroplasty*. 2005;20(8):990-997. doi:10.1016/j.arth.2004.12.060

15. Davidovitch RI, Anoushiravani AA, Feng JE, et al. Home Health Services Are Not Required for Select Total Hip Arthroplasty Candidates: Assessment and Supplementation With an Electronic Recovery Application. *The Journal of Arthroplasty*. 2018;33(7):S49-S55. doi:10.1016/j.arth.2018.02.048

16. Austin MS, Urbani BT, Fleischman AN, et al. Formal Physical Therapy After Total Hip Arthroplasty Is Not Required: A Randomized Controlled Trial. *The Journal of Bone and Joint Surgery*. 2017;99(8):648-655. doi:10.2106/JBJS.16.00674

17. Huang S-W, Chen P-H, Chou Y-H. Effects of a preoperative simplified home rehabilitation education program on length of stay of total knee arthroplasty patients. *Orthopaedics & Traumatology: Surgery & Research*. 2012;98(3):259-264. doi:10.1016/j.otsr.2011.12.004

18. Klement MR, Rondon AJ, McEntee RM, Kheir M, Austin MS. Web-Based, Self-Directed Physical Therapy After Total Hip Arthroplasty Is Safe and Effective for Most, but Not All, Patients. *The Journal of Arthroplasty*. 2019;34(3):513-516. doi:10.1016/j.arth.2018.10.032

19. Brown K, Brosky JA, Topp R, Lajoie AS. Prehabilitation and Quality of Life Three Months after Total Knee Arthroplasty: A Pilot Study. *Percept Mot Skills*. 2012;115(3):765-774. doi:10.2466/15.06.10.PMS.115.6.765-774

20. Chughtai M, Shah NV, Sultan AA, et al. The role of prehabilitation with a telerehabilitation system prior to total knee arthroplasty. *Ann Transl Med*. 2019;7(4):68-68. doi:10.21037/atm.2018.11.27

21. Zachwieja E, Theosmy EG, Yacovelli SJ, Beatty EW, McGrath ME, Lonner JH. Web-Based Self-Directed Exercise Program Is Cost-Effective Compared to Formal Physical Therapy After Primary Total Knee Arthroplasty. *The Journal of Arthroplasty*. 2020;35(9):2335-2341. doi:10.1016/j.arth.2020.04.061

Table 1. Baseline demographics

	[0-3] (n=897)	**[4-7]** (n=792)	**[8+]** (n=600)	**p-value**
Age	64.76 ± 11.72	65.49 ± 11.27	64.19 ± 11.72	p=0.11
Sex				
Male				
Female				

Table 2. PRO scores (HOOS, JR, VR12 PCS, VR12 MCS) at baseline and 12 weeks.

HOOS, JR	**[0-3]** (n=848)	**[4-7]** (n=739)	**[8+]** (n=573)	**p-value**
Preop	51.27	53.14	52.24	p=0.028
3m	77.68	79.79	81.35	p<0.001
VR12 PCS	**[0-3]** (n=897)	**[4-7]** (n=792)	**[8+]** (n=600)	**p-value**
Preop	32.11	31.95	31.81	p=0.80
3m	43.49	44.07	44.91	p=0.023
VR12 MCS	**[0-3]** (n=897)	**[4-7]** (n=792)	**[8+]** (n=600)	**p-value**
Preop	48.66	49.65	50.06	p=0.054
3m	53.93	54.42	55.42	p=0.011