



Controlling and enhancing the post operative care after Knee Arthroplasty: Insights from a Multi-Center Prospective Longitudinal Cohort Study of a Digital Rehabilitation solution

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Abstract

New surgical techniques, such as robotics and augmented reality, promise to increase the quality and reduce the variability of the surgical procedure. But the effect of these new developments could be altered by the variability of the post operative care. Rehabilitation following total knee replacement (TKA) traditionally involves in-person therapy, presenting challenges in terms of protocol adherence, reproducibility, and cost. Digital rehabilitation holds promise in addressing these issues, but existing systems often lack personalization, neglecting factors such as patient pain, participation, and recovery speed. Moreover, most digital platforms lack essential human support.

This study aimed to explore the engagement, safety, and clinical effectiveness of a personalized and adaptive app-based human-supported digital monitoring and rehabilitation program. Conducted as a prospective multi-center longitudinal cohort study, 127 patients were enrolled. A smart alert system managed undesired events, triggering physician interventions in case of suspected issues. The app collected data on dropout rates, complications, readmissions, Patient-Reported Outcome Measures (PROMS), and patient satisfaction.

Results showed a 2% readmission rate, with smart alerts potentially preventing 85% of flagged issues through timely doctor interventions. Program adherence reached 77%, and 89% of patients endorsed the program's use. The integration of personalized, human-backed digital solutions emerged as a transformative approach to standardize and enhance the rehabilitation journey post-TKA, while showing potential cost savings.

1 Introduction

Rehabilitation is a crucial component of postoperative care, as it can decrease pain, improve function, and restore activities of daily living [1]. However, traditional rehabilitation for total knee replacement patients often involves in-person therapy sessions, which can be time-consuming, variable in quality, and costly. In addition, adherence to home exercise therapy is often low, which can lead to suboptimal outcomes and increased healthcare costs [2,3]. The lack of access to rehabilitation services in underserved areas can also be a barrier to effective rehabilitation [4]. Digital rehabilitation has the potential to address these limitations. Mobile apps provide individuals with access to rehabilitation therapy outside of traditional settings, which can increase engagement and improve adherence to therapy [5]. The latest evidence on digital rehabilitation has demonstrated that it is non-inferior to face-to-face interventions and has the potential to improve outcomes for patients [6]. The limitations of most of these systems are related to the fact that they are offering the same protocols for every patient. The aim of this study was to investigate the engagement, safety, clinical effectiveness, and satisfaction of a personalized and adaptative app-based human backed-up digital monitoring and pain management and rehabilitation program after knee replacement arthroplasty.

2 Methods

This interventional, multi-center, single-arm, prospective study was performed on 127 individuals with degenerative knee pain who utilized digital rehabilitation following TKA between January 2021 and May 2022. Those patients underwent no face-to-face rehabilitation. Subjects were included in 13 Belgian and 1 French hospitals.

Individuals were invited to download an app-based telerehabilitation system. ‘moveUP Therapy’ (moveUP®, Bruxelles, Belgium) is registered as a medical device and uses a smart virtual platform for digital rehabilitation.

The intervention was a home-based digital intervention of exercise and education. Patients were monitored remotely by a physical therapist through a secured chat messaging system. The system is composed of a mobile App for the patient and a web-based portal that allows the physical therapist to look daily at patient data (physical activity, pain levels, medication use, exercise adherence, PROMS, pictures, videos) and to personalize the protocol accordingly. Objective data were collected all along the recovery using a commercial activity tracker (Garmin Vivofit 4) worn 24/7 by the patients.

Undesired events were managed through a smart alert system. Doctors were triggered in case of suspicion of problems. The problems are raised directly by the patients, by data-based alerts, or by the physical therapist supervising daily the patient status.

The ethics committee of Universitair Ziekenhuis Antwerpen approved the study protocol and each patient provided written informed consent to the use of their anonymized data for scientific use.

3 Results

A total of 127 patients who were referred to the digital rehabilitation trajectory were analyzed (Figure 1). Fourteen patients did not start the trajectory, and 12 did not continue after surgery. The system was used on average 83 days. Average adherence with the exercise achievement was 77% over the whole rehabilitation journey.

Two patients were readmitted to the hospital for manipulation under anesthesia corresponding to a readmission rate of 2,4 %. 67 alerts were raised through the web-based platforms for 32 patients (39%

of the patients). 32 alerts were raised by the patients (48%), 25 by the physical therapist (52%). Type of alerts are displayed in Figure 1

The three most frequent actions were Medication change (27%), wound information and reassurance and referral (15%). 10 physical consultations were generated by the referrals. Doctor actions through the platform potentially avoided 57 consultations (85% of alerts).

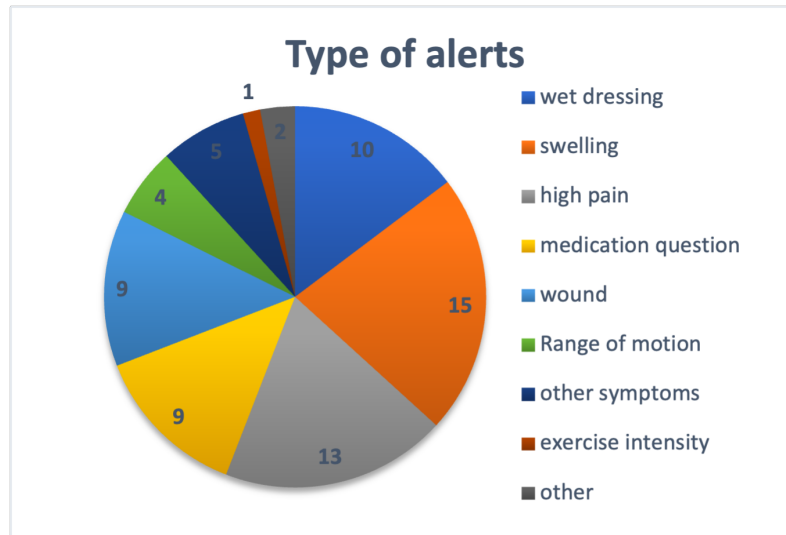


Figure 1: Type of alerts raised by the patient and the physical therapists.

Significant improvements were found at 6 months in all KOOS sub-scales compared to preoperative values. 14 points in KOOS-Pain, 20 points in KOOS-Symptoms, 22 points in KOOS-Function, and 26 points in KOOS-QoL

The cost of the digital intervention was 257,5 euros per person.

This cost comprised the activity tracker of 60 euro, an intake cost of 22,5 euros and the average cost of physical therapy follow-up of 170 euros (average of 18min per week per patient, standard deviation of 5 minutes) and medical follow up 5€ (67 intervention of 4min on average, spread over 86 patients).

The physical therapists logged an average of 18 minutes per week (SD = 5 minutes) with each participant (Figure 2). The doctors logged 67 times to solve the alerts, with an average of 4 minutes (SD = 2 minutes). The time spent by care providers is low because of asynchronous communication, escalation process and platform efficiency.

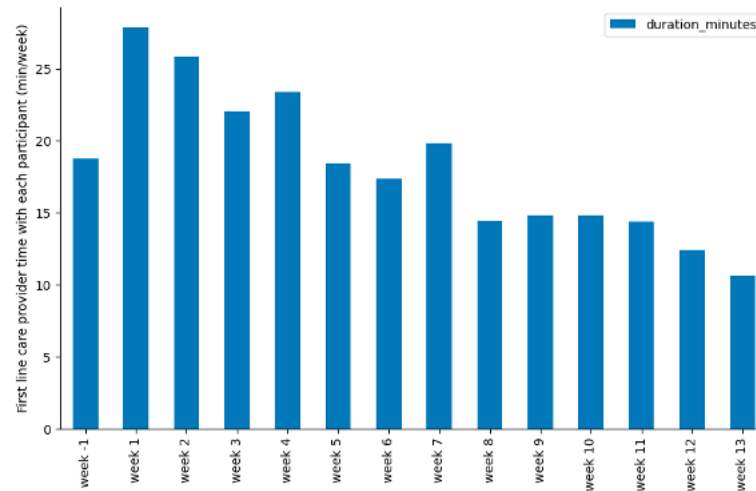


Figure 2: First line care provider time spent with each participant on a weekly basis along the whole rehabilitation.

4 Discussion

One of the limitations of the study was the absence of control group (traditional face to face rehabilitation program) and the results of this study cannot be compared directly with the results of standard rehabilitations programs.

The attrition rate was low compared to previous studies reporting between 7% and 45% attrition rate [6,7]. The results of our study demonstrated a very high adherence level to the proposed exercises (77%). Using a mobile application might be ideal to standardize the follow-up of physical therapy interventions after TKA and provide direct quantitative feed-back to the patients which increases the motivation [5].

As a result of procedure-related complications, the average 90-day readmission rates vary widely in the literature, ranging from 3.5% to 15.6% in TKA [8,9]. The complication rate in our study was only 2,4% (two readmissions) for manipulations under anesthesia. This low rate might be attributed to the smart alert system that triggered the concerned care provider.

The results of our study demonstrated a significant improvement in the patient reported outcome at 6 months post-surgery. The significant improvements were similar than those previously reported after in-person interventions in Belgium and Netherlands [10–12].

We assessed patient satisfaction with the system and found that the patient promoter/satisfaction score was 89%, indicating a high level of patient acceptance. This finding is consistent with a study by Correia et al., which reported a 90% satisfaction rate [13].

Previous studies already indicated that digital rehabilitation is an economically viable alternative to traditional in-person care for post knee arthroplasty rehabilitation[14,15]. The biggest difference with previous studies lies in the asynchronous design of the digital rehabilitation used in this study which reduced the cost drastically.

References

1. Khan, F.; Ng, L.; Gonzalez, S.; Hale, T.; Turner-Stokes, L. Multidisciplinary Rehabilitation Programmes Following Joint Replacement at the Hip and Knee in Chronic Arthropathy. *Cochrane Database Syst Rev* **2008**, *2008*, CD004957, doi:10.1002/14651858.CD004957.pub3.
2. Marks, R.; Allegrante, J.P. Chronic Osteoarthritis and Adherence to Exercise: A Review of the Literature. *J Aging Phys Act* **2005**, *13*, 434–460, doi:10.1123/japa.13.4.434.
3. Bakaa, N.; Chen, L.H.; Carlesso, L.; Richardson, J.; Macedo, L. Reporting of Post-Operative Rehabilitation Interventions for Total Knee Arthroplasty: A Scoping Review. *BMC Musculoskeletal Disorders* **2021**, *22*, 602, doi:10.1186/s12891-021-04460-w.
4. Cyr, M.E.; Etchin, A.G.; Guthrie, B.J.; Benneyan, J.C. Access to Specialty Healthcare in Urban versus Rural US Populations: A Systematic Literature Review. *BMC Health Services Research* **2019**, *19*, 974, doi:10.1186/s12913-019-4815-5.
5. Lang, S.; McLelland, C.; MacDonald, D.; Hamilton, D.F. Do Digital Interventions Increase Adherence to Home Exercise Rehabilitation? A Systematic Review of Randomised Controlled Trials. *Archives of Physiotherapy* **2022**, *12*, 24, doi:10.1186/s40945-022-00148-z.
6. Wang, Q.; Lee, R.L.-T.; Hunter, S.; Chan, S.W.-C. The Effectiveness of Internet-Based Telerehabilitation among Patients after Total Joint Arthroplasty: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. *J Telemed Telecare* **2021**, 1357633X20980291, doi:10.1177/1357633X20980291.
7. Timmers, T.; Janssen, L.; van der Weegen, W.; Das, D.; Marijnissen, W.-J.; Hannink, G.; van der Zwaard, B.C.; Plat, A.; Thomassen, B.; Swen, J.-W.; et al. The Effect of an App for Day-to-Day Postoperative Care Education on Patients With Total Knee Replacement: Randomized Controlled Trial. *JMIR Mhealth Uhealth* **2019**, *7*, e15323, doi:10.2196/15323.
8. Jaibaji, M.; Volpin, A.; Haddad, F.S.; Konan, S. Is Outpatient Arthroplasty Safe? A Systematic Review. *The Journal of Arthroplasty* **2020**, *35*, 1941–1949, doi:10.1016/j.arth.2020.02.022.
9. Thompson, J.W.; Wignadasan, W.; Ibrahim, M.; Plastow, R.; Beasley, L.; Haddad, F.S. The Introduction of Day-Case Total Knee Arthroplasty in a National Healthcare System: A Review of the Literature and Development of a Hospital Pathway. *The Surgeon* **2022**, *20*, 103–114, doi:10.1016/j.surge.2021.01.017.
10. Loef, M.; Gademan, M.G.J.; Latijnhouwers, D.A.J.M.; Kroon, H.M.; Kaptijn, H.H.; Marijnissen, W.J.C.M.; Nelissen, R.G.H.H.; Vliet Vlieland, T.P.M.; Kloppenburg, M. Comparison of KOOS Scores of Middle-Aged Patients Undergoing Total Knee Arthroplasty to the General Dutch Population Using KOOS Percentile Curves: The LOAS Study. *The Journal of Arthroplasty* **2021**, *36*, 2779–2787.e4, doi:10.1016/j.arth.2021.03.050.
11. LeBrun, D.G.; Martino, B.; Biehl, E.; Fisher, C.M.; Gonzalez Della Valle, A.; Ast, M.P. Telerehabilitation Has Similar Clinical and Patient-Reported Outcomes Compared to Traditional Rehabilitation Following Total Knee Arthroplasty. *Knee Surgery, Sports Traumatology, Arthroscopy* **2022**, *30*, 4098–4103, doi:10.1007/s00167-022-06931-6.
12. Van Onsem, S.; Verstraete, M.; Dhont, S.; Zwaenepoel, B.; Van Der Straeten, C.; Victor, J. Improved Walking Distance and Range of Motion Predict Patient Satisfaction after TKA. *Knee Surg Sports Traumatol Arthrosc* **2018**, *26*, 3272–3279, doi:10.1007/s00167-018-4856-z.
13. Correia, F.D.; Nogueira, A.; Magalhães, I.; Guimarães, J.; Moreira, M.; Barradas, I.; Teixeira, L.; Tulha, J.; Seabra, R.; Lains, J.; et al. Home-Based Rehabilitation With A Novel Digital Biofeedback System versus Conventional In-Person Rehabilitation after Total Knee Replacement: A Feasibility Study. *Scientific Reports* **2018**, *8*, 11299, doi:10.1038/s41598-018-29668-0.
14. Francesco Fusco; Giuseppe Turchetti Telerehabilitation after Total Knee Replacement in Italy: Cost-Effectiveness and Cost-Utility Analysis of a Mixed Telerehabilitation-Standard

Rehabilitation Programme Compared with Usual Care. *BMJ Open* **2016**, *6*, e009964, doi:10.1136/bmjopen-2015-009964.

15. Tousignant, M.; Moffet, H.; Nadeau, S.; Mérette, C.; Boissy, P.; Corriveau, H.; Marquis, F.; Cabana, F.; Ranger, P.; Belzile, É.L.; et al. Cost Analysis of In-Home Telerehabilitation for Post-Knee Arthroplasty. *J Med Internet Res* **2015**, *17*, e83, doi:10.2196/jmir.3844.