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Effect of Obesity on Total Knee Arthroplasty Costs and Revision Rate

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Abstract

An increasing number of total knee arthroplasties (TKAs) are performed on obese patients. It is imperative to remain up to date on the effect of obesity on surgical outcomes and reimbursement trends. The purpose of this study was to evaluate the impact different severities of obesity have on primary and revision TKA, specifically: (1) incidence and trends over time; (2) annual growth rate; and (3) admission costs from 2010 to 2014. A retrospective review of a large commercial private payer database within the PearlDiver Supercomputer application (Warsaw, IN) of TKA procedures was conducted. Patients who underwent TKA and subsequent revision were identified by Current Procedural Terminology (CPT) and ninth revision International Classification of Disease (ICD-9) codes. The index procedure was linked with ICD-9 codes for body mass indexes (BMIs) from <19 to >70. Statistical analysis was primarily descriptive to demonstrate the revision incidence and reimbursement deviations due to BMI. Compound annual growth rate (CAGR) was also calculated. Our query returned a total of 87,607 TKA patients within the study BMI ranges. The majority of patients had a BMI of 40 to 44.9 (12.2%) and least in the BMI >70 (0.2%) range. BMI of 40 to 44.9 had the highest overall 5-year mean reimbursement of \$11,521 and the highest overall mean 5-year deviation from normal BMI (19–24) patients of \$3,300. The incidence and burden of TKA revision was highest in patients with a BMI of 60 to 69.9 (21 and 17.3%, respectively). Average 5-year revision reimbursement and deviation from normal BMI (19–24) was highest in patients with a BMI of 40 to 44.9 (\$13,883 and \$4,030, respectively). The number of obese patients receiving TKA is steadily rising. The cost of treating obese patients rises as BMI

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Conflict of Interest

None.

deviates from normal, as does the incidence of revision surgery. Therefore, surgeons must be active in counseling patients on weight optimization as part of preoperative standard of care.

Keywords

total knee arthroplasty; revision; obesity; economics

Obesity is a significant concern among the United States population, a concern that is estimated to have reached a prevalence of 32% in men and 36% in women.¹ Obesity is defined as a body mass index (BMI) of >30 and has been directly correlated to the development of osteoarthritis of the knee.² A recent study examining the national trends of obesity in total knee arthroplasty (TKA) among the Medicare/Medicaid patient population found that from 2002 to 2009, the number of patients who received TKA and were obese rose from 11 to 20%.³ The effects of obesity in TKA has implications in both economic burden and clinical outcomes. A recent study looked at the economic effects of obesity, determining that with every five-unit increase in BMI beyond 30 kg/m² had an associated increase of \$250 to \$300 in costs with primary TKA and a \$600 to \$650 increase of costs in revision TKA.⁴ In addition, a literature review performed by a workgroup of total joint arthroplasty surgeons from the American Association of Hip and Knee Surgeons (AAHKS) found that TKA patients who had a BMI ≥ 40 was the threshold for which the majority of perioperative complications, including infection and revision rates, appear to increase substantially.⁵ Current literature consists of studies that examine data from previous years and have not been updated to reflect new trends.

Therefore, the purpose of this study was to evaluate the impact different severities of obesity have on primary and revision TKA, specifically: (1) incidence and trends over time; (2) annual growth rate; and (3) admission costs from 2010 to 2014.

Methods

A retrospective review of a large, comprehensive private payer database within the PearlDiver Supercomputer application (<http://www.pearldiverinc.com/>; Warsaw, IN) of the index procedure TKA was conducted. The PearlDiver database is a publicly available, Health Insurance Portability and Accountability Act (HIPAA)-compliant national database compiled from the Humana insurance claims. This database contains Current Procedural Terminology (CPT) and International Classification of Diseases, Ninth Revision (ICD-9) codes from 2007 to 2014.

All patients who underwent TKA between 2010 and 2014 were identified by CPT-27447 and ICD-9 code 81.54. Revision TKA patients were identified with CPT- 27486, 27487 and ICD-9 codes 00.80 to 00.84. Primary and revision TKA cohorts were stratified into 10 groups based upon BMI utilizing ICD-9 codes V85.0(BMI < 19 kg/m²), V85.1 (19–24kg/m²), V85.21 to V85.25 (25–29.9 kg/m²), V85.30 to V85.34 (30–34.9 kg/m²), V85.35 to V85.39 (35–39.9 kg/m²), V85.41(40–44.9 kg/m²), V85.42 (45–49.9 kg/m²), V85.43(50–59.9 kg/m²), V85.44 (60–69.9 kg/m²), and V85.45 (> 70 kg/m²). Average yearly

reimbursements were used as a marker for cost during the surgical admission period for each BMI cohort in both primary and revision TKA.

Statistical analysis of this study was primarily descriptive, utilizing frequency tables and means where appropriate. The compound annual growth rate (CAGR) was calculated to determine overall growth or decline over the 5-year study period for each BMI subgroup. A normal BMI of 19 to 24 kg/m² served as the control group to determine which BMI subgroup had the most pronounced deviation from normal.

Results

Our search returned a total of 87,607 primary TKA patients within the 2010 to 2014 study period. The majority of patients receiving primary TKA had a BMI of 40 to 44.9 kg/m² (12.2%) and the least had a BMI >70 kg/m² (0.2%). Patients with BMI of 40 to 44.9 kg/m² also had the highest CAGR (41.9%), while the lowest CAGR was in the BMI of <19 kg/m² range (11.4%). However, there is a growing trend in primary TKA rates across all BMI ranges (►Table 1).

In the primary TKA cohort, a BMI of 40 to 44.9 kg/m² had the highest overall 5-year average reimbursement of \$11,521 and also had the highest overall average 5-year deviation from normal BMI (19–24 kg/m²) patients of \$3,300. Our results show a decline in reimbursements for primary TKA across all BMI ranges, but interestingly, patients in the normal BMI range (19–24 kg/m²) had the greatest decline in reimbursements at a CAGR of –29.1%. ►Tables 2 and 3 detail all studied BMI ranges in reimbursements and deviation from normal BMI reimbursements, respectively.

The incidence and burden of TKA revision was highest in patients who had a BMI of 60 to 69.9 kg/m² (21 and 17.3%, respectively). However, with exception for the BMI of 25 to 29.9 kg/m² range, deviation above and below the normal BMI (19–24 kg/m²) resulted in increased revision incidence (►Table 4). Average 5-year revision reimbursement and deviation from normal BMI (19–24 kg/m²) was highest in patients with a BMI of 40 to 44.9 kg/m² (\$13,883 and \$4,030, respectively) (►Tables 5 and 6).

Discussion

Understanding the impact obesity has on economic burden and clinical outcomes in the utilization of TKA allows for improved management of this patient population. The primary purpose of our study was to help better characterize trends in the effect of BMI on TKA revision rates and cost within the Humana patient population. The primary results of this study demonstrate an upward trend in CAGR from 2010 to 2014 across all BMI ranges.

Obese patients represented 30% of our study's population, showing a substantial increase from a previous study in 2002 to 2009 of Medicare/Medicaid population where 15% of the TKA population was obese.³ Obesity has a strong correlation to osteoarthritis.² With prevalence of obesity in patients over 60 years old as high as 42% in women and 37% in men,¹ it can be expected to see a proportional increase in TKA.

It is important to recognize that despite the growing trend in utilization of TKA among obese patients, there is an overall decline in the reimbursement across all BMI ranges. However, compared with normal BMI patients the cost of treating obese patients is directly proportional to increases in BMI. In a retrospective review of lower extremity arthroplasty, a five-point increase in BMI resulted in a 15% increase in length of stay and a 7-minute increase in operating room time.⁶ Hospital length of stay, operating room time, and prosthesis account for the top three expenditures during primary and revision TKA cases,⁷ highlighting associated increases in costs for obese patients.

The majority of patient's treated with TKA was morbidly obese (BMI 40–44.9, 12%; BMI 45–49.9, 6%) and also represented the highest rate of growth. Patients with a BMI of 40 to 44.9 represented the highest overall 5-year average reimbursement for both primary and revision TKA (\$11,521 and \$13,883, respectively). For primary TKA patients with BMI of 40 to 44.9, there was a reimbursement deviation of \$3,300 from normal BMI, while revision patients were \$4,030 deviated from normal. The increased costs are likely due to the amplified risk and comorbidities associated with patients having a BMI of >40 with occurrence of perioperative complications.⁸ A BMI of >40 is associated with greater rates of reoperation and superficial infection.⁸ A single-center study of direct cost for primary and revision TKA showed revisions for infections, as well as bone/prosthesis fractures to be 25% more costly than revisions due to component loosening.⁷ Furthermore, a recent literature review showed a 22% complication rate with morbidly obese patients resulting in significant lower implants survivorship.⁹

The incidence of TKA revision surgeries increased as BMI increased, with exception of overweight patients (BMI 25–25.9), which represented the lowest incidence of revision surgery. Obesity is a modifiable risk factor and postoperative weight gain has been shown to have negative impacts on outcomes.¹⁰ Weight loss via dietary intervention has been proven to improve outcome postoperatively¹¹ and preserves bone quality.¹² Developing osteoarthritis and thus increasing probability for TKA can be reduced by a two-point reduction in BMI.¹³ Surgeons should incorporate weight management into their pre- and postoperative care routine for obese patients in attempt to decrease implant failure, improve clinical outcomes, and favor patient well-being.

Our study is not without limitations; the PearlDiver database is contingent on accurate CPT or ICD coding, which may lead to a potential reporting bias. Our data may not fully embody the entire United States' trends as data within our study is primarily represented by a single private payer organization (Humana). Lastly, a selection bias may be present as patients enter or exit the database as a natural manifestation.

Conclusion

The number of obese patients receiving TKA is steadily rising. The cost of treating obese patients rises as BMI deviates from normal, as does the incidence of revision surgery. Therefore, surgeons must be active in counseling patients on weight optimization as part of preoperative standard of care.

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Table 1

BMI and TKA annual number of patients

Year	BMI <19	BMI 19–24	BMI 25–29.9	BMI 30–34.9	BMI 35–39.9	BMI 40–44.9	BMI 45–49.9	BMI 50–59.9	BMI 60–69.9	BMI >70
2010	63	348	194	338	321	778	410	221	32	15
2011	50	382	224	442	409	1,663	834	437	66	19
2012	72	531	334	687	600	2,095	1,055	537	85	44
2013	107	1,168	585	1,151	946	2,989	1,408	710	103	46
2014	97	1,368	692	1,306	1,037	3,151	1,428	692	119	39
Total	389	3,797	2,029	3,924	3,313	10,676	5,135	2,597	405	163
CAGR (%)	11.4	40.8	37.4	40.2	34.1	41.9	36.6	33.0	38.9	27.0

Abbreviations: BMI, body mass index; CAGR, compound annual growth rate; TKA, total knee arthroplasty.

Table 2

BMI and TKA average reimbursement

Year	BMI <19 (n = 389)	BMI 19–24 (n = 3,797)	BMI 25–29.9 (n = 2,029)	BMI 30–34.9 (n = 3,924)	BMI 35–39.9 (n = 3,313)	BMI 40–44.9 (n = 1,0676)	BMI 45–49.9 (n = 5,135)	BMI 50–59.9 (n = 2,597)	BMI 60–69.9 (n = 405)	BMI >70 (n = 163)
2010	\$12,010	\$13,338	\$14,392	\$13,932	\$13,694	\$14,164	\$14,330	\$13,104	\$10,036	\$12,837
2011	\$12,193	\$12,689	\$11,469	\$11,390	\$13,427	\$13,279	\$13,257	\$12,388	\$9,797	\$7,043
2012	\$8,662	\$7,231	\$8,442	\$8,824	\$11,056	\$11,426	\$10,948	\$11,020	\$8,285	\$9,091
2013	\$6,821	\$4,482	\$4,763	\$5,758	\$8,197	\$9,617	\$9,870	\$9,804	\$6,733	\$5,229
2014	\$4,707	\$3,367	\$3,869	\$5,586	\$6,355	\$9,120	\$8,866	\$9,801	\$10,072	\$7,011
Annual total	\$44,393	\$41,107	\$42,935	\$45,490	\$52,729	\$57,606	\$57,271	\$56,117	\$44,923	\$41,211
Aggregate (5y) (millions)	\$17.3	\$156.1	\$87.1	\$178.5	\$174.7	\$615.0	\$294.1	\$145.7	\$18.2	\$6.7
Average (5y)	\$8,879	\$8,221	\$8,587	\$9,098	\$10,546	\$11,521	\$11,454	\$11,223	\$8,985	\$8,242
CAGR (%)	–20.9	–29.1	–28.0	–20.4	–17.5	–10.4	–11.3	–7.0	0.1	–14.0

Abbreviations: BMI, body mass index; CAGR, compound annual growth rate; TKA, total knee arthroplasty

Table 3

BMI and TKA reimbursement deviation from normal (19–24)

Year	BMI <19 (n = 618)	BMI 25–29.9 (n = 2,610)	BMI 30–34.9 (n = 4,917)	BMI 35–39.9 (n = 4,177)	BMI 40–44.9 (n = 12,846)	BMI 45–49.9 (n = 6,171)	BMI 50–59.9 (n = 3,229)	BMI 60–69.9 (n = 527)	BMI >70 (n = 196)
2010	(\$1,328)	\$1,054	\$594	\$356	\$826	\$992	(\$234)	(\$3,302)	(\$501)
2011	(\$496)	(\$1,220)	(\$1,299)	\$738	\$590	\$568	(\$301)	(\$2,892)	(\$5,646)
2012	\$1,431	\$1,211	\$1,593	\$3,825	\$4,195	\$3,717	\$3,789	\$1,054	\$1,860
2013	\$2,339	\$281	\$1,276	\$3,715	\$5,135	\$5,388	\$5,322	\$2,251	\$747
2014	\$1,340	\$502	\$2,219	\$2,988	\$5,753	\$5,499	\$6,434	\$6,705	\$3,644
Annual total	\$3,286	\$1,828	\$4,383	\$11,622	\$16,499	\$16,164	\$15,010	\$3,816	\$104
Aggregate (5y) (millions)	\$1.3	\$3.7	\$17.2	\$38.5	\$176.1	\$83.0	\$39.0	\$1.5	\$0.02
Average (5y)	\$657	\$366	\$877	\$2,324	\$3,300	\$3,233	\$3,002	\$763	\$21

Abbreviations: BMI, body mass index; TKA, total knee arthroplasty.

Table 4

BMI and Revision TKA annual

Year	BMI <19	BMI 19–24	BMI 25–29.9	BMI 30–34.9	BMI 35–39.9	BMI 40–44.9	BMI 45–49.9	BMI 50–59.9	BMI 60–69.9	BMI >70
2010	–1	26	15	30	32	115	67	44	–1	
2011	–1	40	–1	48	40	275	123	90	13	–1
2012	19	69	24	69	62	285	157	119	19	–1
2013	16	103	57	115	105	416	200	143	29	–1
2014	22	116	56	134	104	381	206	123	24	–1
Total	61	354	151	396	343	1,472	753	519	85	–1
Rev incidence (%)	15.7	9.3	7.4	10.1	10.4	13.8	14.7	20.0	21.0	
Rev burden (%)	13.6	8.5	6.9	9.2	9.4	12.1	12.8	16.7	17.3	

Abbreviations: BMI, body mass index; TKA, total knee arthroplasty.

Note: –1 denotes a value of <11.

Table 5

BMI and revision TKA average reimbursement

Year	BMI <19 (n = 61)	BMI 19-24 (n = 354)	BMI 25-29.9 (n = 151)	BMI 30-34.9 (n = 396)	BMI 35-39.9 (n = 343)	BMI 40-44.9 (n = 1472)	BMI 45-49.9 (n = 753)	BMI 50-59.9 (n = 519)	BMI 60-69.9 (n = 85)	BMI >70 (n = -1)
2010	\$4,959	\$11,926	\$14,856	\$14,402	\$15,113	\$18,970	\$13,479	\$14,031	\$15,384	
2011	\$12,178	\$15,533	\$10,684	\$12,810	\$16,121	\$13,237	\$12,915	\$13,474	\$9,963	\$20,939
2012	\$13,898	\$7,716	\$9,732	\$8,668	\$11,792	\$13,907	\$13,811	\$12,101	\$6,878	\$611
2013	\$14,692	\$6,949	\$5,641	\$8,694	\$9,073	\$11,664	\$10,969	\$9,386	\$9,557	\$12,583
2014	\$12,380	\$7,141	\$4,749	\$9,548	\$7,652	\$11,639	\$12,942	\$11,388	\$11,556	\$5,958
Annual total	\$58,107	\$49,265	\$45,662	\$54,122	\$59,751	\$69,417	\$64,116	\$60,380	\$53,338	\$40,091
Aggregate (5y) (millions)	\$3.5	\$17.4	\$6.9	\$21.4	\$20.5	\$102.2	\$48.3	\$31.3	\$4.5	
Average (5 y)	\$11,621	\$9,853	\$9,132	\$10,824	\$11,950	\$13,883	\$12,823	\$12,076	\$10,668	\$10,023
CAGR (%)	25.7	-12.0	-24.8	-9.8	-15.6	-11.5	-1.0	-5.1	-6.9	-34.2

Abbreviations: BMI, body mass index; CAGR, compound annual growth rate; TKA, total knee arthroplasty.

Note: -1 denotes a value of <11.

Table 6

BMI and revision reimbursement deviation from normal (19–24)

Year	BMI <19 (n = 61)	BMI 25–29.9 (n = 151)	BMI 30–34.9 (n = 396)	BMI 35–39.9 (n = 343)	BMI 40–44.9 (n = 1,472)	BMI 45–49.9 (n = 753)	BMI 50–59.9 (n = 519)	BMI 60–69.9 (n = 85)	BMI >70 (n = 1)
2010	(\$6,967)	\$2,930	\$2,476	\$3,187	\$7,044	\$1,553	\$2,105	\$3,458	
2011	(\$3,355)	(\$4,849)	(\$2,723)	\$588	(\$2,296)	(\$2,618)	(\$2,059)	(\$5,570)	\$5,406
2012	\$6,182	\$2,016	\$952	\$4,076	\$6,191	\$6,095	\$4,385	(\$838)	(\$7,105)
2013	\$7,743	(\$1,308)	\$1,745	\$2,124	\$4,715	\$4,020	\$2,437	\$2,608	\$5,634
2014	\$5,239	(\$2,392)	\$2,407	\$511	\$4,498	\$5,801	\$4,247	\$4,415	(\$1,183)
Annual total	\$8,842	(\$3,603)	\$4,857	\$10,486	\$20,152	\$14,851	\$11,115	\$4,073	\$2,752
Aggregate (5 y)	\$539,362	(\$544,053)	\$1,923,372	\$3,596,698	\$29,663,744	\$11,182,803	\$5,768,685	\$346,205	(\$2,752)
Average (5 y)	\$1,768	(\$721)	\$971	\$2,097	\$4,030	\$2,970	\$2,223	\$815	\$688

Abbreviation: BMI, body mass index.