THE EFFECT OF TOTAL HIP REPLACEMENT ON DRIVING REACTIONS

WARREN MACDONALD, JOHN W. OWEN

From Oxford Orthopaedic Engineering Centre

The driving reactions of 25 patients were assessed before and after operation for hip replacement. Driving reactions were tested by monitoring the delay and force of brake application after an emergency signal, using a simulated driving control system. Fifteen normal subjects were also tested. Statistical analysis demonstrated significant differences between patients with either left or right hip replacement and between pre- and postoperative testing. Most patients improved by the eighth week, but some had deteriorated and did not recover until re-tested eight months after operation. It is concluded that for most patients eight weeks' delay for return to driving is appropriate, but for a minority of patients with right hip replacement recovery of reaction speed requires longer rehabilitation.

In a society substantially dependent upon the motor car, impaired driving ability is a significant disability which may affect patients with degenerative hip disease. During postoperative rehabilitation also, the inability to drive a car is a real inconvenience. Part of the delay in return to driving is the danger of extreme flexion of the hip soon after operation, and part is the need to avoid excessive forces, such as required for sudden braking. However, we postulate that the main limiting factor is the return of function, as determined by the ability to move the feet between the pedals.

Pre-operative advice to patients is often based on the expectation of an eight-week postoperative delay before return to driving, but there is no factual basis for this period. It was therefore decided to test its validity.

Reaction time has been measured in studies of neurological function and dysfunction (Sivak et al. 1980), drug and pollution effects, and ergonomic design (Morrison, Swope and Halcomb 1986). Specific investigations of driving reaction times have been concerned with the placement of pedals, and assessment of the readiness of stroke or trauma patients to return to driving. Ergonomics of design were first investigated by Davies and Watts (1969, 1970), who found differences with the relative placements of the brake pedal and the accelerator pedal, and a sex difference in the effect of this placement. Morrison et al. (1986), when testing normal young adults, found that differences in the height of the pedals significantly altered reaction time, more so in young women than in men.

Sivak et al. (1981) compared techniques of driving assessment: psychological testing in the laboratory, skill testing in the vehicle and road-testing in real traffic. Three groups of subjects were tested: normal adults, stroke patients and patients with spinal injuries. There was found to be good correspondence between the results of the laboratory and the practical tests, and specific tests were found to relate better to driving practice. Wilson and Smith (1983) used actual driving tests with simulated situations to test the driving ability of stroke patients; an emergency stop was included in the simulation, but the results of this were not specifically reported.

The British School of Motoring have been testing brake reaction times at their Disability Training Centre for several decades. Although no results have been published, the reaction threshold to which disabled performance has been compared is the national average of 0.7 seconds. This is the basis of the braking figures reported in the Highway Code (Department of Transport 1978).

METHOD

An experimental apparatus was developed to measure the force and timing of pressure by the right foot on accelerator and brake pedals (Strange et al. 1985). This was based on a BBC microcomputer and a Kistler piezoelectric force platform. The apparatus (Fig. 1) consisted of an easy chair bolted to a frame on which were mounted the brake and accelerator pedals. The pedals acted about pivots onto pads of foam rubber and thence onto the floor-mounted force platform. The relative position of pedals and seat was adjusted to resemble the subject's normal driving position. A video colour monitor placed
before the subject displayed instructions and the emergency warning. Control, timing and recording were performed by the BBC microcomputer, which sampled the forceplate signal through its analogue-to-digital port at a frequency of 100 hertz.

The program was initiated by the tester, seated beside the test subject; the tester subsequently played no part in the progress of the test. The application of light foot pressure on the accelerator produced a full-size green square on the video screen. After waiting for a random interval (between four and eight seconds), the screen colour changed to red as a signal to brake, and timing was started. Force on all the pedals was monitored to ensure that the foot was removed from the accelerator, and when re-application of force on the brake had exceeded a preset threshold (100 newtons) the timer was stopped. The measured time interval was termed the reaction time \( t_r \). Subjects were permitted several trials to accustom themselves to the controls, and subsequently nine tests were recorded.

If insufficient force was detected on the pedals before the signal, if force was not removed from the pedals after the signal, or if insufficient braking force was developed, then the test was abandoned and a diagnostic message was displayed. In the case of a valid test, the force–time plot (Fig. 2) and the reaction time were displayed on the screen.

The mean of the nine repeats was considered the result for each test session. Statistical analysis of the means was performed by analysis of variance using the generalised linear model, with Scheffe’s post hoc comparison to identify the significant differences between means.

**PATIENTS**

Patients were selected at random from normal admissions to the Nuffield Orthopaedic Centre for total hip replacement. Those who had ceased driving for any reason other than hip disease were excluded. Whether the hip for operation was the right hip or the left, testing was performed on the right leg in all patients. This was done within five days before operation and then retested on presentation to the normal follow-up clinic, nominally eight weeks after operation. Before retesting the patients were asked if they had been advised not to drive (for any reason).

Twenty-five patients were studied in this manner. Three were lost to follow-up, leaving 12 with right hip replacements (eight men, four women; mean age 61 years), nine with left hip replacements (seven men, two
women; mean age 58 years) and one patient with bilateral revision. Fifteen normal subjects over 40 years of age, drawn from the staff of the Oxford Orthopaedic Engineering Centre and Mary Marlborough Lodge, were tested on one occasion; there were nine men and six women, with a mean age of 53 years.

**RESULTS**

The mean reaction time for normal adults using the present methods, was 468 ms (standard error 35 ms) (Fig. 3). Patients for left (contralateral) hip replacement recorded a mean reaction time for the right hip of 594 ms pre-operatively (s.e. 45 ms), and 495 ms postoperatively (s.e. 45 ms). Patients for right hip replacement recorded a mean of 704 ms pre-operatively (s.e. 39 ms), 656 ms at eight weeks postoperatively (s.e. 39 ms), and 591 ms at 32 weeks (s.e. 40 ms).

Some of the patients exhibited markedly longer reaction times after operation than before (Fig. 4). There was one subject in each group of patients with substantially longer pre-operative reaction times than the remainder of the group; however, neither of these outlying subjects had abandoned driving pre-operatively.
Statistically, there was a highly significant difference between subject groups (p<0.01), a significant difference between test visits (p = 0.05), and no significant interaction. Post hoc comparison demonstrated that the significant group differences (p < 0.05) were between the patients with right hip replacement and the two other groups, but not between those with left hip replacement and the normal controls.

DISCUSSION

The test protocol selected is very similar to that reported by Morrison and colleagues (1986). Their braking force threshold was 88 newtons, whereas 100 newtons was used in the present study. The foot pedal geometry was selected so as to require the foot to move proximally as well as medially when braking.

Reaction times for normal subjects fell well within the Highway Code guideline of 700 ms. The patients presenting for left hip replacement also conformed to that guideline, all but one of these patients reacting faster than 700 ms pre-operatively. Patients for right hip replacements showed longer reaction times pre-operatively, the mean being 704 ms, but half this group might be considered still able to drive, from a purely technical consideration of reaction speed. At eight weeks after operation the mean of 656 ms (s.e. 39 ms) implies that 16% of the group would still fall outside the 700 ms cutoff. The worst mean reaction time at the eighth week was about 0.9 seconds. At a speed of 48 kph (30 mph), this would result in a "thinking distance" of 12.1 metres (39.6 feet), compared with the Highway Code figure of 9.1 metres (30 feet), or a 32% increase in thinking time and distance.

It would seem, therefore, that all patients with a left hip replacement could safely resume driving at eight weeks. Not all those with a right hip replacement, however, could with such confidence be restored to driving, and it would seem necessary to differentiate those patients whose reactions remained slower than the assumed norm of the Highway Code. A simple clinical test is needed.

Experimental design was problematic; it was of course not possible to test normal subjects post-operatively. Scheffe’s test, since it included so many normals, proved of no value.

Inspection of the data (Fig. 4) revealed that within the right hip group there was a subgroup of four patients who had actually deteriorated at the 12-week visit. Considering the means for the groups (Fig. 3), it is apparent that there is a trend to improvement with postoperative delay, but the statistical significance of this trend was masked by the subgroup, and also by the experimental design. Although one of the four patients in the subgroup suffered infection of the arthroplasty, no unifying factor could be found within the group, and no explanations could be given for the apparent slower rehabilitation in the remaining three patients. The mean age of the subgroup was 66 years, which is not substantially different from the overall group mean of 61 years. To delineate the groups further, the change in reaction time after operation was expressed as a fraction of the post-operative value, and an unpaired Student’s t-test was used to compare the "non-improver" subgroup with the "improver" subgroup. This was highly significant (p < 0.005). When the BSM guideline of 0.7 seconds is applied to this subgroup of patients, it can be seen that all have deteriorated to reactions slower than the safe threshold, and should be advised against driving at that stage.

The lack of a significant difference between the normal adults and the patients with left hip replacement suggests that the disabling effect is localised to the affected hip, and that the generalised disability is minimal in its effect. It would also seem to indicate that any other effects of the surgery have abated within the eight weeks.

Conclusions. Driving ability, as measured by right foot braking reaction tests, is, as expected, affected to a greater extent by disease of the right hip than of the left. Indeed, when the left foot is not used, there is no significant difference in braking ability between patients with left hip replacement and normal subjects. However, some patients with right hip replacement will not have recovered sufficient hip function to return to driving at two months after operation, and yet may give no other indications of slower rehabilitation. Such patients may be detected by this simple braking test, measuring pedal force and timing, which might help assess their ability to drive. Such a test need not require expensive equipment or time, but would yield specifically useful information as to the rate of postoperative recovery.

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REFERENCES


