Effect of Total Knee Arthroplasty on Metabolic Syndrome

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Abstract: The purpose of this study was to evaluate the effect of changing activity after total knee arthroplasty (TKA) on metabolic syndrome with a follow-up period of 2 years. Two hundred consecutive patients who were to undergo TKA were prospectively enrolled. The patients' blood pressure, fasting plasma glucose level, the lipid profile, the waist circumference, the Knee Society score, and the Lower Extremity Activity Scale were measured preoperatively and at the 2-year follow-up visit. The data from 169 patients were finally collected and reviewed. Two years after primary TKA, there was no change in the prevalence of metabolic syndrome, despite that the patients had a significant increase of their physical activity. **Keywords:** total knee arthroplasty, physical activity, health, metabolic syndrome.
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There are no current prospective studies available in the literature on the real health status improvement after total knee arthroplasty (TKA). Instead, evaluating the health-related quality of life through a validated and patient-completed questionnaire has become the preferred approach [1-5]. The Medical Outcomes Study Short Form-36 [6] and the Western Ontario and McMaster University Osteoarthritis Index [7] have been by far the most commonly used instruments for this purpose [8].

Metabolic syndrome is a constellation of risk factors that are associated with a high risk for diabetes and cardiovascular disease [9,10], and this syndrome is increasing to epidemic proportions. The National Cholesterol Education Program's Adult Treatment Panel III definition [11] uses easily measured clinical findings of an increased abdominal circumference, elevated levels of triglycerides, low levels of high-density lipoprotein (HDL) cholesterol, elevated fasting blood glucose levels, and/or elevated blood pressure. Three of these 5 are required for making the diagnosis of metabolic syndrome. There is great interest in identifying the best lifestyle approach for these patients to reduce the clinical and economical impact of metabolic disorder [12]. The TKA candidates are usually old and they have a sedentary lifestyle, and the risk factors for metabolic syndrome are more prevalent in these patients [13]. Although strong evidence suggests that higher levels of physical activity favorably affect the individual components of metabolic syndrome, to the best of our knowledge, there has been no study that has evaluated the effect of the change of activity associated with TKA on metabolic syndrome.

We hypothesized that TKA may have a beneficial effect on metabolic syndrome. More specifically, we examined 2 hypotheses: (1) the patient's physical activity would increase 2 years after TKA and (2) the prevalence of metabolic syndrome may decrease 2 years after TKA.

Materials and Methods

Subjects

From December 2005 to December 2006, 200 patients undergoing TKA at a university medical center in Korea were enrolled in the study. All patients were of Asian ethnicity. This prospective study was approved by the hospital ethics committee, and the patients gave written informed consent. Of the 200 participants, 26 did not return for blood sampling. Another 5 individuals were excluded because of incomplete data to diagnose them with metabolic syndrome. After all the exclusions, 169 participants remained for the analysis. One hundred fifty-two patients were women and 17 were men. The average age of the patients at the time of TKA was 66.7 years (range, 49-85 years). Seventy-seven patients (45.6%) underwent unilateral TKA, and 92 patients (54.4%) underwent single-stage or staged bilateral TKAs.

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Data Collection

The following assessments were made preoperatively and at the 2-year follow-up visits. Weight; waist circumference (measured by a plastic tape meter at the level of the umbilicus); blood pressure; and the blood glucose, HDL cholesterol, and the triglyceride levels were measured for all patients after an overnight fast. The systolic and diastolic blood pressures (mm Hg) were measured twice with a standard mercury sphygmomanometer in a sitting position after at least 10 minutes of rest. The reported values are the mean of the 2 determinations. We also obtained information on the patients' current antihypertensive medications and their other current drug therapies, including cardiovascular drugs, lipid, glucose, and uric acid-lowering drugs and antithrombotic treatment. The body mass index (BMI) was computed as weight/height squared.

The Knee Society score (KSS) [14] was used for the purposes of functional assessment and outcome measurements. The KSS is a 200-point clinical rating system that is subdivided into a knee score that rates only the knee joint itself and a functional score that rates the patient's ability to walk and climb stairs. The patient's physical activity level was assessed with the Lower Extremity Activity Scale (LEAS) [15]. The LEAS is an 18-level self-administered scale that evaluates a patient's physical activity. The patients were instructed to select the most appropriate level of their current activities, from a scale of 1 (I am confined to bed all day.) to 18 (I am up and about at will in my house and outside. I also participate in vigorous physical activity such as competitive level sports daily.).

Definition of Metabolic Syndrome

There is no universally accepted definition for metabolic syndrome. We used the recent National Cholesterol Education Program Adult Treatment Panel III [11,16] definition. Metabolic syndrome was defined by the presence of at least 3 of the following 5 criteria: (1) a fasting serum glucose level of 110 mg/dL or higher or a clinical diagnosis of diabetes with dietary, oral, or insulin treatment; (2) an arterial blood pressure of 130/85 mm Hg or higher or the current use of antihypertensive medication; (3) a plasma triglyceride level of 150 mg/dL or higher; (4) an HDL cholesterol level of less than 50 mg/dL for females and less than 40 mg/dL for males; and (5) a waist of higher than 88 cm for females and higher than 102 cm for males.

Statistical analyses

The data were analyzed with SPSS version 13.0 statistical software (SPSS Inc, Chicago, IL). The continuous variables were reported as mean (SD) values, the categorical variables were described using frequency distributions, and they were reported as percentages. χ^2 tests were performed to compare the preoperative and 2-year follow-up prevalence of metabolic syndrome and its components. Paired t tests were done for comparing the preoperative and 2-year follow-up data. Statistical significance was defined at $P < .05$.

Results

Of the total study population, 37.8% (64/169) had metabolic syndrome preoperatively. The percentage of patients having antihypertensive medication was 23.6% (40/169), and the percentage of patients receiving diabetes therapy was 21.3% (36/169) preoperatively. Thirteen patients (7.7%) were receiving both antihypertensive medication and diabetes treatment preoperatively.

The mean KSS knee and functional subscores increased significantly from the preoperative assessment to 2 years ($P < .001$). Significant changes of the mean LEAS scores were also found at 2 years of follow-up ($P < .001$) (Table 1).

The mean BMI of the patients was 26.4 ± 4.2 kg/m^2 preoperatively; after 2 years, the mean BMI was 26.2 ± 3.8 kg/m^2. There was no significant BMI change at 2 years of follow-up ($P = .369$). Table 2 shows the changes of the mean values of each component of metabolic syndrome 2 years after TKA. The prevalence of metabolic syndrome and its components in the study population is detailed in Table 3. There were no significant changes in the prevalence of patients with central obesity and low HDL cholesterol.

After 2 years, both the mean systolic and diastolic blood pressures went down, and the mean triglyceride level was lowered significantly, which means better control, although there were no significant changes in the prevalence of hypertension (elevated blood pressure or therapy) and hypertriglyceridemia. On the other hand, there were significant increases in the fasting plasma glucose level and the prevalence of diabetes (elevated plasma glucose or receiving diabetes therapy) 2 years after TKA.

The percentage of patients having antihypertensive medication was 24.9% (42/169), and the percentage of patients receiving diabetes therapy was 23.1% (39/169) 2 years after TKA. There was no significant difference in patient distribution according to the numbers of positive components of metabolic syndrome between the preoperative baseline and postoperative 2 years (Fig. 1). Two years after TKA, 40.2% (68/169) of the patients had metabolic syndrome. The prevalence of

Table 1. Knee Society Score for Functional Assessment and LEAS for Activity Measurement

	Preoperatively	2 y Postoperatively	P
KSS knee	32.1 ± 12.6	95.0 ± 4.2	.000
KSS function	46.5 ± 6.5	93.7 ± 8.6	.000
LEAS	7.7 ± 2.1	10.3 ± 1.6	.000

Table 2. Changes of Mean Values of Components

	Preoperatively	2 y Postoperatively	*P*
Waist circumference (cm)	91.8 ± 6.9	90.5 ± 6.4	.437
Fasting glucose (mg/dL)	110 ± 32	121 ± 36	.001
Fasting HDL (mg/dL)	49.0 ± 15.5	48.8 ± 15.1	.890
Fasting triglyceride (mg/dL)	154.6 ± 77.0	139.8 ± 66.9	.049
Systolic BP (mm Hg)	133 ± 17	127 ± 16	.002
Diastolic BP (mm Hg)	82 ± 11	78 ± 08	.000

BP, blood pressure.

metabolic syndrome was not changed significantly after 2 years (P = .656).

Discussion

In the present study, we evaluated the health improvement after TKA by assessing the prevalence of metabolic syndrome. Metabolic syndrome is widely used in the epidemiologic studies from different countries and for populations with different ethnic backgrounds as a convenient way to report on the clustering of metabolic risk factors that are predictive of future cardiovascular disease and diabetes [17]. The prevalence of the metabolic syndrome worldwide ranges from 8% to more than 40%, and it varies greatly according to the age and ethnicity of the group that is studied and according to the criteria used for its definition [10,13,17-21]. In our TKA population, metabolic syndrome was a highly prevalent condition preoperatively. Furthermore, 2 years after TKA, there was slight increase in the prevalence of metabolic syndrome, but this was without statistical significance.

In this study, we were able to demonstrate a significant increase in knee function and physical activity as measured by the KSS scores and LEAS scores from preoperative condition to 2 years after. Sedentary lifestyles exact a heavy medical and economic toll on individuals and societies [22]. Physical activity lowers all-cause mortality, and it reduces several risk factors for cardiovascular disease. Physical activity is a key component of effective treatment of metabolic syndrome. It can improve the plasma lipid profile as well as other risk factors [12]. In the Finnish Diabetes Prevention Study [23], individuals who increased their leisure time physical activity were about 75% less likely to develop metabolic syndrome. One of the hypothesized mechanisms to explain the independent beneficial role of physical activity may be the antiinflammatory effect of exercise. The association between low-grade systemic inflammation and metabolic syndrome has been supported by many studies [18,24]. Bauman et al [25] reported that patients who undergo total joint arthroplasty maintain a moderate activity level, and many perform active/very active levels of activity. However, in our study, increased physical activity after TKA had no effect on metabolic syndrome.

A number of studies have been carried out to assess the relation between TKA and weight change. Woodruff and Stone [26] and Heisel et al [27] reported that TKA patients' weight did not significantly change postoperatively. Lachiewicz and Lachiewicz [28] investigated the effect of primary TKA on the weight and physical activity of overweight and obese patients. They reported an increase in BMI despite a significant increase in physical activity postoperatively. Our results are similar to the results of these studies. Two years after TKA, the patients experienced no change of their mean BMI and mean waist circumference. Implementation of a healthier lifestyle with an increase in physical activity and a reduction of body weight are the basis for the prevention and treatment of both type 2 diabetes and metabolic syndrome [29]. Both exercise-induced weight loss and diet-induced weight loss

Table 3. Changes of Prevalence of Components

	Preoperatively	2 y Postoperatively	*P*
Elevated waist circumference (>88 cm, women; >102 cm, men) (n)	83 (49.1%)	80 (47.3%)	.744
Elevated fasting glucose (≥110 mg/dL) or therapy (n)	68 (40.2%)	87 (51.5%)	.038
Decreased fasting HDL (<50 mg/dL, women; <40 mg/dL, men) (n)	62 (36.7%)	69 (40.8%)	.435
Elevated fasting triglyceride (≥150 mg/dL) (n)	64 (37.9%)	58 (34.3%)	.497
Elevated BP (≥130/85 mm Hg) or therapy (n)	93 (55.0%)	85 (50.3%)	.383
Metabolic syndrome (≥3 components)	64 (37.8%)	68 (40.2%)	.656

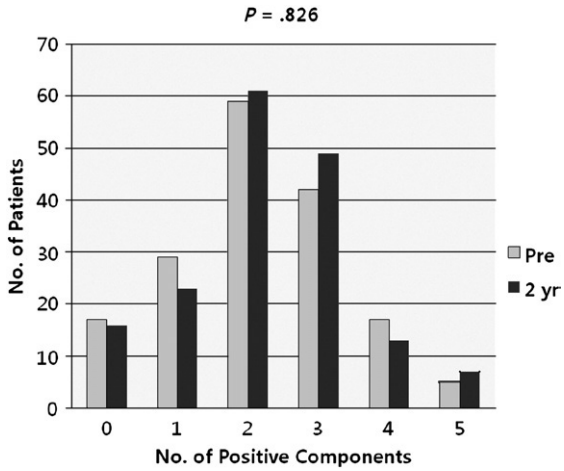

Fig. 1. A graph illustrating patient distribution according to the positive numbers of components of the metabolic syndrome between preoperative and 2 years postoperative conditions.

provide similar reductions in abdominal obesity, visceral fat, and insulin resistance [30]. Our data suggest that the increase in physical activity without weight loss had no benefit for improving the features of metabolic syndrome in a TKA population.

Our study showed a significant increase in the mean fasting plasma glucose level and the prevalence of diabetes/abnormal glucose at 2 years after TKA. At baseline, diabetes was present in 21.3% of the patients. After 2 years, diabetes was present in 23.1% of the patients. Some of the risk factors for diabetes such as elevated plasma glucose concentrations in the fasting state and after an oral glucose load, being overweight, and a sedentary lifestyle are potentially reversible [31]. The US diabetes prevention program research group [31] performed a lifestyle-modification study that focused on 3234 obese subjects with impaired glucose tolerance. The lifestyle-modification group who had goals of 7% weight loss and 150 minutes of physical activity per week resulted in a 58% reduction in the incidence of type 2 diabetes compared with the placebo group. In the present study, the TKA did not lead to a change in lifestyle patterns. The diabetes or abnormal glucose was not a reversible condition with the TKA intervention. Instead, the prevalence of diabetes/abnormal glucose increased at 2 years after the operation.

One potential limitation of our study is the high percentage (89.9%) of female patients. In Korea, 47 961 TKAs were performed in subjects older than 40 years due to osteoarthritis from 2002 to 2005. The rate of TKA has increased for 4 years and was much higher in women than in men. Compared with men, the age-standardized rate ratios for TKA in women ranged from 7.4 to 8.0 [32]. Although there was no big difference in sex ratio between our patients and national registry data, the data would be different if there had been an equal number of males and females.

In conclusion, our study suggests that TKA has no effect on metabolic syndrome. Although there were significant increases in knee function and physical activity 2 years after operation, there was no change in the prevalence of metabolic syndrome in our study population.

References

1. Bennett KJ, Torrance GW, Moran LA, et al. Health state utilities in knee replacement surgery: the development and evaluation of McKnee. J Rheumatol 1997;24:1796.
2. Birdsall PD, Hayes JH, Cleary R, et al. Health outcome after total knee replacement in the very elderly. J Bone Joint Surg Br 1999;81:660.
3. Lavernia CJ, Guzman JF, Gachupin-Garcia A. Cost effectiveness and quality of life in knee arthroplasty. Clin Orthop Relat Res 1997;345:134.
4. Lingard EA, Katz JN, Wright EA, et al. Predicting the outcome of total knee arthroplasty. J Bone Joint Surg Am 2004;86:2179.
5. Lingard EA, Katz JN, Wright RJ, et al. Validity and responsiveness of the Knee Society clinical rating system in comparison with the SF-36 and WOMAC. J Bone Joint Surg Am 2001;83:1856.
6. Ware Jr JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992;30:473.
7. Bellamy N, Buchanan WW, Goldsmith CH, et al. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 1988;15:1833.
8. Ethgen O, Bruyere O, Richy F, et al. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. J Bone Joint Surg Am 2004;86:963.
9. Isomaa B, Almgren P, Tuomi T, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care 2001;24:683.
10. Lorenzo C, Okoloise M, Williams K, et al. The metabolic syndrome as predictor of type 2 diabetes: the San Antonio heart study. Diabetes Care 2003;26:3153.
11. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation 2002;106:3143.
12. Stone NJ, Saxon D. Approach to treatment of the patient with metabolic syndrome: lifestyle therapy. Am J Cardiol 2005;96:15E.
13. Singh G, Miller JD, Lee FH, et al. Prevalence of cardiovascular disease risk factors among US adults with self-reported osteoarthritis: data from the Third National Health and Nutrition Examination Survey. Am J Manag Care 2002;8:S383.
14. Insall JN, Dorr LD, Scott RD, et al. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989; 248:13.
15. Saleh KJ, Mulhall KJ, Bershadsky B, et al. Development and validation of a lower-extremity activity scale. Use for patients treated with revision total knee arthroplasty. J Bone Joint Surg Am 2005;87:1985.
16. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). JAMA 2001;285:2486.
17. Lee CM, Huxley RR, Woodward M, et al. Comparisons of metabolic syndrome definitions in four populations of the Asia-Pacific region. Metab Syndr Relat Disord 2008; 6:37.
18. Bo S, Gentile L, Ciccone G, et al. The metabolic syndrome and high C-reactive protein: prevalence and differences by sex in a southern-European population-based cohort. Diabetes Metab Res Rev 2005;21:515.
19. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. JAMA 2002;287:356.
20. Grundy SM, Brewer Jr HB, Cleeman JI, et al. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation 2004; 109:433.

21. Marques-Vidal P, Mazoyer E, Bongard V, et al. Prevalence of insulin resistance syndrome in southwestern France and its relationship with inflammatory and hemostatic markers. Diabetes Care 2002;25:1371.
22. Bulwer BE. Sedentary lifestyles, physical activity, and cardiovascular disease: from research to practice. Crit Pathw Cardiol 2004;3:184.
23. Laaksonen DE, Lakka HM, Salonen JT, et al. Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. Diabetes Care 2002;25:1612.
24. Kasapis C, Thompson PD. The effects of physical activity on serum C-reactive protein and inflammatory markers: a systematic review. J Am Coll Cardiol 2005;45:1563.
25. Bauman S, Williams D, Petruccelli D, et al. Physical activity after total joint replacement: a cross-sectional survey. Clin J Sport Med 2007;17:104.
26. Woodruff MJ, Stone MH. Comparison of weight changes after total hip or knee arthroplasty. J Arthroplasty 2001; 16:22.
27. Heisel C, Silva M, dela Rosa MA, et al. The effects of lower-extremity total joint replacement for arthritis on obesity. Orthopedics 2005;28:157.
28. Lachiewicz AM, Lachiewicz PF. Weight and activity change in overweight and obese patients after primary total knee arthroplasty. J Arthroplasty 2008;23:33.
29. Esposito K, Ciotola M, Maiorino MI, et al. Lifestyle approach for type 2 diabetes and metabolic syndrome. Curr Atheroscler Rep 2008;10:523.
30. Ross R, Dagnone D, Jones PJ, et al. Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. A randomized, controlled trial. Ann Intern Med 2000;133:92.
31. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med 2002; 346:393.
32. Kim HA, Kim S, Seo YI, et al. The epidemiology of total knee arthroplasty in South Korea. Rheumatology 2008; 47:88.