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# Early resumption of driving within 3 weeks following patient-specific instrumented total knee arthroplasty: an evaluation of 160 cases

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## ABSTRACT

**Objectives** Most patients want to resume normal activities as soon as possible after total knee arthroplasty (TKA), with driving an integral aspect to re-establish social and recreational independence. This study aimed to determine when patients resumed driving after TKA.

**Methods** All patients undergoing patient-specific instrumented (PSI) medial pivot TKA between January 2017 and April 2018 were included. Patients who did not drive were excluded. A detailed questionnaire was sent to patients 2 weeks after surgery to record their driving status. 50 patients were randomly selected to assess flexion at the hip, knee and ankle joints while seated in the driver's seat of their own vehicle.

**Results** 160 patients (female=94 and male=66) with a mean age of 68 years (45–90 years) underwent a PSI TKA (left side [L]=75, right side [R]=85). 73% patients returned to driving within the first 3 weeks after surgery, of which 15 (10%) resumed driving within the first postoperative week, 52 (35%) in the second week and 41 (28%) in the third week. The median time to resume driving following surgery was 3 weeks for both operative sides, with IQR of 2.0 (L) and 1.0 (R).

**Conclusion** A majority of patients resume driving within 3 weeks after undergoing a PSI TKA, regardless of operative side or transmission of vehicle.

**Level of evidence** IV

## INTRODUCTION

Due to the increased longevity of the general population and associated increase in age-related degenerative conditions including osteoarthritis, the incidence of primary and revision total knee arthroplasty (TKA) is rising globally.<sup>1</sup> The primary aims of TKA are to increase mobility and reduce pain, allowing for the resumption of premorbid activities.<sup>2–4</sup> The recent introduction of patient-specific instrumented (PSI) TKA involves a smaller incision with minimal soft tissue disruption and improved accuracy promote enhanced recovery programme.<sup>5–6</sup> This operative technique has enabled patients to mobilise early, thus promoting rapid recovery and increased postoperative comfort and motion.<sup>7,8</sup>

Currently, there is a lack of universal guidelines regarding the timeline for safe resumption of driving following TKA. Current literature recommends a minimum 4–8 weeks of recovery before patients may resume driving, although figures are based on conventional surgical approaches.<sup>9–12</sup> The American Academy of Orthopaedic Surgeons recommend a minimum of 6–8 weeks for right-sided TKA and

## What are the new findings?

- A majority of patients resume driving within 3 weeks after undergoing a patient-specific instrumented total knee arthroplasty (TKA), regardless of side of operation of transmission of vehicle.
- Soft tissue-sparing TKA may shorten recovery time including resumption of normal activities such as driving.

at least 1 week for left-sided TKA.<sup>13</sup> Similarly, the Royal College of Surgeons in the UK state driving should be avoided for patients for at least 8 weeks following TKA.<sup>14</sup> Studies have demonstrated that being unable to drive presents a significant obstacle for patients.<sup>15</sup> In the elderly population, the inability to drive is associated with reduced mobility, loneliness and increased incidence of depression.<sup>9,16</sup> With the advent of newer surgical techniques, including PSI TKA, patients may be able to resume driving earlier than the previously recommended 8 weeks. Following a minimally invasive, soft tissue-sparing TKA, patients should be able to resume normal activities, including work and social interactions with minimal delay.

The primary aim of this study was to determine when patients first resumed driving following a PSI TKA. The protocol used in this study is the same as previously published in an evaluation of resumption of driving after total hip arthroplasty.<sup>17</sup>

## METHODS

All consecutive patients who underwent elective PSI TKA by a single surgeon in one institution between January 2017 and April 2018 were included. Informed consent was obtained from patients. Non-driving patients and those who underwent revision TKA were excluded from the study (n=21). All patients were treated with the same operative technique, perioperative care and postoperative rehabilitation protocol with early mobilisation and discharge to maintain uniformity.<sup>5</sup>

Patient demographics including age, sex, BMI and operative side were recorded prospectively (table 1). A detailed questionnaire (online supplementary appendix 1) was sent to all patients who underwent a PSI TKA between January 2017 and April 2018, 3–6 weeks after their procedure, as previously described.<sup>17</sup> All patients were reviewed 2 weeks postoperative and again at 6–8 weeks postoperative. The driving status at both reviews was

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**Table 1** Patient demographics

Characteristic	n=160 (%)
<b>Age (years)</b>	
Mean	68
Range	45–90
<b>Body mass index</b>	
Mean	31.67
Range	22.7–57.1
<b>Gender</b>	
Female	94 (59)
Male	66 (41)
<b>Operation</b>	
Right TKA	85 (53)
Left TKA	75 (47)
<b>Vehicle type</b>	
Automatic	125 (87)
Manual	11 (8)
Unknown	8 (5)

TKA, total knee arthroplasty.

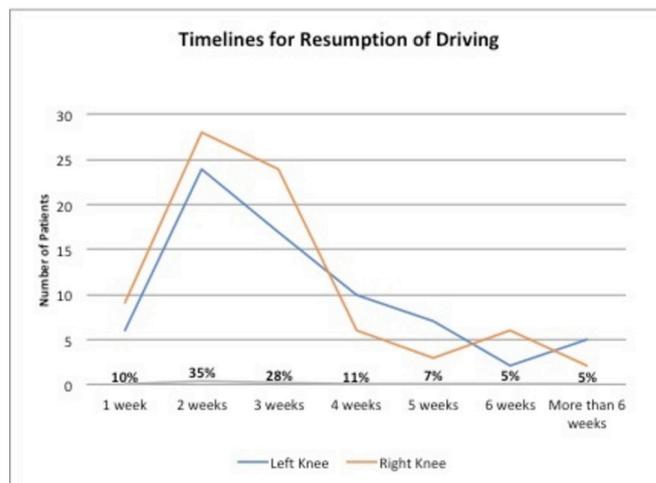
recorded in the patient notes. All patients were referred to a physiotherapist for strength and conditioning as part of their recovery and to encourage return to physical activities as soon as practicable. Patients were only cleared by their treating surgeon to resume driving if they were deemed and met prescribed criteria including feeling confident and comfortable to drive, mobilising pain free, able to be accompanied by a passenger on their first driving occasion postsurgery and no longer taking narcotic analgesia. Patients were instructed by their surgeon to delay driving if they were experiencing joint pain or swelling, drowsiness or did not feel confident. This information was provided in a booklet distributed to all patients during the preoperative assessment period.

At the 2-week postoperative review, 50 patients from the study were randomly selected to measure flexion at the hip, knee and ankle joints while seated in the driver's seat of their own vehicle. Randomisation was performed via patient surnames deidentified and entered into a random number generator. A random patient sample was used in assessments of joint flexion due to constraints regarding equipment and personnel across multiple institutions.

Two measurements of flexion at each joint were recorded with the patient seated in their own vehicle. Measurements were recorded by a single research assistant on one occasion using a goniometer. An average of the two measurements at each joint was used in assessments of joint flexion in order to minimise random error.

### Surgical procedure

All operations were performed using the Evolution medial pivot TKA system in conjunction with the PROPHECY® Pre-Operative Navigation Guides (Microport Orthopaedics, Arlington, Tennessee, USA). A limited medial parapatellar approach was used without tourniquet or patella dislocation. Patellae were not routinely resurfaced; however, marginal osteophytes were removed as deemed clinically necessary by the operating surgeon. Local infiltration analgesia into the deep capsule and surrounding tissues was carried out as part of our enhanced recovery programme.<sup>5 6</sup>



**Figure 1** Timelines for the resumption of driving after patient-specific instrumented total knee arthroplasty.

### Statistical analysis

Ranges and means were calculated for all outcome measures using responses to the driving questionnaire distributed to patients. Correlation between resumption of driving and operative side was undertaken using a  $X^2$  test.

### RESULTS

In total, 108 (72%) patients returned to driving within the first 3 weeks after surgery, of which 15 (10%) patients resumed driving within the first postoperative week, 52 (35%) patients drove in the second week and 41 (28%) returned to driving in the third week (figure 1).

The remaining 41 patients reported that they could have driven earlier but chose not to as they had pre-arranged alternatives. The earliest resumption of driving was on the second day postsurgery ( $n=2$ ), both following right-sided TKAs. One hundred forty-one (93%) patients stated that they were confident when they first resumed driving. There were 11 patients (7%) who did not return to driving postsurgery, 1 patient due to medical comorbidities and the remaining 7 relied on family for transport, however were confident they could have driven themselves if needed.

Although more patients who underwent right-sided TKA resumed driving within the first 3 weeks postsurgery ( $n=61$ ) than patients with left-sided TKA ( $n=47$ ), there was no significant difference in the time taken to resume driving between operative side ( $\chi^2 = 7.7$ ,  $p=0.26$ ). The median time to resume driving following surgery was 3 weeks for both operative sides, with IQR of 2.0 (L) and 1.0 (R). Eighty-one per cent of patients stated that they were more comfortable driving postsurgery than before surgery as their pain and stiffness was eliminated, thus enabling easier entry and exit out from the vehicle. Over 88% of patients were climbing stairs independently before resuming driving while the remaining patients used side railing. Nearly 87% of patients drove automatic cars, 7% were manual drivers and approximately 6% of patients failed to answer the question. Thirty-three per cent of patients were still working at the time of their procedure and the remainder were retirees.

Fifty-seven per cent of our patients were mobilising well before driving without the use of walking aids (table 2).

Of the remaining 43% (66 patients), 55 were using one crutch only. All patients tested the brake before commencing driving, with 3% reporting they were not confident with emergency

**Table 2** Patient responses to driving questionnaire

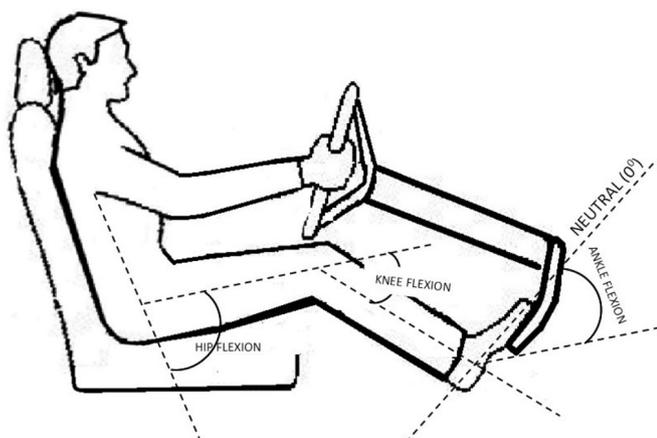
Questions asked in questionnaire	Yes	No
Walking aids used when resumed driving	43%	57%
Able to climb stairs when resumed driving	88%	12%
Confident to perform emergency braking if needed	97%	3%
Confident driving the first time after surgery	93%	7%
Comfort driving postsurgery as compared with presurgery	79%	21%
Ability to get in and out of the car comfortably	81%	19%
Pain while driving	38%	62%
Pain or discomfort as a distraction from driving	8%	92%
Feelings of drowsiness or ill-prepared to continue driving	4%	96%

braking on their first drive following surgery. Thirty-eight per cent of patients reported they felt pain while driving, however stated that the pain was mild and did not distract them. Four per cent stated they felt somewhat drowsy during their initial drive following surgery and thus delayed driving for a further week. There were no motor vehicle accidents or near misses reported by patients during follow-up consultations or reported in the questionnaire. Patients were given strict instructions by their treating surgeon to avoid narcotics before resuming driving. There were no reported complications as a result of the arthroplasty, including infections or thromboembolic events.

The measurements of angles of flexion at hip, knee and ankle during simulated acceleration and emergency braking (figure 2) among 50 patients demonstrated that ankle movements appear to affect driving more than hip and knee movements. While accelerating, patients required a range of 0°–48° ankle plantarflexion and while braking majority of patients had their ankle in 0°–20° plantarflexion (figures 3 and 4). Majority of movements while accelerating or braking are at the ankle joint, however the knee joint is predominantly engaged while braking, with 0°–5° of knee flexion. Hip and knee movements required an average of 73° (65°–77°) and 55° (38°–72°) flexion respectively in the simulated positions.

## DISCUSSION

This study demonstrates that patients are able to resume driving within days after undergoing TKA. Currently, there are very few studies assessing the resumption of driving following a TKA. This is the largest study to date evaluating the actual timeline of



**Figure 2** Demonstration of flexion angle measurement of hip, knee and ankle joints.<sup>17</sup>



**Figure 3** Patient in driving seat day after patient-specific instrumented total knee arthroplasty, with hip flexion (76°), knee flexion (50°) and ankle plantarflexion (36°) while accelerating.

resumption of driving in patients following PSI TKA by a single surgeon.

Many studies in the literature suggest that time to resuming driving varies from 4 to 8 weeks following TKA.<sup>9–12</sup> The American Academy of Orthopaedic Surgeons recommends that patients with right-sided TKA should not drive for 6–8 weeks postsurgery, while those who have undergone left-sided TKA should avoid driving for at least 1 week, provided that these patients are no longer using narcotic analgesia.<sup>13</sup> The Royal College of Surgeons of England states that driving should be avoided by patients for the first 8 weeks following TKA.<sup>14</sup> Despite these recommendations, there are no strict guidelines regarding the timeline for resuming driving following TKA.

Ellanti *et al* evaluated driving after TKA in 98 patients and found that 77 patients (79%) were able to resume driving within 6 weeks of TKA and 18 patients (18%) drove after 12 weeks.<sup>18</sup> They concluded that patients may be advised to drive 6 weeks after TKA, contingent on feeling comfortable and confident enough to do so. We found that 15 (10%) of our patients started driving in the first week postsurgery, 52 (35%) in the second



**Figure 4** Patient in driving seat 2 weeks after patient-specific instrumented total knee arthroplasty with hip flexion (76°), knee flexion (52°) and ankle plantarflexion (10°) while braking.

week and 41 (28%) in the third week, by which a total of 73% (n=105) were already driving without any issues. Moreover, by postoperative week 6, 95% of our patients had resumed driving. Over 93% of patients reported that they were confident and comfortable to drive after surgery, due to reductions in arthritic pain and stiffness as a result of the surgery. Seven per cent of patients stated that they were less confident during their initial drive postsurgery due to ongoing pain and swelling. These patients chose to delay driving by 1–2 weeks, however all patients eventually drove with confidence.

One potential reason for the early resumption of driving in the majority of our patients is the enhanced recovery measures taken. These include the minimally invasive, PSI surgical procedure, which did not involve patella dislocation, violation of intramedullary canals or tourniquets. Infiltration with local analgesia and an early mobilisation schedule were also used in all patients.<sup>5</sup> Our study relies on the patient's experience in their own vehicle, rather than using an automatic car simulator, which may not accurately mimic natural driving conditions. Additionally, the questionnaire used comprises multiple aspects of driving activity, including entering and exiting the vehicle, braking and pain as a distraction. The questionnaire and recovery protocol used in this study had been previously applied to patients undergoing bikini anterior total hip replacements by the same treating surgeon.<sup>17</sup>

The results of this study mirror the findings of an earlier study evaluating resumption of driving following total hip arthroplasty, using the same protocol. Of 198 patients who underwent an anterior bikini total hip replacement in a 16-month period, 76% returned to driving within the first 3 weeks after surgery, with 14% resuming in the first postoperative week.<sup>17</sup> Similarly, measurements of angles of flexion at the hip, knee and ankle during simulated acceleration and emergency braking suggested that ankle movements appeared to affect driving more than hip movements. Patients were reported to require a range of 0°–43° ankle plantarflexion while accelerating, which closely aligns with 0°–48° ankle plantarflexion required by patients following a TKA in this study. A comparison of findings between the two studies suggests that both knee and hip joints are equally as important contributors to the resumption of driving following arthroplasty. It is likely the enhanced recovery protocol and advice given in postoperative reviews by the same treating surgeon are contributing factors to the similar results.

A study by Liebensteiner *et al* assessing break response time (BRT) after TKA in 70 patients recommended a return to driving after 2 weeks, regardless of operative side.<sup>19</sup> They found a comparative increase in BRT between patients with right-sided or left-sided TKA and concluded the impact on quality of life associated with restricting driving beyond 2 weeks was not justified. Conversely, an analysis by van der Velden *et al* demonstrated that BRT returned to baseline 4 weeks after a right-sided TKA, however advice regarding resumption of driving should be individualised.<sup>20</sup> A similar study by Jordan *et al* also concluded that BRT may not return to baseline until 6 weeks postoperative, although a categorical statement regarding resuming driving following TKA cannot be provided. The authors recommended patients refrain from driving until after rehabilitation.<sup>21</sup> We demonstrated that patients who are confident, comfortable and not taking narcotics were able to resume driving within a week after surgery. As stated, there was no correlation between patients who recommenced driving within the first week and operative side.

Overall, 73% of patients in our study resumed driving within 3 weeks of undergoing PSI TKA. There was no association between age, gender, BMI and time taken to return to driving. The majority (80%) of our patients achieved a flexion range of 0°–100° by the time of discharge, which enabled easy access into and out of their vehicle. Additionally, measurements of hip, knee and ankle plantarflexion angles required for acceleration and braking demonstrated that ankle movements, rather than hip or knee, appear to predominantly affect driving. While accelerating, patients required a range of 0°–48° ankle plantarflexion. While braking majority of patients had their ankle in 0°–20° plantarflexion. Similarly, hip and knee movements required an average of 73° (65°–77°) and 55° (38°–72°) flexion, respectively to facilitate the resumption of driving following TKA, granted minimal pain.

There are no validated questionnaires considering driving after joint replacements in the literature. As demonstrated previously with patients undergoing THA, our questionnaire was designed considering safety as a priority and included practical aspects patients would consider before driving.<sup>17</sup> The senior surgeon only allowed patients to drive after thorough postoperative assessment if the patient was deemed medically fit and confident. Patients also needed to be walking pain free with or without a single walking aid, able to enter and exit their car comfortably, not taking oral narcotic analgesia and must be accompanied by a passenger on their first driving occasion. None of our patients have directly or indirectly been involved in any motor vehicle accidents within the 6-week postoperative period, nor did they report any adverse events.

Due to the delay between procedure and distribution of the driving questionnaire, there is a potential recall bias that must be considered. As such, results reported in the questionnaires were cross-referenced with clinical notes recorded at the standard 2-week and 8-week postoperative appointments for comparison. Comparison of driving outcomes between standard instrumentation and patient-specific instrumentation was not completed as all included patients underwent PSI TKA. Additionally, there was no uniformity in the type of vehicle assessed in the study, which may more accurately mimic the variety of vehicles driven by the general population. Although the questionnaire used in this study has not been validated, it was designed using practical and relevant questions comprehensible to the majority of patients and easily reproducible.<sup>17</sup>

## CONCLUSION

This study demonstrates that it is reasonable for patients to resume driving within 2 weeks of undergoing a PSI TKA, regardless of operative side. Patients with complex comorbidities and those continuing narcotic analgesia should consult their treating surgeon before resuming driving.

**Correction notice** This article has been corrected since it was published Online First. The copyright license has been updated to CC BY NC and the article has been made Open Access.

**Contributors** IN: senior author and surgeon who performed all the procedures and postoperative outcome, clinical and radiological assessments and designed the study, methodology and questionnaire. Also wrote sections of the paper and edited the paper in its entirety. AB: orthopaedic fellow who wrote the paper in conjunction with the senior author with guidance from the senior author. SG contributed to the analysis and interpretation of data in addition to drafting and critically revising the manuscript.

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