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TOTAL HIP REPLACEMENT

A Comparison between Cemented (Charnley) and Non-cemented (HP Garches) Fixation by Clinical Assessment and Objective Gait Analysis

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ABSTRACT. In 119 patients with total hip replacement (THR) 61 were operated on with cemented (Charnley) and 58 with non-cemented (HP Garches) fixation. The assessment was performed by clinical examination and objective registration by gait analysis 6 and 12 months postoperatively. The group with cemented fixation (Charnley) demonstrated better results in all variables. The greatest difference between the groups was found at the 6 months' follow-up. The gait analysis was valuable in the assessment of locomotor function.

Key words: total hip replacement, cemented, non-cemented, gait analysis, force plate walkway, mid thigh pain, Harris' hip score, rehabilitation.

The main indication for total hip replacement (THR) is pain. Relief of pain improves hip function which can be assessed by the patient's own opinion, by his performance, by clinical examination and by gait analysis. It has been shown that clinical examination and commonly used evaluation scores for estimating results of a surgical procedure very much depend on which evaluation method is used (1). The registration of stride characteristics is a part of gait analysis that give an indirect information on muscle strength and mobility.

Stauffer et al. (11) studied 25 patients before and after Charnley THR by a force plate and by electrogoniometry. The peak vertical forces were significantly greater postoperatively and occurred somewhat earlier in the cycle than preoperatively. They were, however, slightly less and later than in normal gait. Murray et al. (6) used gait analysis before and after THR in comparative studies on the Charnley and Müller procedures. No difference between the two types of prosthesis was found in the patients' functional performance two to four years after surgery. Another comparison by the same authors (7) between the McKee-Farrar, Charnley and Müller procedures six months after surgery "did not suggest that the performance of anyone group is distinctly better or worse than that of any other group".

Rosenberg (9) conducted a comparative analysis of patients with conventional THR (Müller) and surface hip replacement. Gait analysis included time–distance and joint motion measurements and moments acting at the joint. The ten patients in each group had postoperatively a score of 90 out of 100 according to the Harris' hip rating score (3). The results indicated that the gait of patients with surface hip arthroplasty was significantly worse in so far as they had a shortened stride length, a reduced range of hip motion, and an abnormal moment at the hip joint about the abduction–adduction direction.

Hip function can also be measured by estimating the metabolic cost of walking. Brown & Hislop (2) showed that heart rates and oxygen uptake remained essentially the same after THR even with increased velocity. McBeath et al. (5) followed 77 patients for four years after THR. They found that self-selected walking speed was a satisfactory indicator of walking efficiency.

Macnicol et al. (4) found that mean power output (watts) during stair climbing doubled in 30 women after THR.

Common to all studies of function after THR is that the patients in spite of good results seldom reach normal values.

The purpose of this study was:

- To correlate findings from a quantitative gait analysis (time and distance measurements and vertical floor reaction forces) to a clinical examination (Harris' hip score, measurements of average maximal walking speed and time to ascend stairs) before THR, six months and one year postoperatively.

- To distinguish between possible differences in hip function after cemented (Charnley) and non-cemented (HP Garches) THR.

MATERIAL

One hundred and nineteen patients with either a Charnley (cemented) or a HP Garches (non-cemented) THR were studied. The patients participated in a random prospective and comparative study on results of cemented (Charnley) versus non-cemented (HP Garches) THR.

The cemented THRs were carried out according to the standard Charnley procedure with an anterolateral approach and trochanteric osteotomy.

The non-cemented THRs were carried out according to HP Garches with a posterior approach, no trochanteric osteotomy, screw ring in the acetabulum, and a femoral component with the stem studded with surface pyramids to facilitate bone ingrowth.

Postoperative regimen was for all patients mobilization with full weight bearing the day after surgery. They were instructed to train on their own after discharge according to a program. Forty-five per cent of the patients, the same number from each group were referred to physical therapy during the first six months, most often initiated after the 3-month control. Of the 34 patients, referred between six and twelve months, fifteen had no treatment during the first half year.

Mean age at the time of surgery was 67 years for the Charnley and 64 for the HP Garches group. Mean weight of the 47 men was 79 kg and of the 72 women 67 kg. Mean height was 175 and 163 cm, respectively. The indication for surgery was in all cases intolerable pain. The preoperative diagnosis was osteo-arthritis in 98 hips, problems secondary to trauma in eight hips, avascular necrosis in two hips and rheumatoid arthritis in eleven hips. Sixty-one patients received the Charnley and 58 the HP Garches prosthesis. The distributions of diagnoses or the preoperative assessment in both groups did not differ significantly.

METHODS

Clinical assessment

Clinical variables. The basis for the clinical examination was Harris' hip score (3). The variables of interest in Harris' hip score for comparison with gait characteristics were 1) pain in general, 2) limp, 3) walking distance, 4) ability to sit, 5) ability to put on socks and shoes, 6) presence of deformity, 7) leg length discrepancy, 8) Trendelenburg's sign.

In addition the following variables were selected for comparison: subjective opinion, pain on weight bearing and assistive device (more detailed than that of Harris' hip score).

Finally two self-selected clinical variables were considered suitable for correlation with the gait characteristics: maximal walking speed and time to ascend stairs.

Maximal walking speed. The average velocity was calculated when the patient walked as fast as he could during three minutes using the assistive device that he normally used indoors. The investigator accompanied the patient with a stop watch in hand. The pulse rate was registered before and immediately after the test. The 12 min walking test used by Macnicol (4) was reduced to three minutes in order to make it possible to test all patients.

Time to ascend stairs. The time was noted in climbing as fast as possible a flight of stairs 3.37 m high (each step 16 cm). Power output was calculated according to Macnicol (4):

$$\text{Power output (watts)} = \frac{\text{weight (kg)} \times 9.81 \times 3.37 \text{ (m)}}{\text{time to ascend (s)}}$$

The patients could use the rail and/or an assistive device if necessary. It was noted if they took alternate steps or not. A patient with a painful leg usually climbs stairs leading with the non-involved leg instead of taking the steps with alternate feet. The pulse rate was registered before and immediately after the test.

All variables tested were coded numerically and on an ordinal scale when neccessary for the purpose of correlation. This also applied to the type of assistive device used during the tests.

Quantitative gait analysis

The ground reaction forces as well as the different phases of the gait cycle were registered by a force plate walkway (two 5 metre long walking boards) described by Rydell (10) and expanded and computerized by Olsson (8). The improvements were carried on while this study was going on. Sixty per cent of the 354 tests were made before the computerization. From these registrations only the variables possible to calculate by hand were used in the study as shown in Fig. 1. The patients were instructed to walk at a free and comfortable rate with ordinary shoes and a heel lift if used. The tests calculated by hand were based on one gait run (5 metres), implying three to five gait cycles. Average walking speed, step rate and mean step length were based on a 10 metre distance. The tests made with on line recording were based on an average of five gait runs (2–12) per patient, i.e. 25 metres registered walk and 15 to 25 gait cycles. If the patient used an assistive device indoors he walked on the walkway both with and, if possible, without it in order to achieve better comparison.

The tests were carried out before THR and six and twelve months postoperatively.

Statistical methods

Pearson's correlation coefficent was used to test relations between variables. One hundred and thirty-six correlation hypotheses were tested. Each hypothesis comprised a group of single correlations, which all had to be significant to accept the hypothesis.

Student's *t*-statistic was used to test correlations and differences of means.

RESULTS

Correlation between the clinical examination and the quantitative gait analysis

All reported significant correlations computed on 119 patients, concern the patients' worse leg, and

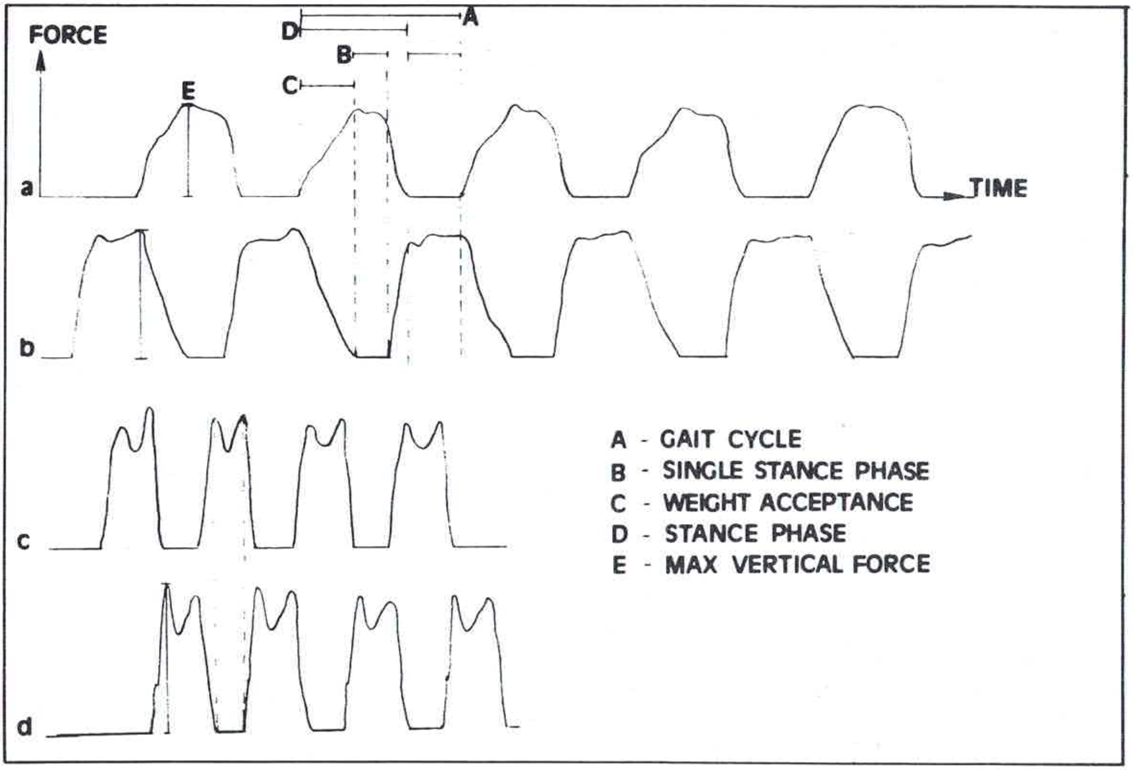

Fig. 1. Variables calculated from force-time curves; a = involved leg preoperatively and c = postoperatively, b and d = uninvolved leg.

$p<0.05$ if not differently stated. Weight acceptance, i.e. double stance phase, when the involved leg is forward, was tested in 78 patients the majority of which had unilateral involvement. The correlations are shown in Table I.

Improvement in gait function usually means increases in velocity, step rate, step length, duration of single stance phase and maximal vertical force and decreases in duration of gait cycle, stance and weight acceptance phases.

The patients were asked to rate their opinion of the operation as very satisfied, satisfied, dissatisfied without regrets or dissatisfied with regrets. Satisfaction with the effect of the THR was reflected in all gait variables as an improved gait except in stance phase time ($p<0.001$).

The occurrence of pain in general was significantly correlated to a lower step rate ($p<0.01$), maximal vertical force ($p<0.01$), velocity, and single stance phase. Duration of gait cycle and weight acceptance was increased with increasing pain. Preoperatively a correlation between step length and pain was found ($p<0.01$) and at six months between pain and stance phase. The majority of strong correlations was found at the 6 months test.

Increased weight bearing pain gave decreased maximal vertical force ($p<0.001$). Significant correlations were also found to step rate and duration of gait cycle and single stance phase ($p<0.01$). Velocity and step length correlated on the $p<0.05$ level. Duration of stance and weight acceptance showed no convincing correlations postoperatively.

Preoperatively a severe limp correlated to a long weight acceptance time ($p<0.01$). It also correlated on all occasions to every gait variable ($p<0.001$).

There was a significant correlation between walking distance and most gait variables ($p<0.001$) preoperatively and at both postoperative tests. Step length and time of single stance correlated to increased walking distance preoperatively, however, on the $p<0.01$ level.

The ability to sit did not correlate to any gait

Table I. *Correlation between gait variables and clinical examination (n=119)*[a]
The variation in *r*-values is given for each correlation hypothesis

Variables	Subjective opinion	Pain in general	Pain on weight bearing	Limp	Walking distance	Harris' score
Velocity	*** −.34 −.41	* .19 .31	* −.21 −.33	*** .49 .58	*** .44 .58	*** .56 .63
Step rate	*** −.34 −.47	** .24 .37	** −.25 −.34	*** .44 .57	*** .46 .59	*** .51 .62
Step lenght (mean)	** −.27 −.29		* −.19 −.24	*** .40 .43	** .30 .46	*** .43 .45
Gait cycle	*** .29 .37	* −.21 −.31	** .24 .25	*** −.38 −.52	*** −.41 −.55	*** −.45 −.58
Single stance per cent gait cycle[b]	*** −.36 −.41	* .19 .27	** −.28 −.36	*** .31 .35	** .27 .47	*** .34 .48
Stance phase per cent gait cycle[b]				*** −.38 −.43	*** −.29 −.49	*** −.33 −.50
Weight acceptance per cent gait cycle[b]	*** .33 .38	* −.28 −.42		** −.33 −.57	*** −.39 −.58	*** −.41 −.58
Maximum vertical force per cent body weight[b]	*** −.51 −.52	** .23 .60	*** −.36 −.41	*** .41 .62	*** .41 .49	*** .49 .69

[a] Weight acceptance was studied in 78 patients.
[b] Of involved leg.

*The single correlations comprised $p<0.05$, $p<0.01$ and $p<0.001$, ** $p<0.01$ and $p<0.001$, ***all single correlation $p<0.001$.

variable before THR, but at six months correlations were found to step rate and duration of gait cycle and weight acceptance ($p<0.01$).

Preoperatively the ability to put on socks and shoes did not correlate to walking ability. After operation an improvement was noted in the ability to put on socks and shoes and correlations were found to all gait variables ($p<0.01$).

Presence of deformity according to Harris' hip score indicating either adduction and internal rotation contracture exceeding 10 degrees and flexion contracture exceeding 30 degrees or a leg length discrepancy of more that 3 cm demonstrated no significant correlations to the gait variables.

Preoperatively no correlation was found to any gait variable but at six months a positive Trendelenburg's sign was correlated to a decrease in maximal vertical force ($p<0.001$). At one year the correlation was on a higher risk level ($p<0.01$).

Leg length discrepancy: No correlations were found.

Harris' hip score showed at all three examinations a significant correlation ($p<0.001$) to every gait variable.

Maximal walking speed showed a significant correlation ($p<0.001$) on all occasions to all gait variables.

The time to ascend stairs correlated strongly ($p<0.001$) on every occasion to all gait variables, i.e. the faster the time to ascend the stairs the better the values of gait performance. Preoperatively the correlation was on a higher risk level ($p<0.05$) between time to ascend and single stance time. The correlations between power output and gait variables were only made for those who took alternate steps. The correlations preoperatively between power output and the gait cycle phases were even stronger ($p<0.01$) than those between time to ascend and the gait cycle phases.

The various assistive devices used at the strenuous tests (stairs and maximal walking speed) were graded according to weight release needed, i.e. type of device, on which side it was used, and how it was used. The correlations to the gait variables were on all occasions strong, i.e. a three point walk with Lofstrand crutches showed a worse walking pattern in every gait variable ($p<0.001$).

The majority of strong significant correlations between gait variables and clinical examination was thus found in maximal vertical force and velocity,

Max. walking speed		Time to ascend stairs		Assistive device at max. speed and stairs	
*** .79	.88	*** −.58	−.76	*** −.56	−.71
*** .63	.69	*** −.48	−.65	*** −.50	−.61
*** .72	.82	*** −.50	−.65	*** −.45	−.67
*** −.58	−.66	*** .52	.68	*** .50	.56
*** .57	.58	* −.23	−.51	*** −.44	−.52
*** −.53	−.67	*** .40	.57	*** .45	.58
*** −.65	−.69	*** .55	.61	*** .44	.60
*** .51	.72	*** −.42	−.58	*** −.52	−.67

closely followed by gait cycle and step rate. Duration of single support and weight acceptance demonstrated correlations on a lower risk level than stance phase time.

Differences in hip function between the cemented and non-cemented THR

1. *Clinical assessment.* The preoperative assessment in both groups did not differ significantly. The result is shown in Table II and Fig. 2. In all registered variables the Charnley group had better results. No significant difference was found in ability to sit, Trendelenburg's sign or the way to climb stairs. The greatest difference was found in pain on weight bearing. At six months 57% of the patients in the HP Garches group reported pain compared to 10% of those in the Charnley group ($p<0.001$). The weight bearing pain was in the majority of cases localized to the mid thigh. As this type of pain was not anticipated, it was not made a special item.

The difference between the groups was greater at six months than at one year in the variables patients' own opinion, pain in general, pain on weight bearing and walking distance.

Improvements were made in both groups between 6 and 12 months but were greater in the HP Garches group. However, they did not at one year reach the 6 month result of the Charnley group.

Significant differences ($p<0.001$) were found in patient's own opinion, pain in general and pain on weight bearing at six months and in limp, leg length discrepancy and Harris' hip score on both postoperative occasions.

After THR the involved leg was longer in 47% of the patients in the HP Garches group compared to 20% of those in the Charnley group. Equal leg lengths were found in 41 and 47% of the groups, respectively.

Before THR the mean of Harris' hip score was 40. It increased in the Charnley group to 87 and at one year to 89 and in the HP Garches group to 74 and 78, respectively.

There was a considerable difference in time to ascend stairs between those who took alternate steps and those who did not. Before THR 79/118 (67%) patients could take alternate steps with a mean power output of 124 watts. The patients who climbed the stairs with the uninvolved leg first on to every step had a mean power output of 60 watts.

Before THR maximal walking speed was 94 cm/s, respectively. It increased in the Charnley group to 120 and at one year to 124 cm/s and in the HP Garches group to 105 ($p<0.05$) and 109 cm/s ($p<0.05$), respectively. In this test twice as many needed an assistive device to unload the involved leg in the HP Garches group as compared to the Charnley group.

Despite the increase in maximal walking speed heart rate did not increase. When the difference between the groups was studied in the patients walking with and without assistive device, the differences were found in those who walked without support. In patients walking with assistive device the only variables demonstrating significant differences at six months were Harris' hip score and at one year time of weight acceptance and stance:

Unoperated leg: Of the 107 patients without pain at six months 47% reported pain before THR ($p\ll0.001$). Of the 89 patients without pain at one year 44% reported pain before THR ($p\ll0.001$) and 8% at six months ($p<0.01$). Of the 58 patients without pain before THR one (2%) reported pain at six months and 12% at one year. Of the 106 patients without pain at six months 23% reported pain at one year.

2. *Quantitative gait analysis.* Before THR the groups did not differ significantly in any variable, though the HP Garches group showed constantly somewhat better values. The results are presented

Table II. *Results after cemented (Charnley n=61) and non-cemented (HP Garches n=58) THR. Clinical examination*

Variables	Preop. Charnley (%)	Preop. HP Garches (%)	Postop. 6 months Charnley (%)	Postop. 6 months HP Garches (%)	p	Postop. 1 year Charnley (%)	Postop. 1 year HP Garches (%)	p
Satisfaction with THR			57 (93)	39 (67)	***	56 (92)	43 (74)	*
Dissatisfaction with THR			4 (7)	19 (33)		5 (8)	15 (26)	
Pain in general								
None	0	0	41 (67)	18 (31)		38 (63)	24 (41)	
Slight or mild	2 (3)	4 (7)[b]	19 (31)	31 (53)	***	20 (33)	28 (48)	**
Moderate or severe	59 (97)	53 (93)	1 (2)	9 (16)		2 (3)	6 (10)	
Pain on weight bearing	61 (100)	58 (100)	6 (10)	33 (57)	***	7 (11)	23 (40)	*
Limp								
None	0	0	26 (43)	7 (12)		32 (53)	11 (19)	
Slight	5 (8)	4 (7)[b]	24 (39)	21 (36)	***	16 (27)	21 (36)	***
Moderate or severe	56 (92)	53 (93)	11 (18)	30 (52)		12 (20)	26 (45)	
Walking distance: no restrictions	0	0	38 (62)	22 (38)	**	41 (68)	32 (55)	
Ability to put on socks and shoes								
With ease	4 (7)	5 (9)[b]	34 (56)	22 (38)		39 (65)[a]	26 (45)	
With difficulty (or tech. aid)	41 (67)	39 (68)	25 (41)	27 (47)	*	18 (30)	23 (40)	*
Cannot	16 (26)	13 (23)	2 (3)	9 (16)		3 (5)	9 (15)	
Presence of deformity	11 (18)	19 (33)[b]	0 (0)	5 (9)	*	0 (0)	4 (7)	*
Trendelenburg's sign positive	23 (38)[a]	25 (44)[b]	8 (13)	17 (29)		4 (7)	10 (17)	
Leg length discrepancy								
No discrepancy	50 (43)		29 (47)	24 (41)				
Involved leg shorter	58 (49)	Whole	20 (33)	7 (12)	***			
Involved leg longer	10 (8)	material	12 (20)	27 (47)				
Harris' hip score	40	41	87	74	***	89	78	***
Maximal walking speed, cm/s	94	93	120	105	*	124	109	*
Stairs								
Normally—alternate feet	39 (64)	40 (70)[b]	49 (82)[a]	47 (84)[c]		54 (89)	48 (87)[d]	
Unnormally	15 (25)	11 (19)	7 (12)	7 (13)		5 (8)	6 (11)	
Cannot	7 (11)	6 (11)	4 (6)	2 (3)		2 (3)	1 (2)	
Assistive device indoors								
No assistive device	24 (39)	28 (48)	46 (75)	30 (52)		52 (85)	39 (67)	
One to unload involved leg	34 (56)	27 (47)	13 (21)	25 (43)	*	9 (15)	18 (31)	*
Two to unload involved leg	3 (5)	3 (5)	2 (3)	3 (5)		0 (0)	1 (2)	

[a] $n=60$. [b] $n=57$. [c] $n=56$. [d] $n=55$.

in Table III and Fig. 3. After THR the Charnley group demonstrated better results in all variables at both tests. Significant differences were found in average velocity ($p<0.05$) at six months and maximal vertical force at both postoperative tests ($p<0.01$).

Before THR average velocity in the Charnley group was 57 cm/s and at six months 84 cm/s implying an increase of 47%. The corresponding values for the HP Garches group were 63 and 74 cm/s implying an increase of 17%. Between 6 and 12 months average velocity increased by 10% in both groups.

Increase in average walking speed was greater as compared to maximal walking speed, where the Charnley group increased 28% and the HP Garches group 13%.

Before THR maximal vertical force under the

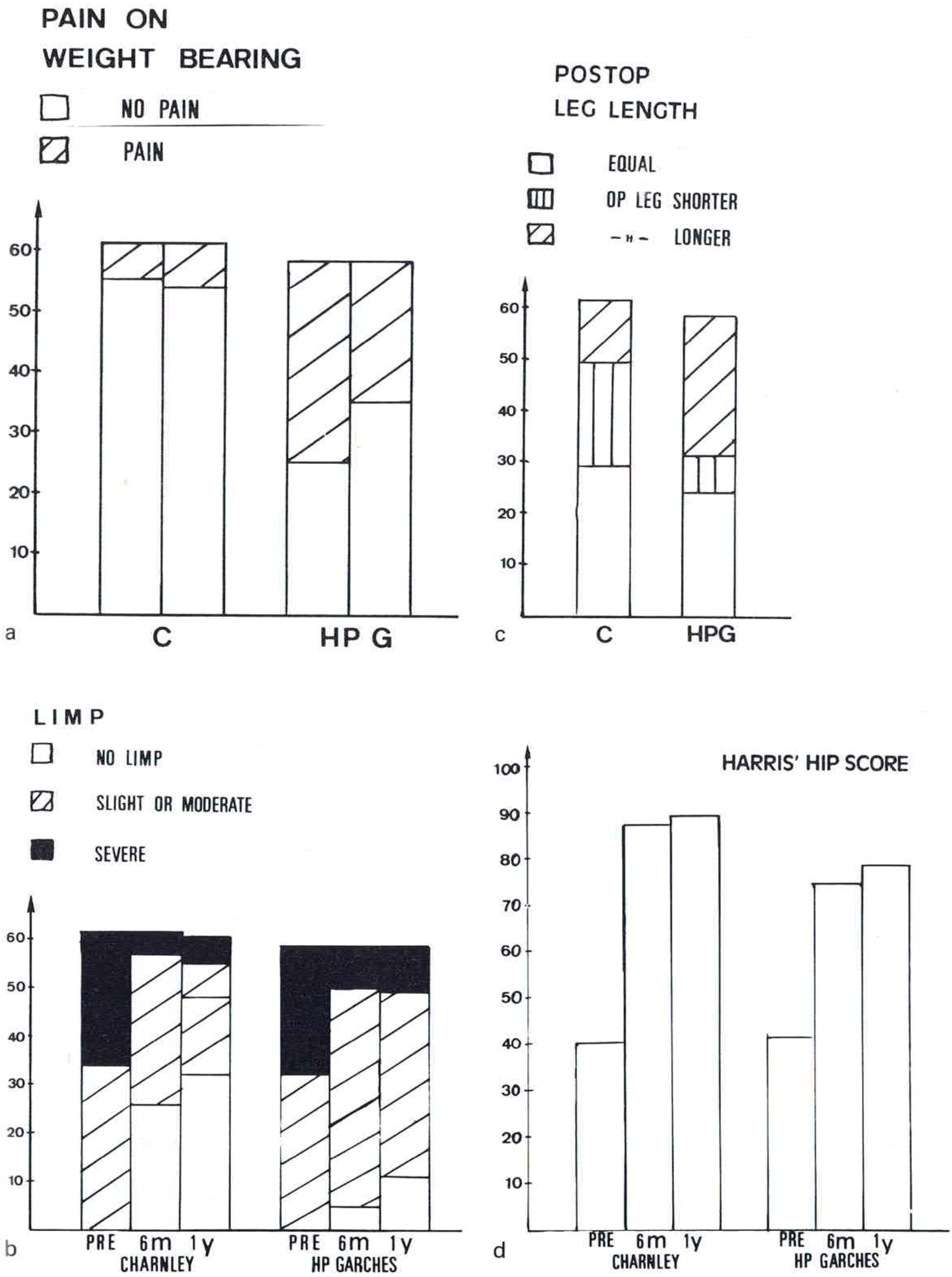

Fig. 2. Results after THR. Clinical examination; a) pain on weight bearing, b) limp, c) leg length discrepancy and d) Harris' hip score.

Table III. *Results after cemented (Charnley n=61) and non-cemented (HP Garches n=58) THR. Gait analysis*

Variables	Preop. All	Preop. Charnley	Preop. HP Garches	6 months postop. All	6 months postop. Charnley	6 months postop. HP Garches	One year postop. All	One year postop. Charnley	One year postop. HP Garches
Velocity, cm/s	60	57	63	79	84	74*	85	89	80
Step rate, steps/s	1.41	1.37	1.45	1.54	1.58	1.50	1.59	1.62	1.55
Step length (mean), cm	41	41	42	50	52	48	52	54	50
Gait cycle, s	1.6	1.6	1.5	1.4	1.3	1.4	1.3	1.3	1.4
Single support phase per cent gait cycle	27	27	28	32	33	32	33	34	33
Diff. single support uninvolved/involved leg	5	6	4	2	2	2	1	1	1
Stance phase per cent gait cycle	68	67	68	66	66	67	66	65	66
Diff. stance phase uninvolved/involved leg	5	6	4	2	2	2	1	1	1
Weight acceptance time per cent gait cycle	21	22	20	18	17	18	17	16	17
Diff. double stance involved/uninvolved leg	3	3	2	2	1	2	1	1	1
Max. vertical force per cent body weight	96	96	96	99	101	96**	101	103	98**
Diff. max. vertical force uninvolved/involved leg	6	7	6	5	5	7	4	3	6

* $p<0.05$, ** $p<0.01$

involved leg regardless of assistive device was 96% body weight for both groups. Thirty-six per cent of the patients in both groups were not able to perform the gait analysis without assistive device.

Charnley: At six months maximal vertical force had increased to 101% body weight. Twenty-five per cent of the patients had to use an assistive device to unload the leg. At one year maximal vertical force was 103% and 16% of the patients walked with assistive device.

HP Garches: At six months maximal vertical force had not increased at all ($p<0.01$) and 40% of the patients used an assistive device ($p<0.05$). At one year maximal vertical force was 98% body weight ($p<0.01$) and 31% used assistive device ($p<0.05$).

The difference between the non-involved and the involved leg was studied in the variables single support, stance and weight acceptance phases and maximal vertical force (Table III). All variables demonstrated a greater difference before compared to after THR. The differences were less at one year than at six months and no difference between the two groups could be found. No statistical analysis was made.

DISCUSSION

One of the problems when estimating hip function and gait is the variety of scoring systems available. Depending on the score chosen, results can be obtained which differ considerably even when applied to the one and same material, as described by Andersson (1). The patient's opinion is of paramount interest, but is often influenced by external factors like patient–doctor relationship, fulfilment of expectations of outcome of surgery and performance in comparison to other individuals, who have undergone the same surgical procedure. The surgeon's approach is also of importance as in general he forms an opinion, which may well be biassed, of the validity of a surgical procedure which will influence his evaluation of the procedure in question.

In view of this it is valuable to have access to a more objective means of registration of the performance of the locomotor system. Gait analysis has been used over the last few years as a method of measurement of the individual elements of gait.

In our study gait analysis was used for two reasons. First, a group of individuals with THR were examined clinically and the information obtained was correlated to some gait variables, thus giving a

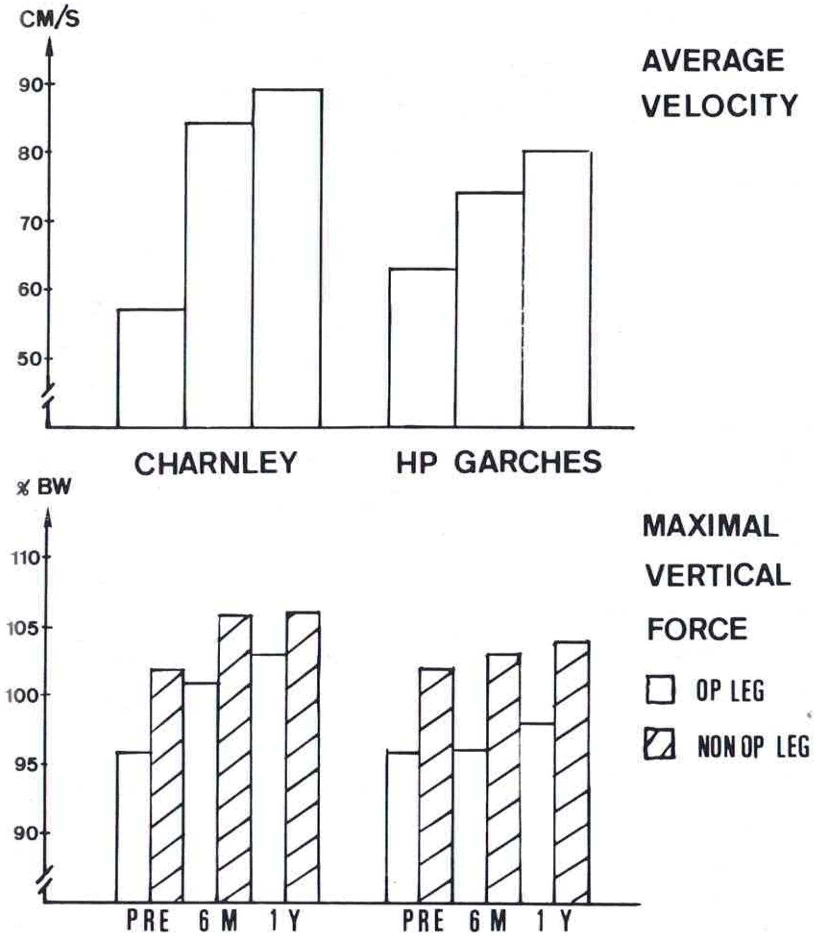

Fig. 3. Results after THR. Gait analysis.

more comprehensive interpretation of locomotor function. Second, the results of two surgical methods for THR, one with and one without cement fixation of the implant components, have been compared clinically and correlated to some gait variables.

In our investigation there was a good correlation between clinical results and gait analysis. However, differences were noted in some aspects. Functions demanding greater range of motion than gait, e.g. ability to sit and to put on socks and shoes were not convincingly reflected in the gait variables.

All patients with a leg length discrepancy walked with a heel lift for compensation which may explain the lack of correlation between leg length discrepancy and gait variables.

Despite the strong correlation between clinical impression of gait pattern and its objective registration, there was a variation in the individual gait variables in relation to the clinical performance. The majority of strong significant correlations between gait variables and clinical examination was found in maximal vertical force and average velocity, closely followed by time of gait cycle and step rate. Duration of single support and weight acceptance demonstrated correlations on a lower risk level than stance phase time.

Between 130 and 100 cm/s the typical peaks of the normal vertical force curve disappear, which makes calculations based on peak registrations, as done by Stauffer (11), difficult to perform in slower walking speeds. The time to load the involved leg is then more accurately measured by weight acceptance phase.

As for the comparison between the cemented and non-cemented prosthesis the Charnley group had better results in all variables at both postoperative examinations. The greatest differences were found at six months.

Pain on weight bearing was the variable in the HP Garches group in which, between six and twelve months, the greatest improvement was found. Maximal walking speed and time to ascend stairs are variables not previously used to compare effects of different treatments. As these variables have demonstrated a sensitivity in distinguishing between the two types of prostheses in this study and also are quick to conduct in routine clinical examination, they can be recommended.

The objective gait variables in discriminating the one method from the other were average velocity and maximal vertical force. The registration of average velocity requires only a stop watch or a pair of photo cells, whereas the registration of maximal vertical force calls for more advanced equipment.

The force plate walkway is unique in its ability to register several consecutive steps for each leg and to provide up to 50 gait cycles as a basis for calculation of maximal vertical force. This is in contrast to the force plates that only register one stance phase making calculation of maximal force more complicated.

New routines for postoperative physical therapy were started as a result of this investigation. On the sixth postoperative week group training was initiated for all patients twice a week. By this, optimal use of the new hip joint was assumed to be made earlier and patients, who needed individual treatment would be detected earlier.

However, it should be noted that these observations have been made only one year after operation which in judgement of the results of joint replacement is too short. Therefore the registrations made have to be regarded as a preliminary study on the value of gait analysis in joint replacement surgery.

Nevertheless, numerical and more detailed and precise information has been obtained in an objective way in this study, supporting and making more elaborate the impression noted at clinical examination, thus making gait analysis a useful tool in the evaluation of locomotor function after surgical procedures.

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