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Time Trends in Total Ankle Arthroplasty in the U.S.: A Study of the Nationwide Inpatient Sample

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Abstract

Objective—To assess the time-trends in utilization, clinical characteristics and outcomes of patients undergoing total ankle arthroplasty (TAA) in the U.S.

Methods—We used the Nationwide Inpatient Sample (NIS) data from 1998 to 2010 to examine time-trends in the utilization rates of TAA. We used the Cochran Armitage test for trend to assess time-trends across the years and the analysis of variance (ANOVA), Wilcoxon test or chi-squared test (as appropriate) to compare the first (1998–2000) and the last time periods (2009–10).

Results—TAA utilization rate increased significant from 1998 to 2010: 0.13 to 0.84 per 100,000 overall, 0.14 to 0.88 per 100,000 in females and from 0.11 to 0.81 per 100,000 in males (p<0.0001 for each comparison for time-trends). Compared to the 1998–2000, those undergoing TAA in 2009–10: were older (41% fewer patients <50 years, p<0.0001); less likely to have RA as the underlying diagnosis (55% fewer patients, p=0.0001); more likely to have Deyo-Charlson index of two or more (197% more, p=0.0010); and had a shorter length of stay at 2.5 days (17% reduction, p<0.0001). Mortality was rare, ranging 0 to 0.6% and discharge to inpatient facility ranged 12.6–14.1%; we noted no significant time-trends in either (p>0.05).

Conclusions—The utilization rate of TAA increased rapidly in the U.S. from 1998 to 2010, but post-arthroplasty mortality rate was stable. Underlying diagnosis and medical comorbidity changed over time and both can impact outcomes after TAA. Further studies should examine how the outcomes and complications of TAA have evolved over time.

Keywords

Ankle arthroplasty; time-trends; utilization; sex; outcomes

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Introduction

Total ankle arthroplasty (TAA) is a surgical treatment for end-stage ankle joint disease (1, 2), an alternative to ankle arthrodesis (3). The introduction of the new generation of ankle prostheses and associated improved outcomes (4–7), has likely led to a rapid increase in its popularity. Recent studies reported an improved 5-year survival of TAA implant at 83–86% in two arthroplasty registers (8, 9). Rates of ankle surgery (combined arthrodesis and TAA) in California peaked in the mid-1990s (10), but declined in the recent years from mid 1990s. Compared to 1983–1987, the relative risk of ankle surgery was 21% higher in 1993–1997 but 39% lower in 2003–2007 (10). This recent decline is ankle surgery rate (that included TAA) is in contrast to rapidly increasing rates of knee, hip and shoulder joint arthroplasty in the recent years (11–13). It is unclear why TAA rates should be declining, while the rates of all other arthroplasties are increasing.

To our knowledge, there are no published studies of time-trends in TAA using nationally representative data. A recent 10-year study using the national inpatient sample compared characteristics and outcomes TAA and ankle arthroplasty (14). The study examined time-trend in TAA volume and patient age from 2000–2010, but did not examine any time-trends in other patient characteristics or outcomes post-TAA and did not examine time-trends by age group or sex. Our objective was to assess the time-trends in patient characteristics and outcomes after TAA for the last 13-years in the U.S. using the Nationwide Inpatient Sample (NIS). We hypothesized that over the last 13-years (a) the utilization rates of TAA have increased, (b) the patient characteristics have changed, and (3) that the outcomes, i.e., length of hospital stay, proportion discharged to home and post-arthroplasty mortality, have improved.

Methods

Data Source

We used the data from the NIS from 1998 to 2010. The NIS is the largest all-payer inpatient care database that is publicly available in the United States, containing data from 5 to 8 million hospital stays and discharges from >1,000 hospitals sampled to approximate a 20-percent stratified sample of U.S. community hospitals; 45 states provide data in the NIS database that comprise over 96 percent of the U.S. population (15). The NIS provides data on hospital inpatient stays on all patients regardless of the payer and includes patients covered by Medicare, Medicaid, private insurance and the uninsured. It has been used to analyze national trends in health care utilization, and study quality of care and outcomes of various conditions during the inpatient stay (16–19). For each hospital admission, the International Classification of Diseases, ninth revision common modification (ICD-9-CM) diagnostic and procedure information are available. The NIS can be weighted to produce national estimates. The data are publically available for analyses. The Institutional Review Board (IRB) at University of Alabama at Birmingham approved the study.

Study Cohort and Covariates

For each Calender year starting from 1998, we identified patients in the NIS dataset with the ICD-9-CM procedure code of 81.56 for Total ankle arthroplasty (TAA). We abstracted patient demographic and clinical characteristics including age (<50, 50–64, 65–79 and 80 years), sex, underlying diagnosis (osteoarthritis (OA), rheumatoid arthritis (RA), avascular necrosis of the bone (AVN), fracture, traumatic arthroplasty and other conditions). Comorbidity was assessed using the Deyo-Charlson index, a validated measure of comorbidity, consisting of 17 comorbidities, based on the presence of ICD-9-CM codes at the index admission preoperatively (20). Hospital length of stay was calculated as the number of days from admission to discharge for the index TAA admission (the length of stay variable). Mortality was assessed using the mortality variable, which combines death either in the hospital, medical facility, home or place unknown related to the index admission.

Patient's discharge status was categorized as discharge to: (1) an inpatient facility that included the short term hospital, skilled nursing facility, intermediate care facility or another type of inpatient facility; or (2) to home with or without home health care. Patients who died in the hospital or left the hospital against medical advice were set to missing. We categorized the annual hospital volumes for TAA as <5, 5–9, 10–14, 15–24 and 25 procedures, based on a review of overall frequency distribution. We divided the calendar years a priori into roughly equal intervals as follows: 1998 – 2000, 2001 – 2002, 2003 – 2004, 2005 – 2006, 2007 – 2008 and 2009 – 2010.

Statistical Analyses

The utilization rates for TAA per 100,000 population for each year were calculated by dividing the estimates by the total population in the respective category, for overall and age-stratified utilization rates. The 95% confidence interval was calculated based on binomial proportions. We used the Cochran Armitage test for trend to assess time-trends across the years and the analysis of variance (ANOVA), Wilcoxon or chi-squared test (as appropriate) to compare the first and the last time periods. The tables show the crude (unweighted) estimates. Data weights were applied to obtain weighted estimates (http://www.hcup-us.ahrq.gov/reports/methods/2003_2.jsp#as) as recommended, presented in figures. Total U.S. population obtained from the U.S. census site (http://www.census.gov/compendia/statab/cats/population.html) was used to calculate TAA utilization rates and arthrodesis rates for the U.S. population, for the respective year. Mortality, length of stay and discharge disposition were compared by each time-period.

Results

Overall clinical and demographic characteristics

3,187 patients in the NIS sample underwent TAA between 1998 and 2010. The mean age of patients undergoing TAA was 61 year and 54% were female (Table 1). The underlying diagnosis was OA in 62%, RA in 7%, avascular necrosis in 1%, traumatic arthropathy in 18% and unspecified arthropathy/other in 12% (Table 1).

Time trends in utilization rates

346 patients underwent TAA in 1998 in the U.S. and 2,608 in 2010 (Table 2). The overall TAA utilization rate increased 7-fold from 0.12 per 100,000 in 1998 to 0.84 per 100,000 in 2010 (Table 2 and Figure 1A). In females, the TAA utilization rate increased 7.1 times from 0.14 per 100,000 in 1998 to 0.88 per 100,000 in 2010 (Figure 1B **and** Appendix 1). In males, TAA utilization rate increased 7.4 times from 0.11 per 100,000 in 1998 to 0.81 per 100,000 in 2010 (Figure 1B **and** Appendix 1).

We also analyzed age-specific TAA utilization rates. TAA utilization rates increased in three higher age categories over time, with relatively lesser increase for those <50 years over the study period (Figure 1C, Appendix 2).

Time trends in patient demographics and comorbidity

Over the 13-year period, the mean age of patients undergoing TAA increased by 1 year, from 61 years in 1998–00 to 62 years in 2009–10 (p<0.0001; Table 1). The proportion of female patients did not increase over the study period (p=0.49). Compared to the 1998–00, significantly fewer proportion of patients <50 years (41% fewer; p<0.0001) and more patients 80 years (85% higher; p=0.047) underwent TAA in 2009–10. RA was less frequently the underlying diagnosis in 2009–10 compared to the earlier periods (55% reduction compared to 1998–00; p=0.0001).

Over the study period, comorbidity increased. In particular, the proportion of patients with Deyo-Charlson index of two or more increased by 197% from 2.3% to 6.9% (p=0.001; Table 1). We noted a significant increase in the proportion of patients with certain Deyo-Charlson comorbidities including diabetes (5.9% to 11.4%; p=0.0024) and moderate or severe renal disease (0.3% to 2.4%; p=0.0073).

Time trends in TAA outcomes

The length of index hospital stay decreased significantly over the study period from 3 to 2.5 days (17% reduction; p<0.0001, Table 3). The proportion of patients being discharged to an inpatient facility increased non-significantly by 12% over the study period from 12.6% in 1998–00 to 14.1% in 2009–10 (p=0.47, Table 3). Mortality was rare after TAA (range, 0–0.6%) and the numbers were too small to perform time-trends comparison.

Discussion

To our knowledge, this is the first detailed study to assess time-trends in TAA utilization rates, patient characteristics and outcomes, in the U.S. population. A previous study of 10-years of NIS data found findings similar to our study with an increasing volume of TAA from 2000–10 and increasing patient age (14). Our study has several important observations that merit further discussion. A key observation in this study is the impressive 670% (or 6.7 times) increase in TAA utilization rate over a 13-year period, especially the increase since 2007. This may be related to better implants and surgical techniques, although the availability of more surgeons with training to perform TAA might also contribute. The previous study reporting a 39% decrease in the rate of ankle surgery (arthrodesis or TAA)

from 1993–1997 to 2003–2007 combined the two surgeries and analyzed data up to 2007 only (10). Therefore, our results focused only on TAA using contemporary data are more likely valid for patients undergoing TAA.

Thus, the increase in TAA utilization rate in the 13-year period far exceeded that noted for knee (3-times) and hip arthroplasty (50%) previously in a similar period (21). This is likely due to the recent evolution of this procedure compared to THA and TKA, surgeries that are well established. This recently rapidly increasing TAA rate also implies that studies are needed for future projections of TAA to assess its future burden and to see if the projected increase is similar to or greater than that projected for primary THA and TKA (174% and 673% respectively, from 2005 and 2030) (12). The increase in utilization rate was similar for females and males.

We also noted a significantly lower proportion of TAA recipients were younger than 50 years in recent years and the mean age of patients undergoing TAA increased by one year over the 13-year study period. Specifically, TAA utilization rates in age groups 50–64, 65–80 and 80 or more increased by 7–10 fold over the study period. This indicates that the increase in TAA utilization is largely attributable to a higher number of older patients receiving this procedure in the recent years.

Increasing comorbidity and increasing age of patients undergoing TAA over time is an important observation. This indicates an increasing complexity of patients, which might lead to worse outcomes over time. This needs to be factored in the interpretation of studies that examine TAA outcomes over time or compare study results to more historical older cohorts. Our finding of increasing age of patients undergoing TAA in the U.S. confirms a similar finding from a recently published study that used NIS data from 2000–10 (14).

There was a 55% reduction in the proportion of patients with RA as the underlying diagnosis for TAA from 1998 to 2010, an impressive decline over a short time-period. This may also be responsible for fewer patients younger then 50 years in the more recent years compared to previously (50% reduction), since RA is a more common reason for TAA in younger patients, as opposed to OA in older patients. For example, in our study 12% of patients under age 50 vs. 5.6% over age 50 had RA as the underlying diagnosis.

Mortality was rare after TAA, ranging 0–0.6%. The length of hospital stay decreased by 17% from 1998–00 to 2009–10. It is reassuring that discharge to inpatient facility was still <15% in recent years, implying that most patients are still being discharged to home. This is an important and impressive finding, given the increase in patient age and comorbidity over the same time. Shorter hospital stays and more discharges to non-home care setting over time have been noted in studies of knee/hip arthroplasty (13, 22).

Our study extends these findings to TAA cohorts. Our study has several limitations. NIS does not include federal facilities, which may miss a small number of patients receiving TAA at these health care facilities. Another limitation is that NIS treats each hospital admission as an event; we would theoretically miss if a patient underwent simultaneous bilateral TAA. This selection bias is likely small, given that bilateral TAA is rare. We used the entire US population and not the population at risk for the denominator for calculating

the rates, but this method has been used in other studies from NIS (23, 24). Comorbidity and underlying diagnosis were captured using the ICD-9 codes in the NIS, and given the method of diagnosis ascertainment, it is liable to misdiagnosis and underreporting.

This study has several strengths as well. The NIS is a nationally representative dataset and studies using NIS data for knee, shoulder and hip arthroplasty have been published (11, 12, 21, 25). We used ICD-9-CM codes for identifying TAA, similar to codes used in other arthroplasty studies, which were reasonably accurate (26). Confirmation of increasing age and increasing annual volume of TAA with time (27) in our study supports the robustness of this finding, now that two independent groups have reported the same finding with slight differences in methods and time-period.

In summary, in this first detailed study of time-trends in patient characteristics and outcomes of TAA in the U.S., a rapidly increasing TAA utilization rate over a 13-year period was noted. The increase in annual TAA volume was seen in both females and males. Patients with age 50 or older were the fastest growing age group for TAA. In the more recent years, more patients with higher comorbidity and older age received TAA than previously. This is an important observation, since increasing patient complexity over time can impact outcomes. More research is needed to understand the impact of increasing comorbidity and age over time on complications following TAA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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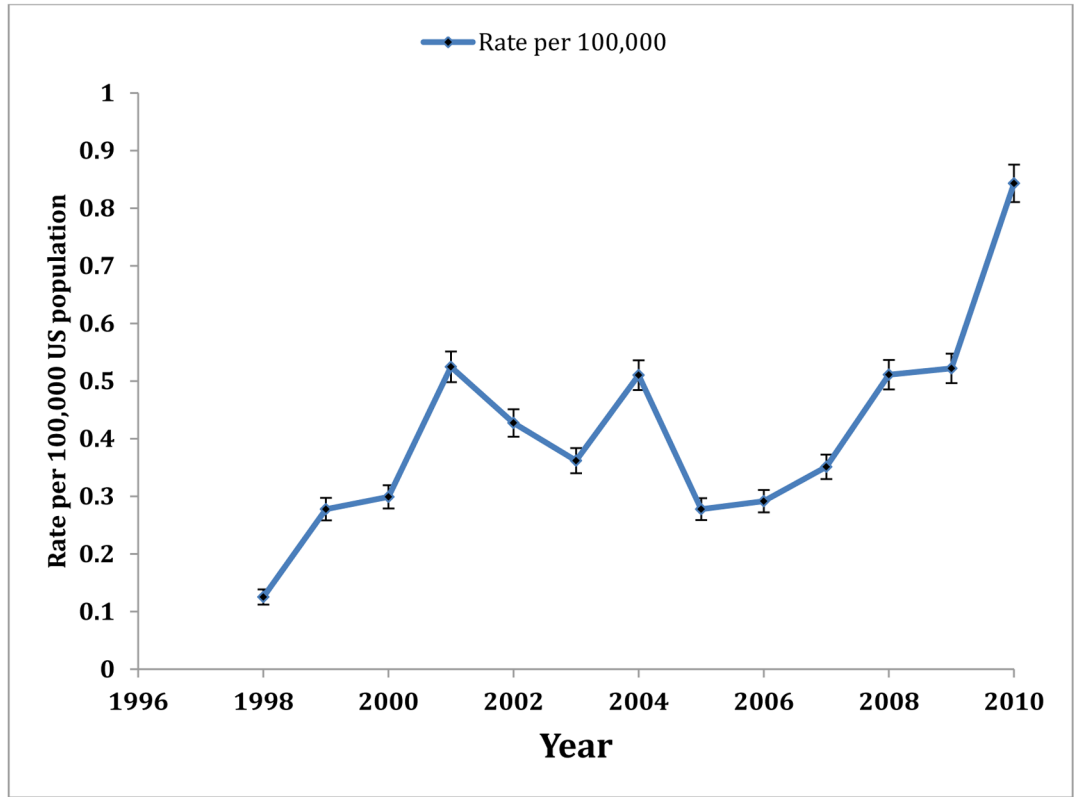
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1A. Overall TAA utilization

1B. TAA utilization by Sex
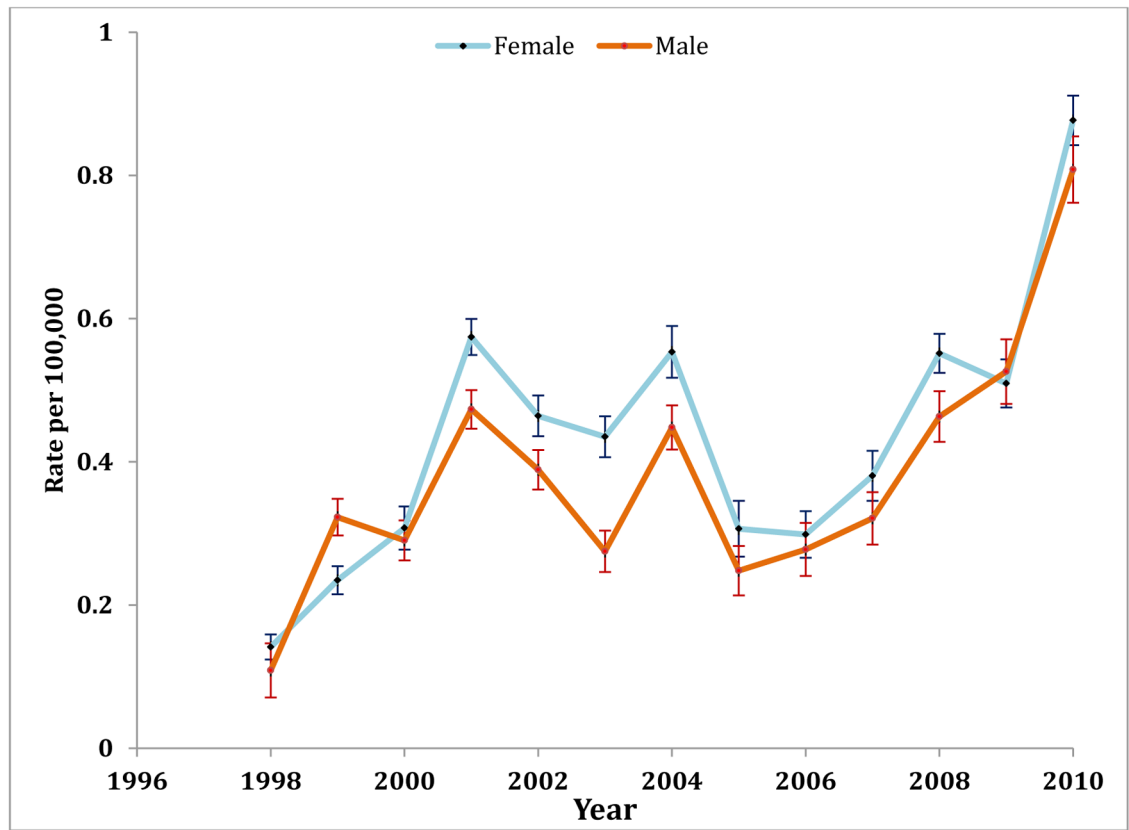
1C. TAA utilization by Age group
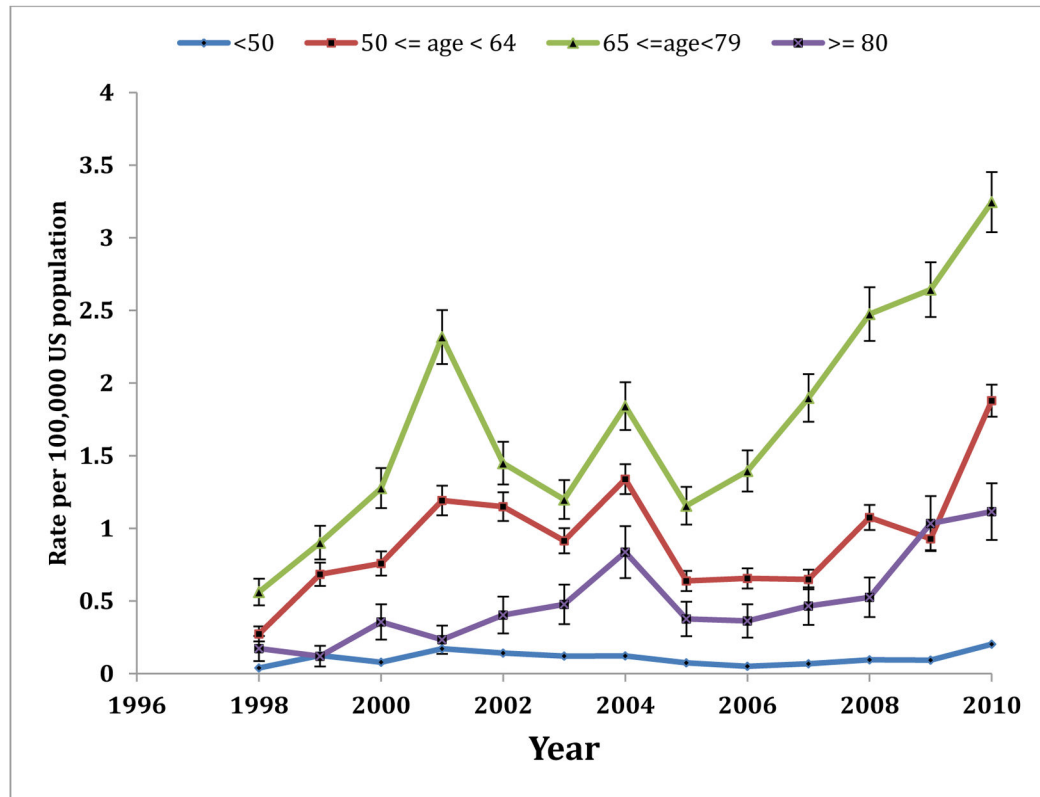
Figure 1.
Time trends in Utilization rates of Total Ankle Arthroplasty (TAA) per 100,000 population (weighted), overall (1A), by sex (1B) and age group (1C)

Whiskers represent 95% error bars

Table 1

Characteristics of patients undergoing primary total ankle arthroplasty

	All patients	Study time-periods						Comparison of 2009–10 (last) to 1998–00 (first)	
	1998–2010	1998–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	Last – first period (% difference)	p-value
Total	**3,187**	390	545	524	346	538	844	–	–
Mean Age	**61 (12.7)**	58 (14.0)	59 (13.2)	60 (12.4)	62 (12.6)	63 (11.6)	62 (12.2)	6.9%	**<0.0001**
% female	**53.9**	49.7	55.8	57.8	53.8	54.8	51.7	3.9%	0.49
Age group									
<50	**18.1**	24.9	23.8	19.7	15.3	13.2	14.6	−41.4%	**<0.0001**
50–64	**38.7**	35.6	38.3	42.7	39.0	36.2	39.1	9.7%	0.24
65–79	**38.6**	36.4	35.6	31.3	40.5	46.1	40.5	11.3%	0.16
80	**4.3**	3.1	2.2	5.1	4.6	4.1	5.7	84.7%	**0.047**
Hospital volume									
<5	**34.6**	37.2	29.0	35.7	44.5	39.2	29.4	−21.0%	**0.006**
5–9	**23.9**	17.7	21.3	19.7	32.4	28.6	24.8	40.0%	**0.006**
10–14	**10.7**	9.0	4.0	12.4	0	10.2	19.3	115.3%	**<0.0001**
15–24	**14.0**	13.8	17.3	20.0	15.3	8.0	13.0	−5.9%	0.69
25	**16.4**	22.3	28.4	12.2	7.8	13.9	13.5	−39.4%	**<0.0001**
Underlying diagnosis									
Osteoarthritis	**61.9**	56.7	56.5	60.3	72.8	67.8	60.7	7.0%	0.18
Rheumatoid arthritis	**6.7**	10.8	8.8	7.6	3.8	5.8	4.9	−54.9%	**0.0001**
Fracture	**0.1**	0	0.5	0	0	0	0	0%	-
Avascular necrosis	**0.7**	0.5	0.9	1.1	0.3	0.7	0.5	−7.8%	-
Traumatic arthropathy	**18.3**	21.0	24.2	17.1	11.8	11.9	20.5	−2.2%	0.83
Other	**12.3**	11.0	9.0	13.7	11.3	13.7	13.5	22.5%	0.22
Deyo-Charlson score									
0	**71.3**	73.6	73.2	75.2	73.4	66.9	68.4	−7.1%	0.06
1	**23.6**	24.1	24.9	21.2	21.7	23.6	24.8	2.7%	0.82
2	**5.1**	2.3	1.8	3.6	4.9	9.5	6.9	197.4%	**0.001**

-, small numbers did not allow for a comparison

Table 2

Utilization rates for TAA per 100,000 US populations based on NIS estimates

Year	Number of patients who underwent TAA	Rate per 100,000 US population
1998	346	0.13
1999	775	0.28
2000	844	0.30
2001	1,495	0.52
2002	1,229	0.43
2003	1,050	0.36
2004	1,494	0.51
2005	821	0.28
2006	870	0.29
2007	1,058	0.35
2008	1,554	0.51
2009	1,601	0.52
2010	2,608	0.84

Table 3

Temporal trends in length of stay, discharge to home and mortality after primary total ankle arthroplasty (TAA)

	All patients	Study Time-periods						Comparison of 2009–10 to 1998–00	
	1998–2010	1998–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	Last - first period (% Difference)	p-value
Length of stay mean (SD), days	**2.7 (2.1)**	3 (1.8)	2.7 (2)	2.9 (2.7)	2.7 (3.0)	2.4 (1.3)	2.5 (1.8)	−16.7%	<0.0001
Discharge, n (%)[a]									0.47
Home	**2,767 (87.0)**	340 (87.2)	490 (89.9)	463 (88.4)	300 (86.7)	450 (83.6)	724 (85.8)	−1.6%	
Inpatient facility	**412 (12.9)**	49 (12.6)	55 (10.1)	59 (11.3)	44 (12.7)	86 (16.0)	119 (14.1)	12.3%	
Mortality, n (%)	**4 (0.1)**	0	0	1 (0.2)	2 (0.6)	0	1 (0.1)	n/a	n/a

[a]
Information missing for 8 patients

n/a, not applicable, since the event rate was zero in the first and low in the last time-period