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HOW EASY IS IT GETTING INTO A CAR FOLLOWING TOTAL KNEE ARTHROPLASTY?

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ABSTRACT

Background: Patients often enquire when they can start driving following total knee arthroplasty (TKA) surgery. Brake response time is an essential factor when resuming driving, and this has been extensively reported, but no data is available on when the patient can get safely in and out of a car based on the restricted knee flexion.

Methods: We investigated the degree of difficulty and required knee flexion (RKF) to get into different car types, comprised of Sedans and Sports Utility Vehicles (SUV), using 11 volunteers with healthy knees. We used an electronic goniometer to record knee flexion required to get into the driver's seat, and participants were asked about their perceived difficulty getting into the car using a Visual Analog Scale (VAS) score (1 no difficulty to 10 impossible). We then restricted the knee flexion to 90, 60 and 30 degrees (using braces) to mimic knee stiffness following TKR surgery.

Results: We observed that the mean range of knee flexion to get into a car comfortably was 101.8 degrees on the left and 110.6 degrees on the right. Restricting knee flexion to 60 and 30 degrees increased the leading leg entry time and led to abnormal body movements more so with SUV's compared to Sedans. This was confirmed by higher VAS scores for SUV's ($p < 0.005$).

Conclusion: Following a left TKA, patients should be allowed to resume driving a Sedan or SUV if they achieve 90 degrees of knee flexion whereas following a right TKA a knee flexion of 60 degrees is required for a Sedan and 90 degrees for an SUV.

Keywords: total knee arthroplasty, knee flexion, getting into a car, driving.

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INTRODUCTION

Total knee arthroplasty (TKA) is a commonly performed operation to relieve pain and disability from knee osteoarthritis [1]. The capacity of TKA to achieve this [2] has been well documented. Post-operatively, patients undergo physiotherapy to regain motion in the operated knee, restricted due to post-operative pain and swelling [3]. This interferes with their ability to return to activities of daily living, which includes driving a motor vehicle. Some authors [4] have suggested that an early return to driving may alleviate financial, personal safety, and dependency issues that concern elderly post-TKA patients. Orthopedic surgeons are often asked to advise on when driving may be resumed. Although there is increasing data on brake response time, there is very little scientific evidence on the difficulties getting into care following total joint arthroplasty. The conventional advice has been not to resume driving for at least 6 weeks, but the time frame from as early as 3 weeks to 8 weeks have been reported [5].

To determine whether patients can resume driving, two conditions have to be fulfilled: 1. they have to be able to get in and out of the car safely, and 2. able to operate the car's controls (brake, clutch, and accelerator). A study by Spalding et al. in 1994 [6] has reported that the ability to transfer the right foot from the accelerator to the brake pedal was not recovered for 8 weeks after a right TKA. However, a more recent study by Pierson et al. in 2003 [7] has suggested that such response time returns to the preoperative level by the 3rd week and improves by the 6th week after surgery.

The ability to safely drive a car following lower limb arthroplasty is multifactorial. Besides brake response time, the other important factor is the range of knee (and hip) motion required to enter and exit a car. Our study aimed to determine the range of knee flexion required following TKA to get into the driver's seat and how this was influenced by car type comparing a Sedan to a Sports Utility Vehicle (SUV).

MATERIALS AND METHODS

We recruited 11 volunteers, 6 males, and 5 females, measuring between 170-180cm and without any knee or hip disease history. Five of New Zealand's top-selling new cars [8,9] each from the 2 car types, Sedans and Sport Utility Vehicles (SUV), were selected. Due to pragmatic reasons, the 10 cars were preferentially selected based on 3 car makes Toyota, Mazda, and Hyundai. This gave a sample size suitable for the timeframe of the study. The participants were asked to get into each of the 10 cars 3 times, and a video recording was made each time. The maximal knee flexion angle (MKFA) of the left leg was recorded by an electronic goniometer (Biometrics Ltd.) directly strapped to the individual's lower limb. The MKFA of the right leg was measured directly from the video recordings. The participants were also asked to rate on a visual analogue scale (VAS) the difficulty getting into the different cars from 1 (no difficulty) to 10 (impossible).

In the second phase of the study, a hinged knee brace (Specter ROM Knee Brace series 37-170) was applied to simulate the restricted ranges of knee motion as

experienced by post-TKA patients in their recovery period. The knee brace was applied first to the left, then the right knee, and set to limit flexion to 90°, 60°, and 30°. The same participants and the same cars as in the first part of the study were used. To reduce potential confounding effects, the car door was opened fully, and the position of the driver's seat was set to the maximum distance from the steering wheel. The video camera was positioned at a right angle to the car at a distance of 1.5 meters centered over the driver's seat back end. Descriptive analysis of the video clips was carried out, looking for abnormal balancing maneuver (BM) and body tilt (BT). Time taken (in seconds) to get into the car was also recorded. The order of the cars studied was randomized.

Statistical analysis was conducted using the STATA software. Multivariate analysis of the angle measurements and VAS scores was performed using the Linear Regression Model's mixed model extension.

RESULTS

Eleven eligible volunteers participated in the study. The mean age (years) was 25±3, and their mean height (cm) 174.7±1.9. The 5 Sedans selected were: Hyundai Getz, Mazda 3, Mazda 6, Toyota Camry, and Toyota Corolla; the 5 SUVs were: Hyundai Tucson, Hyundai Santa Fe, Mazda CX7, Toyota RAV4, and Toyota Landcruiser Prado. Toyota Corolla and RAV4 were selected for phase 2 of the study.

The overall mean of the MKFA for the left leg was 101.8° (SD = 11.4) and 110.6° (SD = 10.8) for the right leg. There was no statistically significant difference ($p > 0.05$) in MKFA between Sedans and SUVs. The means and standard deviations of the MKFA for each car and both legs are shown in Table 1.

	Left leg			Right leg	
	Mean	Std. Dev.		Mean	Std. Dev.
Prado	105.6	12.0		110.8	10.1
Santa Fe	103.1	7.0		112.1	6.7
Tucson	98.9	7.1		110.5	8.5
RAV4	102.2	10.8		120.1	9.8
MCX7	97.5	13.4		110.2	11.6
Corolla	104.2	12.2		110.5	11.7
Camry	105.9	13.0		109.6	12.4
Getz	102.2	6.7		110.2	8.8
M6	100.3	14.2		105.1	9.3
M3	97.6	11.4		107.3	11.2

Table 1: Mean and standard deviations of the maximal knee flexion angle for each car arranged in order of decreasing seat height relative to the ground. No statistically significant difference ($p > 0.05$) between Sedans and SUV's.

The mean and 95% confidence intervals of VAS scores are summarized in Figure 1.

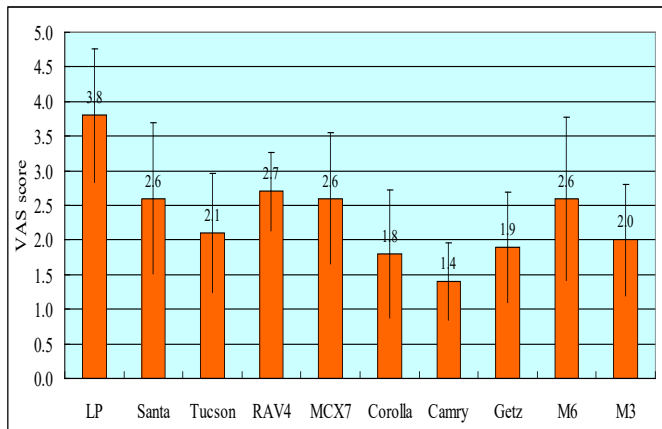


Figure 1: Mean and 95% confidence intervals of the VAS scores for each car showing a statistically significant difference ($p < 0.005$) between Sedans and SUV's.

Statistical analysis revealed no difference between the VAS scores within the Sedan and SUV group of cars. However, there was a significant difference between the two groups with Sedans having a lower VAS score (easier to get into) as compared to SUVs ($p < 0.005$). When the knee brace was applied, as expected, the more the knee flexion was restricted, the higher the VAS score reflecting the increasing difficulty in getting into the car ($p < 0.05$) for both Sedans and SUV's (Fig. 2).

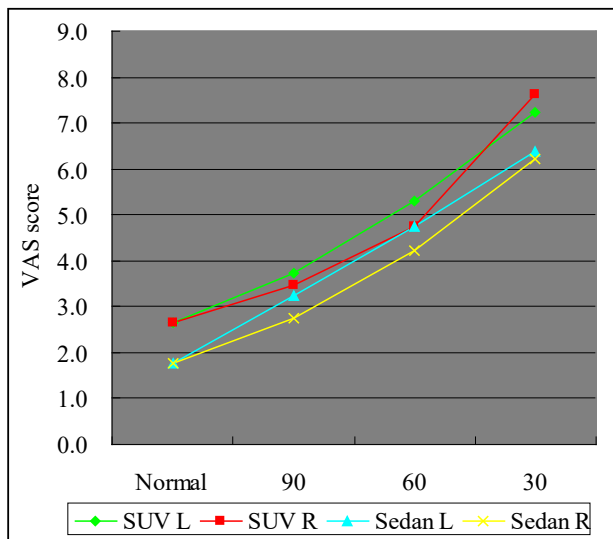


Figure 2: The progression of VAS scores with increasing restriction of knee flexion ($p < 0.05$) irrespective of car type. Normal = without knee brace; L = knee brace applied to the left knee; R = knee brace applied to the right knee; 90, 60, 30 = degree of flexion allowed.

Descriptive analysis of the videos revealed several points. Firstly, it showed that the motion could be divided into two parts involving the left and right leg separately. When getting into the driver's seat, the left leg (the leading leg) was lifted off the ground resulting in the right leg (the following leg) taking the entire weight. With the right knee bending, the leading leg entered the car and approached the floor. The leading leg then found a spot to land, and as soon as this happened, some of the weight-bearing forces were dissipated from the right leg. The range of flexion of both knees then gradually increased until the person's body entered the car and sat on the seat. This concluded the 1st

part. Some participants held onto the steering wheel, the external car frame or the door-side handle to balance the upper body from the inward momentum.

The 2nd part then began with flexion in both the hip and knee joints of the right or following leg. This allowed this leg to pass more easily through the available space until it found a spot on the floor to land. This concluded part 2.

Division of the process of getting into a car into two parts allowed us to study the effect of post-TKA stiffness on the left and right sides separately.

With the left knee restricted to 30° of flexion when getting into a Sedan (Corolla), 81.8% (9/11) demonstrated a longer leading leg entrance time (LLET), and 45.5% (5/11) performed a balancing maneuver (BM) earlier when getting into the car. When the knee flexion was restricted to 60 degrees, the same was observed but in fewer participants. When restricted to 90 degrees, all participants displayed normal body movement.

When the 30 degrees restriction was applied to the right knee, as the leading leg's movement was not restricted, the leading leg entrance time was normal, but 72.7% (8/11) of participants performed an inward upper body tilt (BT) when getting into the car. When the 60 and 90 degrees restriction was applied to the right knee no abnormal body movement was observed (Table 2).

30L = knee brace applied to the left knee allowing 30° of flexion. LLET = longer leading leg entrance time. BM = balancing manoeuver. BT = body tilt

	Longer LLET		Earlier BM		Inward BT		
	Corolla	RAV4	Corolla	RAV4	Corolla	RAV4	
30L	9	10	5	6	30R	8	10
60L	7	9	3	5	60R	/	6
90L	/	2	/	/	90R	/	/

Table 2: Comparison of the frequency count of extra movements involved in getting into a Sedan and SUV with different knee joint restrictions.

As far as the SUV (RAV4) was concerned, we observed a slightly larger number of participants with increased leading leg entrance time with the left knee braced at 30 and 60 degrees and with the right knee brace at 30 degrees the inward body tilt (BT) was also higher at 90.9% (10/11) and persisted in 54.5% (6/11) of participants at 60 degrees. At 90 degrees, no abnormality was detected.

The overall more extra movements observed in participants with their left and right knee braced at 30 and 60 degrees when getting into an SUV compared to a Sedan could explain the increased VAS score for SUVs found in this study.

DISCUSSION

Being able to drive a car after a TKA in elderly patients is essential to returning to independence following surgery. Numerous studies have focused on the return to normal brake response time [10,11,12,13,14,15]. Still, no data is available on when patients can get in and out of a car safely following TKA and whether there is a difference between Sedans and SUV's.

Our study has shown that for both the left and the right leg, there is no difference in the mean knee flexion angles required to get into SUVs or Sedans despite the differences in seat height relative to the ground, and this was independent of the model of a car within the two groups. To get into a car comfortably, a range of left knee flexion of at least 100 degrees is required, whereas the right knee needs to bend an additional 10 degrees on average. This is probably because the right leg has to clear the door and frame of the car when the individual is seated, which reduces the space for the following leg. It appears that both knees act independently of each other as we did not see any influence on the range of flexion of the opposite knee when a brace was used to limit flexion. The difference in VAS scores between SUVs and Sedans is interesting. As there was no difference in mean knee flexion, other factors must make it easier to get into a Sedan than an SUV. Is it the seat height, clearance of door and frame, or other factors. Further research is required to answer these questions.

Qualitative video analysis of individuals with knee braces restricting knee flexion showed a number of abnormalities. For example, a longer leading leg entrance time because the stiffened knee made access through the available space more difficult. This then put the following leg under more pressure, and some used the upper limbs to help, leading to various balancing maneuvers like grabbing the steering wheel or holding on to the door frame. An inward body tilt was also observed as a means of allowing the following leg to enter the car more easily (Fig. 3).

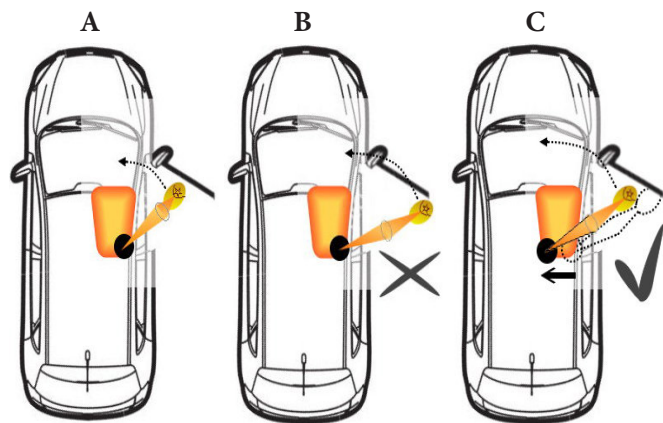


Figure 3: A – Movement of the following leg under normal circumstances with the knee flexed to allow easy access; B – with a stiff knee joint access of the following leg is likely to be denied as shown; C – inward BT effectively utilizes the available space in the car to avoid any obstacle in the way of the following leg.

Inability to flex the knee increases the overall length of the lower limb, which increases the lever arm requiring a greater distance from the vertical part of the seat and the anterior limit of the door frame. The angle of opening of the door, dimensions of the door frame, and the ability to move the seat backward away from the steering wheel will all influence this distance. The single-camera used in our study was set up to measure knee flexion but did not allow the 3-dimensional analysis of the motion of the lower limb and hence the limitation of our data in analyzing complex movements. Further work in a gait lab setting with multiple

cameras is required to shed further light on this issue.

CONCLUSION

In practical terms, it seems advisable that post-TKA patients considering getting back to driving a car should check if they can get safely in and out of a car, which, according to our findings, requires the left knee to flex to 90 degrees and the right to 60 degrees in case of a Sedan and to flex both knees to 90 degrees in case of an SUV. The rationale being that these are the angle thresholds below which abnormal movements can occur, which could lead to pain and injury. However, patients should be advised not to drive until they have recovered enough strength in the operated leg to operate the foot pedals safely, and their brake response time is back to within normal limits.

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