

Orthopaedic Clinic, University of Gothenburg, Gothenburg, Sweden.

WALK-WAY STUDIES AFTER INTERTROCHANTERIC OSTEOTOMY FOR OSTEOARTHRITIS OF THE HIP

CARL HIRSCH & IAN GOLDIE

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In previous studies (*Hirsch 1960, Hirsch & Goldie 1968*) attempts have been made to evaluate the results of intertrochanteric osteotomy for osteoarthritis of the hip-joint. In the study of 1960 complete relief of pain was obtained in 30 per cent of the patients but 80 per cent claimed an improvement. In the study of 1968 comprising 102 patients 85 had a decided improvement in spontaneous pain (Table 1) and 71 reported none or very little weight-bearing pain (Table 2). The further analysis in this study was based on criteria commonly used, such as use of walking aids, walking ability, gait without aids, general mobility and objective registration of range of movement. That which attracted greatest interest was the relationship of walking capacity to the use of a cane (Table 3). As is seen only 10 patients of 65 who had used a cane before operation could manage without it postoperatively in outdoor walking. A more important observation, however, is the fact that of 42 patients who did not use a cane before operation 25 began to use a stick following the immediate postoperative period. These observations have been interpreted by us as a decreased employment by the patient of the operated leg. In order to further analyse this assumed diminished utilization of the operated leg an attempt has been made to estimate in an objective way how much the operated leg is used in comparison to the non-operated. In this investigation we have studied the maximal time during which the patient loads his operated leg as compared to the non-operated and the maximum weight laid on the same leg. To obtain objective measurements of these factors the forces arising between floor and foot in walking was registered. This can be done by

force-plates, one for each foot. With the construction, however, of electronic walk-ways the registration of forces has become much simplified.

For this study we have employed an electronic walk-way which originally was introduced at our clinic and which has been in use for several years. It has been described by *Rydell* (1966) in a study on the forces acting on the hip-joint and in the present study found suitable for measuring the use the patient makes of his leg which has been osteotomized for osteoarthritis of the hip-joint.

MATERIAL AND METHODS

28 patients from the study of 1967 were selected at random. They all made a fair representation of the total material. Of those to be studied eleven did not use a cane at the time of this investigation (Tables 1 and 2), one additional patient had stopped using the cane. Measurements of the forces acting in weight-bearing were made on the electronic floor. This consists of two 5-metre long parallel walking boards of which one is for each foot (Figure 1). These boards register via force transducers each consecutive step. Simultaneously the fore and aft shear and the vertical component of the floor reactions are recorded on a Honeywell measuring bridge. For further details about the electronic equipment see *Rydell* 1966. The curve which in this study has attracted greatest attention is that representing the vertical force component during the stance phase. The shape of the curve for analysis is

Table 1. Spontaneous pain at follow-up 1968.

	Male	Female	Total
Improved	40	45	85
Unchanged	1	4	5
Deteriorated	5	7	12
Total	46	56	102

Table 2. Weight-bearing pain at follow-up 1968.

	Male	Female	Total
Improved	33	38	71
Unchanged	5	11	16
Deteriorated	8	7	15
Total	46	56	102

Figure 1. Electronic walkway. The patient walks on two separate boards which are connected via force transducers with the registration instruments.

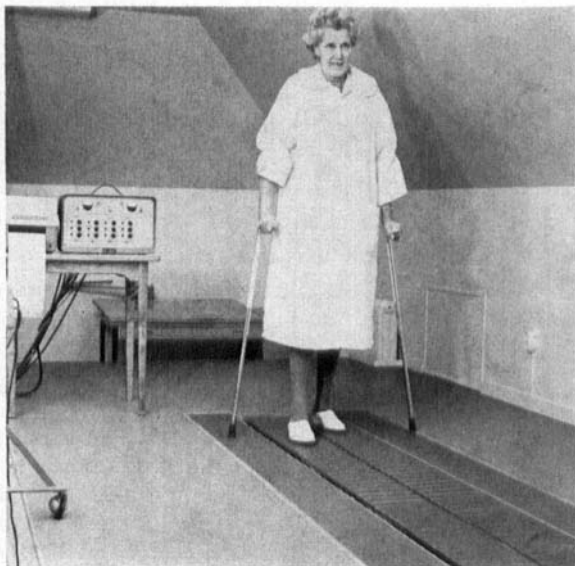


Figure 2 a. X-ray of normal hip-joint in 37-year-old male.

seen in Figures 2, 3, 4, and 5. It represents the moment, A, when the heel strikes the floor and the time, A-E, during which the sequence of vertical forces is acting on the foot with E representing the point at which the toe leaves the recording bar. This part of the curve depicts the stance phase whereas the remaining represents the swing phase. As is noted the vertical forces during the stance phase are not constant but describe maximum (B, D) and minimum (C) points. This has proved of importance in the analysis of the comparative weight-bearing in operated and non-operated side in this investigation. This study has been carried out by letting those patients who still use a stick walk slowly and fast with the cane and then in a new test slowly and fast without the stick. By slowly is meant as near normal

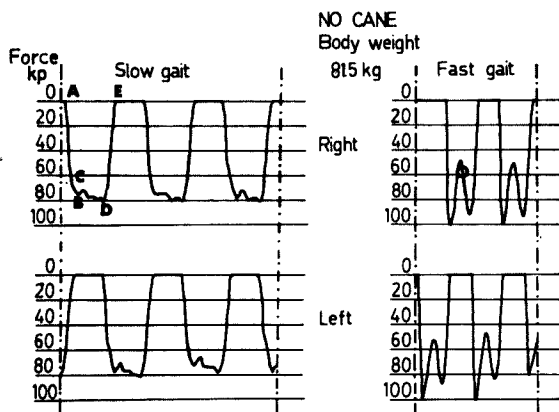


Figure 2 b. Normal pattern of gait in individual whose hip is seen in Figure 2 a. A, heel strike, B and D maximum force points, C, minimum force point, E, toe-off.

A-E is the stance phase. Upper part is right leg, lower left leg. First three registrations normal rate of gait, last three fast rate.

		left	right
Max. loading force	$\frac{P}{W}$	slow gait = 0.99	0.99
Body-weight		fast gait = 1.15	1.23

		left leg	right leg
Max. loading, B-D:	slow gait:	0.53	0.54
	fast gait:	0.40	0.42
Time of loading, A-E:	slow gait:	1.01	1.00
	fast gait:	0.64	0.66
Planimetric evaluation:	slow gait:	6.5	6.6
	fast gait:	4.2	4.6

rate of gait as possible and by fast is meant the quickest possible way they could manage. Those patients who postoperatively do not use a stick did not perform the test with a cane.

A comparison of the following values was then made between the operated and non-operated side:

1. the maximal vertical force (P) in relation to the bodyweight (W) $\frac{P}{W}$
2. the relation of the time, B-D, of maximal loading in seconds
3. the relation of the time of loading i.e. distance A-E, in seconds
4. a planimetric evaluation of the curve which takes into account each individual force during the stance phase, i.e. a summation of maximal and minimal force points.

Figure 3 a. *Slight osteoarthritis left hip in 66-year-old female. Considerable night pain, weight-bearing pain and limping. Limited range of motion. Strong candidate for intertrochanteric osteotomy.*

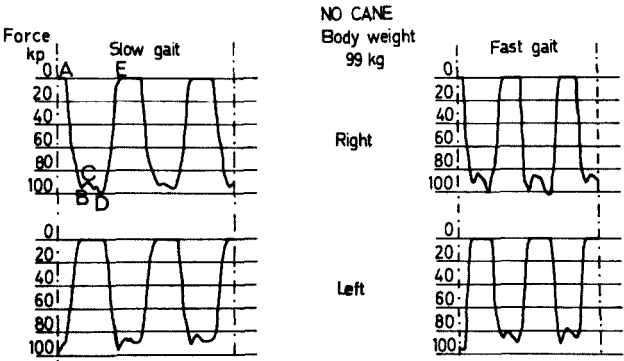


Figure 3 b. *Gait curve of patient in 3 a.*

		left leg	right leg
$\frac{\text{Max. loading force}}{\text{Body-weight}} = \frac{P}{W}$	slow gait:	0.92	0.98
	fast gait:	0.92	0.99
Max. loading, B-D:	slow gait:	0.44	0.51
	fast gait:	0.41	0.41
Time of loading A-E:	slow gait:	1.04	1.14
	fast gait:	0.79	0.85
Planimetric evaluation:	slow gait:	7.2	8.4
	fast gait:	5.5	6.5

RESULTS

The Whole Group Representing Cane-Bearers and Non-Cane-Bearers

The maximal loading force (P) in relation to the bodyweight (W)

<i>Without a cane</i>	operated side	non-operated side
slow gait	$\frac{P}{W} = 1.014 \pm 0.060$	$\frac{P}{W} = 1.023 \pm 0.051$
fast gait	$\frac{P}{W} = 1.115 \pm 0.097$	$\frac{P}{W} = 1.152 \pm 0.081$
<i>With a cane</i>		
slow gait	$\frac{P}{W} = 0.861 \pm 0.091$	$\frac{P}{W} = 0.993 \pm 0.047$
fast gait	$\frac{P}{W} = 0.897 \pm 0.104$	$\frac{P}{W} = 1.050 \pm 0.098$

The relation of the time (B-D) of maximal loading

<i>Without a cane</i>	operated side	non-operated side
slow gait	0.500 ± 0.114	0.571 ± 0.121
fast gait	0.356 ± 0.118	0.413 ± 0.051
<i>With a cane</i>		
slow gait	0.472 ± 0.054	0.556 ± 0.073
fast gait	0.368 ± 0.132	0.447 ± 0.104

The relation of the time of loading, *i.e.* distance A-E

<i>Without a cane</i>	operated side	non-operated side
slow gait	1.006 ± 0.257	1.104 ± 0.189
fast gait	0.680 ± 0.036	0.697 ± 0.070
<i>With a cane</i>		
slow gait	1.014 ± 0.318	1.189 ± 0.148
fast gait	0.826 ± 0.34	0.858 ± 0.201

The planimetric evaluation of the complete stance phase curve including maximal and minimal force points

<i>Without a cane</i>	operated side	non-operated side
slow gait	5.31 $\pm$ 1.57	6.03 $\pm$ 1.63
fast gait	3.98 $\pm$ 0.91	4.56 $\pm$ 1.07
<i>With a cane</i>		
slow gait	4.61 $\pm$ 0.68	6.62 $\pm$ 1.14
fast gait	3.77 $\pm$ 0.76	5.12 $\pm$ 0.95

Group Using a Cane Postoperatively

The maximal loading force (P) in relation to bodyweight (W)

Tests <i>without</i> a cane	operated side	non-operated side
slow gait	$\frac{P}{W} = 0.999 \pm 0.051$	$\frac{P}{W} = 1.002 \pm 0.067$
fast gait	$\frac{P}{W} = 1.024 \pm 0.092$	$\frac{P}{W} = 1.059 \pm 0.120$
<i>Tests with a cane</i>		
slow gait	0.920 $\pm$ 0.110	0.928 $\pm$ 0.140
fast gait	0.939 $\pm$ 0.141	1.058 $\pm$ 0.135

The relation of the time B-D of maximal loading

Tests <i>without</i> a cane	operated side	non-operated side
slow gait	0.367 $\pm$ 0.112	0.433 $\pm$ 0.092
fast gait	0.335 $\pm$ 0.094	0.364 $\pm$ 0.081
<i>Tests with a cane</i>		
slow gait	0.494 $\pm$ 0.101	0.455 $\pm$ 0.153
fast gait	0.420 $\pm$ 0.069	0.435 $\pm$ 0.066

The relation of the time of loading, *i.e.* distance A-E

Tests <i>without</i> a cane	operated side	non-operated side
slow gait	1.021 $\pm$ 0.218	1.021 $\pm$ 0.238
fast gait	0.812 $\pm$ 0.236	0.781 $\pm$ 0.198
<i>Tests with a cane</i>		
slow gait	1.078 $\pm$ 0.180	1.039 $\pm$ 0.199
fast gait	0.819 $\pm$ 0.058	0.821 $\pm$ 0.169

Figure 4 a. 60-year-old male with osteoarthritis of left hip. Intertrochanteric osteotomy with Wainright nail in July, 1965. Started weight-bearing in June, 1966, without a cane and has not used one since then. Completely free of symptoms. X-ray from January, 1968.

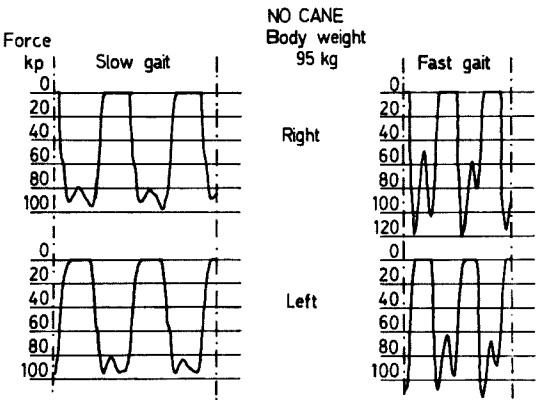


Figure 4. b. Gait curve of patient in 4 a from June, 1967.

		operated side		non-operated side
Max. loading force	$= \frac{P}{W}$	slow gait:	0.96	0.99
Body-weight		fast gait:	1.01	1.08
Max. loading, B-D:		slow gait:	0.43	0.48
		fast gait:	0.33	0.35
Time of loading, A-E:		slow gait:	1.13	1.14
		fast gait:	0.60	0.58
Planimetric evaluation:		slow gait:	7.8	8.6
		fast gait:	4.7	4.7

The planimetric evaluation of the complete stance phase curve including maximal and minimal force points

Tests <i>without</i> a cane	operated side	non-operated side
slow gait	5.17 $\pm$ 1.418	5.28 $\pm$ 1.054
fast gait	4.07 $\pm$ 1.257	4.42 $\pm$ 1.058
Tests <i>with</i> a cane	operated side	non-operated side
slow gait	5.45 $\pm$ 1.418	5.66 $\pm$ 1.442
fast gait	4.09 $\pm$ 1.100	4.64 $\pm$ 0.917

It should be mentioned that of the patients in this study eleven do not use a cane in everyday-walking. Their respective values, which have been included in the overall estimation, show lesser differences between operated and non-operated side and have been separately estimated as seen by the following calculations.

Group Not Using a Cane Postoperatively

Maximal loading force (P) in relation to bodyweight (W)

	operated side	non-operated side
slow gait	$\frac{P}{W} = 1.020 \pm 0.051$	$\frac{P}{W} = 1.018 \pm 0.049$
fast gait	$\frac{P}{W} = 1.114 \pm 0.083$	$\frac{P}{W} = 1.124 \pm 0.088$

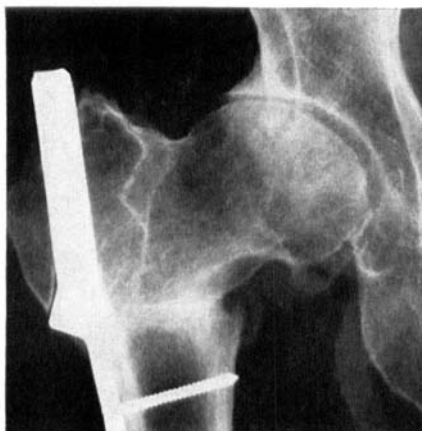


Figure 5 a. 72-year-old female with osteoarthritis of right hip. Intertrochanteric osteotomy with Wainright nail in April, 1965. X-ray from April, 1967. Patient improved but still has slight weight-bearing pain and has to use a cane permanently. Osteotomy completely healed.

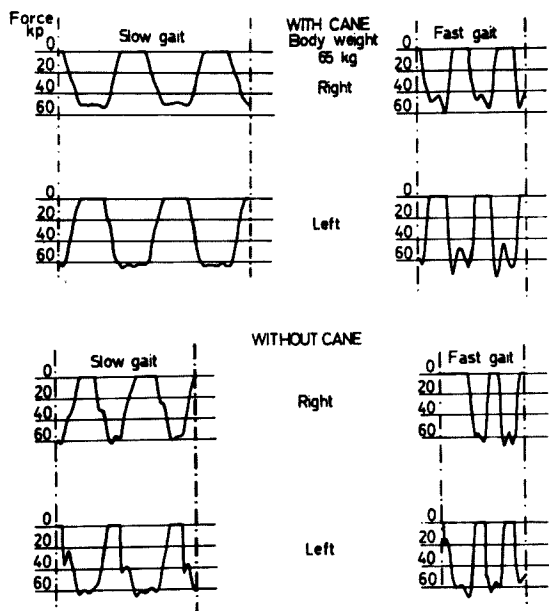


Figure 5 b. Gait curve of patient in 5 a from June, 1967.

<i>Without a cane</i>			<i>operated side</i>	<i>non-operated side</i>
<i>Max. loading force</i>	$\frac{P}{W}$	<i>slow gait:</i>	0.97	0.99
<i>Body-weight</i>		<i>fast gait:</i>	0.99	1.08
<i>Max. loading, B-D:</i>		<i>slow gait:</i>	0.28	0.40
		<i>fast gait:</i>	0.23	0.26
<i>Time of loading, A-E</i>		<i>slow gait:</i>	0.92	1.01
		<i>fast gait:</i>	0.45	0.51
<i>Planimetric evaluation:</i>		<i>slow gait:</i>	3.7	4.9
		<i>fast gait:</i>	0.99	1.08
<i>With a cane</i>				
<i>Max. loading force</i>	$\frac{P}{W}$	<i>slow gait:</i>	0.81	0.99
<i>Body-weight</i>		<i>fast gait:</i>	0.91	1.10
<i>Max. loading, B-D:</i>		<i>slow gait:</i>	0.53	0.55
		<i>fast gait:</i>	0.38	0.35
<i>Time of loading, A-E:</i>		<i>slow gait:</i>	1.28	1.38
		<i>fast gait:</i>	0.72	0.8
<i>Planimetric evaluation:</i>		<i>slow gait:</i>	5.1	6.3
		<i>fast gait:</i>	3.1	3.8

The relation of the time B-D of maximal loading

	operated side	non-operated side
slow gait	0.479 $\pm$ 0.130	0.535 $\pm$ 0.150
fast gait	0.374 $\pm$ 0.041	0.410 $\pm$ 0.055

The relation of the time of loading, *i.e.* distance A-E

	operated side	non-operated side
slow gait	0.013 $\pm$ 0.243	1.081 $\pm$ 0.259
fast gait	0.691 $\pm$ 0.089	0.715 $\pm$ 0.075

The planimetric evaluation of the complete stance phase curve including maximal and minimal force points.

	operated side	non-operated side
slow gait	5.77 $\pm$ 1.783	6.49 $\pm$ 0.336
fast gait	4.14 $\pm$ 0.894	4.58 $\pm$ 0.224

COMMENT

The overall results in this investigation confirm the assumption that patients osteotomized for osteoarthritis in the hip-joint do not use the operated limb to the same extent as the non-operated side. On comparing measurements of individuals without any apparent joint disease there is an indication that the results obtained in the non-operated side of this material fall within normal values (*Rydell* 1966). It thus becomes evident that the patients in our study limit the use of the operated hip to a level below what could be expected as normal. As spontaneous and weight-bearing pain have receded according to the patients' version a natural sequence would be the diminished use of a cane postoperatively. As is seen in Table 3 this is, however, not the case and the discomfort which apparently necessitates the aid of a stick in walking is obvious in the patient's inability to use his limb to full capacity.

In this context, however, we still feel that the subjective satisfaction of each individual patient with the results of the operation is in general so great (Table 4) that intertrochanteric osteotomy is a justified procedure in the surgical management of osteoarthritis of the hip-joint as a pain relieving procedure.

Table 3. Walking capacity as related to the use of cane from the follow-up 1968.

	Before operation	After operation	
		With cane	Without cane
Use of cane	65	55	10
No use of cane	42	25	17

Table 4. Subjective evaluation of postoperative condition at follow-up 1968.

	Male	Female	Total
Satisfied	38	43	81
Not satisfied	15	6	21
Total	53	49	102

SUMMARY

In a material of 102 patients followed up after osteotomy it was found that more patients than expected had to use a cane permanently when walking. Of 65 patients who had preoperatively used a cane only 10 could discard it after operation. Of 42 patients who did not use a cane preoperatively 25 had to use one permanently after operation.

This study was carried out to evaluate the weight-bearing in the leg operated with osteotomy for hip-osteoarthritis.

The tests were carried out on an electronic walk-way.

The results revealed that all patients limited the use of their operated hip to a level well below normal.

The subjective satisfaction of each individual with the operative results nevertheless justifies intertrochanteric osteotomy as a surgical procedure in the management of osteoarthritis of the hip.

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