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ORIGINAL ARTICLE

Influence of Left- and Right-Side Total Hip Arthroplasty on the Ability to Perform an Emergency Stop While Driving a Car

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Abstract

Objective: To show the possible effect of left- and right-side total hip arthroplasty (THA) on the ability to perform an emergency stop when driving a car.

Design: Inception cohort.

Setting: A driving simulator using an actual car cabin, specifically developed for the experiment, was used for testing driving ability.

Participants: Patients (N=40; 20 left-side THA/20 right-side THA) were tested preoperatively and in increments of 8 days and 6, 12, and 52 weeks after surgery.

Interventions: Left- and right-side THA.

Main Outcome Measures: Reaction time, movement time, total brake response time (TBRT), and maximum brake force.

Results: Eight days postoperatively, measurements on driving performance indicated a slight worsening for all outcome parameters in patients after left-side THA and considerably more worsening in patients after right-side THA. For both patient groups, significant improvements in outcome measures were noted during the 1-year follow-up. Brake force declined significantly in patients with left-side THA ($P=.012$) and in patients after right-side THA ($P<.001$). A total of 35% of the patients with right-side THA and 15% with left-side THA could not meet the 600ms TBRT threshold 6 weeks postoperatively.

Conclusions: Most patients who underwent right-side THA reached their preoperative baseline 6 weeks after surgery. Most of the patients with left-side THA showed no TBRT limitations 8 days postoperatively. Because of the patients' highly individual rehabilitation course and considering the possible consequences of the premature resumption of driving a motor vehicle, individual examination and recommendation are necessary.

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Modern lifestyle largely depends on flexibility ensured by the ability to use a motorcar. For elderly people, mobility is an essential basis for independence and quality of life.[1] Because of the demographic trend, an aging society is expected in Western nations in future decades, and the prevalence of osteoarthritis (OA) will largely increase over the coming years.[2] OA affects more than 70% of adults aged between 55 and 78 years in the United States.[3-5] Symptomatic OA prevalence of the hip is considered to be about 10% in adults 45 years and older.[4]

Different approaches for the treatment of hip OA are available, depending on the extent of the individual's ailment and disability. Total hip arthroplasty (THA) is a very successful and highly common approach used in the treatment of end-stage OA of the hip.[5] Three out of 4 THAs are performed because of end-stage OA.[6] Findings of large register studies concluded that a further increase in the implantation rate is expected.[6-8]

Different studies demonstrated an increase in function and a decrease in pain after THA compared with preoperative values.[9-13] However, there is strong evidence indicating postoperative

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limitations in strength and function of the hip, as well as the surrounding muscles involving the hip flexion, extension, and abduction, caused by the surgical approach. There is a decrease of about 25% in muscle strength 1 year after surgery in the hip-surrounding muscles[11] when comparing the affected hip with the nonaffected hip. One study focused on the quadriceps muscle power after THA, and it has been demonstrated that there is also a decrease in force for these muscles after THA.[14]

Clinical experience shows that patients have a substantial interest regarding when they are allowed to resume driving after a THA. It remains unclear to what extent these impairments compromise safe driving.

Different abilities are needed to safely participate in road traffic, and varying approaches exist to determine when it is safe to drive a car. One key element is the ability to perform an emergency stop if required. This time interval is referred to as "total brake response time" (TBRT).[15-18] The braking distance is determined mostly by the car's speed, but it also includes technical features of the vehicle, as well as the surrounding environment. Technical developments over the past decades have shortened the braking distance such that, up to a speed of approximately 60km/h, the reaction distance—that is, the distance covered by the car under standard conditions until the driver reacts and triggers the actual braking process—is longer than the braking distance of the vehicle itself.

Several road authorities suggest different margins for a safe TBRT, ranging from 700 to 1500ms.[19,20] However, it is only vaguely defined under which conditions these times apply. For this simulator-based experimental setup, a 600-ms threshold was chosen according to recent findings of our study group.[21]

The effect of various surgical procedures on TBRT has been investigated.[15-18] Currently, there are only a few studies available regarding the effect of THA on TBRT.[22,23] These studies exclusively analyzed the limiting effects of the procedure on TBRT. Disregarding TBRT, the aim of this study was to consider additional aspects in evaluating a patient's safety to drive. Therefore, TBRT was divided into the components of reaction time (RT) and movement time (MT). Furthermore, the effect of THA on the maximum brake force (BF), as one element for performing an emergency stop, was investigated. This is of major interest because until now, there have been no studies that address the effect of surgical procedures on maximum BF.

We hypothesized that THA compromises not only TBRT, and especially its component MT, but also reductions in maximum applied BF. Regardless of these limitations, we expect that the ability to perform an emergency stop is more restricted compared to left-side THA.

Methods

Participants

A total of 47 patients undergoing unilateral THA because of end-stage OA of the hip were recruited between October 2011 and August 2012. Patients were approached on the day of admission, 24 hours before surgery. Because of a lack of postoperative data, 7 patients did not participate in follow-up testing. Participants had to adhere to the following inclusion criteria throughout the study: unilateral hybrid THA secondary to OA of the hip and regular driving activity with possession of a valid driving license. Exclusion criteria included pathological and infectious etiology, revision arthroplasty, neurological disorders, a motor deficit of <4/5 according to the British Medical Research Council Scale, limited flexibility of the knee and ankle, and drug intake known to affect RT. Twelve patients assigned for right-side THA used manual and 8 used automatic transmission. One half of the patients assigned for left-side THA used manual and the other half used automatic transmission. Transgluteal approach to the hip was performed in a supine position in all patients undergoing THA. Approval of the study protocol was received from the institution's ethics committee (approval no. 268/2009BO2).

List of abbreviations:

BF	brake force
MT	movement time
OA	osteoarthritis
RT	reaction time
TBRT	total brake response time
THA	total hip arthroplasty

Material

Considering the spatial constraints of a car cabin, a brake simulator was developed within a middle-class automobile (fig 1). Force transducers were obtained from Megatron Electronics[a] and mounted on the accelerator and brake pedal to evaluate RT, MT, TBRT, and BF. Because only the accelerator pedal and the brake pedal were armed with a force transducer, patients were advised to react as if using an automatic transmission. Measured time intervals and applied forces were displayed on the computer screen as a diagram after each test (see fig 1). Calibration of the sensor was conducted according to standard procedures to provide exact data for the achieved BF.

Procedure

Participants were asked to wear footwear normally used for driving. The seat's distance and tilt were adjusted to correspond with the individuals' driving position. Standardized instructions about the usage of the brake simulator were given before testing. Depression of the accelerator pedal activated the computer-based registration. Participants were instructed to keep the accelerator pedal permanently depressed with their right foot until a red emergency light, which was mounted on the front lid, flashed up. Within a period of 10 seconds, the investigator randomly activated the emergency signal using an external trigger not visible to the participants. The signal was considered to represent a case of emergency, thus initiating a full emergency stop. The right foot was lifted off the accelerator pedal and transferred to apply maximum BF onto the brake pedal. The interval between the activation of the signal and the initial decrease in force measured on the accelerator pedal illustrates the RT. Previous publications described different endpoints for the MT, which vary from the increase in force[24,25] to a minimum threshold of 100[18,23] and 200N[15,26] measured on the brake pedal. In the present study, MT was defined as the interval between the start of force reduction on the accelerator until the increase in force applied to the brake pedal.

Participants were given 3 practice trials followed by 10 consecutive measurements. The 10 test runs were averaged, and the means of RT, MT, TBRT, and BF were used for statistical analysis. Subjects were tested the day before surgery and 8 days (day of discharge), 6 weeks, 12 weeks, and 52 weeks postoperatively.

A possible learning effect due to repeated testing was investigated. Therefore, the means of the first 2 measurements were compared with the means of the last 2 measurements of each test