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Original Research

Uncemented Total Knee Arthroplasty is on the Rise. A Report of Patient Demographics and Short-Term Outcomes From the Michigan Arthroplasty Registry Collaborative Quality Initiative

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ABSTRACT

Background: Cemented total knee arthroplasty (TKA) is the gold standard treatment for osteoarthritis, but uncemented TKA offers benefits like improved osseointegration and reduced complications from cement debris. This study aimed to investigate (1) if there has been a rise in uncemented TKA from 2017 to 2021 and (2) if there are differences in early complications between cemented and uncemented TKA.
Methods: A retrospective data review was performed on the Michigan Arthroplasty Registry Collaborative Quality Initiative database of TKA patients from 2017 to 2021 at 6 hospitals. Patients with revision or partial knee arthroplasty were excluded. Patients were divided into 2 groups: uncemented and cemented. Hybrid and reverse hybrid fixation data were collected for incidence, but not for demographics or complications. All patient demographics and 90-day postoperative events were collected and analyzed.
Results: A retrospective study of 18,749 primary TKAs found that 89.7% were cemented, 9.7% uncemented, and 0.7% hybrid or reverse hybrid. Uncemented patients were younger, men, heavier, current smokers, and diabetics than cemented patients ($P < .0001$, $P = .03$). They also had a shorter length of stay ($P \leq .0001$) and were on fewer preoperative medications: anticoagulants ($P = .0059$), antiplatelets ($P \leq .0001$), opioids ($P = .0091$), and steroids ($P = .0039$). The rate of uncemented TKA increased from 3.3% to 17.1%, while the rate of cemented TKA fell from 96.2% to 81.9% ($P = .0048$). The readmission rate was higher in cemented TKAs (4.0%) than in uncemented TKAs (2.6%) ($P = .0048$).
Conclusions: The use of uncemented TKA increased from 3.3% in 2017 to 17.1% in 2021, while cemented fixation decreased from 96.7% to 81.9%. There were no significant differences in short-term complications between groups. Uncemented patients were younger, men, took fewer medications, had a shorter length of stay, and were less likely to be readmitted. However, they were more likely to have comorbidities than the cemented group.

Introduction

Total knee arthroplasty (TKA) using cemented tibial and femoral components has been the historical gold standard treatment for end-stage osteoarthritis patients [1]. Over time, advancements in surgical techniques, implant designs, and fixation methods have led to improved outcomes and patient satisfaction. Cemented fixation with polymethyl methacrylate bone cement provides immediate stability by filling gaps between the implant and bone, ensuring a secure initial fixation [2]. However, it is associated with complications such as aseptic loosening and limited resistance to shear and tension forces [3].

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Over the last decade, there has been much improvement with uncemented TKA implants [4]. Earlier reports on uncemented TKA designs raised concerns regarding fixation failure, early implant failure, and suboptimal clinical outcomes. Factors contributing to these failures included inadequate porous coating, suboptimal tibial locking mechanisms, and the use of first-generation polyethylene holes [5,6]. In contrast, newer uncemented fixation techniques offer the advantage of promoting biologic ingrowth of native bone into the implant, facilitating improved osseointegration and reducing systemic complications associated with cement exposure [7]. These techniques rely on press-fit fixation and bone ingrowth to achieve stability, resulting in enhanced long-term implant survival and a minimized risk of aseptic loosening [7,8]. Uncemented fixation enables better preservation of bone stock, which is particularly beneficial for younger or highly active patients who may require revision surgery in the future. Additionally, the overall procedural cost of implanting an uncemented TKA is less than that of implanting a cemented TKA [9].

Although there is a growing trend toward using uncemented fixation in TKA, there is still ongoing development in understanding its clinical outcomes and complications compared to cemented fixation. Previous studies have presented mixed results, with some indicating similar outcomes between the 2 fixation methods, while others have highlighted the advantages or disadvantages of each [10,11]. A systematic review conducted by Cherian et al revealed nearly equal success rates between uncemented and cemented implants over a 10-year follow-up period [12]. Similarly, Manoli et al reported that patients who underwent uncemented TKA had shorter hospital stays, reduced dependence on home care or extended care facilities, and similar rates of complications in the early postoperative period [13].

The purpose of this study was to investigate the utilization trends of uncemented and cemented knee arthroplasty over a 5-year period and to compare patient characteristics and complications between groups. We hypothesize that there has been a rise in the utilization of uncemented fixation over time, and we anticipate similar outcomes between cemented and uncemented TKA.

Material and methods

Study design

Patients who underwent primary TKA from 2017 to 2021 were retrospectively reviewed. All patients were identified via a query of the Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) database [14]. Data from 6 individual hospitals (1 hospital system), involving a total of 78 surgeons, were included. The study design was created based on the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [15] and approved by the Beaumont Health Institutional Review Board. The authors received no specific funding for this work.

Participants

Patients were included if they underwent primary TKA from 2017 to 2021 with available data in the MARCQI database. Patients were divided into 2 groups: uncemented (uncemented fixation of femur and tibia) and cemented (cement fixation of femur and tibia). Patients were excluded if surgery was a revision or partial knee arthroplasty, hybrid or reverse hybrid fixation (cemented and uncemented components mixed) (Fig. 1).

Variables

The primary outcome of interest was a fixation method used in TKA (cemented or uncemented) and its annual trends over 5 years. In addition, demographic information was collected for all patients (Table 1). Comorbidities such as body mass index (BMI), history of smoking and alcohol consumption, history of a bleeding disorder, preoperative medications (such as anticoagulants, antiplatelets, opioids, and steroids), history of deep vein thrombosis (DVT) or pulmonary embolism (PE), diabetes, and American Society of Anesthesiologists Physical Status Classification System score were assessed (Table 2). Outcome variables of interest were evaluated at 90 days postoperatively. These variables included emergency department visits, readmission, death, DVT, PE, urinary tract infection, dislocation, fracture, hematoma, periprosthetic joint infection, or other reason to return to the operating room.

Statistical analysis

All statistical analyses were performed using SAS v9.4. All continuous variables were represented using means and standard deviation, whereas categorical variables were displayed as frequencies and percentages. *T*-test, Chi-square, Fisher exact *P* value, and Wilcoxon rank sum *P* value were used to assess the differences between the cemented and uncemented groups. If inappropriate, nonparametric alternatives were considered and employed when applicable. A post-hoc power test demonstrated adequate power and effect size with a significance level α of 0.05. To calculate percentage change in case load for cemented and uncemented TKA, the percentage change formula was used ($\frac{new\ value - original\ value}{original\ value} \times 100$) (ie, $\frac{no.\ cases\ 2017 - no.\ cases\ 2021}{no.\ cases\ 2017} \times 100$). A line graph was used to visualize the rates of change in uncemented and cemented fixation from 2017 to 2021.

Results

Participants

Demographic characteristics of included patients are summarized in Table 1. Of the 18,631 patients included in this review, 9.67% were uncemented TKA and 90.3% were cemented TKA (Fig. 1). A majority of the study population were women (64.2%). Uncemented TKA patients had a statistically significant higher percentage of patients who are men when compared to the cemented group (47.3% vs 34.6%, $P < .001$).

The mean age of the entire study population was 67 years. There was a statistically significant difference in age between uncemented and cemented groups, with uncemented TKA patients being younger (63.6 ± 8.59 years vs 67.4 ± 9.49 years, $P < .001$). 83.7% of the entire study population was Caucasian, 10.9% Black, and 5.4% classified as other. The mean BMI of the study population was 33.0 kg/m^2. Uncemented TKA patients had a higher BMI than their cemented counterparts (34.4 kg/m^2 vs 32.4 kg/m^2, $P < .0001$). The mean length of stay was 1.7 ± 1.33 days. The uncemented group had a shorter length of stay than the cemented group (1.1 ± 1.07 days vs 1.7 ± 1.34 days, $P < .0001$) (Table 1).

The comorbidities of included patients are presented in Table 2. 27.7% of the study population used preoperative assistive devices (ie, cane, walker, wheelchair), with a higher frequency observed among the cemented group (28.5%) compared to uncemented group (20.2%) ($P < .0001$). Additionally, uncemented TKA patients were also more likely to be current smokers (15.2%), use alcohol (56.9%), have a bleeding disorder (1.8%), and have a diagnosis of diabetes (24.9%) ($P \leq .0001$). They also took fewer preoperative medications, including anticoagulants (7.0%, $P = .0059$),

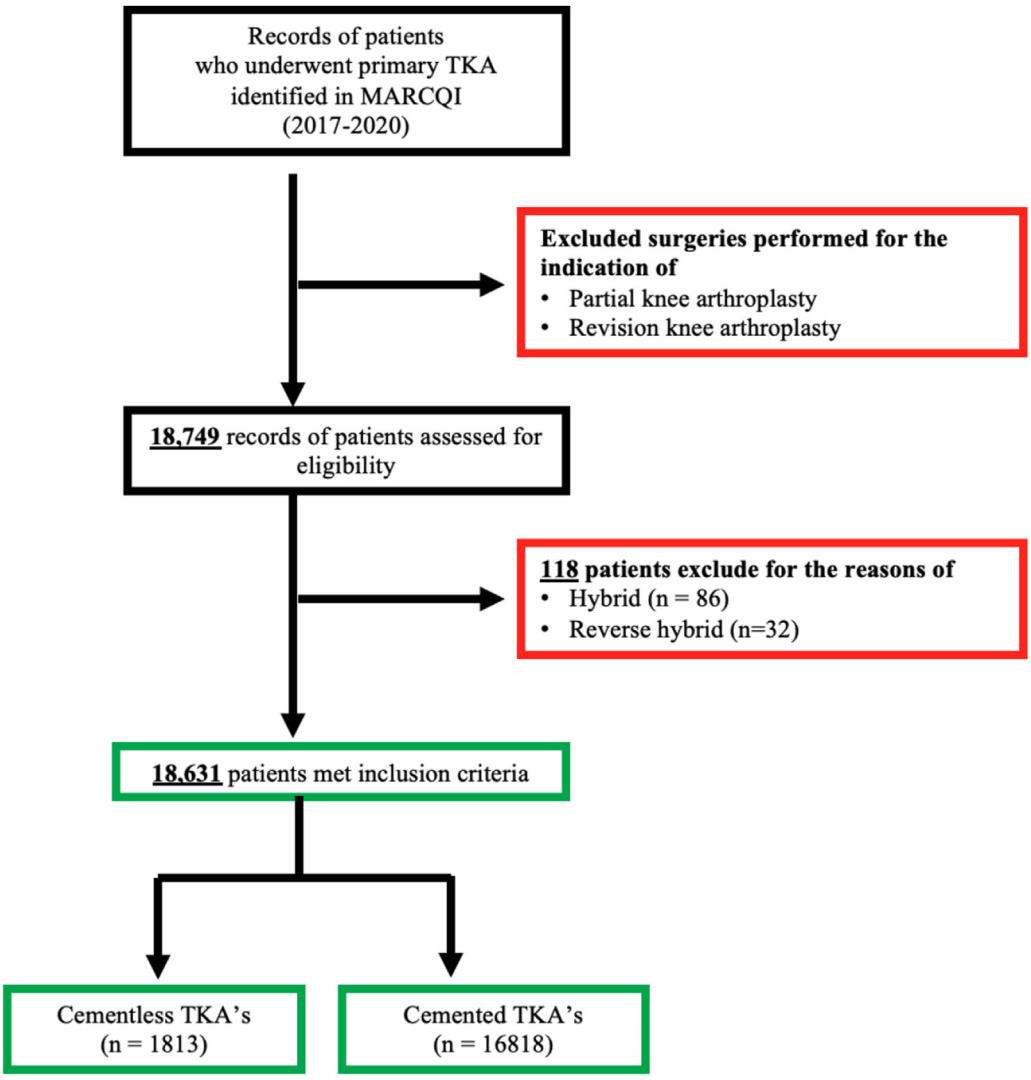

Figure 1. Flow chart of excluded and included patients with reasoning according to STROBE standards. STROBE, Strengthening the Reporting of Observational Studies in Epidemiology.

antiplatelets (31.7%, $P < .0001$), opioids (21.8%, $P = .0091$), and steroids (1.1%, $P = .0039$). Patients in the uncemented group were also less likely to have a history of DVT/PE compared to those in the cemented group (6.7% vs 8.6%, $P = .0056$) (Table 2).

Trends in fixation

Among the included cases, 89.7% were performed using cemented fixation and 9.7% using uncemented fixation. Analysis of fixation method trends revealed that the rate of uncemented TKA

Table 1
Baseline characteristics of patients with uncemented vs cemented primary total knee arthroplasty.

Baseline characteristics				
Characteristic	Uncemented group	Cemented group	Total	*P* value
Patients, total n (%)	1831 (9.7)	16,818 (90.3)	18,631 (100)	
Patient characteristics				
Age, mean, y	63.6 ± 8.59	67.4 ± 9.49	67 ± 9.48	<.0001[a]
Gender, n (%)				<.0001[c]
Female	955 (52.7)	10,997 (65.4)	11,952 (64.2)	
Male	858 (47.3)	5821 (34.6)	6679 (35.8)	
Race, n (%)				.0708[c]
Black	171 (9.5%)	1857 (11.1%)	2028 (10.9%)	
Caucasian	1545 (85.5%)	13,971 (83.5%)	15,516 (83.7%)	
Other	90 (5.0%)	903 (5.4%)	993 (5.4%)	
Body mass index, mean, kg/m[b]	34.4 ± 6.57	32.9 ± 6.91	33 ± 6.89	<.0001[a]

[a] Unequal variance 2-sample *t*-test.
[b] Fisher's exact *P* value.
[c] Chi-square *P* value; Wilcoxon rank sum *P* value.

Table 2
Comorbidities and preoperative risk assessment.

Patient comorbidities				
	Uncemented group	Cemented group	Total	*P* value
Risk factor, n (%)				
Current smoking	275 (15.2)	1502 (8.9)	1777 (9.5)	<.0001[a]
Alcohol use	1041 (56.9)	8708 (51.8)	9749 (52.3)	<.0001[a]
Bleeding disorder	32 (1.8)	168 (1.0)	200 (1.1)	.0026[a]
History of DVT/PE	122 (6.7)	1452 (8.6)	1574 (8.4)	.0056[a]
Diabetes	456 (24.9)	3799 (22.6)	4255 (22.8)	.0115[a]
Preoperative assistive device	369 (20.2)	4796 (28.5)	5165 (27.7)	<.0001[a]
Preoperative medication, n (%)				
Anticoagulation	128 (7.0)	1512 (9.0)	1640 (8.8)	.0059[a]
Antiplatelet	580 (31.7)	6408 (38.1)	6988 (37.5)	<.0001[a]
Opioids	400 (21.8)	4177 (24.8)	4577 (24.6)	.0091[a]
Steroids	21 (1.1)	366 (2.2)	387 (2.1)	.0039[a]
None	898 (49.0)	6786 (40.3)	7684 (41.2)	<.0001[a]
Preoperative ASA score, n (%)				<.0001[a]
I	21 (1.2)	82 (0.5)	103 (0.6)	
II	742 (40.9)	7249 (43.1)	7991 (42.9)	
III	1040 (57.4)	9227 (54.9)	10,267 (55.1)	
IV	10 (0.6)	260 (1.5)	270 (1.4)	
Length of stay, d	1.1 ± 1.07	1.7 ± 1.34	1.7 ± 1.33	<.0001[b]

Uncemented TKA patients were generally younger, with a larger proportion of males and a higher mean BMI. They were also more likely to be current smokers, have a bleeding disorder, and have a diagnosis of diabetes. Additionally, uncemented TKA patients had a shorter length of stay and were on fewer preoperative medications, including anticoagulants, antiplatelets, opioids, and steroids. Uncemented patients were also less likely to have a history of DVT/PE.
ASA, American Society of Anesthesiologists.
[a] Chi-square *P* value.
[b] Wilcoxon rank sum *P* value.

rose over the study period: 3.3% (2017), 6.2% (2018), 9.5% (2019), 17.0% (2020), and 17.1% (2021), representing a 418.2% increase. In contrast, the utilization of cemented fixation steadily decreased over the same time period: 96.2% (2017), 93.4% (2018), 90% (2019), 82.1% (2020), and 81.9% (2021), which represents a 14.9% decrease (Fig. 2, Table 3). The models of prostheses used can be found in the Appendix.

Ninety-day postoperative outcomes

The 90-day postoperative outcomes of the included patients are presented in Table 4. The readmission rate was significantly lower in the uncemented TKA group (2.6%) compared to the cemented TKA group (4.0%) ($P = .0048$). However, no statistically significant differences were observed in other 90-day events, such as DVT, PE, death, dislocation, fracture, or periprosthetic joint infection between the 2 fixation groups. There were also no significant differences observed between groups in regards to intraoperative complications (Table 4).

Discussion

The objective of this study was primarily to examine the increase in the utilization of uncemented TKA from 2017 to 2021 and, secondly, to evaluate potential differences in complications between patients who underwent cemented and uncemented TKA.

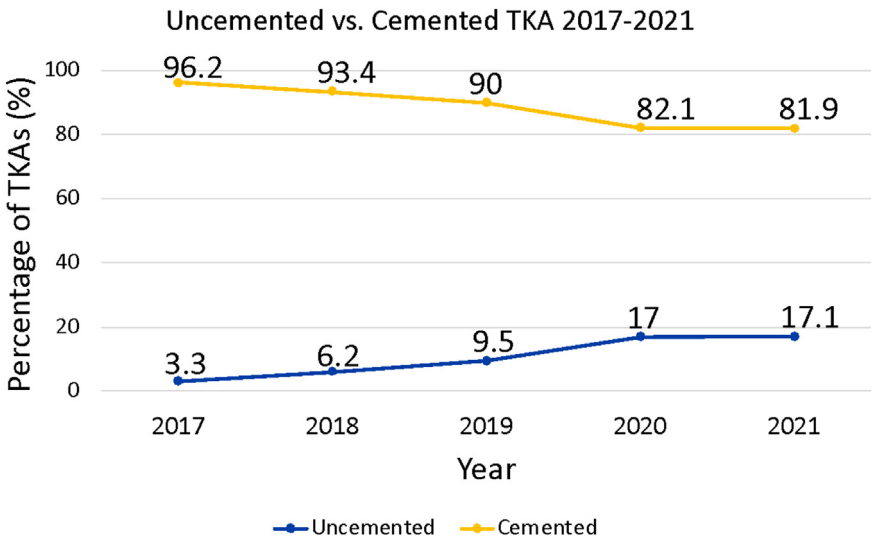

Figure 2. Rates of uncemented TKA rose and cemented fixation fell over 5 years (2017-2021).

Table 3
Rates of uncemented TKA rose and cemented fixation fell over 5 years (2017-2021).

Cement status by year							% change
Cement status	Year						
n (%)	2017	2018	2019	2020	2021	Total	
Uncemented	145 (3.3)	259 (6.2)	403 (9.5)	494 (17.0)	512 (17.1)	1813	+418.2%
Cemented	4252 (96.2)	3916 (93.4)	3810 (90.0)	2390 (82.1)	2450 (81.9)	16,818	−14.9%
Hybrid	23 (0.5)	14 (0.3)	17 (0.4)	17 (0.6)	15 (0.5)	86	
Reverse hybrid	2 (0.1)	3 (0.1)	4 (0.1)	10 (0.3)	13 (0.4)	32	
Total	4422	4192	4234	2911	2990	18,749	

Our findings indicate a significant upward trend in the utilization of uncemented fixation during the 5-year study period (3.3% in 2017 to 17.1% in 2021). This increase is accompanied by a corresponding decline in the use of cemented fixation (96.2% in 2017 to 81.9% in 2021). Patients who underwent uncemented TKA were more likely to be younger, men, take fewer preoperative medications, have shorter hospital stays, and experience fewer readmissions. There were no differences in 90-day postoperative outcomes between groups. These findings align with the growing evidence supporting the advantages of uncemented TKA, including potential long-term implant survival and improved clinical outcomes. One primary benefit of uncemented TKA is improved biologic osseointegration, achieved through press-fit fixation and bone ingrowth, promoting a strong and stable interface between the bone and prosthesis [7,16]. This contributes to enhanced long-term implant survival and reduced risk of aseptic loosening.

Furthermore, our analysis revealed that patients undergoing uncemented TKA were generally younger. However, they had a higher incidence of comorbidities (smoking, alcohol, diabetes, and history of bleeding disorders) than the cemented group. It is likely that the young age of the patients and presumed better bone quality, rather than a higher rate of comorbidity, were the driving factors for surgeons to perform uncemented fixation for possible longer-term implant survival. Better bone quality can drive orthopaedic surgeons to favor uncemented TKA due to the enhanced fixation achieved through biological means [17]. Additionally, uncemented TKA patients had shorter hospital stays and were on fewer preoperative medications (anticoagulants, antiplatelets, opioids, and steroids), most likely related to their younger age. A possible explanation for this trend could be the increasing prevalence of obesity [18]. The uncemented group was found to have a higher BMI than the cemented group in this study (34.4 kg/m^2 vs 32.9 kg/m^2, respectively). It's worth noting that while this difference is statistically significant, its clinical significance may be less pronounced. However, multiple studies have shown that obesity is associated with TKA at a younger age [19,20]. A 2020 report from the American Joint Replacement Registry demonstrating the use of uncemented TKA in patients who are men aged less than 65 years has shown a significantly lower surgical revision rate when compared to cemented TKA [21]. It may be assumed that age alone could sway a surgeon to choose uncemented fixation based on implant longevity. Henceforth, uncemented TKA has been shown to have greater implant survivorship in patients who are younger with higher BMIs and may be a better option in this population [3,22,23].

Our study did find that the readmission rate within 90 days following surgery was lower in the uncemented TKA group compared to the cemented TKA group (2.0% vs 4.0%, respectively), potentially highlighting the advantages of uncemented fixation regarding early postoperative outcomes and healthcare utilization. The lower readmission rate in the uncemented cohort may be

Table 4
90-day postoperative, intraoperative, and inpatient events of patients with uncemented vs cemented primary total knee arthroplasty.

90-day postoperative events				
Event	n (%)			*P* value
	Uncemented group	Cemented group	Total	
Emergency department visit	193 (10.6)	1739 (10.3)	1932 (10.4)	.6855[b]
Readmission	48 (2.6)	671 (4.0)	719 (3.9)	.0048[b]
Death	0 (0.0)	22 (0.1)	22 (0.1)	.2652[a]
Deep vein thrombosis	16 (0.9)	156 (0.9)	172 (0.9)	.8488[b]
Pulmonary embolism	8 (0.4)	73 (0.4)	81 (0.4)	.9647[b]
UTI	0 (0.0)	11 (0.1)	11 (0.1)	.6154[a]
Dislocation	1 (0.1)	5 (0.0)	6 (0.0)	.4590[a]
Fracture	3 (0.2)	36 (0.2)	39 (0.2)	1.0000[a]
Hematoma	17 (0.9)	175 (1.0)	192 (1.0)	.6803[b]
Periprosthetic joint infection	6 (0.3)	56 (0.3)	62 (0.3)	.9886[b]
Other return to OR	59 (3.3)	662 (3.9)	721 (3.9)	.1526[b]
No 90-day postoperative events	1496 (82.5)	13,794 (82.0)	15,290 (82.1)	.6010[b]
Intraoperative and inpatient events				
Intraoperative complication				
Fracture	0 (0.0)	25 (0.1)	25 (0.1)	.1918[b]
Nerve injury	3 (0.2)	7 (0.0)	10 (0.1)	.1032[b]
Tendon/Ligament injury	1 (0.1)	21 (0.1)	22 (0.1)	.6446[b]
Other	0 (0.0)	8 (0.0)	8 (0.0)	.7344[b]
None	1809 (98.8)	16,754 (99.6)	18,563 (99.6)	.3855[b]
Venous thrombolic event during stay	6 (0.3)	53 (0.3)	59 (0.3)	.9094[b]

UTI, urinary tract infection; OR, operating room.
[a] Fisher's exact *P* value.
[b] Chi-square *P* value.

attributed to their younger age and predominantly male composition, as younger, male patients typically have fewer health issues, faster recovery, stronger support networks, and better adherence to postoperative care instructions. Moreover, despite the higher BMI noted in this cohort, usually associated with poorer outcomes [24], it paradoxically correlated with lower readmission rates. Although this disparity may be statistically significant, its clinical relevance remains uncertain. Additionally, factors such as greater muscle mass in younger males leading to a higher BMI or heightened surgeon oversight among obese patients might contribute to these favorable outcomes. Furthermore, no significant differences were observed in other 90-day postoperative events between the 2 groups. These results are consistent with previous studies, such as Manoli et al who demonstrated comparable rates of complications between the 2 fixation methods in the early postoperative period [13]. Moreover, multiple studies have reported nearly equal success rates between uncemented and cemented implants [12,25-27]. Although short-term outcomes and complication rates appear comparable between cemented and uncemented TKA, more research is required to evaluate long-term outcomes and the influence of implant designs on the success of uncemented TKA [28]. It is important to note that the choice of fixation method should be individualized based on patient factors, surgeon experience, and implant characteristics. Cemented fixation remains the preferred choice when immediate stability is critical such as trauma, or in cases of patients with poor bone quality, compromised bone stock, or significant osteoporosis [29,30].

The trends in uncemented fixation cannot be analyzed without commenting on the impact of the COVID-19 pandemic from 2020 to the present. Multiple studies have shown a substantial decline in TKA utilization during the pandemic, with a shift toward outpatient procedures and a decrease in the average length of stay [31]. Additionally, the backlog of delayed TKA cases generated by the pandemic poses challenges that must be addressed as the healthcare system recovers. Therefore, the impact of COVID-19 on elective surgeries and the resulting backlog may contribute to the stable rates of both uncemented and cemented TKAs observed between 2020 and 2021 (17.1%-17% uncemented vs 82.1%-81.9% cemented) [32]. It is also important to consider the supply chain challenges associated with the COVID-19 pandemic [33].

This study provides interesting data about TKA fixation trends, but it is not without limitations. First, its retrospective design introduces potential bias due to data acquisition through diagnostic, pharmaceutical, and procedure codes in the MARCQI database. Second, the outcomes presented are limited to the 90-day postoperative period, and it is thus crucial to consider the significance of these results within the context of this timeframe. We did not attempt to do a query of medical records outside the MARCQI database to assess long-term outcomes such as implant failure, revisions, etc. Third, the significant difference in sample size between the cemented and uncemented groups (16,618 cemented vs 1831 uncemented) may introduce a higher risk of bias in the smaller uncemented group, potentially leading to sampling error. Additionally, while specific differences, such as a 2-point increase in BMI and a 0.6-day decrease in length of stay between the cemented and uncemented cohorts, may achieve statistical significance, their clinical significance remains uncertain. Moreover, we did not directly compare the model of cemented or cementless TKA prothesis and their impact on outcomes. Finally, the generalizability of our findings may be limited due to the specific health system and patient population studied. Further research is warranted to validate our results and explore potential mechanisms underlying the observed outcomes.

Conclusions

This study, comprising 18,631 patients, contributes to the growing body of evidence regarding the utilization and outcomes of cemented and uncemented fixation methods in primary TKA. Our results demonstrate the increasing adoption of uncemented fixation and its association with favorable early outcomes, including lower readmission rates, and support its continued exploration as an alternative to cemented fixation. Subsequent research should extend the follow-up period for these cohorts to examine long-term implant survival, functional outcomes, and patient satisfaction to comprehensively understand the benefits and risks associated with each fixation method. Ultimately, such insights can guide clinical decision-making and optimize outcomes for patients undergoing TKA.

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Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101499.

CRediT authorship contribution statement

Sarah Roth: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Madeleine Grace DeClercq:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – review & editing. **Michael Sacchetti:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. **Jacob Keeley:** Data curation, Formal analysis, Writing – review & editing. **Mark Karadsheh:** Conceptualization, Supervision, Validation, Visualization, Writing – review & editing. **Robert Runner:** Conceptualization, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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Appendix Table 1
TKA models (cemented and uncemented), with manufacturers of included patients.

Model (manufacturer)	Uncemented	Cemented	Total
Columbus (Aesculap)	0	2	2
Attune (DePuy)	65	495	560
Ascent Maxim (Zimmer Biomet)	1	649	650
Evolution (MicroPort)	1	872	873
GMK (Medacta)	0	1	1
GMRS (Stryker)	0	5	5
Genesis (Smith & Nephew)	0	461	461
Journey (Smith & Nephew)	0	499	499
LEGION (Smith & Nephew)	0	14	14
MBT (DePuy)	0	25	25
Natural-Knee II (Zimmer Biomet)	0	519	519
NextGen (Zimmer Biomet)	0	127	127
OSS Modular (Zimmer Biomet)	0	6	6
Sigma (DePuy)	0	133	133
Persona (Zimmer Biomet)	13	4457	4470
Scorpio (Stryker)	0	172	172
Triathlon (Stryker)	1722	7682	9405
Truliant (Exactech)	6	169	175
Vanguard (Zimmer Biomet)	0	21	21

Various manufacturers of uncemented and cemented total knee arthroplasties used throughout the hospital system.