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COMPARISON OF MÜLLER TOTAL HIP REPLACEMENT WITH AND WITHOUT TROCHANTERIC OSTEOTOMY

Kinesiologic Measurements of 82 Cases 2 Years After Surgery

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Function of 37 patients with osteotomy of the greater trochanter during total hip replacement (41 hips) is compared to function of 38 patients (41 hips) without osteotomy. Subjective assessments and cane force measurements were slightly more favorable in the group without osteotomy. Objective measurements of hip motion, hip abductor and adductor muscle strength, weight distribution during standing, and multiple components of free-speed and fast walking showed no statistically significant differences between performance of the groups with and without osteotomy before surgery or 6 months or 2 years after. This suggests that osteotomy provides no functional advantages to the patient beyond those obtained in total hip replacements without osteotomy.

Key words: arthritis; biomechanics; gait; greater trochanter; hip joint; joint prosthesis; muscle contraction

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Osteotomy of the greater trochanter during total hip replacement is a controversial subject. Osteotomy facilitates exposure of the hip during surgery and theoretically improves the mechanical efficiency of the hip abductor mechanism by replacing the trochanter in a more distal and more lateral position than would result without osteotomy. Two of the issues in the controversy are whether patients with trochanteric osteotomy ultimately function better than patients without osteotomy and what effect osteotomy has on the rate of functional improvement in the postoperative period.

To answer these questions, a comparative study was conducted with two groups of patients, one with and one without trochanteric osteotomy. Comprehensive kinesiologic testing was performed before and 6 and 24 months after surgery in all patients, and the results of these tests were used as a basis to determine the effect of osteotomy on functional performance.

PATIENTS AND METHODS

Seventy-five patients with 82 Müller total hip replacements are reported in the study. Osteotomy of the greater trochanter was performed in 50 per cent of the surgical procedures, and no osteotomy was performed in the remaining 50 per cent. All procedures were performed through the anterolateral approach as described by Müller (1970). The groups with and without osteotomy were similar in sex, age and preoperative diagnosis (Table 1). All of the men had unilateral hip replacement, and 7 women had bilateral replacement. None of the patients were known to have complications related to the total hip such as loosening or infection. The osteotomy healed in all but 1 patient. In this man,

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Table 1. Patient population

Patient information	Group with osteotomy (N)	Group without osteotomy (N)
Hips replaced	41	41
in men	16	13
in women	25 (21 women)	28 (25 women)
Preoperative diagnosis		
Degenerative joint disease	30	36
Rheumatoid arthritis	3	1
Problems secondary to trauma	8	4
Mean age ± 1 S.D. (years)		
Men	61±11	60±10
Women	65± 7	67±10

the trochanter had migrated proximally about 1 cm by 6 months after surgery and an additional 3 cm between 6 months and 2 years after surgery. None of the patients had a major lower limb disability other than the operated hip.

Each patient was tested before and 6 months and 2 years after surgery using methods previously reported (American Academy of Orthopaedic Surgeons 1965, Murray & Peterson 1973, Murray & Sepic 1968, Murray et al. 1964, Seireg et al. 1968). The tests measured range of hip motion, strength of the hip abductor and adductor muscles during maximum isometric contraction, weight distribution between the feet during standing, forces applied to canes or crutches, and multiple components of free-speed and fast walking. The patients also rated their hips and answered a questionnaire about pain and the performance of routine daily activities.

In patients for whom adequate roentgenograms were available, we measured bilaterally the distance from the midline of the pelvis to the femoral head center (centralization) and the lateral position of the greater trochanter with respect to the femoral head center (abductor-muscle lever arm).

A multiple classification analysis of variance was used to test for significant differences in functional performance between the groups with and without osteotomy and among the three sessions. A Student's t test was used to compare the functional performance of the patient groups preoperatively and 2 years postoperatively to appropriate normal standards of performance (Murray & Sepic 1968, Murray et al. 1970, Murray et al. 1969).

RESULTS

Subjective ratings of hip status and hip pain

The patients were asked to consider all factors and rate the status of their hips as "much improved, improved, unchanged, worse or much worse" as a result of surgery. None of the patients rated their hips worse or much worse. Six months after surgery, the 41 hips with osteotomy were rated as follows: 37 – much improved; 3 – improved; and 1 – unchanged. The 41 hips without osteotomy were rated: 31 – much improved; and 10 – improved. Two years after surgery, 39 hips with osteotomy and 37 hips without osteotomy were rated much improved and 2 hips with osteotomy and 4 without osteotomy were rated improved.

The patients' descriptions of hip pain were placed into the categories described by Lazansky (1967) (Table 2). None of the patients had severe pain and the 1 patient with "tolerable pain" 2 years after surgery had a trochanteric bursitis. At both postoperative tests, more patients in the group with trochanteric osteotomy reported pain than in the group without trochanteric osteotomy. In each patient group, the pain ratings 2 years after surgery were more favorable than those 6 months after surgery.

Use of assistive devices

Before surgery the two patient groups were not evenly matched in their use of assistive devices (Table 3). The groups seemed evenly matched, however, in their improvement; in each group, approximately 57 per cent of the patients who had used assistive devices before surgery discontinued using devices by 6 months after surgery or reduced their support to only one device. Six

Table 2. Pain ratings

Pain categories	Frequency (in number of hips replaced)			
	Group with osteotomy		Group without osteotomy	
	6 months	24 months	6 months	24 months
No pain	16	19	23	23
Slight, intermittent; begins on initiating motion and decreases with activity	10	11	7	11
Onset of pain with activity; disappears quickly with rest	13	11	10	6
Tolerable pain; permits limited activity	2	0	1	1
Severe pain; limits all upright activity	0	0	0	0
Severe spontaneous pain at rest	0	0	0	0
Total	41	41	41	41

Table 3. Type of assistive devices used and average force applied

	Frequency (in per cent of patients)					
	Group with osteotomy			Group without osteotomy		
	Preop.	6 months	24 months	Preop.	6 months	24 months
Walker	3	0	0	0	0	0
Two crutches or canes	19	0	0	10	0	0
One crutch or cane	62	62	14	56	42	8
No support	16	38	86	34	58	92
Average force applied (kg)*	10	5	8	9	4	3
Range (kg)	1–38	1–12	5–12	2–35	1–10	1–5

*Average force during stance phase of the operative limb for those who used support.

months postoperatively none of the patients used more than one cane or crutch. Of those using an assistive device 6 months after surgery, 80 per cent were walking without support 2 years after surgery.

The average force applied to the assistive devices during the stance phase of the operative limb before and after surgery is also shown in Table 3. None of the patients applied greater force 2 years after surgery than before surgery. The groups were evenly matched before surgery and 6 months after, but 2 years after surgery the 5 patients with osteotomy who used canes were applying higher average forces than the 3 patients without osteotomy who used canes.

Weight distribution between the feet

The average amount of weight borne on the operative limb during tests of quiet standing was nearly identical for the two groups both before and after surgery. In each group the average amount of weight borne on the operative limb was 36 per cent of body weight before surgery, 45 per cent 6 months following surgery and 46 per cent 2 years after surgery.

Range of hip motion

The mean amount of improvement in hip flexion, extension and inward rotation was similar for the two groups (Figure 1). The group with osteotomy, however, improved slightly more in hip abduction and slightly less in hip adduction and outward rotation than the group without osteotomy over the 2-year postoperative period ($P < 0.05$). Improvement in all six directions of hip motion was statistically significant from be-

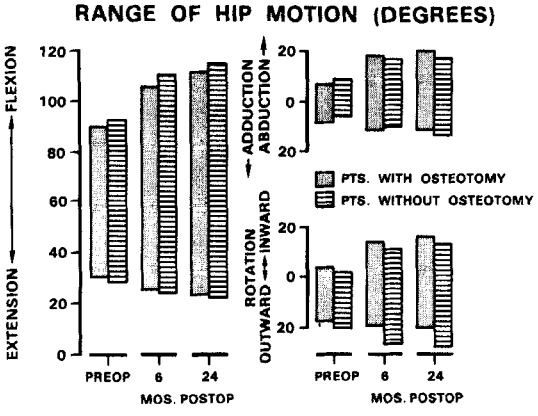

Figure 1. Average range of hip motion before total hip replacement and 6 and 24 months after for 41 cases with osteotomy of the greater trochanter and 41 cases without osteotomy.

fore surgery to 2 years after for both groups of patients ($P < 0.01$).

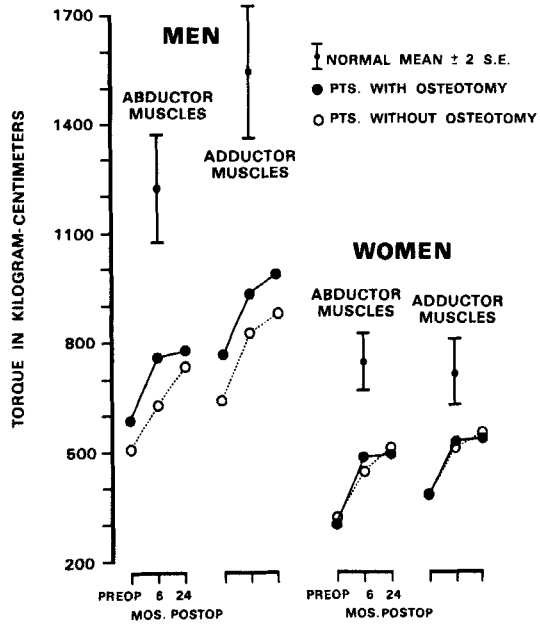

Figure 2. Average preoperative and 6- and 24-month postoperative measurements of hip abductor and adductor-muscle torque during maximum isometric contraction for 16 hips in men and 25 hips in women with trochanteric osteotomy and 13 hips in men and 28 hips in women without osteotomy. The vertical lines indicate the range of normal variability defined by 2 S. E. above and below the mean (Murray & Sepic 1968).

Hip abductor and adductor muscle strength

Mean hip abductor and adductor muscle torques for the groups with and without osteotomy are shown in Figure 2 with the ranges of normal variability. No statistically significant differences were found between the groups with and without osteotomy in strength level at any test session or in amount of improvement over the 2-year period. Improvement in strength of both muscle groups from before surgery to 2 years after was statistically significant for all four groups ($P < 0.01$), but none of the groups reached the lower limits of normal variability.

In abductor muscle strength, the men with osteotomy were stronger than the men without osteotomy preoperatively, but the women had similar preoperative levels. During the first 6 postoperative months, the rate of improvement in hip abductor muscle strength was slightly greater for the men and women with trochanteric osteotomy, but after 6 months the rate of improvement was slightly greater for the men and women without osteotomy. Thus, 2 years after surgery the mean abductor muscle strength for the groups with and without osteotomy was similar (Figure 2).

Ten of the 41 hips *without* osteotomy and 6 of the 41 hips *with* osteotomy had lower abductor muscle strength 6 months after surgery than before surgery. Most of these were still below preoperative strength levels 2 years after surgery.

In hip adductor muscle strength, the two groups of men had different preoperative levels but similar rates of improvement; the groups of women had similar preoperative levels and similar rates of improvement.

Ten of the 41 hips *with* osteotomy and 3 of the 41 *without* osteotomy had lower adductor muscle strength 6 months after surgery than before surgery. Most of these were above the preoperative level 2 years after surgery.

Gait components

In Figures 3 and 4, the average pre- and postoperative measurements of selected components of walking performance for the patient groups are compared to normal standards of perfor-

mance. All of the patient groups achieved statistically significant improvement ($P < 0.01$) between the preoperative and 2-year postoperative testing period with one exception: The group of men without osteotomy did not have significant improvement in free-speed or fast walking measurements of cadence and lateral head motion.

The preoperative level of the groups with osteotomy was usually slightly lower than the preoperative level of the groups without osteotomy. The groups with osteotomy also tended to show more improvement than those without osteotomy during the first 6 postoperative months, though this may be related to the different preoperative levels. No statistically significant differences were found, however, between the groups with and without osteotomy at any testing interval. For both groups, the greatest amount of improvement was seen during the first 6 postoperative months with less improvement measured between the 6th and 24th postoperative months. In spite of the significant amount of improvement over the 2-year postoperative period, none of the groups of subjects reached the lower limits of normal variability with the exception of the men with osteotomy whose mean ca-

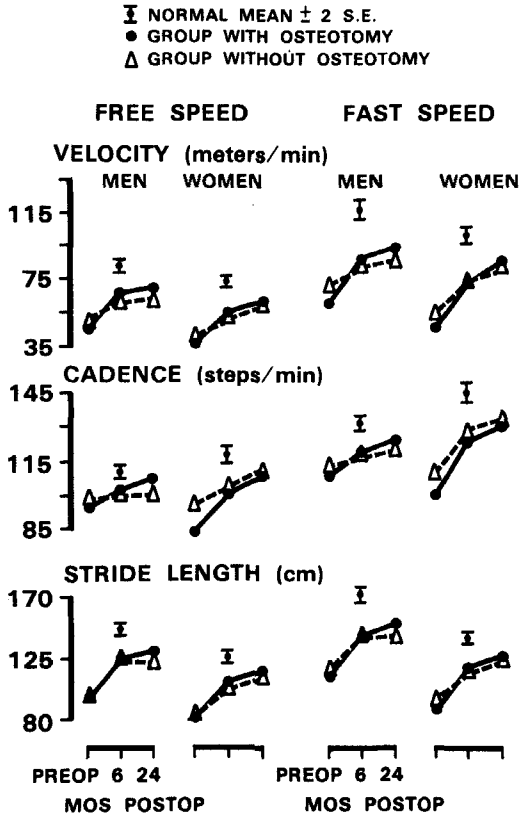

Figure 3. Average preoperative and 6- and 24-month postoperative measurements of velocity, cadence and stride length during free-speed and fast walking for 16 men and 21 women with osteotomy of the greater trochanter and 13 men and 25 women without osteotomy. The symbols for the range of normal variability represent the mean and 2 S. E. above and below the mean for normal men and women (Murray et al. 1970, Murray et al. 1969).

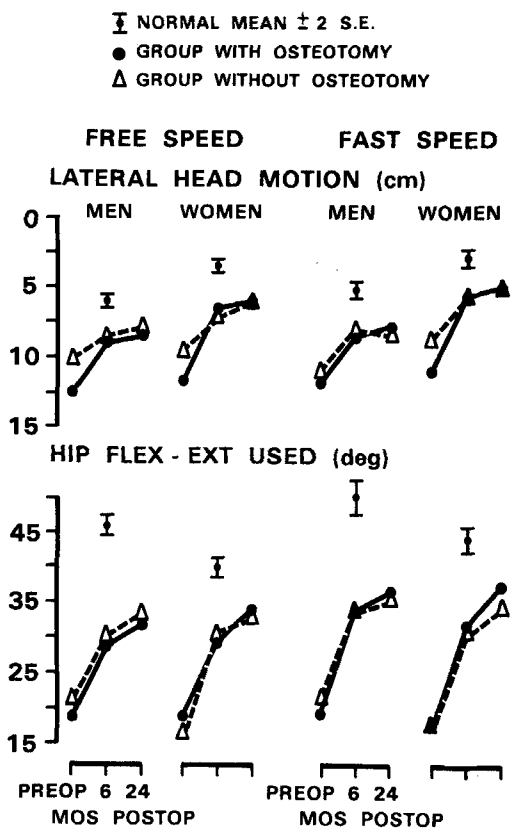

Figure 4. Average preoperative and 6- and 24-month postoperative measurements of lateral lurching and total excursion of hip flexion-extension used during free-speed and fast walking for 16 men and 21 women with osteotomy of the greater trochanter and 13 men and 25 women without osteotomy. The vertical lines bisected by dots represent the mean and 2 S.E. above and below the mean for normal men and women (Murray et al. 1970, Murray et al. 1969).

dence at free-speed walking was within the normal range.

The gait of healthy men differs in some components from that of healthy women. For example, healthy men walk faster, take longer strides, walk at a slower cadence, use more hip motion, and have more lateral motion of the head than healthy women. These differences were also observed in the gait components of both patient groups at all test sessions with one exception: No sex-related differences were found in the amount of hip flexion-extension used during walking.

In Figure 5, three ratios are used to describe the degree of symmetry and smoothness in the gait of normal men as compared to that of the patients. The ratios are formed from the single-limb-support times of each limb, the step lengths of each limb, and the velocity of the subject as he moves over each limb (velocity index). In normal subjects, the performance of the right and left limbs are symmetrical and all of these ratios average 1.0.

In both patient groups, the subnormal preoperative ratios indicate a shorter period of single-limb support on the painful limb than on the sound limb, a longer step with the disabled limb, and a "stop-start" type of limp characterized by faster velocity as the patient moves over the painful limb than over the sound limb (Figure 5). Postoperatively, the patients' ratios approach or reach the normal limits of variability with no significant difference between the two groups of patients.

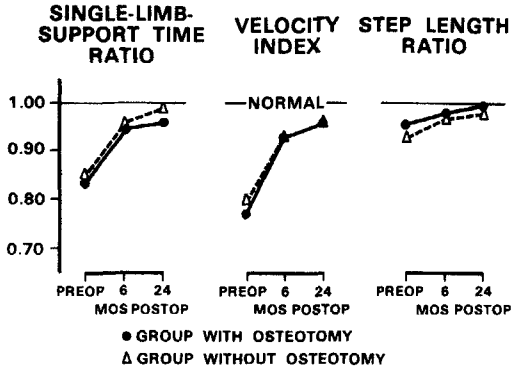

Figure 5. Average preoperative and 6- and 24-month postoperative ratios (indicating symmetry and smoothness of gait) for patients with unilateral disability (33 patients with osteotomy and 35 without osteotomy) during free-speed walking. Measurements of the sound and disabled limbs were used to calculate the ratios. The measurement for the sound limb was the numerator in calculating the ratio for velocity index and step length; the denominator in calculating the ratio for single-limb-support time. One S. E. for normal men and women = 0.006 for step length ratio, 0.008 for single-limb-support time ratio, and 0.003 for velocity index.

Roentgenographic measurements

Roentgenographic measurements were available on approximately 75 per cent of the patients in each group. These measurements showed significantly greater centralization of the prosthetic femoral head relative to the uninvolved femoral head center for the men and women with osteotomy as compared to the men and women without osteotomy by an average magnitude of 0.5 cm ($P < 0.05$). The average measurements of the lateral position of the greater trochanter on the operated relative to the uninvolved side were not significantly different between the groups with and without osteotomy, although there was a slight trend for more lateral positioning of the greater trochanter by an average of 0.3 cm in the groups with osteotomy.

DISCUSSION

Trochanteric osteotomy certainly provides excellent exposure of the proximal femur and acetabulum during total hip replacement. Whether this wide exposure is routinely necessary, or even desirable, is questionable. The disadvantages of trochanteric osteotomy, as opposed to procedures without osteotomy, include increased operating time, increased blood loss, more ectopic bone formation, problems associated with healing of the osteotomy, problems with the fixation devices used to maintain the position of the trochanter, and prolongation of the immediate rehabilitation period (Parker et al. 1976). The advocates of osteotomy, however, maintain that the wide exposure obtained permits more accurate component positioning and provides the opportunity to improve function of the hip abductor muscle by changing the position of

the greater trochanter. In most cases, the trochanter is moved distally to obtain optimal length of the hip abductor muscles so that greater muscle tension can be generated. In addition, the trochanter can be placed more laterally to increase the abductor muscle lever arm and thereby decrease the amount of muscle force required for any given activity. These mechanical and physiological advantages can be achieved without increasing the length of the neck of the femoral component and, theoretically, would ultimately result in better patient function.

The wider exposure of the hip afforded by osteotomy of the greater trochanter may explain the fact that we found greater centralization of the prosthetic femoral head center in the groups of men and women with as compared to without osteotomy. Centralization decreases the amount of hip abductor-muscle force required during walking to stabilize the pelvis, and accordingly decreases the hip joint load. Because centralization decreases the distance between the femoral head center and the vertical projection of the mass center of the superimposed body weight, the need for lateral lurching during walking decreases. Indeed, the groups of men and women with osteotomy had a greater decrease in lateral head motion during walking from before to after surgery than the men and women without osteotomy. Even though the patients in all groups had less lateral lurching after as compared to before surgery, their lateral head motion was still in excess of normal 2 years after surgery. Since the patients had little or no complaints of hip pain 2 years after surgery, the excessive lateral motion during walking must have resulted in part from the persistent weakness of the hip abductor muscles which we documented.

The length of the abductor-muscle lever arm was slightly greater in the groups with than without osteotomy. This difference in abductor-muscle lever arm between the groups, however, was not of sufficient magnitude to affect the amount of improvement in hip abductor-muscle torque.

Wiesman et al. (1978) also made roentgenographic measurements of the length of the abductor-muscle lever arm, but in their study the measurements were made before and after surgery in 12 patients who had bilateral hip replacement with osteotomy on one side and not the other. Our findings are in agreement with those of Wiesman et al. in that their patients had a mean increase in the abductor-muscle lever arm length on the osteotomy side which was not significantly greater than on the non-osteotomy side.

In our series, 1 patient's greater trochanter migrated proximally 3 cm between the 6th and 24th postoperative months. During the same period we measured a loss in abductor-muscle torque from 1000 kg-cm to 640 kg-cm. In each of the motions which were measured passively, that is, flexion, extension, abduction and adduction, his range of motion increased approximately 10 degrees between 6 and 24 months. However, on inward rotation which we measured actively, he lost 15 degrees of motion. His free-speed and fast walking measurements were essentially the same 6 months and 2 years postoperatively.

In our subjective assessments, we found that the groups with and without osteotomy of the trochanter seemed equally satisfied with their hip replacements even though at both postoperative periods more patients in the group with osteotomy had complaints of postoperative pain than in the group without osteotomy. The number of patients using canes 2 years after surgery was only slightly higher in the group with osteotomy than in the group without osteotomy. Of greater importance is the fact that those without osteotomy who used canes 2 years after surgery were applying low average forces in the range of 1 to 5 kg, suggesting use of the cane for security reasons; however, those with osteotomy who used canes 2 years after surgery were applying moderate average forces of 5 to 12 kg, suggesting use of the cane to decrease hip joint load or to decrease their lateral lurching.

In general, the patients with trochanteric osteotomy had their operations during a period of time in our community when osteotomy was routinely done during the hip replacement procedure and, thus, most of the patients did not have the osteotomy because of anticipated difficulties during surgery. In terms of the number and type of assistive devices used by the patients, the group to have osteotomy appeared to be more disabled than the other group. This trend was also

apparent, but only to a slight degree, in measurements of range of hip flexion-extension and measurements of walking performance without assistive devices.

No significant differences were found between the preoperative measurements of the two groups for any component of function measured, nor were any significant differences found between the two groups at either of the postoperative tests. In a few of the measurements, we found significantly different amounts of improvement for the two groups (range of motion). There were also components of walking performance (cadence and lateral lurching) in which one group achieved significant improvement while another did not, but these differences could be related to the fact that the group which showed more improvement had slightly lower preoperative measurements and thus greater potential for improvement.

We feel that the results of this study clearly demonstrate that no long-term functional advantage or disadvantage is derived from satisfactory osteotomy of the greater trochanter during total hip replacement. In view of the documentation of operative and immediate postoperative problems with trochanteric osteotomy, this approach should be reserved for difficult hip replacement procedures in which trochanteric removal is required for exposure or to correct some anatomic malformation.

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