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Driving reaction time after right knee arthroscopy

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Abstract Driving reaction times of 30 right knee arthroscopy patients were measured using a computer-linked car simulator. Each patient was tested pre-operatively and 1 week after and 4 weeks after arthroscopy. As controls, 25 normal subjects were also tested. In the control group the average reaction time was 634 ms; the measurements at 1 week and at 4 weeks were 550 ms and 582 ms, respectively. In the arthroscopy group the average reaction time pre-operatively was 736 ms; the measurements 1 week and 4 weeks post-operatively were 920 ms and 685 ms, respectively. Two clinical tests (the stepping and standing tests) were also performed at each assessment. Statistical analysis showed a good correlation between these and reaction time. We conclude that it is appropriate for patients to delay their return to driving for at least 1 week, and that the actual timing of return to driving may be determined by performance on these two clinical tests.

Key words Driving reaction time · Knee arthroscopy

Introduction

Driving reaction times of patients following right total hip and right total knee arthroplasties have been measured, and guidelines regarding return to driving have been suggested [5, 9]. However, there are no clear guidelines as to when a patient can return safely to driving following a right knee arthroscopy. This study evaluated patients' reaction times under simulated driving conditions before and after right knee arthroscopy in an attempt to produce guidelines on safe return to driving.

Materials and methods

Participants

Every patient undergoing elective right knee arthroscopy at our centre within a 12-month period between 1995 and 1996 was asked to participate in the study. All patients who gave consent entered the study. Thirty patients were recruited. The types of arthroscopic surgery performed included partial meniscectomies, chondroplasties and diagnostic arthroscopies. Arthroscopic synovectomies, lateral releases and reconstructive procedures were excluded. All procedures were performed by consultant surgeons or clinical fellows under consultant supervision. All patients and controls were regular drivers with automatic transmissions, and all were accustomed to braking with their right leg. Those who were aged under 17 years or over 70, non-drivers, those who had co-existing neurological disorders and those who had a history of previous knee surgery were excluded. Each patient was tested within 24 h before the arthroscopy, 1 week after and 4 weeks after right knee arthroscopy. Twenty-five normal subjects were also tested. The study was approved by the Ethics Committee of the Austin and Repatriation Medical Centre prior to commencement.

Clinical testing

Two clinical tests, the stepping test and the standing test, were performed to test the function of the lower limbs before each reaction time measurement. The stepping test was performed with the patient seated and both the knees and the hips flexed at 90°. An oblong paper box measuring 2.5 × 2.5 × 30 cm was placed alongside the patient's right foot. The patient was to step across either side of the box with the right foot without touching it. Each step must involve firm planting of the heel; tiptoeing was not allowed. This test was devised to simulate the action of foot transfer during emer-

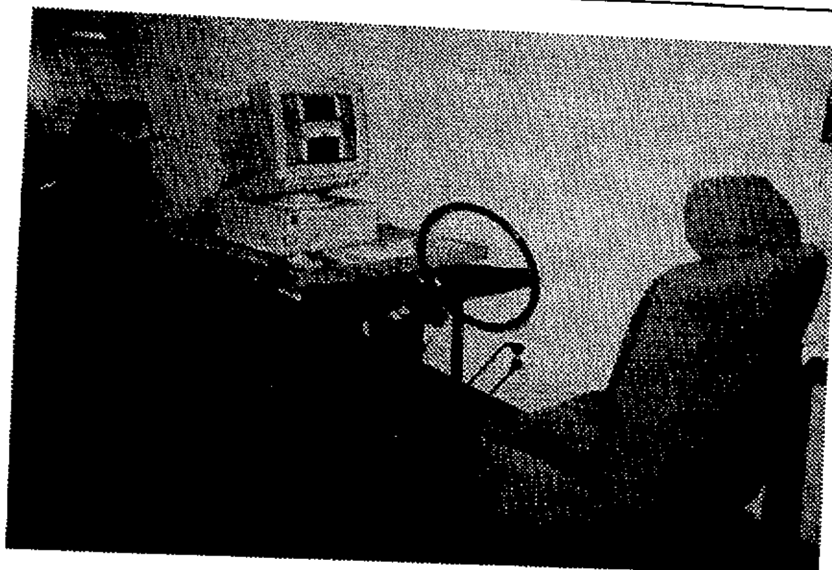

Fig. 1 Car simulator

gency braking. The number of steps achieved in 10 s was recorded. The standing test involved the patient standing up from a seated position until the knees were fully extended before resuming the seated position. The number of stands achieved in 10 s was recorded.

Reaction time

The computer-linked car simulator was constructed by the Department of Electrical and Computer Systems Engineering of Monash University (Fig. 1). The car seat was adjustable in both tilt and distance, while the steering column was adjustable in angle only. The brake and accelerator pedals were built in the same vertical level. A force transducer was connected to the brake pedal to measure any force applied. A 35-cm display monitor was placed in an elevated position behind the steering wheel. During the test the patient was instructed to depress the accelerator pedal fully while the green signal appeared on the display monitor. The patient was also instructed to steer towards the direction of a bar indicator that appeared on the screen as a distracter. A red signal then appeared after a random time interval to simulate an emergency stop situation. When the red signal appeared, the patient was instructed to transfer the right foot from the accelerator pedal to the brake pedal as hard and as quickly as possible. The reaction time was the interval between the display of the red signal and the moment that 200 N force was applied on the brake pedal; a force of 200 N was chosen as the threshold to reflect more closely the maximum pedal force in normal subjects [6]. Five practice runs were allowed for each patient, and the average of the next five runs was recorded. Any complications were also recorded.

Table 1 Demographic details of arthroscopy and control groups

	Arthroscopy ($n = 30$)	Control ($n = 25$)
Males:females	9:21	8:17
Age (years)	42.4 ± 14.2	33.6 ± 11.0
Weight (kg)	79.8 ± 16.2	73.2 ± 11.3
Height (cm)	173.6 ± 9.0	175.0 ± 8.7

Table 2 Number of steps and stands achieved in 10 s

	Average number of steps		Average number of stands	
	Arthroscopy	Control	Arthroscopy	Control
Pre-operative	14.1 ± 2.0	16.7 ± 2.1	6.6 ± 2.3	8.3 ± 2.2
One week	12.9 ± 3.8	18.4 ± 2.2	5.7 ± 2.5	9.9 ± 2.7
Four weeks	15.6 ± 2.3	17.8 ± 2.0	7.3 ± 2.1	9.7 ± 2.3

Table 3 Reaction time (ms)

	Arthroscopy	Control	P^a
Pre-operative	736 ± 191	634 ± 140	0.03
One week	920 ± 519	550 ± 115	0.00001
Four weeks	685 ± 174	582 ± 121	0.008

[a] Mann-Whitney test

Results

The demographic details of both the arthroscopy and the control groups are shown in Table 1. There was no correlation between the age, sex, height or weight of the participants in relation to reaction time. In the control group the average number of steps and stands increased significantly from baseline to the 1-week test (Tables 2, 3). There was a corresponding, statistically significant decrease in the reaction time in the same interval ($P = 0.001$, Wilcoxon signed rank test). There was no significant difference in the numbers of steps and stands or in the reaction time between the 1-week and the 4-week tests ($P = 0.3$, Wilcoxon signed rank test).

In the arthroscopy group none of the patients required any narcotic analgesics on review after 1 week, and there were no complications. The average number of steps and

Table 4 Average change in reaction time (ms)

	Arthroscopy	Control	P[a]
From baseline to 1 week	172 ± 488	−81 ± 84	0.0004
From 1 week to 4 weeks	−244 ± 464	11 ± 38	0.00001
From baseline to 4 weeks	−52 ± 13	−87 ± 95	0.3

[a]Mann-Whitney test

stands decreased significantly from the pre-operative test and the 1-week post-operative test (Tables 2, 3). We found 63% of patients tested after 1 week to have slower reaction time than pre-operatively. The average change in reaction time was 172 ms (Table 4; $P = 0.03$, Wilcoxon signed rank test). The type of arthroscopic surgery performed had no effect on the change in reaction time. Four weeks post-operatively the number of steps and stands had increased compared to the pre-operative test. The average reaction time had also improved by 52 ms compared to the pre-operative measurement, and this change was significant ($P = 0.02$, Wilcoxon signed rank test). However, 30% of patients tested after 4 weeks continued to have a slower reaction time than pre-operatively.

Statistical analysis showed that there was a significant correlation between the number of steps and stands in relation to the reaction time. Spearman's rank correlation coefficient for the number of steps and the reaction time was between −0.45 and −0.79 ($P < 0.001$). The correlation coefficient for the number of stands and the reaction time was between −0.45 and −0.70 ($P < 0.001$).

Discussion

Reaction time can be described as two main portions, namely perception time and foot transfer time. One prospective study using a car simulator found that while perception time remained unchanged after total knee replacements, foot transfer time increased significantly [9]. In this study perception time was not measured separately.

We found a similar pre-operative reaction time in the arthroscopy group (736 ms) to that in persons waiting for total knee replacements (710 ms) [9]. This is in spite of a higher threshold (200 N) set on the force transducer compared to the previous study (100 N). In an on-road study of normal drivers, in which the drivers were expecting an emergency, the median reaction time was found to be 660 ms with a range of 300–1200 ms [3]. The average pre-operative reaction time found in this study fell well within this range. It is noteworthy that throughout the study the reaction time of the arthroscopy group remained consistently and significantly longer than that of controls (Fig. 2). This difference was not found in the other study involving reaction time of patients with total knee replacement [9]. The reason for this discrepancy is unclear. However, it is

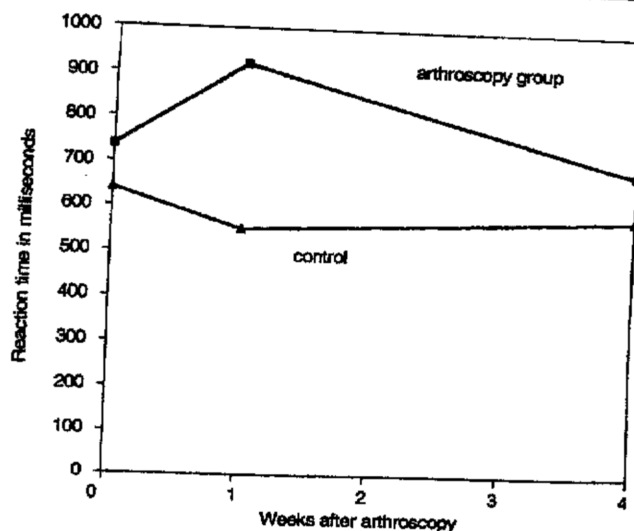

Fig. 2 Reaction times of arthroscopy and control groups

probably not unreasonable to expect that the reaction time of a knee with a meniscal tear to be longer than that of a normal knee. In addition, the control group averaged 9 years younger than the arthroscopy group, and this could also have shortened the reaction time.

The reaction time of the control group significantly improved between baseline and the 1-week test. This most likely represents a learning effect, which was not repeated at the 4-week test. In the arthroscopy group there was an increase in reaction time from 736 to 920 ms between baseline and 1 week. This increase translates into an increase of 5.2 m in stopping distance at the speed of 100 km/h.

A wide range of reaction times has been assumed to be the 'safe' level by various road authorities. The German Commission on Reaction Times recommends that the driver must react within 1500 ms [1]. On the other hand, the Department of Transport in the United Kingdom assumes a reaction time of 700 ms when calculating the safe tailing distance [2]. When determining what the 'safe' reaction time is, it should be stressed that factors such as the type of signal, level of ambient light, level of fatigue, speed of the vehicle, alcohol or drugs intake and the location of brake lights all affect the reaction time of the driver [4, 7, 8, 10]. Not all of these factors could be realistically represented in a car simulator situation. We used the pre-operative reaction time as guide against which the post-operative reaction time was compared. Assuming that the patients were not unsafe when they drove pre-operatively, they must therefore have been safe to drive post-operatively once their reaction time had returned to the pre-operative level.

A good correlation was found between the number of steps and stands achieved in 10 s in relation to the reaction time. These tests can be used on follow-up review to gauge the patient's recovery. These tests can be of important

value, considering 30% of the patients in this study had a slower reaction time 4 weeks after the operation.

We conclude that it is appropriate to delay return to driving for at least 1 week, and that the stepping test and the standing test may be performed to monitor the patient's recovery on follow-up.

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