



Post-Operative Range of Motion Exercises Performed Most Days at 50% Maximum ROM with Recupe Digital Health Improved ROM Recovery and Reduced Complications

**Timothy Hui ^{a*}, Hunter Greene ^b, Paul Sasaura ^b,
Subu Subramanian ^a, Bereket Ayalneh Sharew ^a,
Yordanos Woldebirhan ^a and Jamin Gorman ^a**

^a *Plethy Inc. San Jose, CA, United States.*

^b *Summit Orthopedics, Carmichael CA, United States.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Range of Motion (ROM) exercises are common after knee surgeries, but little has been researched about the actual amount of movement performed in active exercises at home. This was previously difficult to measure, as the patient was not in the office. But now, with wearables used during home exercises, Plethy Recupe, a digital health platform, was able to shed some light on whether full ROM is required for post-operative ROM exercises after Total Knee Arthroplasty (TKA).

*Corresponding author: E-mail: timothyehui@gmail.com;

This study involved 170 TKA patients performed by the same orthopedic group. Demographics, such as age, gender, and BMI, office visits, and physical therapy care were all similar. For patients using Recupe, exercises were performed an average of 4.84 days per week. Recupe used a mobile app to direct exercises, and a wearable to measure the ROM. The ROM performed by these patients during home exercises ranged from 46.9 (sd 19.3) degrees in the first two weeks post-op, to 50.6 (sd 23.0) degrees at 1 month post-op. Meanwhile, the maximum ROM, as measured by the orthopedist, rose from 114 (sd 10.76) degrees before surgery, to 120 (sd 9.08) degrees at 1 month post-op.

These are vastly different numbers, greater than 2 SD, and the home exercises show a great deal more variation. What is clear though is the fact that the patient did not bend their knees anywhere near the maximum range. Still, these patients experienced significantly better knee flexion recovery compared to patients at the same center who did not use Recupe, averaging 120 degrees versus 114 degrees. Also, patients using Recupe experienced significantly fewer Manipulation Under Anesthesia (MUA) complications, 2% versus 5%. As the other variables were similar for patients using Recupe and those who did not, the likely cause for these differences was frequency of home exercise performance. However, there is not a measurement of the home exercise frequency for those patients not using digital health.

So, from this data, it appears that bending post-surgical knees to full range is not required for recovery. Instead, it appears that the key is exercise plan adherence, where the Recupe group performed exercises around 5 times per week.

Keywords: Range of motion exercises; ROM recovery; reduced complications; total knee arthroplasty; knee surgery; ROM improvement.

1. INTRODUCTION

A common knee surgery is a total knee arthroplasty (TKA), where the knee joint is replaced due to osteoarthritis, a common cause of disability with the geriatric population [1]. Post-surgery, patients have been shown to have improved function and quality of life [2]. One factor to a patient's function is their knee Range of Motion (ROM). Thus, ROM recovery is a key goal of rehabilitation after knee surgery [3]. With ROM recovery to 120 degrees shown to allow for full function in activities of daily living [4].

Many studies have investigated different therapies for ROM improvement. Some treatments include CPM and Physical Therapy (PT) [5]. Studies on CPM use have been mixed. One Cochrane review showed little ROM benefit with little reduction of manipulation under anesthesia, a secondary procedure used for inadequate ROM recovery [6]. Some studies showed short-term ROM benefit, but none for long term use [7]. Overall, there was no statistically significant difference in flexion, edema or drainage, functional gains, or pain [8,9].

Physical Therapy (PT) involves both in-office appointments in an outpatient setting as well as home exercises prescribed in a home exercise plan (HEP). During treatment sessions, as well

as HEPs, patients will perform range of motion exercises, such as heel slides [10]. For active ROM exercises, one study showed functional benefits [10]. However, there is little data as to the actual range of motion performed during these exercises or during active care home exercises compared to the maximum ROM attained during rehabilitation.

For home exercises, studies have shown functional benefits and decreased pain from its use. [11,12] However, patient compliance with HEPs can be very poor, with one study finding 70% non-compliance [13].

Digital health offers a solution to these challenges. Plethy's Recupe platform features a motion sensor connected to a mobile app as it leads patients through healthcare provider prescribed, remotely supervised home exercises plans for surgical and non-surgical diagnoses. The motion sensor measures joint ROM as the patient performs exercises, with accuracy at over 90% from research. This provides objective information in real-time along with recording exercise data. Other data recorded includes exercise adherence and time, pain, red-flag symptoms, and mood.

Along with adherence, Recupe tracks pain, joint range of motion with exercises, red flag

symptoms, patient engagement, and patient behavioral/sentiment. ROM accuracy was researched and found to be over 90% accurate [14,15]. This digital health solution can hold patients accountable to their healthcare provider for recovery performed without in-person supervision [16,17]. Along with these benefits, the Recupe wearable sensor allows for greater visibility as to what the recovering patient is performing at home with their HEP.

Digital health benefits are not limited to Recupe. Other studies using digital health with rehabilitation after TKA have shown improved functional outcomes, measured on instruments such as the WOMAC and Berg Balance Scale [18].

This goal of this study was to compare the ROM performed during home exercises with the ROM measured during orthopedic office visits and cross-reference that with other recovery metrics. Also, overall recovery was compared in groups that used Recupe and others who did not. With this, we aim to assess the importance of the ROM performed during rehabilitation exercises.

2. SUBJECTS

Using the EHR of Summit Orthopedics in California, a cohort for TKA was identified by searching for the CPT code for TKA from 9/1/21 to 4/30/22. 170 patients were identified. These patients were cross-referenced with the Recupe database, identifying which patients used Recupe for their rehabilitation. All patients attended outpatient physical therapy along with their orthopedist follow-up visits.

2.2 Data from Recupe Group

	Preop 1-2 weeks	Post Op 1-2 weeks	Post Op 3-4 weeks	Post Op 5-6 weeks
Avg. ROM	80	46.9	50.6	54.8
ROM SD	29.5	19.3	23	24.5
Avg. PT Time	20	18.2	21	23.8
PT Time SD	16.6	14	17.7	31
Avg. PT Reps	178	125	139.7	193
PT Reps SD	72.6	58.7	62	106

The ROM performed by the Recupe group is significantly lower than the maximum ROM measured during Orthopedist visits. However, the Recupe group achieved an average of 120 degrees knee flexion.

There were three patients who had TKAs on both knees, and each surgery was classified as a different patient for this study. One patient was removed due to no available data. 13 patients were eliminated due to no use of Recupe after surgery. Patients who did not use Recupe a minimum of 3x per week on average were removed, eliminating 20. Finally, patients who did not have heel slides in their home exercise program were removed, eliminating 2 patients. This is because heel slides, both active range of motion and active assisted range of motion, were used as a measurement of knee ROM performed during home exercises. Adherence was the times per week that the patients performed their exercise programs.

2.1 Summit Recupe Only

Ave. Adherence	4.84 days per week	(SD 1.47)
Avg. Age	67.8	(SD 8.7)
Gender		
Male	59.45	
Female	40.54	

For the Recupe group, there were 39 patients who met all inclusion criteria.

For the non-Recupe group, there were 111 patients. The average age was 69.35 (sd 9.44).

By gender, there were 58.95% male and 41.05% female.

Average BMI: 31.9

BMI

Mean: 31.305470
SD: 6.458838

Pre-op knee flexion ROM

Recupe – average **114 degrees (sd 10.76)**
Non recupe – average **112 degrees (sd 13.69)**
p-value - .18

Post op knee flexion ROM

For patients using Recupe – average **120 degrees (sd 9.08)**
For all Non-Recupe patients – average **112 degrees (sd 11.56)**
p-value - .0037

Also, the Recupe group demonstrated fewer Manipulations Under Anesthesia (MUA).

MUA

non-recupe – 111 patients - 5 MUA – 5%

Recupe – 39 patients - 1 MUA – 2%

P-value – less than 1.0 e-25.

3. DISCUSSION AND CONCLUSION

A main question for this study was the importance of performing ROM exercises to full range.

Heel slides were measured as they are both commonly performed after TKA surgeries and also an exercise where patients can potentially bend their knee to the maximum range of motion.

Initially, the patients averaged 46.9 degrees knee flexion for their heel slide. This only increased to 54.8 degrees after the first month. By comparison, at the orthopedic surgeon's office, their maximum knee flexion averaged 120 degrees, which differs by more than two standard deviations. Thus, even with the standard deviation of 24.5 degrees and any possible user error, the patients were not flexing their knees anywhere close to 120 degrees during their heel slides. Since the Recupe group also demonstrated superior results, it appears that full ROM is not required when performing knee flexion exercises. It also suggests that the key to home exercises is regular adherence, not the specific ROM performed. From CPM studies, moving the knee a certain ROM did not result in benefits, so it may be more important that the patient actively performs those motions themselves [5-9].

An item to note is that the Recupe patient group still missed exercise sessions. 4.8 exercise sessions per week is good, but days were missed. Even with this, the ROM improvement was excellent. Compared to a previous study tracking ROM progression after TKA, [16,19] the Recupe group regained knee flexion substantially faster.

One question this brings up is that if with reduced range and some missed sessions this patient population still exceeded expectations, how poor is HEP adherence without this monitoring? Previous studies reported non-adherence at up to 70%, which seems like a fair estimate. Also, it appears that full range of motion is less important than the fact that the patients are moving their knees with active motion. Compared to CPM data, the recovery of patients using Recupe is far superior, also reducing the percentage of MUA. This data also suggests that consistent adherence to ROM exercises is more important than the amount of motion per exercise, and that encouragement towards adherence may be more valuable than having patients push through their pain.

Overall, the data from this study demonstrates improved results from ROM exercises performed most days at a range significantly less than the maximum ROM. More research is required in this field, but the findings suggest that the greatest benefits in recovery may come through adherence to the exercise plan.

Some weaknesses to this study are the lack of randomized cohorts, though the demographics are very similar. Also, user error cannot be eliminated as the patients are not directly supervised in their exercises. However, their ROM was clearly less than the maximum measured ROM in the orthopedic clinic. Also, heel slides were not performed by all of the Recupe patients each week, averaging 86%. Still, even with the decreased adherence, and the 4.84 days exercised per week, the Recupe group had significantly better ROM improvement and reduction of complications.

CONSENT AND ETHICAL APPROVAL

It is not applicable

CONFLICT OF INTEREST

Study IRB approval and Conflict of Interest review have been completed through BRANY. The Principle Investigator/lead author is an employee of Plethy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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