

## When Can I Drive?

### Brake Response Times After Contemporary Total Knee Arthroplasty

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#### Abstract

**Background** After right total knee arthroplasty (TKA), patients are usually eager to return to driving. Previous studies suggest 6 weeks postsurgery is a safe time. However, recent advances in surgical technique, pain management, and rehabilitation have theoretically improved recovery after TKA.

**Questions/purposes** We therefore determined if (1) the timeframe for return to driving, as determined by attainment of preoperative braking levels, would be shorter after contemporary right TKA than that reported previously for a traditional TKA; and (2) gender or age influence recovery of baseline response time.

**Methods** Brake response times for all 29 patients undergoing right-sided TKA between January 17, 2008, and

January 29, 2009, were scheduled to be measured by a trained occupational therapist before surgery and at 4, 6, and 8 weeks after surgery. For each patient, testing was discontinued once the preoperative level was achieved.

**Results** All patients returned to baseline braking levels by 4 weeks after surgery. Gender and age did not influence recovery times.

**Conclusions** If other requirements for driving are met, surgeons may consider allowing patients treated with contemporary right TKAs to drive 4 weeks after surgery.

#### Introduction

After TKA, patients can expect a better quality of life [1] and improved function and pain levels [3, 8]. In addition, with the use of a contemporary TKA procedure (defined as limited soft tissue disruption, multimodal pain management protocols, and intense postoperative rehabilitation), patients are more comfortable and more mobile earlier in their postoperative course [7, 9].

In the weeks after hospital discharge, patients are often eager to return to driving, which allows them to resume their social and recreational activities or even to return to work. Delaying patients' driving privileges may result in their dependence on public transportation, family members, or friends; such reliance on others for transportation may cause social isolation and irregular attendance at outpatient physical therapy or other medically related appointments. Therefore, the question asked of almost every orthopaedic surgeon is, "When can I drive?"

Data to guide a response are sparse. The available literature recommends that patients undergoing right-sided TKAs should wait to drive until 6 [10] to 8 [11] weeks after surgery.

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The goals of our study were to establish (1) if the timeframe for return to driving, as determined by attainment of preoperative braking levels, would be shorter for patients treated with a contemporary right TKA than that reported previously for a traditional TKA; and (2) if gender or age impacts recovery of baseline response time.

## Patients and Methods

We prospectively enrolled 29 patients (18 women, 11 men; average age, 66 years; range, 47–81 years) who were scheduled to have unilateral right TKAs between January 17, 2008, and January 29, 2009. All patients had osteoarthritis. All patients had failed other nonoperative treatments for their right knee osteoarthritis such as activity modification, weight loss, nonsteroidal anti-inflammatories, and cortisone injections. All patients during the study period, regardless of participation in this study, were treated with the same surgical technique, pain management protocol, and postoperative rehabilitation program. Twenty-nine patients agreed to participate in this study. Three patients used a cane preoperatively; 4 weeks after surgery, 11 patients were using a cane. The others did not require external support. All patients were able to drive preoperatively.

All TKAs were performed by the senior author (DFD) in a similar fashion using a limited extensor mechanism approach (trivector approach [2]), gentle retractor use, and periarticular injections. Skin incisions were between 10 and 14 cm. The patella was everted as needed. The patella was resurfaced in all patients, and all components were cemented. All knees were cruciate-retaining (Sigma TKAs; DePuy, Warsaw, IN). Of the 29 patients, 28 had spinal anesthesia and one had general anesthesia. Identical perioperative analgesia was used in all patients, including preemptive multimodal analgesia and periarticular injections.

On the day of surgery, patients were encouraged to be out of bed and ambulate with assistance with weightbearing as tolerated. Postoperative physical therapy and occupational therapy were identical for all patients and included a total of five 30-minute sessions beginning on postoperative Day 1. Patients were started with a walker and progressed to a cane as tolerated. Physical and occupational therapy in the hospital was supervised. ROM was active and active-assisted. Patients were discharged to their homes or an inpatient rehabilitation facility on postoperative Day 3 and continued to have in-home, inpatient, or outpatient physical therapy three times a week under supervision. Of the 29 patients, 26 were discharged home from the hospital and three were discharged to an inpatient rehabilitation center (all three were discharged home by postoperative Day 8).

**Table 1.** Mean preoperative and postoperative pain and function scores

Parameter	Mean preoperative value (range)	Mean postoperative value (range)*	p value
Knee Society score			
Pain	9.31 (0–30)	44.83 (40–50)	< 0.001
Function	62.41 (45–80)	88.62 (60–100)	< 0.001
Overall	39.78 (18–60)	90.01 (58–100)	< 0.001
Flexion (°)	125.7 (115–140)	117.1 (90–130)	< 0.001
Extension (°)	8.86 (0–15)	3.45 (0–20)	< 0.001

\* Postoperative values were recorded at 6 weeks.

Patients were routinely seen for followup at 6 weeks after surgery for ROM assessment, Knee Society evaluation, and radiographic evaluation (anteroposterior, lateral, and sunrise views). We evaluated pain, ROM, and function measurements preoperatively and postoperatively (Table 1). Knee Society pain, functional, and overall scores [4] were evaluated preoperatively and at 6 weeks postoperatively. Average pain scores improved from 9.31 preoperatively to 44.83 postoperatively ( $p < 0.001$ ), function scores increased from 62.41 to 88.62 ( $p < 0.001$ ), and overall scores increased from 39.78 to 90.01 ( $p < 0.001$ ). Although mean flexion was better preoperatively than at 6 weeks after surgery ( $p < 0.001$ ), mean extension improved postoperatively ( $p < 0.001$ ) (Table 1).

Each patient was prospectively scheduled to be tested for brake response times by a trained occupational therapist at four time points: 4 weeks before surgery (baseline) and 4, 6, and 8 weeks after surgery. For each patient, testing was discontinued once the postoperative response time equaled the baseline measurement. This testing procedure is a commonly used assessment tool. The instrument used to measure and record the brake response times was a Vericom stationary reaction timer (Model 117325; Vericom Computers, Inc, Rogers, MN), which is designed to test, in an office setting, a patient's ability to drive. In this testing device, the patient faced a computer monitor, a steering wheel was mounted on a table, and pedals were placed on the floor in front of the patient (Fig. 1). The position was adjusted to simulate normal driving for each patient with the patient's arms placed on the steering wheel, although no turning motion was required. Normal driving footwear was worn. Patients were instructed on use of the brake response testing device and viewed a supervised, computerized demonstration of the system before testing. Directions were given to depress the accelerator with the right foot. After the accelerator was depressed, a video simulation of a moving vehicle was displayed on the computer monitor (Fig. 2). The patient was then instructed to keep the foot on the accelerator until a red light stimulus was observed on the screen, at which point the patient was



**Fig. 1** The Vericom stationary reaction timer setup includes a steering wheel and brake pedals. The computer monitor and chair position are adjusted for each patient.



**Fig. 2** The simulated driving program displays red lights instructing the patient to lift the foot off the accelerator and apply the brake.

to release the accelerator, lift the foot completely off the floor, and step on the brake pedal with the right foot as quickly as possible. The red light stimulus was illuminated at random time intervals during each trial from 1 to 10 seconds after the patient depressed the accelerator and reached 30 miles per hour on the simulator. Up to five practice trials were done. After the patient was adequately familiarized with the use of the system, five testing trials were recorded. Once a patient's postoperative brake

reaction time was equal to or faster than the preoperative reaction time, the patient was considered to have "passed" and was discontinued from additional testing. Patients were not questioned regarding narcotic use at the testing sessions.

Measured parameters included (1) "gas-off time," the time from display of the red light stimulus to the time the driver's foot was removed from the accelerator; (2) "transition time," the time from the point at which the driver's foot was removed from the accelerator to the time when the foot made contact with the brake pedal; and (3) "reaction time," the time between the red light stimulus and the actual depression of the brake pedal. An average of the five test session results was recorded for each parameter.

We calculated standard descriptive statistics, including proportions mean, SD, and range. We used a two-by-two factorial analysis of variance with one within-subject factor (time: preoperative versus postoperative) to determine statistical differences between preoperative and postoperative measures and one between-subject factor (gender: female versus male). A second correlation analysis tested whether patient age predicted reaction time improvement.

## Results

All 29 patients passed the brake response test by 4 weeks after surgery. The mean gas-off times and overall mean reaction time improved from pre- to postoperatively at 4 weeks; the mean transition time did not change (Table 2).

The mean postoperative reaction time (490 msec) was faster ( $p = 0.002$ ) than mean preoperative reaction time (530 msec). A similar difference ( $p = 0.015$ ) was seen for gas-off times (mean preoperative: 330 msec, mean postoperative: 310 msec). There was no difference ( $p = 0.661$ ) in transition times (mean preoperative and postoperative: 150 msec). Gender did not influence reaction time, gas-off time, or transition time. Patient age did not correlate

**Table 2.** Mean preoperative and postoperative response times

Simulator measurement point	Mean preoperative value (msec) (range)	Mean postoperative value (msec) (range)*	p value
Gas-off	330 (260–500)	310 (240–380)	0.015
Transition	150 (90–220)	150 (90–240)	0.661 <sup>†</sup>
Reaction	530 (410–720)	490 (400–620)	0.002

\* Postoperative values were recorded when the patient passed the break reaction test (all patients passed at 4 weeks); <sup>†</sup> only the transition values were not statistically significant.

( $r = -0.258$ ,  $p = 0.18$ ) with improvements in reaction times from preoperative to postoperative assessments.

## Discussion

In the past, many patients with right TKAs have not been able to drive for extended periods because of pain and lack of mobility. Contemporary knee arthroplasty with multimodal pain control protocols and aggressive rehabilitation programs have allowed patients to be more comfortable earlier in the postoperative period. In our experience, patients are now more eager to drive earlier in their postoperative course, and they commonly ask for permission to drive well before the sixth postoperative week. Our goal was to determine if contemporary TKA with multimodal pain control protocols and intense rehabilitation would allow patients to return to driving earlier than 6 weeks after a right TKA. To examine this timeframe, we evaluated patients' preoperative and postoperative brake reaction times. Second, we evaluated the effect of gender and age on recovery to baseline brake response time.

There are several limitations that must be emphasized before the findings reported here can be categorically implemented as a change in recommended time to return to driving. First, we did not control for general changes in reaction time such as comorbidities during the testing because doing so was beyond the scope of this study. Second, our unselected group of patients could introduce bias into our data, ie, patients tested may have been those individuals who were most eager to return to driving. However, the study group is representative of our standard TKA patient population. Third, it is clear that a simple reaction time on an office computer simulator cannot be the only factor when determining when patients undergoing right TKAs may operate a motor vehicle. However, a driving simulator that evaluates braking ability is commonly used by occupational therapists to assess an individual's driving capability. If physicians have any doubts regarding a patient's ability to do so, on-the-road driving assessments are available. Fourth, we did not study

other factors that might affect a patient's driving ability such as narcotic use or visual acuity. Finally, given the limitations of our study and the legal implications, endorsement of possible return to driving earlier than 4 weeks after surgery mandates additional investigation.

Several previous publications document a return to baseline braking ability after right TKA [6, 10, 11]. Our study, looking at contemporary TKA, shows a quicker recovery to baseline compared with that of more traditional TKA (Table 3). We found that all patients who had a contemporary TKA with less tissue disruption, a multimodal pain management protocol, and aggressive rehabilitation returned to their preoperative braking reaction time by 4 weeks after surgery. In fact, gas-off time and reaction time were both faster postoperatively in our study. There was no statistical difference between preoperative and postoperative transition times. In comparison, in 1994, Spalding et al. [11] established that 8 weeks was the timeframe when preoperative brake response returned to baseline. Spalding et al. [11] also observed the main prolongation in brake response time was between foot lift-off from the accelerator and achieving a brake pressure of 100 N (defined in their study as "transfer time") [11]. In our study, however, transition time showed no statistical difference. Our study also differed from that of Spalding et al. [11] in that our patients were not required to achieve a brake pressure of 100 N, which Spalding et al. [11] considered necessary for adequate braking. The reaction timer used in our study does not provide pressure resistance and, therefore, may be a less valid representation of true braking ability. In 2003, Pierson et al. [10] studied 31 patients with TKAs and found brake response times at 6 and 9 weeks after surgery were improved compared with preoperative levels. They also tested patients at 3 weeks after surgery but did not find any improvement. In another study, Marques et al. [5] investigated the effects of left TKA on the brake response time of the right leg 10 days after surgery. Although the performance change in response times was not statistically significant in their study, they suggested patients with left TKA may resume driving 10 days after surgery as long as the car has an

**Table 3.** Summary of published return to driving guidelines

Author	Year	Number of patients evaluated	Testing times	Suggested time to return to driving
Spalding et al. [11]	1994	29	Preoperatively and at 4, 6, 8, and 10 weeks postoperatively	8 weeks
Pierson et al. [10]	2003	31 (13 bilateral, 12 right, 6 left)	3 weeks preoperatively and at 3, 6, and 9 weeks postoperatively	6 weeks
Marques et al. [6]	2008	21	Preoperatively and at 10 and 30 days postoperatively	30 days
Current study	2010	29	4 weeks preoperatively and 4 weeks postoperatively	4 weeks

automatic transmission. They did not evaluate the ability of the left leg to depress the clutch pedal [5]. In 2008, Marques et al. [6] also studied the brake response time of 21 patients after right TKA in relation to task complexity and found that at 30 days after surgery, brake response time was no longer increased compared with preoperative values. This finding suggested that patients may safely return to driving at 30 days. We did not assess task complexity in our study; however, we also found that at 4 weeks after surgery, brake reaction times return to baseline after a right TKA. Recognizing that all of our patients had passed at the 4-week mark, we decided to test an additional subgroup at 2 and 3 weeks. Of those eight patients, six passed at 2 weeks, one passed at 3 weeks, and one passed at 4 weeks. This observation is encouraging and should lead to additional study to evaluate if, in fact, most patients may drive safely at 2 weeks rather than at 4 weeks after a right TKA.

Both men and women showed improvement in reaction time postoperatively. Gender did not influence return to baseline reaction times in our study. Pierson et al. [10] did find that women were significantly slower than men at 3 weeks after surgery. Overall, men had a shorter brake response time than did women [10]. We found improvements in brake reaction times after a right TKA unrelated to patient age. To our knowledge, no other study has correlated patient age with changes in brake reaction times.

Despite the limitations of our study, these data may serve as the basis for a change in guidelines on return to driving times for patients undergoing right TKAs with contemporary methods, multimodal pain management protocols, and intense physical therapy. Brake response times returned to baseline levels in all patients by 4 weeks postoperatively. If other requirements for driving a vehicle are met, surgeons may consider allowing their patients to drive at 4 weeks after right TKA.

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