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ORIGINAL ARTICLE

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Full weight bearing after non-cemented total hip replacement is compatible with satisfactory results

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Abstract Two matched groups of 29 patients underwent hydroxyapatite-coated non-cemented total hip replacement. One group was started on immediate protected-weight-bearing walking and the other group was started on immediate full-weight-bearing walking. They were followed up regularly for 2 years. They were assessed with Harris hip score clinically and Engh's criteria of osteo-integration radiographically. No difference was found between the two groups. All patients had excellent clinical outcome after hip replacement, and all femoral stems were stable radiographically. Patients can walk with full weight bearing safely immediate after hydroxyapatite-coated non-cemented total hip replacement.

Résumé Deux groupes appairés de 29 malades ont eu une arthroplastie totale de la hanche avec une prothèse non cimenté, recouverte d'hydroxyapatite . Un groupe a repris la marche immédiatement avec appui protégé et l'autre groupe avec appui complet. Ils ont été suivis pendant 2 années régulièrement. Ils ont été étudiés avec le score clinique de Harris et les critères radiographique d'Engh pour l'ostéointégration. Aucune différence n'a été trouvée entre les 2 groupes. Tous les malades ont eu un excellent résultat et toutes les tiges fémorales étaient stables radiographiquement. Les malades peuvent marcher avec appui complet immédiat après une prothèse de hanche sans ciment recouverte d'hydroxyapatite.

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Introduction

We compared the 1-year and 2-year clinical and radiological outcomes in two matched groups of patients bearing partial weight and full weight in the first 6 weeks a fter total hip replacement.

Patients and methods

Since 1991, we have performed non-cemented total hip replacement on patients younger than 65 years old. We used a grit-blasted, collarless, straight titanium-alloy femoral implant (Omnifit HA, Osteonics, Stryker, USA) with normalizations and a dense layer of hydroxyapatite on the proximal one third of the stem.

Before September 1996, we allowed our patients only to walk with protected weight bearing in the first 6 post-operative weeks. Since September 1996, we allowed our patients to walk on full weight immediately after operation.

Two groups of 29 patients were reviewed retrospectively. All were assessed clinically and radiologically at 1 month, 3 months, 6 months, 12 months, 18 months and 2 years after surgery. The first group of patients (PWB group) was allowed to walk for 6 weeks with protected weight bearing after surgery. The second group (FWB group) was allowed to walk immediately with full weight bearing. There were 12 female and 17 male patients in each group.

All the femoral stems were described as stable during operation and no intra-operative complication occurred. The two groups were matched in gender, age, body weight, pre-operative activity level and diagnosis. Mean age of the PWB group was 50.5 (±14.4) years and that for the FWB group was 49.5 (±16.3) years. Mean body weight of the PWB and FWB groups respectively was 127.75 (±26.9) lbs and 134.75 (±24.6) lbs. Walking ability of the two groups before operation was similar. Only one patient in the FWB group was classified as Gustilo and Burnham type 3 (able to perform moderately stressful activities, able to participate in some sports and full time work, able to do home-making). The remaining 57 patients in both groups were classified as Gustilo and Burnham type 1 (sedentary, able to walk occasionally, limited to indoor activity only) or type 2 (able to be engaged in non-stressful activity, able to walk but only for a limited distance) [7].

Clinical assessment

We used the Harris hip score to assess the clinical status pre-operatively, and at the first-year and second-year follow-up.

Radiological assessment

The antero-posterior radiographs taken post-operatively and at 1-year and 2-year follow-up were examined using the criteria described by Engh [4]. The absence of reactive lines adjacent to the on-growth surface of the implant and the presence of spot welds of endosteal new bone contacting the on-growth surface were considered as major signs of osteo-integration. An extensive reactive line around the on-growth portion of the implant was considered as a major sign for the absence of osteo-integration. The absence of spot weld was considered as minor sign of failed osteo-integration. The absence of migration, absence of a lucent line around the smooth part of the stem, absence of bone implant interface deterioration, absence of distal pedestal formation associated with distal lucency and the presence of calcar atrophy were suggestive of stem stability.

Radiolucency was defined as a radiolucent line that was parallel with and in close proximity to the implant and was associated with a thin radiopaque layer of bone paralleling the line. Only a radiolucent line that encompassed at least 50% of the length of the zone, as described by Gruen [6], was taken as significant lucency. Spot weld was defined as new cancellous bone formation between the implant and the endosteal surface of the femur seen on follow-up radiographs. Atrophy of the calcar was present when there was a loss of either the height or width of the femoral calcar. Migration was measured from the tip of the greater trochanter of femur to the shoulder of the femoral prosthesis. A 2 mm discrepancy of distance measured was considered as significant. A bone pedestal is defined as a shelf of endosteal new bone, either partially or completely bridging the intramedullary canal. If this new bone formation was in direct contact with the distal tip of the femoral stem and there was no new radiolucency or reactive line around the stem tip, this bone pedestal would be defined as a pedestal associated with a stable stem. In contrast, if there was radiolucency and a reactive line surrounding the distal stem, the pedestal beneath the stem would be considered associated with an unstable stem tip.

A score was assigned to each of the above-mentioned radiological findings. Any undetermined finding was given with a zero score. The fixation scale and the stability scale were then calculated by adding up the respective scores.

Periosteal cortical hypertrophy was recorded when there was an increase in the outside diameter of the cortex in each zone around the implant. Cortical bone hypertrophy at the junction between the hydroxyapatite-coated and the smooth part of the prosthetic stem was called junctional cortical hypertrophy. Distal cortical bone hypertrophy was referred to hypertrophy of femoral cortex around the tip of femoral prosthesis [3].

Inter-observer error

Two authors, who were not the operating surgeons, individually re-examined the radiographs of 16 randomly selected femora. The score for each radiological sign assigned by these two authors were then compared. Agreement on the interpretation of the radiological signs between different observers was then assessed.

Statistical assessment

The interval data of the FWB and PWB groups were compared using Student's *t*-test for equality of means and Levene's test for equality of variances. The nominal data were compared with the Pearson chi-square test. Significance was assumed when P was lower than 0.05. The degree of matching on the diagnosis between the two groups and the degree of agreement on interpretation on radiological signs between different observers were tested with correlation tests. Pearson correlation test was used for interval data and chi-square test (phi coefficient and Cramer's V coefficient) was used for nominal data. If the correlation coefficient were 1, the two variables tested would have perfect positive correlation. If the coefficient were –1, the correlation would be perfect negative. If the coefficient were zero, no correlation between the variables existed. All tests were performed using the Statistical Package of Social Sciences (SPSS 9.0).

Table 1 Outcome difference between the partial weight bearing (PWB) and full weight bearing (FWB) groups

Interval data	Levene's test for equality of variances	Student's *t*-test for equality of means
Harris hip score 1 year	0.346	0.687
Harris hip score 2 years	0.832	0.177
Appearance at porous interface at 1 year	0.043	0.322
Appearance at porous interface at 2 years		Mean scores of the two groups are equal
Spot welds at 1 year	0.678	0.559
Spot welds at 2 years	0.002	0.085
Appearance at smooth interface at 1 year	0.598	0.826
Appearance at smooth interface at 2 years	0.002	0.105
Pedestal when fixed at 1 year	0.621	0.833
Pedestal when fixed at 2 years	0.536	0.650
Calcar remodelling at 1 year	0.143	0.320
Calcar remodelling at 2 years	0.429	0.693
Interface deterioration at 1 year	0.003	0.187
Interface deterioration at 2 years	0.001	0.079
Migration of stem at 1 year	0.691	0.985
Migration of stem at 2 years	0.857	0.889
Fixation scale at 1 year	0.957	0.629
Fixation scale at 2 years	0.000	0.086
Stability scale at 1 year	0.962	0.898
Stability scale at 2 years	0.164	0.406
Nominal data	**Pearson's chi-square test**	
Junctional cortical hypertrophy at 1 year	0.410	
Junctional cortical hypertrophy at 2 years	0.557	
Distal cortical hypertrophy at 1 year	0.601	
Distal cortical hypertrophy at 2 years	0.085	

Results

Clinical performance

The Harris hip scores for the PWB group were 48.0 (±18.9), 91.9 (±6.2), 93.1 (S±4.3) at pre-operative, 1-year follow-up and 2-year follow-up respectively, whereas those for the FWB group were 43.7 (±15.0), 90.8 (±13.1) and 94.8 (±5.2) respectively. There was no statistically significant difference for the Harris hip scores at pre-op, at 1 year and at 2 years between the two groups (Table 1). The pre-operative hip scores for both groups were poor. After hip replacement, both groups had hip scores at 1-year and 2-year periods graded as excellent. Only two patients had post-operative complications; both belonged to the PWB group. One patient had prosthesis dislocation that was successfully reduced with closed reduction and one suffered from transient peroneal nerve palsy.

Radiographic assessment

The mean fixation scales at 1-year and 2-year follow-up for the PWB group were 6.3 (±3.7) and 8.5 (±2.7) respectively and for the FWB group 5.6 (±3.7) and 7.1 (±3.6) respectively. The mean stability scales at 1-year and 2-year follow-up for the PWB group were 11.6 (±5.1) and 12.3 (±4.3) respectively and for the FWB group 12.1 (±4.6) and 13.2 (±3.7) respectively. There was no significant difference on either the fixation scales or the stability scales at 1-year and 2-year follow-up (Table 1). Occurrence of individual radiographic sign between the matched pairs in both groups at 1-year and 2-year follow-up did not differ statistically (Table 1). In both groups, the femoral stems were considered stable and osteo-integrated.

Inter-personal observer error

The interpretation of radiological signs between different observers was found correlated. The correlation coefficient of all the 22 tested factors was positive. The coefficient was >0.7 in 16 factors. (Table 2).

Discussion

The stability of non-cemented femoral prosthesis is dependent on the initial mechanical fit between the intramedullary canal and the prosthetic stem and subsequent bone on-growth on a hydroxyapatite-coated implant.

Is protected weight bearing effective in decreasing the force and subsequently the shear across the bone implant interface? Joint reaction force over each hip joint during single-legged stance is three times the body weight. This force decreases to one sixth of the body weight with protected weight bearing. The respective limb bears the weight of itself only [1]. The force transmitted to the prosthetic stem and subsequently to the implant-bone interface is therefore smaller with protected weight bearing than with full weight bearing.

However, strong force is also generated across the hip joint during muscle contraction. It has been shown that this force increases to four times the body weight when the patient is being placed on a bedpan [8]. Shear across the bone-implant interface is also caused by bending and

Table 2 Inter-personal observer correlation

	Pearson correlation Coefficient (interval data)	Chi-square test Phi coefficient and Cramer's V (ordinal data)
Appearance at porous interface at 1 year	1	–
Appearance at porous interface at 2 years	1	–
Spot welds at 1 year	0.941	–
Spot welds at 2 years	1	–
Appearance at smooth interface at 1 year	0.683	–
Appearance at smooth interface at 2 years	1	–
Pedestal when fixed at 1 year	1	–
Pedestal when fixed at 2 years	0.787	–
Calcar remodelling at 1 year	0.775	–
Calcar remodelling at 2 years	0.934	–
Interface deterioration at 1 year	0.683	–
Interface deterioration at 2 years	0.806	–
Migration of stem at 1 year	1	–
Migration of stem at 2 years	1	–
Fixation scale at 1 year	0.654	–
Fixation scale at 2 years	0.754	–
Stability scale at 1 year	0.946	–
Stability scale at 2 years	0.436	–
Junctional cortical hypertrophy at 1 year	–	0.303
Junctional cortical hypertrophy at 2 years	–	1
Distal cortical hypertrophy at 1 year	–	1
Distal cortical hypertrophy at 2 years	–	1

torsional moments over the prosthetic stem [10]. These bending and torsional forces are present in all kinds of daily activities beside standing and walking. Therefore, it seems that protecting the patient from full weight bearing after surgery alone is not sufficient.

The other question is does motion at the bone-implant interface always cause loosening? Interestingly, it has been shown that bone can form around a hydroxyapatite-coated implant despite continuous micro-motion [12]. In addition, the shear strength over the implant-bone interface will continuously increase from 6 weeks to 1 year despite motion and will eventually be close to that of the implant-hydroxyapatite interface [5]. In our study, we found that there was no difference for Harris hip score, fixation scale and stability scale between the groups in the first 2 post-operative years.

The radiographic criteria described by Engh were originally used to assess stability and fixation of porous-coated femoral stems. The Omnifit HA femoral stem is coated with a layer of hydroxyapatite and is not porous coated. Particle shedding, an assessment index on implant stability, will therefore not occur. This sign was obviously not included in our assessment. According to Engh, most patients with stability scores above 5 were asymptomatic and had definite roentgenographic signs of bone in-growth. Patients with positive scores between 0 and 5 had equally good clinical results but fewer signs of in-growth. Negatives scores implied that the prosthesis was sub-optimally fixed. The more negative the value, the less stable the implant, and the more symptomatic the patients will be [4]. In our study, the 1-year and 2-year stability scales for both groups were higher than 11. Therefore, most implants were graded as stable.

If the hydroxyapatite-coated proximal part of the prosthetic stem is well fixed, stress will be transferred to the surrounding bone, stimulating cortical bone hypertrophy. Junctional cortical bone hypertrophy (cortical hypertrophy occurring between the hydroxyapatite-coated and the smooth part of the prosthetic stem) is a radiological indicator of proximal prosthetic stem stability [11]. If the proximal prosthetic stem is not fixed, stress will be transferred distally to a region where the stem is able to sit. Stress will then be concentrated over that region, stimulating distal cortical bone hypertrophy. Therefore, distal cortical bone hypertrophy may indicate failure of proximal stem fixation. In our study, there was no significant difference in the occurrence of femurs with junctional or distal cortical hypertrophy between the two groups. This means that stem stability is independent of the type of post-operative weight-bearing regime.

The follow-up in our study was only 2 years. We believe that this duration was adequate in detecting any instability or failure of osteo-integration. It has been shown that less than 2 mm of subsidence might occur in the first 3 months after operation using a hydroxyapatite-coated femoral stem. Thereafter, there will be no migration of stable stems [13]. Adequate fixation would also have occurred 2 years after surgery in most hydroxyapatite-coated prostheses [9].

Immediate post-operative full-weight-bearing regime carries several advantages. The patients can start to walk independently earlier and the hospital stay can be shortened. The rehabilitation course is shorter and there will be fewer complications. It has been shown that patients undergoing non-cemented total hip replacement with delayed weight bearing have a greater risk for deep venous thrombosis [2]. Some patients may not be able to learn partial weight-bearing walking and may therefore spend most of their time in bed.

Immediate post-operative full weight bearing is compatible with satisfactory results if component stability is achieved at surgery. We conclude that protected weight bearing after a hydroxyapatite-coated non-cemented total hip replacement is unnecessary.

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