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Cementless versus Cemented Fixation in Total Knee Arthroplasty: Usage, Costs, and Complications during the Inpatient Period

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Abstract

Cemented fixation has been the gold standard in total knee arthroplasty (TKA). However, with younger and more active patients requiring TKA, cementless (pressfit) fixation has sparked renewed interest. Therefore, we investigated differences in (1) patient demographics, (2) inpatient costs, (3) short-term complications, and (4) discharge disposition between patients who underwent TKA with cemented and cementless fixation. The National Inpatient Sample database was queried for TKA patients with cement or cementless fixation between October 1 and December 31, 2015. Primary outcomes of interest included complications, length of stay (LOS), discharge disposition, and inpatient costs. Student's *t*-test and chi-square analysis were used to assess continuous and categorical data, respectively. Multivariable analysis evaluated the effects of fixation type on the continuous and categorical dependent variables. Patients who received cementless fixation were more often younger (63.5 vs. 65.9 years), male (47.4 vs. 40.3%), Black (10.7 vs. 7.7%), from the Northeast census region (29.1 vs. 17.1%), and under private insurance (49.2 vs. 40.3%; $p < 0.001$ for all). Cementless fixation involved higher inpatient hospital costs (US$17,357 vs. US $16,888) and charges (US$67,366 vs. US$64,190; $p < 0.001$ for both), lower mean LOS (2.63 vs. 2.71 days; $p < 0.001$), and higher odds of being discharged to home (odds ratio = 1.99; $p = 0.002$). This study revisited the outcomes of TKA with cementless fixation and demonstrated higher inpatient charges and costs, shorter mean LOS, and higher odds of being discharged home. Future studies should arthroplasty investigate patient outcomes and complications past the inpatient period, evaluate long-term survivorship and failure rates, and implement a prospective study design.

Keywords

cementless fixation; cementless total knee arthroplasty; total knee arthroplasty; cost

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Conflict of Interest

None.

Total knee arthroplasty (TKA) is a highly effective procedure for patients suffering from end-stage knee arthritis, with demand expected to grow nearly sevenfold by 2030.[1] Despite its success, there have been increasing pressures to improve patient outcomes and modernize TKA procedures to reflect the newer demands of health care reform[2–5] and accommodate a rapidly changing patient population. As such, several issues, including optimal surgical approach, type of prosthesis, efficacy of surgical assistive technologies, pain control, and infection prophylaxis, have surfaced as areas of contention.

Similarly, identifying the ideal fixation method has become a renewed topic of debate. While cemented fixation remains the gold standard due to its long reliable history, a growing demand for TKAs among younger and more active patients, in conjunction with growing concerns over cement-mediated osteolysis,[6–8] has led to a revisiting of cementless fixation TKAs. The use of cementless prostheses was first implemented as a response to early total hip arthroplasty (THA) failures in young patients.[9,10] While its success was demonstrated in THA recipients, early use of cementless TKA was less than promising due to reports of early tibial and patella component loosening.[11,12] However, this failure has since been attributed to early design flaws, which were characterized by poor osteoconductive surfaces and inadequate fixation devices.[13] Newer implants have incorporated effective solutions such as porous coatings, plasma spray, and rotating platforms that reduce stress conditions and micromotion at the bone-metal interface.

The reported benefits of cementless fixation are preservation of bone stock, decreased operating room time, ease of revision, and elimination of complications associated with cementing.[13] However, anecdotal reports have hinted toward higher costs associated with the use of cementless prosthesis. Thus, with newer studies reporting excellent short- and midterm outcomes with cementless TKA,[14–19] a comparison of costs and value outcomes between the two fixation methods is now warranted. This is increasingly more important as newer reimbursement models centered on cost reduction and quality improvement are being implemented in our nation's health care system.[2,3,20] Thus, the purpose of this study was to investigate differences in patient selection, costs, and quality outcomes between cemented and cementless TKA. More specifically, by using a large validated database, (1) patient demographics, (2) inpatient costs, (3) short-term complications, and (4) discharge disposition were assessed for patients who underwent a TKA procedure with either cemented or cementless TKA fixation.

Methods

Database and Patient Selection

The National Inpatient Sample (NIS) database was used to identify all patients who underwent a TKA procedure with either cemented (International Classification for Diseases, Tenth edition, procedure code [ICD-10 PCS]: 0SRD0J9 and 0SRC0J9) or cementless fixation (ICD-10 PCS: 0SRD0JA and 0SRC0JA). Exclusion criteria included patient age less than 18 years, patients who underwent TKA as a nonelective procedure, and patients without osteoarthritis as the primary diagnosis for TKA (►Fig. 1). This yielded a total of 167,930 cases (mean age = 65.83 years; women = 59.5%).

The NIS was created through a private and federal partnership between the Healthcare Cost and Utilization Project (HCUP) and the Agency for Healthcare Research and Quality. Currently, NIS is the largest all-payer inpatient care database in the United States, containing data on more than 7 million hospital stays annually.[21] Weighted, it estimates more than 35 million hospitalizations annually[22,23] and reliably reflects the U.S. demographics of all inpatient stays.[24] Prior to 2015, patient episodes of care were identifiable using ICD-9-CM coding; however, as of October 1, 2015, the NIS was updated to include ICD-10 coding system.[25]

Independent Variables

Patient demographics (age, gender, race, and insurance status) and hospital characteristics (rural, urban nonteaching, urban teaching, small bed size vs. large bed size, medium bed size vs. large bed size) were used as variables in predictive models. Charlson Comorbidity Index (CCI),[26–29] a validated predictor of inpatient mortality, hospital length of stay (LOS), 10-year mortality, and readmission, was used to assess patient preoperative health status.[30–32]

Risk Factors and Adverse Events

Complications were adopted from Martin et al,[33,34] which was grouped as either major or minor. Major complications include evidence of deep infection (T84.50XA), sepsis (ICD-10: T81.12, T81.1), shock (ICD-10: T81.10), wound dehiscence (ICD-10: T81.3, T81.31), pulmonary embolism (ICD-10: I26.90, I26.92, I26.99, I26.01, I26.02, I26.09), postprocedural cardiac failure/ insufficiency (ICD-10: I97.121, I97.110), cerebrovascular accident (ICD-10: I97.8), and death. Minor complications included superficial surgical site infection (L03.119, T814), postoperative pneumonia (ICD-10: J95.1, J95.2, J95.3, J95.4),[35] urinary tract infection (ICD-10: N99.89), peroneal nerve injury (S84.10XA), deep vein thrombosis (ICD-10: I82.401, I82.402 I82.403, I82.409), and acute renal failure (ICD-10: N17.0, N17.1, N17.2, N17.8, N17.9).[36] Coding adopted from HCUP. net[37] was used to distinguish between chronic and acute medical conditions. Discharge disposition was recoded as a binomial dependent variable, with “routine discharge” (i.e., transfer to home) coded as “1 “ and categories such as “transfer to short-term hospital” and “transfer other” (includes skilled nursing facility, intermediate care facility, or other type of facility, and home health care) coded as “0.”

Statistical Analysis

Continuous and categorical data were analyzed using Student’s *t*-test and chi-square analysis, respectively. All continuous data were assessed and corrected for violations to normality. Generalized mixed models were used to explore the effects of fixation methodology on continuous and categorical dependent variables. Firth’s log regression[38] was used for categorical data for small sample events. A two-tailed *p*-value of 0.05 was set as the threshold for statistical significance. Statistical analysis was conducted using SPSS version 25 (IBM Corporation, Armonk, NY) and R version 3.4.1.

Results

Patient Demographics and Hospital Characteristics

Analysis of weighted data demonstrated a statistically significant difference in age (63.5 vs. 65.9 years; $p < 0.001$), gender (women = 52.6 vs. 59.7%; $p < 0.001$), race (African-American = 10.7 vs. 7.7%; $p < 0.001$), census region (Northeast = 29.1 vs. 17.1%; $p < 0.001$), and primary payer (private insurance= 49.2 vs. 40.3%; $p < 0.001$) distributions between episodes of cementless and cemented TKA (►Table 1). There was a significant difference in CCI scores between the groups ($p < 0.001$), in which a lower proportion of patients with a CCI of 2 or more underwent cementless TKA fixation when compared with cemented fixation (6.1 vs. 8.4%). There was no difference in hospital location/teaching status between the two groups ($p = 0.103$).

Costs and Length of Stay

Analysis revealed higher total inpatient mean costs (US $16,010.43 vs. US$15,394.45; p = < 0.001) and charges (US$58,652.50 vs. US$57,383.35; $p = 0.006$) for episodes that involved cementless TKA fixation (►Table 2). Similarly, analysis demonstrated higher estimated mean costs (US $17,357.18 vs. US$16,887.92; $p < 0.001$) and charges (US $67,365.53 vs. US$64,190.12; $p < 0.001$) after adjusting for differences in patient demographics (age, gender, bed size, race, region, primary payer) (►Table 3).

There was a lower mean LOS for patients undergoing cementless TKAs (2.48 vs. 2.55 days; $p < 0.001$) (►Table 2). Even after adjusting for patient and regional level clustering, linear mixed effects modeling demonstrated a lower mean LOS for patients undergoing cementless TKAs (2.63 vs. 2.71 days; $p < 0.001$) (►Table 3).

Short-Term Complications and Discharge Disposition

General mixed models demonstrated no association between fixation methodology and the development of acute renal failure (adjusted odds ratio [OR]: 0.8344; $p = 0.088$), urinary tract infection (adjusted OR: 0.989; $p = 0.898$), or pulmonary embolism (adjusted OR: 1.247; $p = 0.492$) (►Table 4). Firth's log regression revealed no association between fixation type and the development of surgical site infection (adjusted OR: 2.31; $p = 0.99$) postoperative pneumonia (adjusted OR: 2.26; $p = 0.99$), or deep vein thrombosis (adjusted OR: 1.19; $p = 0.99$). There were no ICD-10-identifiable cases of deep infection, sepsis, shock, wound dehiscence, postprocedural cardiac insufficiency, cerebrovascular accident, and peroneal nerve injury in the database during this time period, thereby preventing analyses of these endpoints. Mixed-effects log regression analysis revealed slightly higher odds of being discharged to home if having received cementless TKA (OR = 1.99; $p = 0.002$) after adjusting for patient- and hospital-specific variables.

Discussion

Ideal fixation during TKA is a topic of contentious debate among arthroplasty surgeons. While cemented prostheses remain the current gold standard for fixation methodologies, evidence of an increasing demand among young and active patients, coupled with an

increasing life expectancy, has spurred renewed interests in the use of press-fit options. This study used NIS data to explore patient demographics and regional fixation differences, inpatient costs differences, LOS, and complication fixation differences for TKA recipients during the final quarter of 2015.

The difference in patient demographics may indicate selective use of cementless fixation modalities by arthroplasty surgeons. This comes as no surprise as cementless fixation technology is predicated on good bone quality with high metabolic activity,[39] which is negatively correlated with increasing patient age.[40] Furthermore, a higher proportion of cementless TKA recipients among private insurance beneficiaries may be a function of private insurance policies that more readily permit the use of newer technologies.[41] Still, it was interesting to note a higher proportion of African-Americans receiving cementless TKAs when compared with cemented TKA recipients (10.7 vs. 7.7%).

However, the increased acute care costs associated with cementless fixation (adjusted cost difference = +US$469.26) can spur some hesitation in its use. With increased government and private sector pressures to reduce costs, increased expenditure from cementless fixation may result unfavorably.[2,3,42] As such, the use of cementless fixation modalities may warrant some bargaining between arthroplasty providers and implant companies to decrease implant costs. This was demonstrated by Elbuluk and Bosco[43] in a continuous series involving 52 revision TKA episodes. The authors revealed an approximate US$7,000 and US$1,000 increase in acute care episode savings with “direct to hospital” and “fixed pricing” models, respectively, yielding a potential savings of US$8,000 per revision TKA based on implants alone.

Our mixed logit regression modeling revealed improved odds of discharge to home with cementless TKA when compared with cemented TKA (OR: 1.99). While this may demonstrate a small association between fixation choice and discharge status, it can translate to significant savings for high-volume arthroplasty institutions. This was illustrated by Zeng and Waldo in a retrospective review entailing 8,801 TKA surgeries.[44] In their study, the authors reported significant increases in 90-day costs for inpatient rehabilitation (+US $22,921; $p < 0.05$), skilled nursing facility (+US$15,489; $p < 0.05$), and home health care (+US$6,620; $p < 0.05$). Similarly, in a retrospective review of 2,328 consecutive TKA recipients, Barad et al[45] revealed that a decrease in mean LOS (2 days to 1.3 days) coupled with an increased discharge to home (9% to 53%) translated to a mean costs savings of US $3,245. Furthermore, the authors reported no change in readmission rates during the study duration (2009–2014).

Current studies have reported similar short- to long-term outcomes with cemented and cementless TKA. Prudhon and Verdier[46] retrospectively compared 100 cemented TKA with 100 cementless TKA (mean follow-up = 11 years; range: 11–16 years). The authors reported no difference in survivorship between the two groups (90.2 vs. 95.4%; $p = 0.32$). Similarly, Miller et al[15] compared midterm outcomes (mean follow- up = 5.3 years) in a case-control study of 400 primary TKAs (200 cemented TKAs vs. 200 cementless TKAs). The authors reported higher mean Knee Society functional scores (70 vs. 76; $p = 0.016$) and Knee Society knee scores (91.5 vs. 94.1; $p = 0.007$) at 2 years for the cementless TKA recipients.

Interestingly, one study reports the superiority of using cementless fixation for obese patients. In a multicentered review of 298, of which 292 were morbidly obese (body mass index > 40 kg/m^2), Bagsby et al[47] reported a higher rate of revisions among cemented TKA recipients when compared with patients who received cementless TKA (13 vs. 0.7%; $p < 0.05$). Additionally, the authors revealed superior improvement in postoperative range of motion for the cementless group (+23.7° vs. +5.7°; $p < 0.001$) when compared with cemented TKA recipients at final follow-up.

This study is not without its limitations. Our study is retrospective by nature and thus limits the assertions of causality. As such, any differences in our results should be interpreted as an association and not causation. Also, the NIS database covers inpatient episodes, thus rendering us incapable of exploring differences in costs and outcomes that extend past the acute care period. This may have impacted our ability to detect adverse events in that a large portion of complications related to TKA procedure and costs often occur after the acute care period. However, such analysis is still warranted as reimbursement models such as the inpatient prospective payment system incorporate negative adjustments for adverse events and excessive costs that occur during inpatient care periods.[48] Additionally, our analysis did not allow us to distinguish hybrid fixation options from fully cementless fixation. This limitation was due to lack of specificity in the ICD-10 coding to distinguish between the two modalities. Despite these limitations, the large representative sample size in our study allowed us to make well-powered comparisons and thus may be able to guide hospital administration policies and physician level of practice.

Conclusion

Although cemented fixation is presently the gold standard in TKA, a younger and more active patient population has reignited interest in the cementless technique. In this study, we demonstrate that TKA with cementless fixation is associated with higher inpatient charges and costs, shorter mean LOS, and higher odds of being discharged home relative to TKA with cemented fixation. Future areas of interest include a comparison of complications and patient outcomes occurring past hospital discharge, as well as long-term survivorship and failure rates of TKA with the present operative techniques and implant designs.

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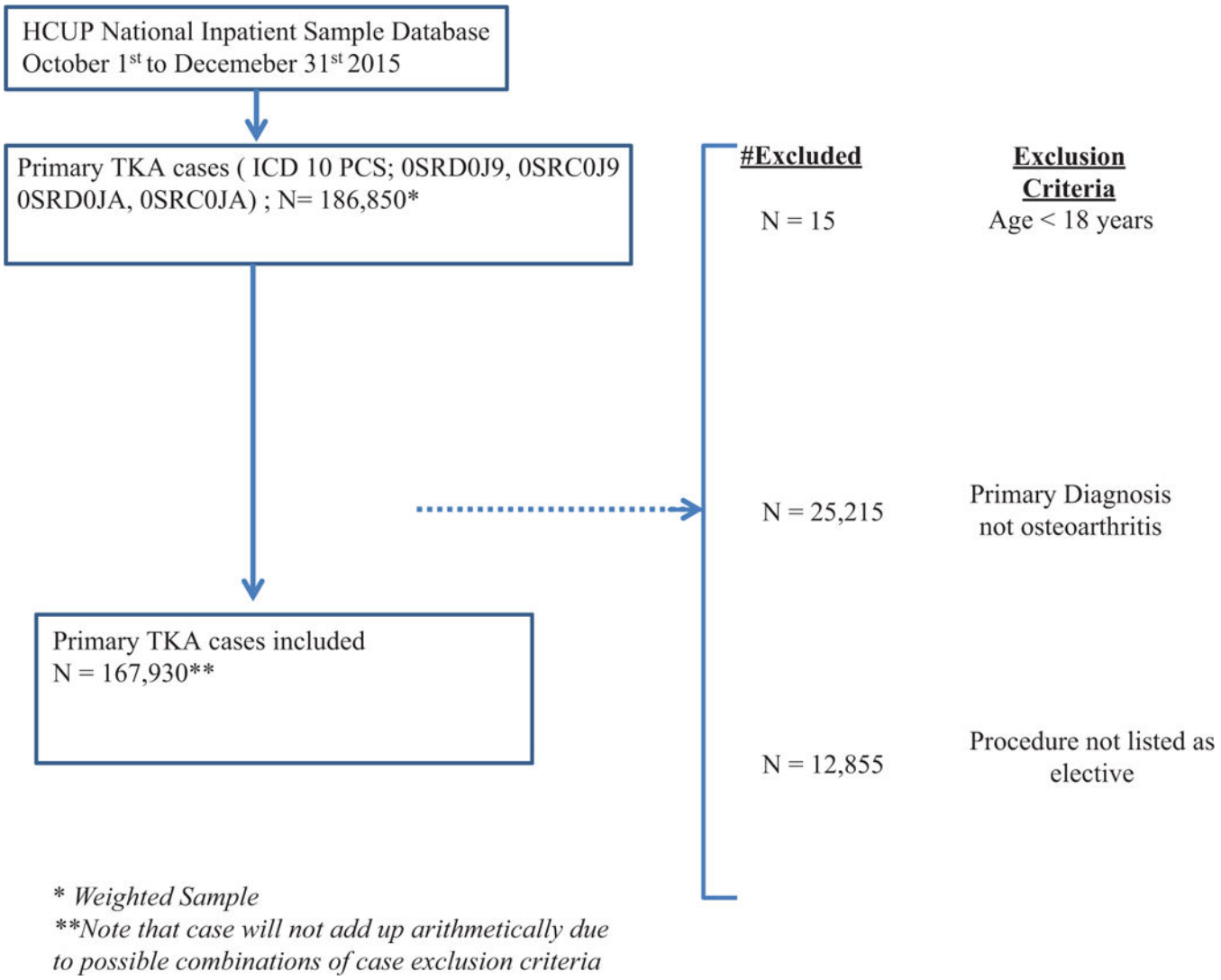

Fig. 1.
Exclusion criteria. TKA, total knee arthroplasty.

Table 1

Demographic and hospital characteristic between cementless and cemented TKA cases

	Cementless (4,870)	**Cemented (163,060)**	***p*-Value**
Mean age in years (standard deviation)	63.51 (9.45)	65.9 (9.5)	<**0.001**
Women	52.6%	59.7%	<**0.001**
Morbid obesity (BMI over 40 kg/m^2)	9.8%	9.4%	0.378
Charlson-Deyo comorbidity			
0	73.8%	71.4%	
1	20.1%	20.2%	<**0.001**
2	4.6%	6.4%	
3	1.5%	2.0%	
Bed size			
Small	28.1%	28.6%	
Medium	37.3%	29.0%	<**0.001**
Large	34.6%	42.4%	
Location/teaching status of hospital			
Rural	10.0%	10.1%	
Urban nonteaching	30.8%	32.2%	0.103
Urban teaching	59.2%	57.7%	
Race			
White	83.8%	83.2%	
Black	10.7%	7.7%	
Hispanic	3.1%	5.1%	<**0.001**
Asian or Pacific Islander	0.7%	1.6%	
Native American	0.0%	0.4%	
Other	1.8%	2.0%	
Region			
Northeast	29.1%	17.1%	
Midwest	23.7%	29.4%	
South	32.2%	34.1%	<**0.001**
West	14.9%	19.5%	
Primary payer			
Medicare	41.2%	53.0%	
Medicaid	5.8%	3.5%	
Private insurance	49.2%	40.3%	
Self-pay	0.5%	0.5%	<**0.001**
No charge	0.0%	0.0%	

Abbreviations: BMI, body mass index; TKA, total knee arthroplasty. Note: Statistically significant values appear in bold.

Table 2

Unadjusted comparisons for differences in costs, charges, and length of stay

	Cementless	**Cemented**	***p*-Value**
Mean charges (standard deviation)	US$58,652.50 (US$33,524.44)	US$57,383.35 (US$31,561.53)	0.006
Mean costs (standard deviation)	US$16,415.71 (US$6,557.79)	US$16,008.97 (US$6,790.50)	<0.001
Mean length of stay (standard deviation)	2.48 d (1.27 d)	2.55 d (1.42 d)	<0.001

Table 3

Comparison of costs, charges, and length of stay after adjusting for differences in patient and hospital characteristics

	Cementless	Cemented	*p*-Value
Mean charges (standard error)	67,365.53 (6,058.14)	64,190.12 (6,041.335)	<0.001
Mean costs (standard error)	17,357.18 (1,208.66)	16,887.92 (1,204.761)	<0.001
Mean length of stay (standard error)	2.63 (0.14)	2.71 (0.14)	<0.001

Table 4

Model[a] assessment for association between fixation type, adverse events, and discharge disposition

	Odds ratio[b]	*p*-Value	Confidence intervals
Acute renal failure	0.83	0.088	0.68 to 1.03
Urinary tract infection	0.99	0.898	0.83 to 1.17
Pulmonary embolism	1.25	0.492	0.66 to 2.34
Superficial surgical site infection	2.31	0.999	−5.05 to 10.68
Postoperative pneumonia	2.27	0.999	−5.01 to 10.31
Discharge home	1.99	**0.002**	1.29 to 3.08

[a]There were no ICD-10 (International Classification for Diseases, Tenth edition) identifiable cases of deep infection, sepsis, shock, wound dehiscence, postprocedural cardiac insufficiency, cerebrovascular accident, and peroneal nerve injury in the database during this time period.

[b]Reference = cemented total knee arthroplasty.

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