Preoperative activity levels are an important indicator of postoperative activity in cementless TKAs

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ABSTRACT

Introduction: It is of interest if preoperative activity level has an impact on postoperative activity level following cementless TKA.

Methods: This review contained 127 patients who had a preoperative Lower Extremity Activity Scale (LEAS) score $\geq$ 10 (active patients) and 121 patients $<$ 10 (inactive patients).

Results: Postoperatively, the results showed a difference in LEAS Activity (Active 10.5 vs. Inactive 8.7, $p < 0.001$). Active patients had a drop in their activity level by 1.2 on the LEAS score, yet inactive patients increased by 1.6 ($p < 0.0001$).

Conclusion: Preoperative activity levels are a good indicator for postoperative activity in cementless TKA.

1. Introduction

By 2025, there is an estimated 110% increase in primary total knee arthroplasty (TKA) in the United States.¹ The growth of TKA may be attributed to patients 45–64 years of age.² The use of cementless TKAs have risen in recent years in young patients as a means to overcome the alterations of the bone/cement interface that previously led to osteolysis.³ Cementless TKA has shown similar improved functional outcomes and pain reduction in young patients at a mean follow-up of 12 years and between 2 and 13.6 years in two meta-analyses.^{4,5}

Patients in this age category are likely to be more physically active and have higher demands in terms of returning to physical activity after surgery. However, several studies have reported mixed results in regards to patient satisfaction in this cohort. One study reported more knee-related dissatisfaction in the more active cohort after surgery, which wasn't reflected in the higher levels of self-reported activity and lower pain scores preoperatively and postoperatively.⁶ Another study found that active patients were more commonly satisfied with their ability to perform recreational activities than inactive patients (67.2% vs. 57.7%; $p = 0.001$) without a direct association between satisfaction and clinical outcomes.⁷

The Lower Extremity Activity Scale (LEAS) is known to be a verifiable measurement in order to assess patient activity level. One study found that LEAS in TKA identified a weak correlation ($r = 0.11$) between preoperative LEAS and higher patient expectations for TKA.⁸ On the

other hand, another study found no difference in patient satisfaction between a cohort of active patients (LEAS: 13–18) and inactive patients (LEAS: 7–12), but a higher revision rate at 5–10 years postoperatively (3.2% vs. 1.6%, $p = 0.019$, respectively).⁷ To our knowledge, preoperatively active (LEAS $\geq$ 10) and inactive patients (LEAS $<$ 10) undergoing cementless TKA have not been compared in terms of postoperative outcomes at two-years follow-up. It remains crucial to continue to identify relevant factors in the young cohort that can affect clinical outcomes after TKA, particularly postoperative activity levels in order to properly adjust patient expectations.

2. Methods

From 2017 to 2019, a single surgeon performed 329 primary, cementless TKAs at one large volume institution using a single implant design. There were 127 patients in the active cohort and 121 patients in the inactive cohort. The inclusion criteria for a cementless knee implant consisted of adequate bone stock and good bone quality. The exclusion criteria included prior fracture, bone defect on preoperative radiographs, and a diagnosis other than osteoarthritis. A minimum follow-up of one-year was required for inclusion in the study. Fifty-nine patients were excluded due to a follow-up less than one year. There were 13 patients were lost to follow-up (3.9%). The remaining 9 patients were excluded because of a diagnosis of inflammatory arthritis ($n = 5$) and a diagnosis of post-traumatic arthritis ($n = 4$).

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The patients were retrospectively divided in two cohorts based on the preoperative Lower Extremity Activity Scale (LEAS) score, which has shown superior construct validity to other measures of physical activity.⁹ Patients with a LEAS score greater than or equal to 10 were placed into the active cohort and patients with a LEAS score less than 10 were placed in the inactive cohort. This assessment was based on a study that correlated activities to a metabolic equivalent value (MET) and deemed physical activity below 3.5 METS is unlikely to produce health-related changes in this age cohort.^{10,11}

The cementless knee implant used was the Triathlon Titanium (Stryker Orthopaedics, Mahwah, New Jersey, USA). The patellofemoral groove is designed with a deepened trochlear groove to enable deep flexion and reduce contact stresses across the patella by providing minimal resistance to rotation.¹² The single-radius design provides minimal resistance to internal and external motion, which minimizes stress transfer to the tibial fixation interface as well as producing symmetric rollback.¹³ This design has showed better functional short-term outcomes, reduced anterior knee pain and painless crepitation.^{14,15} The metal-backed cementless patella allows for penetration of the polyethylene to the 3D-printed porous surface in order to maintain biological fixation.¹⁶ The 3D-printed highly porous tibial baseplate combines a keel and four pegs to provide optimal support for patients with inferior bone quality to reduce lift off.¹⁷

2.1. Postoperative protocol

Follow-up clinical and radiology visits took place at 6 weeks, 3 months, 1 year, 2 years, and each subsequent year. The physician assessed function and recorded the patient's activity levels. The patient then filled out the patient recorded outcome measurements (PROMs), including i) Lower-Extremity Activity Scale (LEAS), which measures the patients physical activity level; ii) Knee Society survey (function and total), which measures patient's function abilities including walking and stair climbing and has a ROM component that contributes to Knee society total; iii) the Pain Visual Analogue survey (Pain VAS), which measures the amount of pain; and iv) Veterans RANS 12 Item Survey (VR-12), which measures the patient's overall perspective of health and acts as a proxy for patient satisfaction in this study.

2.2. Statistical methods

A post-hoc power analysis was performed using the change in mean LEAS activity score from preoperative to postoperative to determine the appropriate sample to achieve a power of 0.95. Normally distributed continuous data was compared using the Students t-test. A p-value <0.05 was set as statistically significant. In the preoperative outcomes, outcomes with a p-value <0.05 in the univariate analysis were used in the multivariate analysis to calculate the adjusted p-value that showed the influence of significant preoperative outcomes on postoperative activity levels.

3. Results

The post-hoc power analysis showed a sample size of $n = 67$ in both cohorts would yield a power of 0.95 based on the mean change in LEAS activity score from preoperative to postoperative timepoints. A single surgeon performed 329 primary, cementless TKA from 2017 to 2019 with an average follow-up of 2.0 years in both cohorts. There were 127 patients in active cohort and 121 patients in the inactive cohort. We found similar demographics, including average age (61.7 vs. 61.7, $p = 0.96$), average BMI, and male to female breakdown (62:59 to 52:75, $p = 0.10$) in the active cohort and inactive cohort, respectively (Table 1). We evaluated preoperative PROMs and found a significant difference in LEAS activity score (11.8 for active vs. 7.1 for inactive, $p < 0.001$) as per the design of the study. The VR-12 score also showed a significant value (31.4 for active compared to 28.8 for inactive, $p = 0.005$). We then

Table 1

Patient Demographics between the cohorts.

	Active patients	Inactive patients	P-value
Average age	61.7	61.7	0.96
Average BMI	32.2	33.2	0.27
Male: female breakdown	62:59	52:75	0.10
Average follow-up	2.0 years	2.0 years	N/A

performed a multivariate analysis to evaluate preoperative differences on postoperative activity levels. Preoperative activity levels were the only significant predictor of postoperative activity levels ($p < 0.001$), while preoperative VR-12 did not affect postoperative activity levels ($p = 0.06$). The other preoperative PROMs, including Knee society-total function (49.5 for active vs. 44.9 for inactive, $p = 0.10$), Knee society-total score (91.6 for active, 84.0 for inactive, $p = 0.07$), and Pain VAS (6.2 for active, 6.8 for inactive, $p = 0.09$) were not statistically different (Table 2).

In terms of postoperative PROMs, we found a significant difference between the cohorts, in terms of LEAS activity (10.5 vs. 8.7, $p < 0.001$), Knee society- Total function (79.2 vs. 69.1, $p < 0.001$), Knee society-Total score (160 vs. 142 $p = 0.008$), and VR-12 score (39.3 vs. 35.8, $p = 0.01$), while Pain VAS (2.5 vs. 3.1, $p = 0.11$), VR-12 (39.3 vs. 35.8, $p = 0.01$), average tourniquet time (48 min vs. 45 min, $p = 0.22$), manipulation rate (3.3% vs. 1.5%, $p = 0.38$) and revision rate (1.7% vs. 1.5%, $p = 0.96$) were not significantly different between the active cohort and the inactive cohort, respectively (Table 3). The two revisions in the active cohort were due to periprosthetic joint infection and fracture of medial tibial plateau with collapse after fall in physical therapy three weeks postoperatively. The two revisions in the inactive cohort were due to fracture of the medial tibial plateau with collapse after moving heavy motorcycle 2 ½ years postoperatively and sustained lateral condyle fracture and valgus collapse of femoral component after 5 months postoperatively.

We measured change in preoperative and postoperative PROMs and only found a significant difference in terms of LEAS activity score (-1.2 for active vs. 1.6 for inactive, $p < 0.0001$), while Knee society-total function (37.7 vs. 34.7, $p = 0.49$), Knee society-total score (40.2 vs. 34.2, $p = 0.60$), pain VAS (2.6 vs. 3.2, $p = 0.25$), and VR-12 (8.3 vs. 7.3, $p = 0.70$) did not show a significant difference between the active and inactive cohorts, respectively (Table 4).

4. Discussion

The novel finding was that patients' preoperative physical activity levels was the only significant predictor of postoperative activity levels after undergoing cementless TKA. We found support in the literature in finding that patients in the active preoperative physical activity cohort had a significant reduction from preoperative to postoperative physical activity compared to the preoperative inactive cohort without a reduction in VR-12 score or pain levels.⁶ The secondary finding was similar postoperative complications, including manipulation rate (3.3% for

Table 2

Preoperative Patient-Reported Outcomes and influence on postoperative LEAS score.

	Active patients	Inactive patients	P-value	Adjusted p-value for postoperative LEAS score
LEAS activity score	11.8	7.1	$P < 0.001$	$P < 0.001$
Knee society-Total Function	49.5	44.9	0.10	NA
Knee society-Total Score	91.6	84.0	0.07	NA
Pain VAS	6.2	6.8	0.09	NA
VR-12	31.4	28.8	0.005	$P = 0.06$

Table 3

Postoperative patient-reported outcomes.

	Active patients	Inactive patients	P-value
LEAS activity score	10.5	8.7	$P < 0.001$
Knee society-Total Function	79.2	69.1	$P < 0.001$
Knee society- Total Score	160.5	142.8	$P = 0.008$
Pain VAS	2.5	3.1	0.11
VR-12	39.3	35.8	0.01
Average tourniquet time	48 min	45 min	0.22
Manipulation rate	3.3%	1.5%	0.38
Revision rate	1.7%	1.5%	0.96

Table 4

Change in preoperative and postoperative patient-reported outcomes.

	Active patients	Inactive patients	P-value
LEAS activity score	−1.2	1.6	$P < 0.001$
Knee society-Total Function	37.7	34.7	0.49
Knee society- Total Score	40.2	34.2	0.60
Pain VAS	2.6	3.2	0.25
VR-12	8.3	7.7	0.70

active patients vs. 1.5% for inactive patients, $p = 0.38$) and revision rate (1.7% for active patients vs. 1.5% for inactive patients, $p = 0.96$) between the cohorts at two-year follow-up.

The literature provides evidence regarding the strength of the relationship between preoperative activity levels and postoperative physical activity in TKA. Poortinga et al. and VanLeeuwen et al. found that preoperative activity level had no relationship with leisure-time physical activity and recovery in their studies of 1,061 patients and 22 patients undergoing primary TKA, respectively. Poortinga et al. used a self-reported questionnaire that translated physical activity to minutes per week of exercise while VanLeeuwen et al. assessed physical activity based off a preoperative strength training program.^{18,19} Interestingly, we found LEAS activity and VAS-12 to be the only significant preoperative outcomes that were different between the cohorts, which minimizes the margin of error of physical activity level being accurately assessed by our division of the cohorts by LEAS cutoffs. The studies above do not provide evidence of intergroup differences other than physical activities that may influence the results of the study.

Lutzner et al. found that preoperative activity significantly predicted postoperative improvement in daily step number, but this was not independent and also influenced by age and BMI at 1 year follow-up. Preoperative activity level was defined based on the threshold of greater than 7,500 steps/per day.²⁰ Also, Williams et al. found that preoperative UCLA activity score, age, male sex and BMI predicted high postoperative activity scores in their study of primary TKA. In their study, they defined high activity as a UCLA score of 7 or more, which correlates to a 13 on the LEAS activity score based on a crosswalk methodology between the two scales.^{21,22} While our definition of active patients differed, we also found the predictive value of preoperative activity scores on postoperative activities but independent of age and BMI. The major differences between the studies are in regards to the classification of preoperative physical activity. We divided the cohorts based on the correlation between the MET scale to the LEAS scale,^{10,11} which supports an easy conversion between the two and overall support of the LEAS activity scale for its high construct validity.⁹

We found support in the literature that patients in preoperative active TKA group had a reduction in change from preoperative to postoperative physical activity compared to the inactive TKA group. A meta-analysis revealed that at 6 months after TKA patients did not show a significant increase in pre-to postsurgery physical activity levels and stressed the significance of creating physical activity goals to guide behavior postoperatively.²³ Ponzio et al. conducted a similarly designed study dividing patients into two categories based on the preoperative LEAS activity score. They divided active patients based on a LEAS level

of 13 through 18 and an inactive patient based on a LEAS level of 7 through 12. They excluded patients with an LEAS less than 7 on the basis of a very limited functional activity, but we decided to include the those patients on the basis of a more encompassing representation of two distinct categorical groups. In their study of 1,008 active patients matched to 1,008 inactive patients, Ponzio et al. found that only the inactive patient group improved in activity level at 2 years while 72.7% of active group reported no change or a decrease in their activity levels below their baseline postoperatively, which was a similar finding to our current study. Ponzio et al. hypothesized that native knee biomechanics may result in functional limitations that limited the high activity group. Their study did not make it apparent the type of implant used in their analysis.⁶

The manipulation and revision rates between the cohorts were similar a two-year follow-up, which maybe be attributed to the use of cementless TKA implants. Interestingly, we found no significant difference between valgus knee alignment preoperatively, postoperatively, or change between preoperative and postoperative, which minimizes the potential for implantation or surgical variation. In addition, we found no difference in tourniquet time, which has also been associated with increased risk of complications after TKA.^{24,25} This may also minimize the intraoperative implications that could have impacted the post-operative complications. Cementless TKA, which was used in the current analysis, has shown a significant difference in radiographic outcomes, including the absence of radiolucent lines and pain reduction.⁵ Cementless TKA has also been associated with bone stock preservation which can prevent third body cement wear and achieve a quality biological fixation.^{26,27} On the other hand, high levels of physical may increase implant wear and can lead to aseptic mechanical failure in young patients.^{28,29} Cementless TKA may be protective against mechanical failure as Epinette and Manley found a survivorship of 98.14% at a mean follow-up of 11.2 in a 146 primary, cementless TKA.³⁰ However, the literature currently supports an increased revision rate in active patients, however this effect on cementless TKA has not been observed yet.

The limitations in the study include the retrospective nature, which prevent the opportunity for a more appropriate definition of preoperative physical activity. However, our unique classification of preoperative physical activity takes into account an epidemiological interpretation rather than a post-hoc interpretation of the clinical data, which may add to the generalizability of the study.⁶ We were not inclusive with factors that could influence postoperative activity levels but did show several preoperative factors were similar between the active and inactive regardless of the large ranges in preoperative LEAS activity levels between the groups. It would be relevant to include a longer follow-up than two-years in order to truly observe the impact of cementless TKA on postoperative complications based on the evidence that revision rates may increase in highly active patients.^{27,28} A post-hoc power analysis showed that the size of cohorts were large enough to achieve a power of 0.95 when assessing the change in preoperative and postoperative LEAS activity score. Patient satisfaction was not explicitly measured, but VR-12 score was used as a proxy and has received support in the literature for its combination of physical and mental components.³¹ Surgical variance was minimized by use of a single surgeon with similar tourniquet time and valgus alignment. Future analyzes should continue to better define physical activity in a way that allows for a more uniform comparison across studies and minimizes extraneous variables, including the relationship between patient satisfaction and clinical outcomes, which has not been establish in this context yet.⁶ In addition, cementless TKA should continue to be examined with larger patient cohorts to examine the relationship between active patients and cementless implants.

Preoperative activity level (LEAS score) was the only predictor of postoperative activity level. In addition, inactive patients improved from preoperative baseline, while active patients did not achieve their preoperative baseline levels. At two years, there was no difference in manipulation rates or revision rates between the cohorts. Going

forward, the importance of patients' preoperative activity level should be emphasized regardless of their preoperative activity level. At the same time, active patients should be guided about the expectation of their return to similar preoperative activity levels at two years postoperatively.

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