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Bone Mineral Density Changes in the Hip and Spine of Men and Women 1-Year After Primary Cemented Total Knee Arthroplasty: Prospective Cohort Study

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ABSTRACT

This study evaluated age- and sex-adjusted changes in total hip and spine bone mineral density (BMD) within 1 year of total knee arthroplasty (TKA) using a prospective, longitudinal cohort with a one-year follow-up. Preoperatively, subjects underwent routine bone mineral densitometry of their hip and spine, which was repeated 12 months postoperatively. Of 108 subjects, 97 (90%) completed BMD testing. Total hip BMD decreased significantly over time (1.80% change, $P < 0.001$) with females losing more than males ($P < 0.001$). The pattern was similar, but attenuated in the spine. Subjects undergoing primary cemented TKA had significant bone loss in the hip within 12 months, beyond that expected with age.

Bone mineral density (BMD) may be affected by the presence of a total knee arthroplasty (TKA). Some small studies have suggested that there is generalized loss in BMD in the lower extremity postoperatively after TKA, which may increase future fracture risk in a population at already high risk for osteoporosis-related complications [1,2]. Age related osteoporosis, often measured by the loss of BMD, is a known risk factor for fractures in the elderly, which have significant negative consequences for patients [3–5]. Many factors, including female sex, postmenopausal status, and decreased body mass index (BMI) are known to affect the rate of BMD decline [6–9]. The timing of TKA surgery often occurs at a similar point in a patient's life as the observed decreases in BMD related to normal aging.

There are several reasons why patients undergoing TKA might have accelerated loss of BMD in the first postoperative year [10–13]. Surprisingly, there have been very few studies aimed at actually measuring changes in general BMD in the post-TKA patient [1,2,14,15], and they have reached variable conclusions regarding changes in BMD after TKA. One study suggested that there is an increase in BMD following a TKA [14], while others have suggested no change in general BMD after TKA [1,2,15].

The objective of our study was to evaluate change in general BMD, by measuring the total hip and lumbar regions, over the first postoperative year following primary cemented TKA. We hypothesized that the general BMD loss at 12 months following a TKA would be greater than that expected with "normal" aging.

Methods

Study Design

This was a prospective, longitudinal cohort with a one year of follow-up after TKA. We used a 2:1 female:male ratio because women are at greater risk of underlying low bone mass. All subjects provided written informed consent and the study received ethics approval from the local institutional review board (Pro00012220).

Selection Criteria

The following patients were potentially eligible: a) females 50 years and older or males 60 years and older; b) lived within the metro region; c) willing and able to undergo BMD testing preoperatively and again 12 months postoperatively. The following patients were ineligible: a) use of any bone active medication (e.g. bisphosphonates) in

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the past 5 years; b) body mass index (BMI) >40 kg/m^2; c) unable or unwilling to provide written informed consent.

Measurements

Preoperatively, subjects underwent a routine clinical BMD (bone mineral densitometry) study using DXA (dual energy x-ray absorptiometry). A single Hologic QDR4500A (with Discovery upgrade) scanner was used with Software version Apex 3.4. Conventional spine and hip measurements were obtained. The least significant change (LSC) for the total hip was 0.016 g/cm^2 and for the spine was 0.020 g/cm^2.

As per convention, hip measurements were obtained from the left side unless scanning of the right hip was obligatory due to the presence of an arthroplasty. A repeat BMD study was performed on the same machine 12 months after TKA. Overall, 50 (47%) (16 males; 34 females) scans were performed on the operative side and 57 (53%) (18 males; 39 females) were performed on the non-operative side.

Data Collection

Potentially eligible subjects were approached at a central intake clinic for TKA at their initial preoperative visit, where the study was explained and informed consent obtained. Age, sex, and BMI were recorded preoperatively. In addition, subjects completed a co-morbidity profile, the RAND-36 – a publicly available generic health status questionnaire, and the University of California – Los Angeles (UCLA) Activity questionnaire [16] – a standardized patient-reported questionnaire regarding activity level.

Following enrollment, patients were booked for their preoperative BMD within three months of surgery. Patients were contacted by phone to complete the UCLA activity questionnaire at 12 months postoperatively and also underwent repeat BMD evaluation on the same extremity as the preoperative evaluation at 12 months postoperatively.

Surgical intervention

All subjects received a cemented femoral and tibial component with the specific prosthesis type (i.e., cruciate retaining or posterior stabilized; mobile or fixed bearing) and manufacturer at the surgeons' discretion. Patellar resurfacing was also performed at the surgeons' discretion. When patellar resurfacing occurred, all patellar components were cemented all-polyethylene designs. Standard surgical approaches and third generation cementing techniques were used in all cases.

Outcome

The primary outcomes were the age- and sex-adjusted changes in total hip and spine BMD over the first postoperative year. We also compared these data with relatively comparable normative data drawn from a large longitudinal cohort study of almost 9500 Canadians aged 25 years and older (Canadian Multicentre Osteoporosis study [CaMOS]) as well as a smaller Danish cohort of 525 subjects [6,9]. These normative data afforded an opportunity to examine BMD changes following TKA and determine how TKA impacts overall bone loss in the total hip and spine regions relative to the normal aging process after controlling for impact of age and sex.

Post hoc power analysis

Based on the differences observed in the total hip and spine in our study, the power ($\alpha = 0.05$) was nearly 100% for both the total hip and the spine for the overall primary cohort analyses. When the same power calculations were performed for secondary exploratory analyses stratified by patient sex, the power ($\alpha = 0.05$) was nearly 100% for women and 80% for men at the total hip and 78% for women and less than 50% for men at the spine.

Statistical analysis

Descriptive statistics (means, quartiles, standard deviations & proportions) were generated. Repeated measures analysis of covariance (ANCOVA) was used to control for age and sex and assess the changes in BMD at the total hip and spine between preoperative and 12 months post TKA. Because we only had two measurements, the ANCOVA results represent an analysis of "complete" cases, i.e., those who had both baseline and follow-up BMD measurements. Age was categorized in five year intervals except for those females less than 60 years of age, who were classified as a single age category (50–59 years) due to the small sample size. The mean percentage changes in BMD (([BMD-12 m – BMD-pre]/BMD-pre)*100) were also calculated for each age category stratified by sex as well as the overall percentage changes according to sex. Change in reported activity levels as well as absolute activity levels were evaluated to determine their impact on changes in BMD. We considered a P-value of less than 0.05 to be statistically significant, except for 2-way interaction terms where we considered a P-value of less than 0.1 to be significant. We considered P-values of 0.05 to 0.10 to represent a trend. All analyses were done using the Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc., Chicago, IL, USA).

Results

Enrollment

Of 108 subjects who underwent cemented TKA and received a preoperative BMD test, 97 (90%) completed the 12-month BMD test. Of the 11 individuals who did not complete the study, six indicated that they did not want to have a second BMD test, while the other five were unable to be contacted despite numerous telephone and mailout attempts. There were no differences in age ($P = 0.61$), sex ($P = 0.33$), comorbidities ($P = 1.00$), BMI ($P = 0.68$), self-reported preoperative activity level ($P = 0.77$) or physical health status ($P = 0.24$) between those who completed the 12-month evaluation and those who did not. In addition, there was no difference in the BMD measured preoperatively in the spine ($P = 0.33$) or total hip ($P = 0.19$) between those completed and did not complete the 12-month evaluation.

Demographics

For the 97 subjects who completed preoperative and postoperative BMD tests, 64 (66%) were female and 61 (63%) were 65-years or older. Because of the differential age inclusion criteria for males and females, males were older than females (Table 1). Women had a higher BMI than men but otherwise reported similar numbers of comorbidities and preoperative activity levels (Table 1). Most participants (n = 70 [72%]) had normal BMD preoperatively with no differences in BMD between males and females (Table 1).

Change in BMD over time

Generally, BMD decreased substantially over time in the overall cohort, and the losses were greater in the total hip region than in the spine, particularly for females (Table 2).

In the *Total Hip*, BMD decreased significantly over time for the cohort (1.80% change over 1-year, $P < 0.001$) with females losing even more BMD than males ($P < 0.001$). There was a significant interaction between age and sex ($P = 0.016$) with females less than 70 years and males older than 70 years losing the most BMD.

Although the pattern was similar in the *Spine*, the losses were attenuated as compared to the total hip region. The BMD change over time showed a trend to statistical significance (1.06% change over 1-year, $P = 0.07$) and again, women lost more BMD than men ($P = 0.049$).