WALKING ABILITY AFTER TOTAL HIP REPLACEMENT

A COMPARISON OF GAIT ANALYSIS IN UNILATERAL AND BILATERAL CASES

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We studied 50 patients before and after unilateral total hip replacement, and compared them, using gait analysis, with 22 having staged bilateral operations. The average age of the patients was 65 years at the first operation. The mean follow-up was 53 months for the unilateral cases and 27 months, after the second THR, for the bilateral cases. The average interval between first and second THR was 24 months.

Patients with bilateral hip disease did not gain optimal function, even on the first side, until both hips had been replaced. Unilateral replacement gave better gait analysis results than did either side after bilateral procedures.

Adult hip disease requires bilateral surgery in 15% to 25% of cases (Lazansky 1967), and reports on total hip replacement (THR) often include patients with unilateral and bilateral involvement. The assessment of the results in bilateral cases poses special problems (Charnley 1972). If only individual hips are considered, the inclusion of bilateral cases may fail to give a clear picture of the outcome; results should be reported separately after the first and second replacement.

The percentage improvement in many elements of walking is greater in patients with bilateral THR than in those with unilateral replacement (Murray, Brewer and Zuege 1972), but this may not be evident until the contralateral painful hip has been treated. Indeed, surgery on the first hip may appear to be unsuccessful until the contralateral hip has been replaced.

The primary functions of the hip in walking are to allow an adequate stride length and rapid limb advancement: the free-walking speed being the product of step length and step frequency. The second function, that of mobile weight-bearing, is indicated by the patient's single-stance duration (Murray et al 1981; Olsson, Öberg and Ribbe 1986). Hip function can also be measured by the metabolic cost of walking, which correlates strongly

with maximal walking speed (Arborelius, Carlsson and Nilsson 1976).

We aimed to study walking ability in different stages of recovery after bilateral THR and to compare the results of bilateral and unilateral THR by gait analysis.

PATIENTS AND METHODS

As part of a prospective randomised comparison between cemented and non-cemented THR, we examined 150 patients pre-operatively, at six months, one year, and then annually for three to five years (Wykman et al 1991).

Of these, 23 patients had bilateral THR performed separately at an average interval of 24 months (nine to 58). One partially blind patient was unable to perform the gait test, leaving 22 to form the bilateral group. There were nine men and 13 women; their average age was 64 years, and their mean weight 75 kg. At the first THR, 12 patients received an HP-Garches cementless prosthesis (Howmedica France, Bagneaux, France). Another HP-Garches implant was used in the second hip of ten, and two had a Charnley prosthesis. All ten patients who had a cemented Charnley prosthesis on the first side had the same implant for the contralateral hip (Table I). The Charnley prosthesis was inserted through a lateral approach with trochanteric osteotomy and the HP-Garches through a posterolateral approach with no trochanteric osteotomy.

The unilateral group included 50 patients with unilateral hip disease; none of them had pain or discomfort in the contralateral hip at any time. The mean age, weight, and diagnostic range did not differ significantly from those of the bilateral group.

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Clinical evaluation. We used the Harris hip score, and recorded maximal walking speed as the average velocity of walking as fast as possible for three minutes, using a cane when needed.

Gait analysis. Gait analysis was performed on a walkway consisting of two 5 m-long force-measurement platforms, which provide a continuous record of a sequence of several steps for each foot during level walking (Fig. 1; Olsson, Goldie and Wykman 1986). The patients were instructed to walk at a comfortable rate with ordinary shoes and a heel lift if needed. If possible, the patient performed the gait test without a cane.

We recorded free-walking speed (cm/s), step frequency (steps/s), stride length, related to lower extremity length, and the single-stance duration of each leg expressed as a percentage of the gait cycle.

The mean of each variable was derived from 10 to 30 gait cycles. We used the Mann-Whitney U test to analyse the bilateral group, and Student's *t*-test to compare the two groups. The level of significance was taken as $p < 0.001$, if not stated otherwise.

RESULTS

The mean Harris hip score of the patients in the bilateral group improved from 41 to 73 after the first THR, and to 93 after the second procedure (Table II). In the unilateral group, the Harris hip score increased from 43 to 96 (Table III).

The median maximal walking speed in the bilateral group was 88 cm/s before the first THR. This did not increase significantly until after the second THR, reaching 130 cm/s ($p < 0.05$). In the unilateral group maximal walking speed increased from 105 to 147 cm/s after THR. The pre-operative differences between the groups were not significant.

Gait analysis. In the bilateral group, the *free-walking speed* increased from 43 to 74 cm/s after the first THR ($p < 0.05$) and to 100 cm/s after the second THR (Table II). In the unilateral group free-walking speed increased from 68 to 113 cm/s (Table III). The pre-operative free-walking speed was higher in the unilateral group ($p < 0.05$).

In the bilateral group, *step frequency* increased after the first THR, from 1.17 to 1.60 steps/s ($p < 0.05$), and to 1.77 steps/s after the second procedure. In the unilateral group step frequency increased from 1.49 to 1.84 steps/s. Pre-operative step frequency was higher in the unilateral group ($p < 0.05$). In the bilateral group, 'stride length' did not increase after the first THR, but after the second THR it increased from 1.07 to 1.27 ($p < 0.05$). In the unilateral group stride length increased from 1.01 to 1.39. There were no pre-operative differences between the groups.

In the bilateral group, the 'single-stance phase of the initially operated leg' increased from 30% to 36% of the gait cycle after the first THR, and did not increase after

the second THR. In the unilateral group, the single-stance phase increased from 28% to 35% of the gait cycle. There were no statistically significant differences in the pre-operative values.

The 'single-stance phase of the contralateral leg' in the bilateral cases was 33% of the gait cycle pre-

Table I. Details of patients studied before and after unilateral and bilateral THR

	Unilateral	Bilateral
Number of patients	50	22
Mean age in years	65	64
Mean weight in kg (range)	74 (50 to 96)	75 (46 to 95)
Female: male	33:17	13:9
HP-Garches/Charnley	23:27	12:10 (first hip) 10:12 (second hip)
Mean follow-up in months (range)	53 (18 to 64)	27 (2 to 51) after second operation
Interval between THRs in months		24 (9 to 58)

Fig. 1

The force plate walkway at the Karolinska Hospital, Stockholm.

operatively and did not change after the first surgical THR. However, after this hip had been replaced, the single-stance phase increased to 37% ($p < 0.01$). In the unilateral group, the single-stance phase of the contralateral leg increased from 35% to 37% of the gait cycle ($p < 0.01$). Pre-operatively, the single-stance phase of

Table II. Results in 22 patients having bilateral THR, giving the p values for differences in median values

	Pre-operative	P-value of difference	One THR	P-value of difference	Two THR
Harris hip score	41	<0.001	73	<0.001	93
Maximal walking speed (cm/s)	88	NS	100	<0.05	130
Free-walking speed (cm/s)	43	<0.05	74	<0.001	100
Step frequency (step/s)	1.17	<0.05	1.60	<0.001	1.77
Stride length/leg length	0.94	NS	1.07	<0.05	1.27
Single-stance phase (first leg)*	30	<0.001	36	NS	36
Single-stance phase (second leg)*	33	NS	32	<0.01	37

*as the percentage of the gait cycle

Table III. Results in 50 patients having a unilateral THR (mean values)

	Pre-operative	P-value of difference	Postoperative
Harris hip score	43		96
Maximal walking speed (cm/s)	105		147
Free-walking speed (cm/s)	68		113
Step frequency (step/s)	1.49		1.84
Stride length/leg length	1.01		1.39
Single-stance phase (involved leg)*	28		35
Single-stance phase (uninvolved leg)*	35	<0.01	37

* as the percentage of the gait cycle

Table IV. Comparison of the results after unilateral and bilateral THR, using median values

	Unilateral	P-value of difference	Bilateral
Harris hip score	96	<0.001	90
Maximum walking speed (cm/s)	147	<0.001	120
Free-walking speed (cm/s)	113	<0.01	96
Step frequency (step/s)	1.84	<0.05	1.72
Stride length/leg length	1.39	<0.01	1.23
Single-stance phase (involved leg)*	35	NS	35
Single-stance phase (uninvolved leg)*	37	<0.05	35

* as the percentage of the gait cycle

the most recently operated leg in the bilateral group was shorter than that of the uninvolved leg in the unilateral group ($p < 0.05$).

The bilateral and unilateral groups did not differ pre-operatively according to the Harris hip score, in maximal walking speed, stride length, and single-stance phase of the initially operated leg. However, at the last follow-up the results of the bilateral group, as measured

by these variables, were inferior to those of the unilateral group, except for single-stance phase of the initially operated leg (Table IV).

DISCUSSION

Most studies of function after total hip replacement include a majority of patients with unilateral disability. We have studied patients with bilateral disease before operation and after each side had been replaced, showing that optimal function is not gained until both THRs have been performed. Thus, the functional result in a mixed group of patients is obscured.

Previous studies on bilateral THRs have focused on surgical technique and postoperative management (Salvati, Hughes and Lachiewicz 1978; Ritter and Stringer 1980) or radiographic assessment (Wejner and Stenport 1988) and not on functional outcome, and it has been assumed that the functional end results of unilateral and bilateral THR are equivalent. We have shown that the function of a THR in a bilateral case is inferior to that in a unilateral case as measured by the Harris hip score, and gait measurements such as maximal walking speed and stride length. Although patients with bilateral hip disease gain considerable pain relief and improve-

ment after the first THR, the optimal improvement, as demonstrated by gait analysis, is not seen until after the second replacement. The major cause of diminished step length is limited hip extension of the unoperated leg, but in spite of this, free-walking speed had improved after the first THR, apparently due to increased step frequency. However the maximal walking speed for bilateral patients did not improve after the first operation, probably because the patients could not take longer steps and/or increase step frequency.

Gait analysis has confirmed that bilaterally disabled patients are in great need of the second THR on the

opposite leg if they are to gain optimal function, and the time lapse between THRs is clearly important. This will be the subject for further work, since it is clear that gait analysis can help to decide when such a patient should have the second THR. We also found that unilaterally disabled patients achieved a better gait analysis result after THR than either side of bilaterally operated patients. A healthy hip is better than even a well functioning THR.

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