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## Time trends in the Characteristics of Patients Undergoing Primary Total Knee Arthroplasty

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### Abstract

**Objective**—To study the time-trends in socio-demographic and clinical characteristics of patients undergoing primary total knee arthroplasty (TKA).

**Methods**—We used the Mayo Clinic Total Joint Registry to examine the time-trends in patient demographics (body mass index [BMI], age), underlying diagnosis, medical (Deyo-Charlson index) and psychological comorbidity (anxiety, depression) and examination findings of primary TKA patients from 1993–2005. We used chi-square test and analysis of variance.

**Results**—7,229 patients constituted the primary TKA cohort; 55% were women. The mean age decreased by 1.3 years (69.3 to 68.0), BMI increased by 1.7 kg/m<sup>2</sup> (30.1 to 31.8) and Deyo-Charlson index increased by 36% (1.1 to 1.5) over the 13-year study period ( $p < 0.001$  for all). Compared to 1993–95, significantly more patients (by 2–3 times) in 2002–05 had ( $p < 0.001$  for all): BMI 40, 4.8% vs. 10.6%; age <50, 2.9% vs. 5.2%; Deyo-Charlson index of 3, 12% vs. 22.3%; depression, 4.1% vs. 14.8%; anxiety, 4.1% vs. 8.9%; and a significantly fewer had an underlying diagnosis of rheumatoid/inflammatory arthritis, 6.4% vs. 1.5%. Compared to 1993–95, significant reductions were noted in 2002–05 for the physical examination findings ( $p < 0.001$  for all): knee joint effusion, anterior-posterior knee instability, medial-lateral knee instability, moderate-severe knee synovitis, severe limp, fair or poor muscle strength and absent peripheral pulses.

**Conclusions**—In this large U.S. total joint registry study, we found significant time-trends in patient characteristics, diagnosis, comorbidity and knee/limb examination findings in primary TKA patients over 13-years. These secular trends should be taken into account when comparing outcomes over time and in policy-making decisions.

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**IRB approval:** The Mayo Clinic Institutional Review Board approved this study and all investigations were conducted in conformity with ethical principles of research.

## Keywords

Total knee replacement; time trends; arthroplasty; joint replacement; diagnosis; obesity; comorbidity; osteoarthritis

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Primary TKA is the most common joint replacement surgery performed in the U.S. and is associated with significant improvement in patient outcomes (1). The burden of primary TKA is rapidly increasing and at least 500,000 procedures were performed in the U.S. in 2009 (2–5). Recent studies have described the time-trends in utilization and outcomes after primary TKA (2, 6–8). However, this addresses only one aspect of this issue. The other aspect is to understand whether the patient complexity is also changing over time, and if so, how. Not surprisingly, the studies of changing characteristics of patients undergoing TKA are gaining more attention.

To our knowledge only few such studies of U.S. population have been published, each with limitations. In Medicare recipients 65 years and older undergoing TKA, the number of comorbidities increased from 1.2 to 2.3 from 1991 to 2010 (2). However, these data are not representative of all patients, since at least 1/3<sup>rd</sup> of all TKAs are performed in those younger than 65 (4, 9), the fastest growing age group for the receipt of TKA over time (10). A more representative study of the national inpatient sample (NIS), a dataset that includes all age groups, showed a decrease of age of 2 years and a 35% increase in Deyo comorbidity index in patients undergoing TKA from 1998 to 2008 (6), confirming a similar earlier finding using NIS data (11). While these studies provided an initial insight into the time-trends in age and comorbidity, several important characteristics of patients undergoing TKA have not been examined. Time trends in key patient characteristics, including the underlying diagnosis (12–14), body mass index (BMI) (15–17) and patients' psychiatric comorbidity (12, 18–22), which have all been linked to TKA outcomes, have not been studied in detail.

Understanding better how these important determinants of patient outcomes are changing over time can allow us to truly understand the change in patient outcomes after TKA over time. It is not known to what extent the time-trends in these patient characteristics (underlying diagnosis, BMI and psychiatric and medical comorbidity) vary by age, which is unarguably the most rapidly changing characteristic of patients undergoing primary TKA. None of the previous studies examined whether preoperative surgeon's knee examination findings have changed over time. Physical examination findings, in particular, the overall knee joint assessment, constitute important information for the surgeon making treatment decisions, potentially impacting surgical choices. Our aim was to examine time-trends in these important, but understudied characteristics of patients undergoing primary TKA. We used the data from a U.S. institutional total joint registry to address our objectives to: (1) examine time trends in key patient characteristics, i.e., BMI, underlying diagnosis and psychiatric and medical comorbidity; (2) assess whether these time-trends were similar in younger and older patients; and (3) study whether surgeon examination findings of the index knee, including stability and synovitis, have changed over time.

## Methods

### Study cohort selection

We used the data from the Mayo Clinic Total Joint Registry, a large institutional registry that has prospectively collected preoperative and postoperative follow-up data on all patients who underwent arthroplasty at Mayo Clinic, Rochester since the first hip and knee arthroplasty were performed in 1969 and 1971, respectively (23). Preoperative data are reported by patients and recorded by orthopedic surgeons using a standardized data collection form and trained, dedicated Total Joint Registry staff coordinators ensure the completeness of data. Since 1993, registry staff have captured and entered these data into electronic database. We chose the study period of 1993–2005 to study the recent time-trends in the last decade and since electronic data were available for this period. The Mayo Clinic Institutional Review Board approved this study and all investigations were conducted in conformity with the ethical principles of research.

### Study outcomes

We studied the time trends by dividing the study period into four intervals (1993–95, 1996–98, 1999–2001 and 2002–05). The outcomes of interest were: (a) patient characteristics: BMI, diagnosis; (b) medical comorbidity assessed by Deyo-Charlson index comorbidities; (c) psychological comorbidity assessed by anxiety and depression; and (d) surgeon's knee examination findings including joint effusion, synovitis, peripheral pulses, instability (medial-lateral and anterior-posterior), active range of motion and muscle strength.

Patient characteristics and clinical variables were categorized as follows. Age was categorized as previously,  $\leq 60$ ,  $>60-70$ ,  $>70-80$  and  $>80$  years (24–26). BMI was categorized as normal,  $<25$ , overweight,  $25-29.9$ , obese and very obese,  $30-39.9$ , or extremely obese,  $\geq 40$  as previously (24), as per WHO classification (27). Operative diagnosis was categorized as follows: osteoarthritis, rheumatoid arthritis (RA)/inflammatory arthritis, and other. Medical comorbidity was assessed with the Deyo-Charlson index (28), a validated measure of comorbidity, consisting of a weighted scale of 17 comorbidities (including cardiac, pulmonary, renal, hepatic disease, diabetes, cancer, hemiplegia etc.), expressed as a summative score (29, 30), and individual comorbidities. Deyo-Charlson index was based on the presence of International Classification of Diseases, ninth revision, common modification (ICD-9-CM) codes at the time of surgery. Deyo-Charlson index was categorized as none, one, two and three or more comorbidities, similar to previous studies (31). Depression and anxiety were assessed based on the presence of the respective ICD-9-CM codes at the time of index TKA.

To examine the time-trends in patient characteristics by age, we categorized age into categories considering the Medicare age cut-off of 65 years, as  $<50$ ,  $50-65$ ,  $65-80$  and  $>80$ , to make our findings comparable to current and future studies using Medicare data.

### Statistical Analyses

Summary statistics were calculated as proportion or mean (standard deviation). The number of patients within each category (proportion) of patient characteristic was compared using

the chi-square test. Means were compared using analysis of variance. Analyses were performed using Statistical Package for Social Sciences (SPSS, version 21, Chicago, IL). A p-value <0.05 was considered significant.

## Results

The primary TKA cohort consisted of 7,229 patients, 55% were women, 10% were 80 years or older, 8% had BMI of 40 or more, 44% had ASA grade III–IV, the diagnosis was OA in 94% and 98% had cemented/hybrid implant fixation (Table 1).

### Time Trends in socio-demographic and clinical characteristics

The mean age decreased by 1.3 years over the 13-year period of study and the mean BMI increased by 1.7 kg/m<sup>2</sup> over the same time period, both statistically significant (Table 2). A significant higher proportion of patients had BMI ≥ 40 in most recent period compared to the earliest period, 4.8% to 10.6%. Another significant observation was that proportion of those 50 years and younger doubled over the study period. The underlying diagnosis for patients undergoing primary TKA changed over the study period with proportion of patients with RA/inflammatory arthritis decreasing from 6.4% in 1993–95 to 1.5% in 2002–05, the most recent period (Table 2). During the same period, medical comorbidity load, as measured by Deyo-Charlson score of 3 or more comorbidities increased from 12% to 22%, a statistically significant increase. The prevalence of preoperative anxiety and depression increased significantly, with prevalence of depression increasing >3-fold and anxiety >2-fold over the study period (Table 2).

### Time Trends in medical comorbidity

We noted a significant increase in the prevalence for all 17 Deyo-Charlson comorbidities over the study period except myocardial infarction, dementia, metastatic solid tumor and AIDS (Table 3). For example, the prevalence of congestive heart failure and peripheral vascular disease almost doubled during the study period (Table 3). The mean Deyo-Charlson comorbidity index increased by 36% from 1.1 to 1.5 during the study period.

### Time Trends in patient characteristics within each age group

We explored time trends in the prevalence of BMI ≥ 40 (extreme obesity), RA/inflammatory diagnosis as underlying diagnosis, Deyo-Charlson index of ≥ 3, depression and anxiety, within each age group. While an increase in prevalence of BMI ≥ 40 was noted in three younger age groups, the increase was most dramatic from 2.3% to 20.6% (>6-fold increase) in those younger than 50 years (Table 4). Similarly, the most significant decline in the proportion with an underlying diagnosis of RA/inflammatory arthritis was noted in the two younger age groups, those <50 years from 48.7% to 9.8% (80% reduction) and in those 50–65 years from 13.9% to 1.2% (91% reduction). The increase in proportion with depression was significant across all four age groups, but most impressive in the youngest group <50 years, from 2.3% to 17.1% (>7-fold).

The increase in prevalence in anxiety was noted in the three older age groups, being most impressive among the oldest age group, group ≥ 80 years, by almost 5-fold (Table 4). Deyo-

Charlson index of 3 or more increased significantly in higher age groups and the most impressive increase was seen in the two oldest groups, 65 to <80 and ≥80 years, by almost 2-fold and 2.5-fold respectively (Table 4).

### **Unadjusted and Adjusted Odds in key patient characteristics over time**

The odds of patients with BMI ≥40 in each period compared to the first period are shown in Table 5. In unadjusted analyses, compared to 1993–95, the odds of patients with BMI ≥40 were 1.62, 2.13 and 2.37 in the next three time periods (Table 5). After adjustment for age-, sex- and comorbidity in multiple models, we noted minimal attenuation of odds ratios (Table 5).

The odds of patients with RA/inflammatory arthritis as the underlying diagnosis were 0.79, 0.50 and 0.21 in the respective next three time periods, compared to 1993–95 (Table 5), which also were minimally attenuated with adjustment for age, sex- and comorbidity in the multivariable-adjusted models.

Compared to 1993–95, the odds ratios of higher comorbidity indicated by Deyo-Charlson index of 3 or more for the next 3 time periods were 1.11, 1.57 and 2.11, respectively. These odds were minimally attenuated with adjustment for age and sex (Table 5). The prevalence of depression increased by 1.77, 2.61 and 4.04 and the prevalence of anxiety increased by 1.30, 1.33 and 2.27 higher odds in the respective three time periods. There was minimal attenuation of odds in the three hierarchical multivariable-adjusted models for both anxiety and depression.

### **Time Trends in examination findings**

We examined the time trends in knee examination findings by the surgeon. Over time, there were significant reductions in the prevalence of knee joint effusion, anterior-posterior instability, medial-lateral instability, severe limp, fair or poor muscle strength, absent peripheral pulses and moderate-severe synovitis (Table 6). Active knee range of motion improved over time, with fewer proportion of patients with <90 degrees knee motion (Table 6).

## **Discussion**

In summary, in this U.S. Total Joint Registry study of 13-year data, we found significant time-trends in important patient demographic and clinical characteristics, as well as surgeons' physical examination findings. Key changes were a significant reduction in age and the proportion of patients with RA/inflammatory arthritis as the underlying diagnosis, but also a significant increase in BMI, Deyo-Charlson index, depression and anxiety. There was a reduction in the prevalence of worse joint examination findings over time, and more patients had normal peripheral pulse and muscle strength examinations in later time periods than earlier. This indicates that while the overall patient medical and psychiatric morbidity has increased over time, the joint morbidity has declined. To our knowledge, this is the first study to examine time-trends in underlying diagnosis, depression, anxiety, specific medical comorbidities and knee examination findings in patients undergoing primary TKA. Several study findings deserve further discussion.

Several findings in our study are new, and add to the current knowledge. First, we provided time trends in each of the 17 Deyo-Charlson index comorbidities and the overall comorbidity score. On further analyses by age groups, this increase in comorbidity load over time was primarily seen in those aged 80 years or more (2.5-fold increase from 1992–1995 to 2002–2005 of those with Deyo-Charlson score of 3 or higher) and in those 65 to <80 year (2-fold). This indicates that although much younger patients are now undergoing primary TKA than 1.5 decades ago, those that are 65 years and older have a much higher medical comorbidity load than before. With the exception of few comorbidities, that did not have a significant upward time-trend, most comorbidities such as congestive heart failure, peripheral vascular disease etc. increased in prevalence by almost 2-fold in our study period. The doubling confirms and extends a similar finding for diabetes and congestive heart failure from 1991 to 2010 in Medicare patients undergoing TKA (2), now extended to all age groups in our study. While overall medical comorbidity has increased in the last 2 decades in patients undergoing primary TKA, our previous study showed no increase in 30-day post-operative complications (2). This indicates that TKA is being offered to patients with higher comorbidity and that postoperative complication rates have not increased suggesting an improved perioperative management. The discrepancy between an increase in the diagnosis of peripheral vascular disease (3.9% to 7.7%) and an increasing rate of normal peripheral pulses on examination (65% to 78%) is unexplained; it may indicate a discrepancy between physical examination and diagnosis made based on history, examination and imaging.

Another novel finding was the increasing prevalence of depression and anxiety in patients undergoing primary TKA, over time. Over a similar period, the increase in depression in the general U.S. population was from 3.3% to 7.1% (1991 to 2002), a rate lower than that in our TKA sample (32). In 2002, the prevalence of anxiety in the US population was 11.1% (33), similar to the 9% rate in our arthroplasty population. To our knowledge, there are no previous comparator studies examining the time-trends in anxiety and depression in primary TKA patients. Although, this increase was seen across all age categories, it was most impressive in the youngest age group. Anxiety and depression are well-recognized predictors of poorer pain and function outcomes after arthroplasty (20, 21, 25, 34). This has important implications for patient care. Our study suggests that increasing medical and psychological comorbidity was evident in patients undergoing primary TKA, who were also on average, were one year older compared to 1.5 decades ago. This higher patient comorbidity can lead of variation in arthroplasty outcomes, including PROs, over time.

An interesting observation from our study was that while comorbidity increased over time, joint/limb examination findings improved over time, with lower prevalence of joint effusion, synovitis, poor muscle strength and severe limp over time and better range of motion. Thus, our study is among the first to document an interesting dichotomy between the statuses of the knee joint vs. general health over time in primary TKA. These study findings lay the foundation for future research that should explore whether patients undergoing primary TKA in the recent years have better or worse pain and functional limitation at the time of surgery compared to previous time-periods, and whether postoperative PROs such as pain, function and quality of life outcomes, are improving or worsening over time.

The prevalence of extreme obesity has increased over the study period, with the majority of increase in the youngest age group of those <50 years, where it's prevalence increased by 8-times from 2.3% to 20.6%. This is a new finding as well. These increasing rates of obesity in TKA patients are consistent with the obesity epidemic in the U.S. (35, 36) and imply that not only is the obesity epidemic leading to higher rates of TKA, but also that patients undergoing TKA are more obese now than in the past (37).

The prevalence of an underlying diagnosis of RA/inflammatory arthritis decreased dramatically overall from 6.4% to 1.5%, a >75% reduction. Similarly, the proportion of patients with inflammatory findings on surgeon's examination decreased over time, as evident on synovitis and knee joint effusion, corroborating these findings. The most dramatic reduction in RA/inflammatory arthritis occurred in those younger than 50 years. The likely dramatic reduction in RA/inflammatory arthritis as the underlying diagnosis is likely due to the availability and more frequent use of effective disease-modifying treatments for RA, including methotrexate and/or biologics (38, 39).

Our study confirms previous findings of reduction in age of almost 2 years in patients undergoing knee arthroplasties in the U.S. from 1998–2008, as noted in the NIS sample, a nationally representative sample (6). A 36% increase in Deyo-Charlson index was noted in our study, which is in line with the 36% increase in NIS study (6). The study durations were similar. Our findings not only confirm these findings, but the similarity of the magnitude of change to a national study indicates that our single center sample is representative of the U.S. adults undergoing primary TKA.

At least 1/3<sup>rd</sup> of all TKAs are performed in those younger than 65, as demonstrated in recent studies of the Kaiser Permanent Joint Registry (4) and the NIS (9) that has a representative U.S. sample. This younger age group is also the fastest growing group for the receipt of TKA over time among all age groups (9, 10). Therefore, we performed analyses of change in demographics, diagnosis, and comorbidity by age categories in our study, which provided important information and helped us understand time-trends better.

Our findings have important implications for the policy makers, who assess the costs and benefits of various procedures and their contribution to improving health to make the reimbursement and coverage decisions. Clearly, there has been a major change in the demographics of patients undergoing primary TKA in the U.S. in the last two decades, making this an important consideration for policy makers. In the recent years, a higher proportion of much younger patients who are more obese than before and older patients who are much sicker medically and psychologically compared to the years prior, are now undergoing primary TKA procedures. Additionally, a lower proportion of patients undergoing primary TKA have rheumatoid arthritis as the underlying diagnosis in the recent years.

These findings also have implications for patients. We noted an increase in patient medical and psychological comorbidity and obesity over years, alongside no increase in post-TKA complications (2). This suggests that better and more efficient peri-operative pathways that improve peri-operative comorbidity management and lower the risk of post-operative

complications (40–42), better patient knowledge and participation (43) and lower preoperative functional limitation (less limp, less knee instability etc., as shown in our study) may have contributed to stabilized/improving medical and local complications outcomes post-TKA. Better knowledge and less postoperative complications may also increase patient satisfaction and expectations, both of which have positive impact on post-arthroplasty pain and function outcomes (44–48). We are not aware of any major change related to TKA insurance coverage or in TKA indications during this study period that can explain these time-trends; the changes in reimbursement related to diagnosis-related group (DRG) preceded the study period (49).

So, what unique information does this study add to the previous studies from Medicare or NIS data? Studies using Medicare data help us understand TKA epidemiology and outcomes in U.S. adults 65 and older, but are not representative of all-comers for TKA in the U.S. NIS offers an excellent resource to examine questions in time-trends and in-hospital outcomes. Data on several important patient characteristics are limited in these datasets that can be examined more comprehensively using data from total joint registries. Neither dataset provided surgeon's examination findings, which are important in surgeon's decisions and were collected systematically in our total joint registry.

Our study had several strengths and limitation. The study strengths include a large representative sample from a well-established U.S. total joint registry, the completeness of data on a majority of the patients, availability of electronically captured data for more than a decade and robustness of our findings across several models. Our findings must be interpreted considering study limitations. One may question, whether findings from a single medical center are applicable to other settings. However, our institution provides surgical care for referrals from other institutions as well as primary orthopedic care to the local population (similar to community-based practices). The similarity of our cohort to other published studies (50–52) as well as the NIS sample (6), and similarity in magnitude of increase in comorbidity to the recent NIS study (6) support our sample's representativeness and the generalizability of these findings. We adjusted our multivariable-adjusted analyses for several important covariates, but residual confounding is possible in a cohort study. The lack of radiographic data in electronic format in the total joint registry limited us from examining associated time-trends.

In conclusion, in this large study of primary TKA, we described the time-trends in demographic and clinical characteristics of patients over a 13-year study period. Higher rates of obesity, medical and psychological comorbidity, and decreasing prevalence of patients with RA/inflammatory arthritis, were noted in the 13-year study period. These findings have important implications for the policymakers, who need to take these important findings into account, when comparing results over time and across intervention and procedures and making public policy and reimbursement decisions. These data represent the changing complexity of primary TKA patients in the U.S. Surgeons and patients can have more informed discussion during the informed consent process in light of these findings. Future studies need to examine if pre-operative pain and functional limitation of patients are changing over time and to examine whether correlates of evolving postoperative PROs



including pain, functional limitation and quality of life have changed over time in patients undergoing primary TKA.

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### Significance and Innovation

1. Rate of extreme obesity (body mass index  $\geq 40$ ), high comorbidity (Deyo-Charlson index of  $\geq 3$ ) and anxiety have doubled over a decade in patients undergoing primary TKA.
2. The prevalence of depression in patients undergoing primary TKA increased almost four times over a decade.
3. We noted a 75% reduction in the proportion of patients undergoing primary TKA with an underlying diagnosis of rheumatoid/inflammatory arthritis.
4. Significantly fewer patients in the most recent years had preoperative evidence of joint effusion, synovitis or fair/poor muscle strength.

**Table 1**

Preoperative patient characteristics of the primary TKA cohort

	<b>Primary TKA (n=7,229) N (%) or Mean (SD)</b>
Gender	
Females	3,994 (55%)
Males	3,235 (45%)
Age	
<50	303 (4%)
50-65	1,748 (24%)
65- <80	4,456 (62%)
80	722 (10%)
BMI	
<25	938 (13%)
25-29.9	2,492 (35%)
30-34.9	2,137 (30%)
35-39.9	1,023 (14%)
40	608 (8%)
ASA class	
I	107 (2%)
II	3,944 (55%)
III	3,106 (43%)
IV	42 (1%)
Diagnosis	
Inflammatory arthritis	274 (4%)
Osteoarthritis	6,800 (94%)
Other	155 (2%)
Cement Fixation	
Uncemented	135 (2%)
Cemented/hybrid	7,084 (98%)
Age, mean (SD)	68.4 (9.8)
Deyo-Charlson Index, mean (SD)	1.3 (2.0)
BMI, mean (SD)	31.1 (6.0)

Missing data: BMI, n=31; ASA score, n=30

SD, standard deviation

**Table 2**  
Time trends in demographics and clinical characteristics of patients undergoing primary TKA

Age category	1993–1995 (n=1,510)	1996–1998 (n=1,646)	1999–2001 (n=1,593)	2002–2005 (n=2,480)	P-value
<50	2.9	3.0	5.0	5.2	<0.001
50–<65	19.5	23.9	25.0	26.7	
65–<80	67.2	63.9	59.6	58.1	
80	10.5	9.2	10.4	10.0	
Mean age (SD)	69.3 (9.5)	68.6 (9.1)	68.2 (10.2)	68.0 (10.0)	0.001
Female gender	55.6	55.3	55.2	55.0	0.99
BMI					<0.001
<18.5	0.5	0.3	0.1	0.3	
18.5–24.9	14.2	12.8	13.4	11.4	
25–29.9	37.4	36.0	35.0	31.8	
30–34.9	30.1	28.6	29.3	30.4	
35–39.9	13.1	14.7	12.6	15.6	
40	4.8	7.5	9.6	10.6	
Mean BMI (SD)	30.1 (5.4)	30.9 (5.9)	31.3 (6.2)	31.8 (6.3)	<0.001
Operative Diagnosis					<0.001
Osteoarthritis	89.7	92.3	95.1	97.2	
RA/inflammatory arthritis	6.4	5.2	3.4	1.5	
Other	3.9	2.4	1.5	1.3	
Deyo-Charlson Index					<0.001
0	53.6	56.7	50.2	45.7	
1	22.2	18.1	19.0	18.8	
2	12.3	12.0	13.2	13.1	
3 or more	12.0	13.2	17.6	22.3	
Depression	4.1	7.0	10.0	14.8	<0.001
Anxiety	4.1	5.3	5.4	8.9	<0.001

SD, standard deviation; RA, rheumatoid arthritis, BMI, body mass index

**Table 3**

Time trends in medical comorbidity from 1993 to 2005 in patients undergoing primary TKA

Deyo-Charlson comorbidities (in %)	1993–1995	1996–1998	1999–2001	2002–2005	P-value
Myocardial Infarction	4.2	4.6	4.9	5.8	0.10
Congestive Heart Failure	2.7	2.9	5.5	4.8	<0.001
Peripheral Vascular Disease	3.9	3.5	5.5	7.7	<0.001
Cerebrovascular disease	6.1	6.2	8.0	9.5	<0.001
Dementia	0.1	0.2	0.3	0.2	0.65
COPD	8.5	8.1	12.0	13.3	<0.001
Peptic ulcer disease	7.2	7.1	8.9	10.3	<0.001
Mild liver disease	1.3	1.6	2.3	3.0	0.001
Diabetes	6.8	9.8	10.4	12.2	<0.001
Diabetes with end organ damage	1.1	2.4	2.8	3.9	<0.001
Hemiplegia	0	0.2	0.4	0.4	0.04
Moderate/severe renal disease	3.8	4.3	5.3	7.9	<0.001
Moderate/severe liver disease	0.1	0.4	0.5	0.8	0.02
Metastatic solid tumor	4.0	2.8	2.6	3.1	0.09
AIDS	0.1	0	0	0	0.29
Rheumatologic disease	9.8	7.0	8.5	6.2	<0.001
Other cancer	12.8	12.3	14.1	17.6	<0.001
Mean Deyo-Charlson Score (SD)	1.1 (1.9)	1.1 (1.9)	1.3 (2.0)	1.5 (2.2)	<0.001

COPD, Chronic Obstructive Pulmonary Disease; AIDS, Acquired Immune Deficiency Disease; SD, standard deviation

Table 4

Time-trends in patient characteristics (in %) by patient age category from 1993 to 2005 in patients undergoing primary TKA

	1993-1995	1996-1998	1999-2001	2002-2005	P-value
BMI 40					
Age, <50	2.3	16.0	16.5	20.6	0.043
Age, 50-<65	10.2	12.7	17.9	19.2	0.001
Age, 65-<80	3.9	5.9	6.9	7.2	0.006
Age 80	0.6	2.0	1.8	2.0	0.72
Diagnosis of RA/inflammatory arthritis					
Age, <50	48.7	19.6	16.2	9.8	<0.001
Age, 50-<65	13.9	7.8	3.1	1.2	<0.001
Age, 65-<80	3.9	4.2	2.9	1.0	<0.001
Age 80	0.6	2.8	1.8	1.2	0.48
Deyo-Charlson Index 3					
Age, <50	9.1	2.0	3.8	8.5	0.25
Age, 50-<65	7.1	7.4	10.6	12.7	0.01
Age, 65-<80	13.0	15.0	19.4	25.1	<0.001
Age 80	15.2	19.2	31.3	38.9	<0.001
Depression					
Age, <50	2.3	10.0	8.8	17.1	0.041
Age, 50-<65	4.4	7.4	11.1	18.1	<0.001
Age, 65-<80	4.0	7.0	9.8	12.6	<0.001
Age 80	4.4	5.3	9.6	17.0	<0.001
Anxiety					
Age, <50	0	4.0	3.8	7.0	0.27
Age, 50-<65	1.7	4.8	6.3	8.9	<0.001
Age, 65-<80	5.2	5.1	5.0	8.5	<0.001
Age 80	2.5	7.9	6.6	12.1	0.005



**Table 5**

Unadjusted and adjusted odds of extreme obesity (BMI of 40 or higher), an underlying operative diagnosis of RA/inflammatory arthritis, Deyo-Charlson index of 3 or higher, depression or anxiety over time

		1993–1995	1996–1998	1999–2001	2002–2005
<b>BMI 40 (extreme obesity)</b>					
Unadjusted	Ref	1.62 (1.20, 2.18) <sup>†</sup>	2.13 (1.59, 2.84) <sup>*</sup>	2.37 (1.81, 3.10) <sup>*</sup>	
Age- and sex-adjusted	Ref	1.50 (1.11, 2.03) <sup>†</sup>	1.98 (1.48, 2.67) <sup>*</sup>	2.19 (1.67, 2.88) <sup>*</sup>	
Comorbidity-adjusted	Ref	1.62 (1.20, 2.18) <sup>†</sup>	2.12 (1.58, 2.82) <sup>*</sup>	2.34 (1.78, 3.06) <sup>*</sup>	
Age-, sex- and comorbidity adjusted	Ref	1.51 (1.11, 2.05) <sup>†</sup>	1.96 (1.46, 2.63) <sup>*</sup>	2.11 (1.60, 2.78) <sup>*</sup>	
<b>Diagnosis of RA/ inflammatory arthritis</b>					
Unadjusted	Ref	0.79 (0.58, 1.07)	0.50 (0.35, 0.70) <sup>*</sup>	0.21 (0.15, 0.31) <sup>*</sup>	
Age- and sex-adjusted	Ref	0.72 (0.53, 0.97) <sup>¶</sup>	0.44 (0.31, 0.63) <sup>*</sup>	0.19 (0.13, 0.27) <sup>*</sup>	
Comorbidity-adjusted	Ref	0.79 (0.58, 1.07)	0.48 (0.34, 0.68) <sup>*</sup>	0.20 (0.14, 0.29) <sup>*</sup>	
Age-, sex- and comorbidity adjusted	Ref	0.72 (0.53, 0.97) <sup>¶</sup>	0.43 (0.30, 0.61) <sup>*</sup>	0.17 (0.11, 0.24) <sup>*</sup>	
<b>Deyo-Charlson Index 3</b>					
Unadjusted	Ref	1.11 (0.90, 1.34)	1.57 (1.39, 1.92) <sup>*</sup>	2.11 (1.76, 2.53) <sup>*</sup>	
Age- and sex-adjusted	Ref	1.17 (0.94, 1.45)	1.66 (1.35, 2.04) <sup>*</sup>	2.26 (1.88, 2.72) <sup>*</sup>	
<b>Depression</b>					
Unadjusted	Ref	1.77 (1.29, 2.43) <sup>*</sup>	2.61 (1.93, 3.53) <sup>*</sup>	4.04 (3.06, 5.34) <sup>*</sup>	
Age- and sex-adjusted	Ref	1.76 (1.28, 2.42) <sup>*</sup>	2.61 (1.92, 3.53) <sup>*</sup>	4.06 (3.07, 5.36) <sup>*</sup>	
Comorbidity-adjusted	Ref	1.79 (1.30, 2.46) <sup>*</sup>	2.56 (1.89, 3.47) <sup>*</sup>	3.84 (2.90, 5.07) <sup>*</sup>	
Age-, sex- and comorbidity adjusted	Ref	1.77 (1.29, 2.44) <sup>*</sup>	2.54 (1.87, 3.44) <sup>*</sup>	3.81 (2.88, 5.03) <sup>*</sup>	
<b>Anxiety</b>					
Unadjusted	Ref	1.30 (0.93, 1.82)	1.33 (0.95, 1.86)	2.27 (1.70, 3.04) <sup>*</sup>	
Age- and sex-adjusted	Ref	1.32 (0.94, 1.85)	1.35 (0.97, 1.89)	2.33 (1.74, 3.11) <sup>*</sup>	
Comorbidity-adjusted	Ref	1.32 (0.94, 1.84)	1.30 (0.93, 1.82)	2.13 (1.60, 2.85) <sup>*</sup>	
Age-, sex- and comorbidity adjusted	Ref	1.32 (0.94, 1.85)	1.30 (0.93, 1.83)	2.16 (1.61, 2.89) <sup>*</sup>	

Ref, reference category

Osteoarthritis is the reference for diagnosis

<sup>¶</sup>P<0.05;

<sup>†</sup>P<0.01;

<sup>\*</sup>P<0.001

Table 6

Time trends in Physician examination findings of Index Knee Joint from 1993 to 2005 in patients undergoing primary TKA

	1993-1995	1996-1998	1999-2001	2002-2005	P-value
Knee Joint Effusion					
None	44.1	43.3	43.1	38.3	0.001
Slight	40.9	41.6	44.5	47.9	
Moderate	11.7	12.0	9.3	11.3	
Severe	0.8	0.8	0.8	0.6	
Synovitis					
None	53.6	58.8	60.1	57.0	<0.001
Slight	31.3	25.8	25.9	29.5	
Moderate	7.4	6.0	4.6	5.6	
Severe	0.7	0.5	0.1	0.2	
Knee Instability, anterior-posterior					
<5 mm	85.5	89.6	88.5	91.0	<0.001
5-10 mm	7.2	4.0	5.2	4.9	
>10 mm	0.4	0.4	0.6	0.4	
Knee Instability, medial-lateral					
<5 degrees	59.3	62.9	63.6	76.4	<0.001
5-10 degrees	33.4	29.3	29.6	19.3	
>10 degrees	1.9	2.2	2.0	1.2	
Limp					
None	10.4	11.7	13.5	8.2	<0.001
Slight	40.6	43.8	44.4	44.6	
Moderate	21.1	20.7	20.0	38.2	
Severe	12.3	11.8	9.8	8.2	
Unable to walk	1.5	0.5	0.9	0.5	
Muscle strength					
Good	75.2	77.9	83.1	85.2	<0.001
Fair	16.4	14.2	11.7	10.9	
Poor	1.5	2.0	1.1	1.0	

	1993–1995	1996–1998	1999–2001	2002–2005	P-value
Peripheral pulses					<0.001
Normal	65.2	71.9	73.4	77.7	
Diminished	20.3	16.3	17.5	16.0	
Absent	2.6	1.4	1.5	1.3	
Active Knee Range of motion*					<0.001
90 degrees	24.4	29.7	19.1	16.3	
91–100 degrees	17.6	15.4	16.5	15.9	
101–110 degrees	18.6	19.0	23.9	22.9	
111–120 degrees	19.0	19.7	22.0	26.9	
>120 degrees	20.3	16.3	18.4	18.0	

\* Due to missingness of measurements, data were available only for 4,840 patients for the active range of motion of the index knee