DRIVER REACTION TIMES AFTER TOTAL KNEE REPLACEMENT

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We measured the driver reaction times of 40 patients before total knee replacement (TKR) and 4, 6, 8 and 10 weeks after operation. The ability to perform an emergency stop was assessed as the time taken to achieve a brake pressure of 100 N after a visual stimulus. There were 18 drivers and 11 non-drivers; the latter had longer reaction times.

In drivers, the ability to transfer the right foot from accelerator to brake pedal did not recover to preoperative levels for eight weeks after right TKR and was unchanged after left TKR. Patients should be advised that they should not drive for at least eight weeks after right TKR.

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No strict criteria are available for when a patient may return to driving after total knee replacement (TKR). The UK Driving and Vehicle Licensing Agency (DVLA) advises that return to driving may be permitted once limb function is "satisfactory", but do not define the term (Jones, personal communication, 1992). An essential requirement for safe driving is the ability to stop rapidly in an emergency. This requires an acceptable reaction time and sufficient power in the limb.

Driver reaction times have been measured in the assessment of Parkinson's disease (Madeley et al 1990), after various psychotropic drugs (Hindmarch 1980), in alcohol intoxication, in relation to pedal position (Morrisson, Swope and Halcomb 1986) and after total hip replacement (Macdonald and Owen 1988). We have studied reaction times after TKR in an attempt to produce guidelines on safe return to driving.

METHODS

We used a driver reaction jig (Fig. 1) constructed by the Rover Group car manufacturers in collaboration with the Oxford Orthopaedic Engineering Centre (Turner-Smith et al 1990). Transducers fitted to the brake, accelerator and clutch pedals recorded force and movement in response to a visual stimulus on a screen. Subjects were asked to match the horizontal motion of a vertical line controlled...
by the accelerator, to the random motion of a second line controlled by the computer. An emergency stop was simulated by the screen turning red. The instruction given for driving reaction tests asked the subject to lift the foot off the accelerator and to depress the brake pedal firmly. A computer-generated trace (Fig. 2) allowed measurement of the various components of the response.

We also measured upper-limb reaction time to eliminate the effect of any general change in reactions on the day of the test, which could have resulted from drugs, alcohol, illness or fatigue. Hand reaction time on the dominant side was measured by asking the patient to press a switch at the end of an indicator stalk on the steering column when the screen changed colour.

The total reaction time which is termed “thinking time” in the UK Highway Code, includes both neurological delay and transfer time. The neurological reaction delay was recorded as the time between the signal and the initiation of foot removal from the accelerator pedal. Transfer time was the delay between this and achieving a brake pressure of 100 N. This was the force used by Macdonald and Owen (1988) and was considered to be necessary to achieve adequate braking.

Patients were assessed before operation (0) and 4, 6, 8 and 10 weeks after TKR. At each test, the patient was allowed time for familiarisation with the format and the driving controls. Each assessment included three trial runs and three tests, after ensuring that the patient was strong enough to achieve pressure of 100 N on the brake pedal.

As controls for the normal range of reaction times we also tested some of the relatives of patients of a similar age group with no osteoarthritis of the legs.

RESULTS

We studied 20 control subjects and 40 patients having TKR. One patient died during the study period and another developed early postoperative infection and was excluded. Data on another nine patients were incomplete due to failure to attend for all tests. The results for 29 patients were therefore available for analysis. Eighteen of these were drivers with an average age of 74 years (61 to 83); 12 had had right TKR and six left TKR. Of the 11 non-drivers, eight had had right TKR and three left TKR. The average age of the non-driver group was 71 years (59 to 82).

The 20 control subjects had a mean age of 67 years (52 to 85) and 14 of them were drivers. Drivers and non-drivers. The preoperative reaction times for the study group and control group are shown in Table I. The visual reaction delay for both hand and leg was similar for drivers and non-drivers, but the total reaction time, including transfer, was significantly longer for the non-drivers (p < 0.05, Student's t-test).

Drivers. Figure 3 relates the total reaction times to the number of weeks after TKR. Patients having a left TKR acted as an additional control group, and their reaction
times remained constant throughout the study. After right TKR, reaction times were prolonged at four and six weeks, failing to return to preoperative values until eight weeks after surgery.

The visual reaction delay remained practically unchanged during the study: the main prolongation in total reaction time was the transfer time. At four weeks after TKR the mean transfer time had increased by over 50% before returning to preoperative values at eight weeks (Fig. 4; p < 0.1, Wilcoxon signed-rank test).

Non-drivers. Though the reaction time in non-drivers was longer (Table I), recovery after operation showed an overall trend similar to that found for drivers. There was an improvement between four and six weeks, but normal times were not achieved until eight weeks.

DISCUSSION

Hakkinen (1976) has shown that accident proneness can be related to psychomotor abilities assessed on a simulator, but some caution is needed in extrapolating from simulator results to real driving (Madeley et al 1990). Patients tend to adjust their driving speed according to their reaction time and their perception of risk. The most relevant reaction time for safety is the delay in performing an emergency stop. This reaction time is considered to be a 'learned co-ordinated movement response', and our findings for non-drivers support this definition in that leg-transfer time was commonly greater than that for drivers. We therefore compared only individual postoperative leg-reaction times with the preoperative results for each patient.

Left TKR did not impair the ability to carry out an emergency stop on the rig. This suggests that patients can return to driving after left TKR as soon as they can depress the clutch pedal with sufficient force for their vehicle. By contrast, we found that right TKR was followed by significantly increased transfer times at four weeks with return to normal by about eight weeks. Macdonald and Owen (1988) reported similar findings for total hip replacement, using a simulated driving control system; most patients had adequate improvement by eight weeks, but a few did not recover for a prolonged period. In our study only one patient failed to recover the preoperative ability to brake in an emergency-stop simulation by ten weeks. With this exception, all others had recovered their preoperative reaction times by eight weeks, and therefore should be able to drive after this time.

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REFERENCES


Table I. Mean reaction times ± SD in seconds for patients before operation (n = 40) and control subjects (n = 20)

<table>
<thead>
<tr>
<th></th>
<th>TKR patients</th>
<th>Control subjects</th>
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<tbody>
<tr>
<td></td>
<td>Driver</td>
<td>Non-driver</td>
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<tr>
<td>Hand (neurological)</td>
<td>0.27 ± 0.06</td>
<td>0.23 ± 0.08</td>
</tr>
<tr>
<td>Leg (neurological)</td>
<td>0.34 ± 0.05</td>
<td>0.32 ± 0.06</td>
</tr>
<tr>
<td>Leg transfer</td>
<td>0.38 ± 0.24</td>
<td>0.59 ± 0.21</td>
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<tr>
<td>Total</td>
<td>0.72 ± 0.26</td>
<td>0.98 ± 0.24</td>
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Fig. 4

Relative foot transfer times for drivers (mean ± SD) related to the number of weeks after operation.