

BRAKE RESPONSE TIME BEFORE AND AFTER TOTAL KNEE ARTHROPLASTY

Tracking Possible Effects of the Surgery Technique on Motor Performance: Report of Two Cases

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Abstract: After total knee arthroplasty (TKA) patients often ask when they can resume car driving. This question was the aim of some studies in the past, however no study was found on the possible effects of different surgery techniques on brake response time (BRT). A randomized controlled trial on the effects of two surgery techniques (minimally invasive vs. standard approach) on BRT was designed. In this paper the motor performance of two female patients was compared. Surgery had different effects on the mean BRT of both Patients. The mean BRT of the MIS Patient wasn't increased 7 days after surgery, while the BRT of the Patient undergoing standard surgery was increased by 46.8% at the same time.

1 INTRODUCTION

Patients undergoing total knee arthroplasty (TKA) frequently ask when they can resume car driving. Six studies on this topic were published in the past years (Dalury et al., 2010, Liebensteiner et al., 2010, Marques et al., 2008a, Marques et al., 2008b, Pierson et al., 2003, Spalding et al., 1994). All studies investigated the effects of TKA on brake response time (BRT), an important human factor used in accident prevention research.

The results document a BRT increase after right TKA. The time frame needed for the BRT to return to preoperative values varied and ranged from 8 (Pierson et al., 2003) to 4 weeks (Dalury et al., 2010). In the study by Dalury and colleagues (2010), where the patients were submitted to "contemporary TKA with less tissue disruption", the BRT of all patients returned to preoperative values 4 weeks after surgery. A small group of patients reached the preoperative values already 2 weeks after surgery.

The BRT can be fractionated in reaction time (RT) and movement time (MT). The RT, also called neurological time, is the time required for stimulus perception, response selection and response initiation. The MT can be subdivided in foot transfer time (FTT) and brake pedal travelling time (BPTT).

In the studies where the components of the BRT (RT and MT) were investigated (Spalding et al., 1994, Marques et al., 2008b, Marques et al., 2008a, Dalury et al., 2010) it was observed that ten days after TKA the central components of the task were not affected once RT was not changed.

Total knee arthroplasty seems to affect peripheral aspects related with the execution of the movement and the soft tissue lesion may be the cause of such performance impairments.

Minimal invasive surgery (MIS) techniques for TKA have been used for several years as an alternative to standard approaches. Supporters of MIS techniques go from the assumption that a smaller soft tissue injury with a reduction of the muscle quadriceps lesion leads to a faster

rehabilitation with better early functional outcomes, less pain and shorter stay duration. To the best of our knowledge we don't know of any available data on the effects of different surgery techniques on motor performance while executing an emergency brake in a car simulator. The purpose of this study is to compare the effects of MIS and Standard approach for TKA on BRT components. Once the study is ongoing the data of two cases will be reported.

2 METHODS AND MATERIALS

2.1 Design

A randomized controlled trial with one between-subject factor (surgery technique: MIS or Standard) and one within-subject factor (time: one day before and 7 days, 30 and 40 days after surgery) was designed (Marques et al., 2011). After consent to participate the patients were randomly assigned to MIS or standard approach surgery. The patients were blinded to the surgery technique they underwent and they all received the same standard physiotherapy treatments.

One experienced orthopaedic surgeon performed all surgeries. In the operation room a concealed envelope was opened and the surgeon got to know which technique he would have to perform.

The MIS technique used was the mini-midvastus approach (Haas et al., 2006). The peri-patellar approach with inversion of the patella was standard. Independently from the surgery technique all operations were performed with the use of the OrthoPilot navigation system and all patients got a Columbus total knee endoprosthesis (BBraun Aesculap, Germany).

The study protocol was approved by the Ethics-Committee of the Federal State of Hamburg, Germany (Project Nr.: PV3349). The trial registration number at the German Clinical Trial Database (DRKS) is: DRKS00000552.

2.2 Participants

The patient selection is taking place at the Schön Klinik Hamburg Eilbek in Hamburg, Germany. The patients addressed the clinic for elective primary right TKA and were asked if they were car drivers. If the patient drove regularly (at least once a week) he/she was informed about the study and asked for consent.

The patient selection started on January 10th 2011 and is still ongoing. Eleven patients have

signed the informed consent until now, of which the complete data of 8 Patients is available: MIS n=5 (4 male; 1 female); Standard approach n=3 (1 male; 2 female). Because the number of cases is still small and the distribution of male and female patients in the groups is unlike, we will present only the primary outcome results of two female patients (Pat. A and Pat. B).

2.3 Instruments/ Equipment

The patients performed the emergency brakes in a car simulator (Fig.1) which was built based on a European middle class car already used in two former studies (Marques et al., 2008a, Marques et al., 2008b).



Figure 1: Car simulator with bioPlux Research system.

The data acquisition system consists of a bioPlux Research system with wireless connectivity via Bluetooth (Plux –Wireless Biosignals, S.A.), one trigger to command the stimulus light (red LED) turn on/off and two load cells connected with the brake and accelerator pedals.

2.4 Study Outcomes

The primary outcomes of the study are the brake response time (BRT), which is time frame between the onset of the red LED and the achieving of a brake force on the brake pedal of 150N (ms). The BRT was fractionated in reaction time (RT), foot transfer time (FTT) and brake pedal travelling time (BPTT).

2.5 Procedures

The assessments took place in a closed room to avoid secondary distraction sources. A trained physiotherapist performed all tests.

After sitting down in the car simulator the patients were required to adjust the seat in order to

find a comfortable position. A simple and a more complex

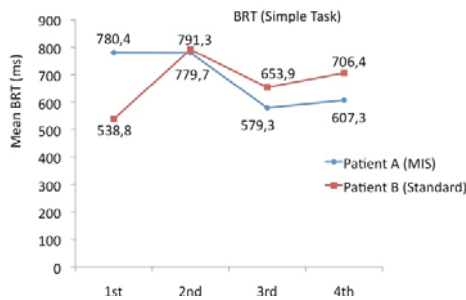


Figure 2: Mean BRT values across the four measurements.

task were used to assess the components of BRT. At each measurement day patients performed 5 practice and 10 test trials for each task.

2.6 Data Analysis

Two types of signals were collected: the digital signal from the light trigger and the force signals from the accelerator and brake pedal load cells. The digital signal was used to slice the signals in the 10 break trials for each task. The force signals were calibrated considering that in the initial instant the foot is not pressing any of the pedals and the acquired value in the initial 100ms was considered the zero of the load cells.

After the pre-processing steps, the onset points of the force signals were detected by applying a signal-independent algorithm, which marks significant events in a signal, based on a morphological analysis approach (Santos et al., 2012) and the values of the variables were detected.

3 RESULTS

Patient B is 15 years older than patient A. Despite that difference patient B had faster baseline performances in both tasks when compared with patient A.

Table 1: Demographic data of both patients.

	Patient A	Patient B
Age (y)	61	76
Body weight (Kg)	71	74
Stature (cm)	167	175
Technique	MIS	Standard

The effects of TKA on BRT are different when comparing the data of both cases in the simple task

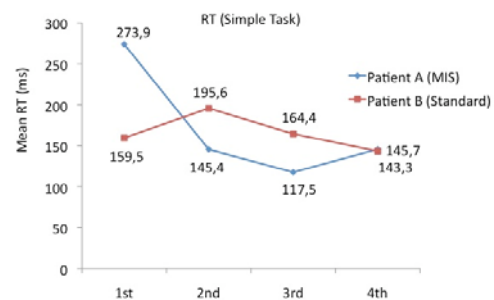


Figure 3: Mean RT values across the four measurements.

(Fig. 2). Seven days after surgery the mean BRT of Patient B (Standard) had increased by 46.8% while the mean BRT of Patient A remained practically unchanged (decreased 0.08% from the first to the second measurement). From the second to the third measurement the mean BRT had decreased by 25.7% and 17.3% for patients A and B respectively. Thirty-two days after surgery patient A performed on average 201.1ms quicker than at baseline, while the mean BRT of patient B was still 115.1ms increased when compared with baseline.

The BRT increased due to an MT increase. The RT (Fig. 3) decreased for both patients across the time, with exception of patient B, who's RT had increased by 22.6% from the first to the second measurement.

The analysis of the MT components (FTT and BPTT) revealed that the BRT increased mainly due to an increase of the FTT. The FTT (Fig. 4) had increased by 57.8% (189.7ms) and 53.7% (144.6ms) from the first to second measurement respectively for patient A and B. At 40 days the mean FTT values of both patients were still over baseline (see Figure 5).

The BPTT decreased across the time for Patient A, however, it increased by 65% for patient B between the 1st and second measurement (Fig. 6), showing that surgery techniques might have had different effects on this variable.

4 DISCUSSION

Total knee Arthroplasty reduces pain and increases function and quality of life in patients with knee impairments resulting from osteoarthritis. Many patients undergoing TKA want to know when they can resume car driving after surgery.

The preliminary data of two patients suggests that the surgery technique might have an influence on BRT recovery after TKA.

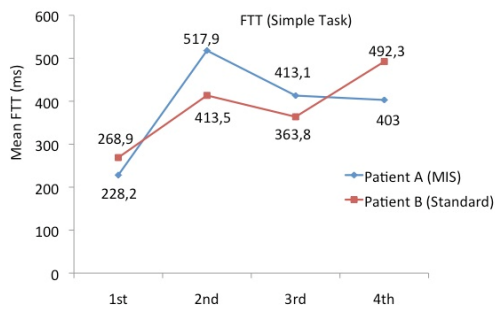


Figure 4: Mean FTT values across the four measurements.

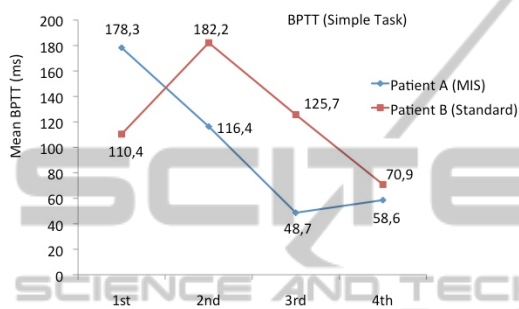


Figure 5: Mean BPTT values across the four measurements.

The mean BRT of the MIS Patient was not increased 7 days after surgery, while the BRT of the Patient undergoing standard surgery was increased by 46.8% by same time. Our results reinforce the results by Dalury and colleagues (2010).

The components of MT (FTT and BPTT) characterize two distinguished parts of the leg movement. While during the FTT the leg is being moved in an open system, with the foot having no contact with the pedals, during the BPTT the leg is being moved in a closed system, with the foot pressing the brake pedal and the knee making an extension. The performance pattern of the patients in the open system (FTT) is very similar (Fig. 4), with both patients showing a performance increase after surgery followed by a decrease. On the other hand, in the closed system (BPTT), the patient's performance provides an interesting difference, with the MIS patient having no performance impairments after surgery (Fig. 5). The eversion of the patella during the standard approach may be the reason behind the BPTT differences (Majima et al., 2011).

In order to find out, whether the observed trends are related with the surgery technique the patients underwent and not due to inter-subject variations, a bigger sample is necessary.

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