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## EFFECT OF TOTAL KNEE ARTHROPLASTY ON BALANCING CAPACITY AFTER SUDDEN PERTURBATION IN PATIENTS OPERATED ON BY CONVENTIONAL TECHNIQUES

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### SUMMARY

The aim of this study is to assess equilibrium ability after sudden perturbation in patients operated on by total knee arthroplasty (TKA) using conventional methods. Our clinical trial included 45 female and 45 male healthy elderly subjects, and 6 male and 4 female patients. Prior to and 6 and 12 weeks after the surgery we conducted provocation tests using an oscillatory platform and determined the Lehr's damping ratio (D), which represented the balancing capacity after sudden perturbation. Prior to and after the TKA, D values determined for standing on both limbs were similar to those for standing on the non-affected limb; those determined for standing on the affected limb were significantly lower compared to the other two values. Prior to surgery, the D values under all three conditions were significantly lower compared to the values of healthy subjects. 6 weeks after TKA, D values did not differ significantly from those prior to surgery. The D values significantly increased from the 6<sup>th</sup> week postoperatively; they were significantly higher compared to the values determined prior to and 6 weeks after TKA; however, they did not reach normal values 12 weeks after surgery. The results demonstrate that patients were less capable of responding to perturbation prior to surgery and in the early postoperative period.

### INTRODUCTION

Pain is relieved and functional abilities are partly restored by total knee arthroplasty (TKA), but gait patterns [1, 2] and the variability of gait [3,4,5] are significantly modified during the postoperative period. The parameters of stabilometry in case of standing on both limbs and on a single limb increased significantly after TKA compared to the values prior to surgery; however, they did not reach normal values [5,6].

The aim of this study was to specify the dynamic balancing ability in response to sudden unidirectional perturbation – modelled by ultrasound-based provocation tests – following TKA. For this purpose, ultrasound-based provocation tests [7] were conducted prior to and at 6 and 12 weeks after TKA.

### METHODS

The healthy control group consisted of 22 women (age 60.4 ± 4.1, body mass 69.7 ± 11.4, body height 166.7 ± 3.8) and

23 men age 60.9 ± 3.2, body mass 70.4 ± 9.8, body height 170.4 ± 5.8). The population of the patient group consisted of 6 males (age 75.4 ± 3.1, body mass 90.8 ± 11.4, body height 175.4 ± 4.9) and 4 females (age 65.4 ± 6.2, body mass 74.1 ± 7.7, body height 166.2 ± 3.1); they were operated on by a conventional technique. Inclusion criteria were the following: unilateral hip arthritis evidenced by X-ray, walking without aid, and age between 65-80 years. Exclusion criteria were the following: any lesion and/or surgery affecting a lower limb or the lumbar spine, osteoarthritis affecting opposite hip or bilateral knee joints, neurological alterations, uncontrolled hypertension, and unstable angina.

Balancing ability after sudden perturbation was examined by provocation tests. Sudden perturbation was simulated by releasing the unit as the rigid plate of the PosturoMed device suddenly started to move and swung back into resting position. The participant had to balance and re-equilibrate as the plate moved. Details of provocation tests are included in [9]. During the provocation tests, the motions of the rigid plate were recorded using a ZEBRIS CMS10 (ZEBRIS, Medizintechnik GmbH, Isny, Germany) ultrasound-based motion analysis system. The measuring frequency was 100 Hz. The measuring methods are detailed in [7].

Each test had three scenarios (stance on double-leg; stance on dominant leg; and stance on non-dominant leg) at healthy subjects and three scenarios (stance on double-leg; stance on unaffected/healthy leg; stance on affected leg) at patients. Each of them was repeated three times. The average values of the Lehr's damping ratios were used for statistical analysis [9]. The motion of the rigid plate parallel with the direction of displacement follows a second-order damped response, which is modeled by the Lehr's damping ratio [7].

In order to compare results in the same group (comparison of the results of different scenarios and of results prior and after TKA) a one-sample t-test was used, applying a symmetrical critical range; and to compare results in different groups (healthy and patient group), a two-sample t-test applying a symmetrical critical range was used.

### RESULTS AND DISCUSSION

All three parts of the tests were completed by each participant, nobody was excluded for incomplete testing. The results (mean±SD) are shown in Table 1.

At patients prior to and after surgery, the Lehr's damping ratio based on the results determined during standing on both limbs was nearly the same as the value based on the results determined during standing on the unaffected leg (Table 1). The Lehr's damping ratio determined during standing on the affected limb was significantly lower than the other two values (Table 1). This means that the non-affected side was always the dominant side.

Prior to surgery, the D values under all three conditions were significantly lower compared to the values of healthy subjects (Table 1). Reduction in the balancing capacity of the affected limb can be caused by decreased joint mobility, joint surface lesion, reduced muscle strength and pain [8].

6 weeks after TKA, D values did not differ significantly from those prior to surgery, but decreased compared to normal values (Table 1). This means that the balancing ability after sudden perturbation during standing on the affected limb decreased 6 weeks after surgery compared to healthy subjects; this finding correlated to the results of Quagliarella et al [6]. However, our results showed that the D values determined during standing on both limbs and the non-affected limb decreased. Such deterioration can be caused by decreased joint mobility and loss of muscular strength [8].

The D values significantly increased from the 6<sup>th</sup> week postoperatively: they were significantly higher compared to the values determined prior to and 6 weeks after TKA; however, D values did not reach normal values 12 weeks after surgery (Table 1). This means that the non-affected side could not compensate the decreased balancing ability of the affected side, and the regeneration of the joint capsule had not finished yet.

## CONCLUSIONS

In patients after surgery, the unaffected leg was always the dominant leg. 12 weeks after TKA the balancing ability after sudden perturbation increased compared to preoperative values; however, balancing ability did not

reach normal values. Decreased balancing ability after sudden perturbation may also indicate an increased risk of falling, which means it could be taken into account in compiling the rehabilitation protocol and in the use of different aids.

## ACKNOWLEDGEMENTS

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**Table 1:** Mean  $\pm$  standard deviation of Lehr's damping ratio (D) calculated from results of provocation test

		Standing on			
		both limbs	dominant/ non-affected limb	non-dominant/ affected limb	
<b>Control group</b>	<i>male</i>		4.65 $\pm$ 0.33	4.47 $\pm$ 0.30	2.90 $\pm$ 0.39 <sup>a,b</sup>
	<i>female</i>		4.99 $\pm$ 0.29 <sup>g</sup>	4.83 $\pm$ 0.28 <sup>g</sup>	3.41 $\pm$ 0.31 <sup>a,b,g</sup>
<b>Postoperative group</b>	<i>male</i>	preop	3.25 $\pm$ 0.49 <sup>c</sup>	3.05 $\pm$ 0.42 <sup>c</sup>	0.84 $\pm$ 0.49 <sup>a,b,c</sup>
		4 w postop	3.21 $\pm$ 0.34 <sup>c</sup>	3.17 $\pm$ 0.39 <sup>c</sup>	1.05 $\pm$ 0.39 <sup>a,b,c</sup>
		12w preop	3.62 $\pm$ 0.37 <sup>c,d,e</sup>	3.57 $\pm$ 0.35 <sup>c,d,e</sup>	1.87 $\pm$ 0.35 <sup>a,b,c,d,e</sup>
	<i>female</i>	preop	3.20 $\pm$ 0.41 <sup>c</sup>	3.12 $\pm$ 0.49 <sup>c</sup>	0.88 $\pm$ 0.47 <sup>a,b,c</sup>
		4 w postop	3.08 $\pm$ 0.37 <sup>c</sup>	3.04 $\pm$ 0.37 <sup>c</sup>	1.08 $\pm$ 0.33 <sup>a,b,c</sup>
		12w preop	3.67 $\pm$ 0.35 <sup>c,d,e</sup>	3.60 $\pm$ 0.37 <sup>c,d,e</sup>	1.91 $\pm$ 0.33 <sup>a,b,c,d,e</sup>

<sup>a</sup> Significant difference compared to D values determined during standing on both limbs

<sup>b</sup> Significant difference compared to D values determined during standing on dominant/non-affected limb

<sup>c</sup> Significant difference compared to values of controls

<sup>d</sup> Significant difference compared to values determined prior to TKA