

# Occupational Outcomes and Revision Rates for Medial Unicondylar Knee Arthroplasty in U.S. Military Servicemembers

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## Abstract

This study evaluates return to work and revision rates for medial unicondylar knee arthroplasty (UKA) in a high-demand military cohort. Patient demographic and clinical variables were isolated from the medical records of active-duty military servicemembers with at least 2 years of postoperative follow-up and correlated with return to work, medial UKA survivorship, and perioperative complications. The medial UKA annual revision rate was calculated as the percentage of implants revised per observed component year. A total of 39 servicemembers underwent 46 primary medial UKAs (32 unilateral and 7 bilateral) with a mean follow-up of 3.9 (2.0–6.6) years. At a minimum of 2 years postoperatively, 33 (85%) servicemembers returned to military service or successfully completed their service obligation. Older servicemembers (odds ratio [OR] = 0.67; 95% confidence interval [CI]: 0.45, 0.99) had a significantly decreased OR for knee-related medical separation. Nine servicemembers (20%) had conversion to TKA at an average of 2.4 (range, 0.6–5.6) years with a medial UKA annual revision rate of 5%. When compared with Navy/Air Force, Army/Marine servicemembers had an increased TKA conversion rate (OR = 5.40; 95% CI: 1.13, 25.81). Older age decreased the likelihood of medical separation and Army/Marines service was the sole risk factor associated with conversion to TKA. The level of evidence is IV, therapeutic case series.

## Keywords

- ▶ unicompartmental knee arthroplasty
- ▶ work
- ▶ military
- ▶ occupation
- ▶ functional outcomes

Osteoarthritis (OA) is a chronic degenerative condition that can result in severe knee pain, functional limitations, and disability.<sup>1,2</sup> It can occur throughout the knee or be isolated to a single compartment of the knee. Participation in sports, impact activities, and heavy labor are reported risk factors for the development of OA of the knee and subsequent primary knee replacement.<sup>3–8</sup> Military servicemembers pose a unique population given their young age and high

level of physical and occupational demands. Compared with age-matched groups, they have increased rates and earlier onset of lower extremity OA.<sup>9,10</sup> OA and posttraumatic OA, particularly of the knee, remain among the leading sources of medical disability and subsequent military discharge among servicemembers.<sup>11–13</sup>

While generalized OA of the knee has been successfully treated with total knee arthroplasty (TKA), arthritis localized

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to a single compartment can be managed through the unicompartmental knee arthroplasty (UKA). Proposed benefits of medial UKA include less invasive approach, quicker recovery time, less pain, and better functional outcomes when compared with either TKA<sup>14–21</sup> or high tibial osteotomy (HTO).<sup>22–24</sup> However, there is limited information detailing the outcomes in a younger patient demographic, particularly as it relates to an ability to return to work. Medial UKA has demonstrated a threefold increase in utilization,<sup>25,26</sup> especially as an intermediate surgical treatment option for patients younger than 55 years.<sup>27</sup> Given that younger patients are more prone to return to higher occupational demands and recreational athletic activities, early wear and high revision rates remain concerning for medial UKA. These factors may also have important cost implications and increased rates of complications more commonly associated with revision knee arthroplasty surgery<sup>28–30</sup> in spite of improved mid-term medial UKA survivorship at high-volume centers.<sup>31,32</sup>

Return to sporting activity is reported to occur at a higher rate with UKA versus TKA; however, both procedures demonstrate a decrease in return to high impact activities with patients favoring low impact sports.<sup>33–35</sup>

To our knowledge, the surgical outcomes of medial UKA within a high-demand, athletic military cohort were previously assessed through limited sampling as a part of a larger overarching study detailing joint arthroplasty in military servicemembers.<sup>36</sup> The purpose of this study was to determine rates for return to work and revision in a large-homogeneous, active population after medial UKA with a minimum 2 years of follow-up. We hypothesize that medial UKA in a cohort of military servicemembers allows them to reliably return to previous lower extremity function.

## Methods

After Institutional Review Board approval, all active-duty military servicemembers undergoing a medial UKA (Current Procedural Terminology code 27446) for the established diagnosis of knee OA International Classification of Disease, Ninth Revision, 715.16 between January 2008 and December 2012 were identified using the Military Health System Management Analysis and Reporting Tool database. Exclusion criteria included nonactive duty beneficiaries, individuals with less than 2 years of clinical follow-up, and instances of miscoding.

The U.S. Department of Defense electronic health record (Armed Forces Health Longitudinal Application [Version 3.3]) was examined to confirm the accuracy of procedural coding of the index medial UKA procedure and to record laterality, body mass index (BMI), branch of military service, tobacco use, unilateral versus bilateral medial UKA, secondary surgical procedures, and commencement of a medical discharge due to chronic, rate-limiting knee issues. Additionally, fellowship training and subspecialty of the surgeon was evaluated. The medial UKA annual revision rate was calculated as the percentage of implants revised per observed component year.<sup>37</sup> Groups were determined by rank, including enlisted servicemember (E1 [private]–E9 [sergeant major]) and officer (WO1 [warrant officer]–O6 [colonel]).

The outcomes of interest were the ability to return to military occupation 2 years or more after medial UKA and conversion of a medial UKA to a TKA. The standards for medical fitness are detailed within the regulations of the Air Force, Army, and Navy and include the occupational requirements of all military servicemembers.<sup>38–40</sup> These regulations are specific to each branch of the military, but commonly entail passing a semiannual physical fitness test that includes a timed aerobic event and adhering to weight and body composition standards. The Physical Profile (DA 3349) within the e-Profile electronic profiling system (Version 3.17, Medical Operational Data System, Falls Church, VA) is utilized to document all physical duty limitations in addition to final medical separations. All military servicemembers with an authenticated initiation of a knee-related medical separation after medial UKA were identified and cross-referenced to confirm the cause of separation using the electronic medical record, U.S. Physical Disability Agency Database, and the e-Profile system.

Univariate analysis was used to determine the association between the independent patient demographic and surgical variables (listed in ►Tables 1 and 2) and the outcomes of a servicemember being medically separated (►Table 1) or undergoing a conversion to a TKA (►Table 2) following medial UKA. Variables found to have a *p*-value of < 0.2 were utilized in the multivariate analysis. Significant independent predictor variables were established as those that sustained *p*-values < 0.05 with odds ratio (OR) and 95% confidence interval (CI) exclusive of 1. All statistical analyses were performed with the use of SAS software, Version 9.4 (SAS Institute, Cary, NC).

The modest sample size of the present study (*N* = 39) may have limited the significance of the conducted statistical comparisons. To assess this, a post hoc power analysis was conducted with G\*Power 3.1.9.7 (Erdfelder, Faul, & Buchner, 1992). The calculated power ( $1 - \beta$ ) ranged between 0.32 and 0.81 for older servicemembers with decreased OR for military separation and Army or Marine with increased OR for TKA conversion, respectively. Thus, the required sample size to achieve a desired power of 0.80 was calculated as 180. It is likely that our negative findings can be partially attributed to a limited sample size.

## Results

### Demographics

There were a total of 46 consecutive medial UKA procedures, including 32 unilateral and 7 bilateral staged medial UKAs, identified among 39 active-duty U.S. military servicemembers during the study period. The mean patient age at the time of surgery was 44.5 (standard deviation [SD] 5.6, range 36–60) years, while the average BMI was 29.0 (SD 3.3, range 23.1–36.3 kg/m<sup>2</sup>). The majority of patients were male (95%), did not use tobacco (77%), were < 45 years old (62%), were enlisted rank group (63%), had a BMI < 30 (62%), and underwent a unilateral medial UKA (82%). The mean follow-up from the time of surgery was 3.9 (SD 1.3; range, 2.0–6.6) years. Those patients who underwent bilateral staged medial UKAs had an average time interval of 18.9 (SD 12.8, range 7–45) months

**Table 1** Risk factors for medical separation following medial unicondylar knee arthroplasty in military servicemembers

	N (%)	Medical separation	No medical separation	Odds ratio (95% CI)	p-Value
Age, mean $\pm$ SD (y)	44.5 $\pm$ 5.6	40.7 $\pm$ 1.6	46.0 $\pm$ 5.7	0.67 (0.45, 0.99)	0.0434
Age < 45	24 (62%)	6 (30%)	14 (70%)	Referent	0.0918
Age $\geq$ 45	15 (38%)	0 (0%)	15 (100%)	0.07 (0.01, 1.53)	
Sex					
Male	37 (95%)	6 (18%)	27 (82%)	1.18 (0.03, 53.86)	0.9316
Female	2 (5%)	0 (0%)	2 (100%)	Referent	
BMI Mean $\pm$ SD	29.0 $\pm$ 3.3	27.4 $\pm$ 2.1	29.0 $\pm$ 3.6	0.85 (0.63, 1.16)	0.3025
BMI < 30	24 (62%)	5 (21%)	19 (79%)	Referent	
BMI $\geq$ 30	15 (38%)	1 (9%)	10 (91%)	0.38 (0.04, 3.71)	0.4054
Tobacco use					
Yes	9 (23%)	3 (38%)	5 (62%)	4.80 (0.74, 31.08)	0.0998
No	30 (77%)	3 (11%)	24 (89%)	Referent	
Servicemember population					
Enlisted (E1–E9)	22 (63%)	5 (28%)	13 (72%)	11.00 (0.50, 244.46)	0.1297
Warrant officer/officer (WO1–O6)	13 (37%)	0 (0%)	13 (100%)	Referent	
Branch of service					
Army/Marines	15 (38%)	2 (14%)	12 (86%)	0.71 (0.11, 4.51)	0.7151
Navy/Air Force/other	24 (62%)	4 (19%)	17 (81%)	Referent	
Bilateral procedure					
Yes	7 (18%)	0 (0%)	6 (100%)	0.28 (0.01, 7.03)	0.4374
No	32 (82%)	6 (21%)	23 (79%)	Referent	
Fellowship surgeon					
Yes	22 (56%)	2 (10%)	18 (90%)	0.31 (0.05, 1.95)	0.2105
No	17 (44%)	4 (27%)	11 (73%)	Referent	

Abbreviations: BMI, body mass index; CI, confidence interval; SD, standard deviation.

between staged procedures. Details regarding the number of servicemembers at each stage are provided in ► **Figs. 1** and **2**.

### Occupational Outcomes

At minimum occupational follow-up period of 2 years post-operatively, 33 military servicemembers (85%) had returned to full active duty service or fulfilled their remaining service obligations, while 6 (15%) were medically separated secondary to persistent, rate-limiting knee symptoms (► **Table 1**). The mean time for servicemembers undergoing a medical separation was 1.4 (SD 0.4, range 0.9–1.7) years from the index medial UKA. Univariate analysis revealed that older military servicemembers (OR = 0.67 per annual increase in patient age; 95% CI: 0.45, 0.99) had a significantly decreased OR for being medically separated following a medial UKA (► **Table 1**).

### Surgical Outcomes and Rates of Revision

Of the 46 medial UKAs, there were a total of nine conversion to TKA procedures (20%) performed at an average of 2.4 (SD 1.7, range 0.6–5.6) years (► **Table 2**). No other revision procedures were performed. The calculated annual revision rate was 5.0%.

Among the nine servicemembers who underwent a TKA conversion, all were aseptically and none was medically separated from military service. The indications for the medial UKA to TKA conversions included progression of OA (56%), persistent pain (22%), component loosening (11%), and component malposition (11%). Univariate analysis demonstrated an increased rate of TKA conversion following a medial UKA in Army or Marine servicemembers (OR = 5.40; 95% CI: 1.13, 25.81) when compared with Navy or Air Force servicemembers (► **Table 3**).

### Discussion

The current investigation sought to evaluate the surgical outcomes and revision rates of medial UKA within an active military cohort. The physical demands of servicemembers are stratified by workload, with medium demands defined as occasionally lifting more than 80 pounds and consistently lifting 40 pounds or more.<sup>41</sup> As such, this study offers unique insights about the functional results of patients returning to the rigorous physical fitness and distinct occupational demands required of medium to heavy labor military service.

**Table 2** Risk factors for conversion to total knee arthroplasty following medial unicondylar knee arthroplasty in military servicemembers by procedure (N = 46)

	N (%)	Medical separation	No medical separation	Odds ratio (95% CI)	p-Value
Age, mean ± SD (y)	44.4 ± 5.3	46.6 ± 7.6	43.8 ± 4.5	1.10 (0.96, 1.25)	0.1712
Age < 45	29 (63%)	5 (17%)	24 (83%)	Referent	
Age ≥ 45	17 (37%)	4 (24%)	13 (76%)	1.48 (0.34, 6.48)	0.605
Sex					
Male	44 (96%)	9 (20%)	35 (80%)	1.34 (0.03, 59.19)	0.8801
Female	2 (4%)	0 (0%)	2 (100%)	Referent	
BMI Mean ± SD	29.2 ± 3.4	30.6 ± 3.2	28.9 ± 3.4	1.17 (0.94, 1.45)	0.1678
BMI < 30	29 (63%)	5 (17%)	24 (83%)	Referent	
BMI ≥ 30	17 (37%)	4 (24%)	13 (76%)	1.48 (0.34, 6.48)	0.605
Tobacco use					
Yes	10 (22%)	2 (20%)	8 (80%)	1.04 (0.18, 5.99)	0.9686
No	36 (78%)	7 (19%)	29 (81%)	Referent	
Servicemember population					
Enlisted (E1–E9)	27 (66%)	3 (11%)	24 (89%)	0.31 (0.06, 1.66)	0.1719
Warrant officer/officer (WO1–O6)	14 (34%)	4 (29%)	10 (71%)	Referent	
Branch of service					
Army/Marines	16 (35%)	6 (38%)	10 (62%)	5.40 (1.13, 25.81)	0.0346
Navy/Air Force/other	30 (65%)	3 (10%)	27 (90%)	Referent	
Bilateral procedure					
Yes	14 (30%)	2 (14%)	12 (86%)	0.28 (0.01, 7.03)	0.5534
No	32 (70%)	7 (22%)	25 (78%)	Referent	
Fellowship surgeon					
Yes	25 (54%)	7 (28%)	18 (72%)	3.69 (0.68, 20.19)	0.1316
No	21 (46%)	2 (10%)	19 (90%)	Referent	

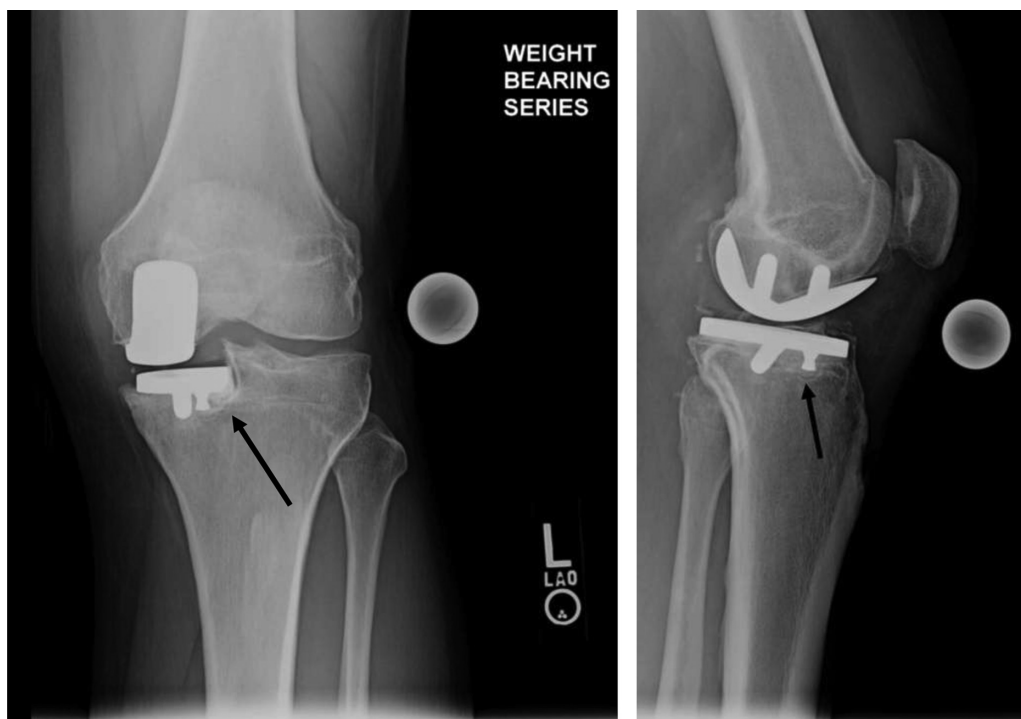
Abbreviations: BMI, body mass index; CI, confidence interval; SD, standard deviation.

While our study found that the majority of patients undergoing medial UKA remained on active duty or completed their term of service, there was a high rate of conversion to TKA.

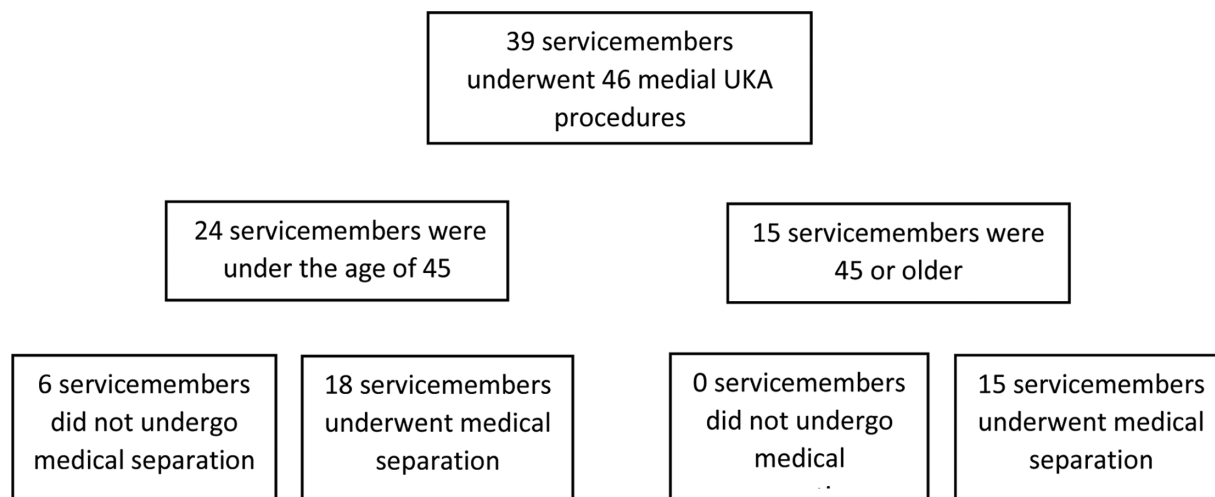
Given the twofold increase in knee arthroplasty among patients younger than 50 years,<sup>42</sup> it is important to assess return to gainful employment. While previous medial UKA studies have identified successful return to work as an important and undervalued metric in patient-centered outcomes, these reports have not adequately addressed patients with moderate-to-high-occupational demands. The reported rates of return to preoperative employment after medial UKA range from 82 to 91% in civilian patients. However, these studies have several shortcomings including unspecified average age at index surgery, low-demand or sedentary level of activities, less than 2-year minimum follow-up, lack of preoperative occupational demand classification, and an absence of TKA conversion data.<sup>20,43</sup> In the present study, 85% of military servicemembers returned to military function at short-term follow-up.<sup>44,45</sup> Older servicemembers were at decreased risk (OR 0.67) of medical separation with age analyzed as a continuous variable.

Similar findings were documented by Belmont et al, where servicemembers under 45 years of age were at significantly higher risk of medical separation after TKA.<sup>46</sup> The inherent occupational demands and performance expectations of younger, more junior ranking servicemembers following knee arthroplasty procedure may offer a plausible explanation for their greater risk of medical separation.

The most common underlying reasons for conversion of UKA to TKA include progression of tibiofemoral arthritis, prosthetic loosening, and persistent knee pain.<sup>47</sup> While large-scale studies examining more than 8,000 UKAs demonstrate revision rates of 10.5 to 10.9% at mid-term follow-up, 20% of medial UKA knees underwent TKA conversion in the current study.<sup>48–50</sup> These findings are consistent with those of W-Dahl et al, who demonstrated a 20% revision rate for UKA patients under the age of 55 years.<sup>25</sup> Ostensibly, younger military servicemembers with high activity levels and longer life expectancy have an increased likelihood for TKA conversion. However, the medial UKA cohort annual revision rate of 5.0% far exceeds the recommended cost-effective annual revision rate threshold of 1.5% established for



**Fig. 1** Number of servicemembers stratified by bilateral versus unilateral procedure and necessity of revision. UKA, unicompartmental knee arthroplasty.



**Fig. 2** Number of servicemembers stratified by return to duty versus medical separation. UKA, unicompartmental knee arthroplasty.

medial UKA patients < 65 years.<sup>37</sup> The sole risk factor associated with TKA conversion (OR = 5.40; 95% CI: 1.13, 25.81) was service in the Army or the Marine Corps, which typically entails greater physical and occupational demands.

Medial UKA to TKA conversion is associated with inferior surgical outcomes, including revision rates approximately four-fold higher than primary TKA, and patient-reported outcomes similar to those of revision TKA.<sup>49,51</sup> Consequently, the poorer outcomes associated with conversion of UKA to TKA must be balanced against more conservative and joint-preserving options in younger, more active patient populations. Additional registry data also demonstrate a significantly increased risk of revision following previous medial UKA and previous closed-wedge HTOs compared with primary TKA.

Stemmed or revision arthroplasty implants were required in 17 to 34% of UKA to TKA conversions compared with 4% of HTO to TKA conversions.<sup>28,50,51</sup> These increased revision rates may be due to the high preoperative expectations for knee arthroplasty common in younger and male patients. Patients anticipate significant improvements in ability to perform routine activities of daily living, work, and leisure.<sup>52,53</sup> Therefore, these medial UKA patients with substantial occupational demands should be preoperatively counseled about return to previous employment, including difficulty kneeling and squatting, potential long-term effects on implant survival, progressive adjacent compartment degeneration, prosthetic complications, possible persistence of knee pain, and the risks and complexities associated with conversion to TKA.



**Table 3** Demographics and indication for conversion to TKA

Patient	Age	Branch of service	Time until conversion to TKA (y)	Indication for revision
1	39	Air Force	5.5	Pain/progression of OA
2	55	Army	1.6	Progression of OA
3	49	Army	4.3	Progression of OA
4	41	Navy	1.4	Component malposition
5	39	Army	3.0	Component loosening
6	43	Public Health Service Corps	3.0	Progression of OA
7	60	Army	1.2	Anterior knee pain
8	42	Army	0.7	Persistent pain
9	51	Army	0.5	Pain/progression of OA

Abbreviations: OA, osteoarthritis; TKA, total knee arthroplasty.

Prospective long-term studies of patients with medial UKA resuming moderate- to high-occupational demand jobs are warranted to better characterize the medical and economic risks vis-à-vis expected pain relief, improved physical function, and psychosocial well-being.<sup>54,55</sup>

The strengths of this study include the closed health care system, universally mandated physical fitness requirements, and intense occupational demands for these active duty servicemembers who underwent medial UKA. However, there are limitations. First, the retrospective study of prospectively gathered data limits the amount of information that can be reliably obtained from preexisting medical records, including patient-reported outcomes. Second, this military cohort's occupational and physical demands are generally nonmodifiable and may be very challenging to perform following medial UKA. Third, servicemembers may be inclined to pursue a disability-associated medical separation to protect themselves from further injury or secondary surgery, as seen in the Workers' Compensation system.<sup>56</sup>

## Conclusion

Medial UKA offers young, highly active military servicemembers a potential option for treatment of isolated medial compartment OA with 85% of patients remaining on active duty or completing their term of service. However, patients should be counseled that a persistent high rate of activity, such as that of Army or Marines service, may contribute to a 20% rate of TKA conversion. Accordingly, these data might be used as a benchmark for assessing occupational outcomes and revision arthroplasty rates for medial UKA or other surgical treatment options for medial tibiofemoral OA in other active patient populations with increased occupational demands.

### Note

The findings presented in this manuscript have not been previously presented.

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None.

### Conflict of Interest

Some authors are employees of the U.S. federal government and the United States Army. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense or U.S. government..

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