BALANCE ADJUSTMENT DURING OBSTACLE CROSSING IN PATIENTS WITH TOTAL HIP ARTHROPLASTY

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INTRODUCTION

Total hip arthroplasty (THA) is a common surgery for a deteriorated hip joint to effectively regain its functions. Approximately 250,000 THA were performed in the United States every year [1]. THA surgical approach has been identified as a major factor for post surgery joint stability and functions [2]. Patients undergoing THA are found to have higher risks of falls due to the residual deficits in balance control and joint functions [3]. However, the differences between anterior and lateral surgical approaches have not been well addressed, and studies analyzing the obstacle crossing performance, which challenges the balance [4] and joint stability [5], have not been conducted in THA patients. The purpose of this study is to investigate the effect of anterior and lateral surgical approaches on the balance control for obstacle crossing in patients undergoing THA.

METHODS

Thirty-one adults were recruited and divided into three groups in this study. There were 12 subjects undergoing THA with anterior approach (7 men, 5 women, age = 56.9 ± 3.3 yrs, BMI = 31.98 ± 5.13 kg/m^2), 9 subjects undergoing THA with lateral approach (8 men, 1 woman, age = 55 ± 6.5 yrs, BMI = 31.31 ± 3.9 kg/m^2) and 10 control subjects (5 men, 5 women, age = 59.9 ± 5.3 yrs, BMI = 26.3 ± 3.9 kg/m^2). Pre-surgery Harris hip scores of hip joint function were 52.8 ±12.7 and 58.7 ±11.8 for the anterior and lateral groups, respectively. All patients received the same un-cemented Zimmer hip implants and followed the same physical therapy regimens during the study period. THA patients were tested three times at pre-surgery, 6-weeks and 16-weeks post surgery. Control subjects were tested twice with one month apart.

An eight-camera motion analysis system (Motion Analysis Corp., Santa Rosa, CA) was used to collect the whole body motion during level walking and crossing an obstacle corresponding to 10% of individual's body height. A total of 29 reflective markers were placed on bony landmarks. Two force plates (Advanced Mechanical Technology Inc., Watertown, MA) were placed in series at the center of a 10-m walkway. The surgical limb of THA patient, or the dominate limb of the control subject, was instructed to cross the obstacle as the trailing limb.

Ranges of motion of the antero-posterior (AP) and medio-lateral (ML) CoM-CoP inclination angles during a gait cycle were calculated to assess balance control [6]. All variables obtained during obstacle crossing condition were then presented as percentage of changes from level walking performance to quantify adjustments needed for obstacle negotiation. Paired t-test was used to compare the variable differences between obstacle crossing and level walking, and a mixed-model analysis of repeated measures was used to analyze the effects of groups and time. Significance level was set at 0.05.

RESULTS AND DISCUSSION

Gait velocity decreased significantly in all subjects when stepping over an obstacle (Table 1). Significant group differences were detected between the control and anterior groups at pre-surgery and 6-week post surgery, and between controls and lateral group at 6-week post surgery. Compared to pre-surgery, significant time effects were detected in THA patients at 16-week post surgery. Obstacle crossing also induced a significant increase in the AP CoM-CoP inclination angles for all three groups (Table 1). Both THA patient groups walked with a significantly reduced inclination angle than their controls at pre-surgery and 6-week post surgery. Similarly, significant time effects were detected in THA patients at 16-week post surgery. The ML CoM-CoP inclination angles were generally decreased during obstacle crossing for all three groups. However, no significant differences between obstacle crossing and level walking conditions were detected. In general, all THA patients walked slower with a smaller AP but greater ML CoM-CoP inclination angle. No significant group differences were detected between the anterior and lateral THA groups.

When stepping over an obstacle of 10% body height, control subjects exhibited approximately a 13% reduction in gait velocity (Fig. 1), 14% increase and 1.3% reduction in AP and ML CoM-CoP inclination angles, respectively (Figs. 2 and 3). Our data demonstrated a trend that gait and balance control of THA patients could be affected by the presence of obstacle to a greater extent than their controls, especially prior to the surgery (Figs 1, 2 & 3). There is also a tendency for these obstacle-induced differences being normalized after THA surgery.

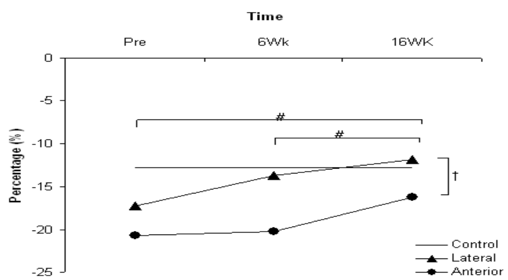

Figure 1: Changes in gait velocity (% level walking values; † group effect; # time effect)

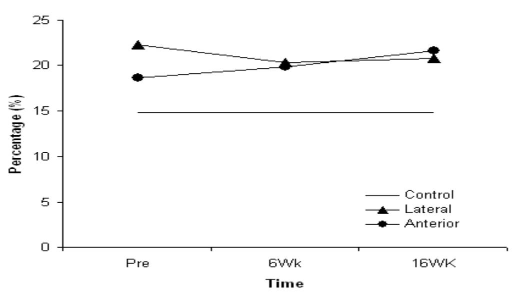

Figure 2: Changes in AP CoM-CoP inclination angles (% level walking values)

CONCLUSIONS

Stepping over an obstacle induced changes in the CoM-CoP inclination angles. These changes tended to be greater in THA patients, which could imply a greater balance perturbation. Both THA surgical approaches improve patients' ability to accommodate changes in balance control during obstacle crossing. However, the small sample size could limit the findings of this study.

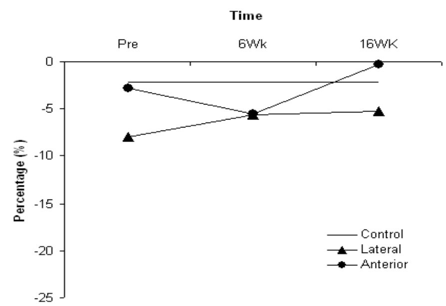

Figure 3: Changes in ML CoM-CoP inclination angles (% level walking values)

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Table 1: Gait velocity and CoM-CoP inclination angles and during obstacle crossing and level walking

	Controls		Anterior THA						Lateral THA					
			Pre-surgery		6-week post surgery		16-week post surgery		Pre-surgery		6-week post surgery		16-week post surgery	
	OB	Level	OB	Level	OB	Level	OB	Level	OB	Level	OB	Level	OB	Level
Gait Velocity (m/s)	1.11*	1.28	0.88*†	0.94	0.87*†	1.08	0.99*#	1.19	0.97*	1.18	0.96*†	1.07	1.09*#	1.23
	(0.12)	(0.17)	(0.09)	(0.26)	(0.20)	(0.2)	(0.17)	(0.17)	(0.16)	(0.1)	(0.13)	(0.14)	(0.15)	(0.09)
Antero-posterior (°)	29.96*	26.33	24.77*†	20.65	24.27*†	20.49	27.03*#	22.41	27.64*†	22.75	24.97*†#	20.18	27.82*#	23.12
	(3.17)	(4.02)	(1.61)	(2.44)	(3.37)	(3.82)	(3.83)	(4.03)	(3.43)	(3.16)	(3.09)	(2.59)	(2.71)	(2.72)
Medio-lateral (°)	7.09	7.18	8.81	10.14	8.37#	8.9	8.78	8.89	8.58	9.37	8.09#	8.60	8.13	8.60
	(1.87)	(0.83)	(1.43)	(3.32)	(2.04)	(1.8)	(1.98)	(2.09)	(1.91)	(2.19)	(2.08)	(1.52)	(1.66)	(1.28)

* Significant differences when comparing obstacle crossing to level walking; † group effect; # time effect.