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CLINICAL RESEARCH

Are Barbed Sutures Associated With 90-day Reoperation Rates After Primary TKA?

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Abstract

Background Studies have suggested that barbed sutures for wound closure in TKAs are an acceptable alternative to standard methods. However others have observed a higher risk of wound-related complications with barbed sutures.

Questions/Purposes (1) Do 90-day TKA reoperation rates differ between patients undergoing a barbed suture arthrotomy closure compared with a traditional interrupted closure? (2) Do the 90-day reoperation rates of wound-related, deep infection, and arthrotomy failure complications differ between barbed suture and traditional closures?

Methods A retrospective analysis of a longitudinally maintained institutional primary TKA database was conducted on all TKAs performed between April 2011 and September 2015. We compared 884 primary TKAs, where the arthrotomy was closed with a barbed suture, with 1598 primary TKAs closed with the standard interrupted suture. After barbed sutures were introduced at our institution in 2012, the majority of surgeons gradually switched to barbed suture closures, with many using them exclusively by the end of the data collection period. We confirmed in-person followups and available data past 90 days for 97.4% (1556 of 1598) of the knees in patients with standard sutures and 94.8% (838 of 884) of the knees in patients with barbed sutures. Our primary endpoint was all-cause 90-day reoperation; our secondary endpoints considered: wound-related reoperation, as defined by previous studies; deep infection per Musculoskeletal Infection Society guidelines; and arthrotomy failure, defined intraoperatively as an opening or dehiscence through the previous arthrotomy closure. T tests and chi-square analyses were used to determine differences between the suture cohorts, and bivariate logistic regression was used to determine associations with our 90-day reoperation outcomes.

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Results With the numbers available, there was no association between suture type and 90-day all-cause reoperation (odds ratio [OR], 1.70; 95% CI, 0.82–3.53; p = 0.156). Suture type was not associated with wound-related reoperation (OR, 2.73; 95% CI, 0.97–7.69; p = 0.058). A 0.6% (five of 884) arthrotomy failure rate was observed in the barbed cohort while no (0 of 1598) arthrotomy failures were noted in the traditional group (p = 0.003). Deep infections were rare in both groups (two of 884 barbed sutures, 0 of 1598 standard sutures) and could not be compared.

Conclusions Although we saw no difference in overall and wound-related 90-day reoperation rates by suture type with the numbers available, we observed a higher frequency in our secondary question of arthrotomy failures when barbed sutures are used for arthrotomy closure during TKA. Given the widespread use of this closure technique, our preliminary pilot results warrant further investigation in larger multicenter cohorts.

Level of Evidence Level III, therapeutic study.

Introduction

Knotless, barbed, sutures are widely available as an option for wound closure during TKA [6, 9, 12, 19, 21]. Several studies have highlighted the time and cost savings associated with their use [8, 10, 20, 21], with randomized control trials (RCT) showing savings of nearly 5 minutes and from USD 95 to USD 175 per TKA [7, 15]. Three RCTs using barbed sutures to close the arthrotomy and subcutaneous layer [7, 20], or all wound layers [15], did not find differences in postoperative complications between patients receiving the two suture types. Similarly, retrospective studies evaluating barbed sutures for closing the arthrotomy and subcutaneous layer found no differences in closure-related perioperative complications to conventional sutures [8, 10, 19].

However, concerns related to extensor-mechanism failures when using barbed sutures for arthrotomy closure [22] and higher risks of infection with barbed closure of subcuticular [14] or all layers [17] also have been reported. These concerns were validated by a study showing substantially higher proportions of deep infection (4.7% barbed versus 0.8% standard, p = 0.018), superficial infection (11.8% versus 3.2%, p = 0.001), and overall wound complications (19.5% versus 7.3%, p < 0.001) when barbed sutures are used for subcutaneous and subcuticular closure in a group of patients undergoing partial TKAs and TKAs [4]. One large retrospective study of unicompartmental knee arthroplasties (UKA) found an increased risk of wound-related complications in patients whose UKAs were closed with barbed suture for the subcuticular layer or for the subcuticular and arthrotomy layers, but use of a barbed suture for arthrotomy closure was not independently associated with risk of infection [5]. Our synthesis is that previous studies have raised greater wound-healing concerns with the use of barbed sutures for subcutaneous or subcuticular closure [4, 5] than for their use for the arthrotomy repair [7, 15, 20]. Postoperative complications are rare occurrences requiring large sample sizes to determine whether differences truly exist, and this has been a limitation of most studies to date. Recent meta-analyses have pooled data and reported no differences in minor complications, major complications, deep infection, or wound dehiscence [2, 11, 24], but remain limited by sample size, using overall pooled observations of fewer than 1800 patients. Additional studies including more patients and prospective data are needed to definitively compare wound-related complications between barbed and traditional sutures in TKAs.

Among the surgeons performing TKAs at our institution, many have adopted using barbed sutures for arthrotomy closure while others use more-traditional methods, but all use more-traditional closure methods in the more-superficial layers. This variation in technique between surgeons and with time provided an opportunity to compare the suture material through our longitudinally maintained orthopaedic data repository.

We therefore asked: (1) Do 90-day TKA reoperation rates differ between patients undergoing a barbed suture arthrotomy closure compared with a traditional interrupted closure? (2) Do the 90-day reoperation rates of wound-related, deep infection, and arthrotomy failure complications differ between barbed suture and traditional closures?

Methods

After our institutional review board conducted an approved expedited review and waived consent approval, we retrospectively reviewed a longitudinally maintained database of all TKAs completed at our academic tertiary institution in rural northeastern USA from April 2011 through September 2015 (Fig. 1). TKAs were performed by 11 surgeons; nine surgeons used both suture types during the study period. The database included at least 90 days of followup for each patient to ascertain reoperations.

The database review produced 1887 eligible patients who underwent 2002 primary TKAs, 480 of whom underwent simultaneous bilateral procedures with two attending surgeons, resulting in 2482 knees. Twelve patients, constituting 22 TKAs, were excluded from the initial patient cohort owing to unknown suture type (n =

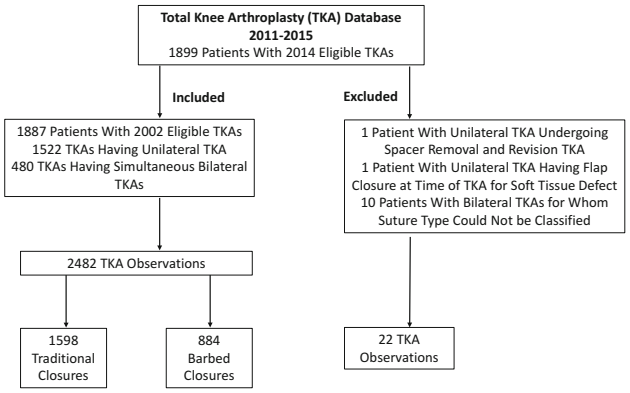

Fig. 1 The diagram shows our study protocol for the patients reviewed in the longitudinally maintained database and compared in the study analyses.

10), necessity for flap closure (n = 1), or miscoding (n = 1). There were no other exclusions. This allowed 884 knees with a barbed suture arthrotomy closure to be compared with 1598 knees closed with traditional sutures. We confirmed in-person followups and available data past 90 days for 97.4% (1556 of 1598) of the knees of patients with standard sutures and 94.8% (838 of 884) of the knees of patients with barbed sutures. Suture-purchasing data and operative notes were used to group patients.

There were no differences in terms of age, sex, BMI, or tobacco use between the cohorts, although there were preoperative differences in race/ethnicity and patient-reported physical function (Table 1).

Description of Experiment, Treatment, or Surgery

Two thousand four hundred eighty-two knees were completed though a medial parapatellar approach and included, depending on surgeon preference and patient anatomy, quadriceps tendon splitting, mid-vastus, and subvastus arthrotomies. In general, most surgeons in the study gradually adopted the use of the barbed suture after it was introduced at our institution in 2012, and ultimately used it near exclusively for their unilateral cases. There were a smaller number of surgeons who either never used the barbed suture or used them for a short period in 2012 or 2013 before returning to standard methods. In the traditional closure group Number 1 Vicryl® (Ethicon Inc; Cincinnati, OH, USA) was used in an interrupted fashion to close the arthrotomy. In the barbed suture group a Number 1 Stratafix™ Spiral PDO (Ethicon Inc), 36 cm in length was used in a running fashion to close only the arthrotomy. In all knees, the subcutaneous layer was closed with Number 2-0 Vicryl® (Ethicon Inc), while the skin was closed according to surgeon preference.

Variables, Outcome Measures, Data Sources, and Bias

The rate of reoperation within 90 days of the index TKA included open or arthroscopic procedures of any type on the same knee. Wound-related reoperations were procedures completed to address any type of wound issue including septic or aseptic complications, similar to groupings in previous studies [4, 5, 10]. We defined deep infections according to the Musculoskeletal Infection Society guidelines [13]. The presence of an arthrotomy failure was determined intraoperatively as an opening or dehiscence through the previous arthrotomy closure. If a patient sustained a periprosthetic fracture at the time of the arthrotomy violation, this was not classified as a failure. All of this information was obtained through review of operative and clinical notes. All preoperative variables, including provider-recorded BMI and Veterans RAND-12 (VR-12) patient-reported physical and mental function, were obtained through standard clinic visits. Peri- and postoperative findings were obtained through our standing orthopaedic data repository, with additional chart or purchasing review as needed.

Statistical Analysis, Study Size

Few variables were missing values and we had no concerns with missing data (Table 1). As reoperation and infection percentages varied widely in earlier studies [2, 4, 5, 7, 11, 15, 20, 24], we were unsure what percentage of reoperations we would find by suture a priori. With our captured reoperations, post hoc power analyses of the primary and secondary outcomes showed power of 0.29 for 90-day reoperations, 0.41 for wound-related reoperations, and 0.70 for arthrotomy failures. We used chi-squared analyses and Student's t tests for qualitative and quantitative comparisons, respectively (Table 1). There were five arthrotomy failures, all of which occurred after TKAs with barbed sutures (Table 2). Unadjusted bivariate logistic regressions were performed for 90-day and suture-related reoperations (Table 3). All arthrotomy failures occurred in the barbed cohort, making regression analyses between groups impossible. Deep infections were too rare to be compared meaningfully. All analyses were performed used Stata 12MP™ (StataCorp, College Station, TX, USA).

Results

There was no association between suture type and 90-day reoperation (odds ratio [OR], 1.70; 95% CI, 0.82–3.53; p = 0.156) (Table 3). No variables were associated with 90-day reoperations.

Table 1. Data for relevant variables for primary TKAs by suture status

Variable	Total count (n = 2482)	Standard sutures % (n =1598; 64%)	Barbed sutures % (n = 884; 36%)	p Value*
Preoperative prospective data				
Surgery year	2482			< 0.001
April – December 2011	416	100	0	
2012	644	93	7	
2013	657	53	47	
2014	465	36	64	
January – September 2015	300	22	78	
Age group (years)	2482			0.829
< 55	340	14	13	
55–59	351	14	14	
60–64	466	19	18	
65–69	523	21	22	
70–74	378	15	16	
75–79	250	10	10	
80 +	174	7	7	
Sex	2482			0.145
Male	1030	40	43	
Female	1452	60	57	
Race/ethnicity	2482			0.007
Non-hispanic white	2436	99	97	
Other	46	1	3	
Tobacco use preoperative	2428			0.446
Never	1135	48	45	
Quit	1127	45	48	
Yes	166	7	7	
Charlson score	2482			0.005
0	1469	61	56	
1	513	21	20	
2 +	500	18	24	
Any VR-12 PRO preoperative?	2482			< 0.001
Yes	2364	93	99	
No	118	7	1	
VR-12 PCS Preoperative (continuous)	2360	31.4 (SD, 11.1)	30.6 (SD, 10.7)	0.071
VR-12 PCS preoperative (grouped)	2360			0.174
50 +	159	7	6	
40.00–49.99	343	15	14	
30.00–39.99	566	25	22	
20.00–29.99	952	39	43	
< 20	340	14	14	
VR-12 MCS preoperative (continuous)	2360	51.5 (SD, 14.2)	56.3 (SD, 11.2)	< 0.001
VR-12 MCS preoperative (grouped)	2360			< 0.001
60 +	993	39	48	
50.00–59.99	528	20	27	
40.00–49.99	353	15	15	
30.00–39.99	322	17	8	
< 30	164	10	3	

Table 1. continued

Variable	Total count (n = 2482)	Standard sutures % (n =1598; 64%)	Barbed sutures % (n = 884; 36%)	p Value*
Second primary TKA?	2482			< 0.001
No	2367	97	92	
Yes	115	3	8	
BMI preoperative (kg/m^2) (continuous)	2276	32.6 (SD, 7.5)	32.3 (SD, 7.5)	0.381
BMI preoperative (kg/m^2) (grouped)	2276			0.329
Normal < 25	320	13	16	
Overweight 25–29	666	30	28	
Obese 30–34	548	24	24	
Severely obese 35–39	382	17	17	
Morbidly obese 40+	360	16	15	
Bilateral TKA	2482			< 0.001
No	1522	53	76	
Yes	960	47	24	
Laterality	2481			0.412
Left	1216	50	48	
Right	1265	50	52	
Operating surgeon[&]	2482			< 0.001
1	497	42	58	
2	373	99	1	
3	455	36	64	
4	363	91	9	
5	255	49	51	
6	233	77	23	
7	46	4	96	
8	32	19	81	
9	2	100	0	
10	223	92	8	
11	3	100	0	
Postoperative prospective data				
Length of surgery (minutes) (continuous)	2480	102 (SD, 20)	90 (SD, 19)	< 0.001
Length of surgery (minutes) (grouped)	2480			< 0.001
52–80	447	10	33	
80–89	450	16	22	
90–99	554	25	18	
100–109	440	20	13	
110–276	589	30	13	
Length of stay (days) (continuous)	2482	3.34 (SD, 1.71)	2.85 (SD, 1.38)	< 0.001
Length of stay (grouped)	2482			< 0.001
1–2	746	23	42	
3	1108	47	41	
4	381	18	10	
5 +	247	12	7	
Discharge disposition	2479^			< 0.001
Home	1315	49	60	
Facility	1164	51	40	
Any 90-day reoperation?	2482			0.152
No	2453	99	98	
Yes	29	1 (n = 15)	2 (n = 14)	

Table 1. continued

Variable	Total count (n = 2482)	Standard sutures % (n =1598; 64%)	Barbed sutures % (n = 884; 36%)	p Value*
Any 90-day reoperation that may be wound-related?	2482			0.048
No	2467	100	99	
Yes	15	0 (n = 6)	1 (n = 9)	
Any 90-day arthrotomy failure?	2482			0.003
No	2475	100	99	
Yes	7	0 (n = 0)	1 (n = 5)	
Reoperation data for 29 knees (using numbers rather than percentages)[§]				
Days to reoperation (continuous)	29	18 (SD, 11)	27 (SD, 23)	0.181
Reoperation laterality	29			0.040
Left	15	5	10	
Right	14	10	4	

2482 surgically treated knees, 2002 TKAs, 1887 patients; not all percentages will add up to 100 and counts to 2482 owing to rounding or missingness; *using t test or chi-square analysis depending on whether variable is continuous or categorical; ^2 individuals (3 knees, 2 standard and 1 barbed) died while inpatients; [&]the actual surgeon performing surgery on the individual knee, not the "attending" surgeon with oversight for the whole surgery; [§]15 reoperated knees had standard sutures, 14 had barbed sutures, the same sutures were used for reoperations as used in the initial primary operation; VR-12 = Veterans-RAND 12-Item Survey; PRO = Patient-reported outcome; PCS = Physical Component Score; MCS = Mental Component Score.

We found no difference between barbed and conventional sutures for 90-day wound-related reoperations (OR, 2.73; 95% CI, 0.97–7.69; p = 0.058) (Table 3). No other variables were associated with 90-day wound-related reoperations (Table 3). There was a 0.6% (five of 884) rate of arthrotomy failure in the barbed cohort and no failures (0 of 1598) in the traditional cohort (p = 0.003) (Table 1). Two deep infections were observed in the barbed suture group, and none in the traditional closure group; these numbers were too small to compare statistically.

Discussion

Although barbed sutures generally have been considered to be an accepted alternative to a traditional interrupted closure [6, 7, 10, 15, 19, 20], recent studies have shown concerns regarding increased risk of infection in arthroplasty wounds closed with barbed sutures in the deep and superficial layers [5] or superficial layers alone [4], indicating that further study is warranted. We present the results of a large-scale, single-center, retrospective cohort study of prospectively collected data comparing barbed suture arthrotomy closure with traditional closure in TKA. To our knowledge, our study is the largest on this topic, including pooled meta-analyses [2, 11, 24], by hundreds of knees. Using our data, we estimate that approximately 4235 knees would be needed of each suture type to achieve power of 0.80 for 90-day reoperations, assuming the point estimates for event rates are as we observed them, an amount that does not seem achievable at a single institution for many years. With the numbers available, our findings indicate no difference in the 90-day reoperation or 90-day wound-related reoperation rates between the suture types when used for arthrotomy closure.

This study is limited by some baseline differences between the two cohorts (Table 1). Owing to rare outcomes, we were unable to adjust for these differences in analyses. Although differences are noted, there are no discrepancies that can clearly account for an increased complication rate in the barbed suture cohort, nor were any variables associated with reoperations (Table 3). More patients in the traditional suture cohort underwent simultaneous bilateral TKAs, although this is likely owing to the higher proportions of institutional bilateral TKAs during the years before barbed sutures (data not shown). In addition, preoperative patient-reported VR-12 values were higher in the barbed suture group, but the clinical importance of this is debatable [1, 18]. Some complications may not have been captured if patients presented to another institution; however, we have in-person followups and available data past 90 days for 97.4% (1556 of 1598) of the knees in patients with standard sutures and 94.8% (838 of 884) of the knees in patients with barbed sutures (data not shown). There may be differences in surgical techniques by surgeon, such as in skin closure techniques. However, there were no differences in 90-day reoperation rates by surgeon, and most surgeons used both sutures (Table 1). In addition, recent randomized control trials suggest no differences in wound complications when comparing staples with nylon

Table 2. Arthrotomy failures in patients in the study

Suture type	Demographics	Medical history	Postoperative day	Case description	Intraoperative findings	Culture data
Barbed	61-year-old male	Diabetes mellitus, non-ST segment elevation myocardial infarction	23	Acute onset of atraumatic swelling and pain. 100,200 WBCs in aspiration	Arthrotomy dehiscence proximal to patella, gross purulence, well-fixed implants	Methicillin-sensitive *Staphylococcus aureus*
Barbed	73-year-old female	Diabetes mellitus, chronic kidney disease, hypertension	59	Pinhole area of nonhealing wound with sanguinous drainage. No evidence of infection	Arthrocutaneous fistula, arthrotomy dehiscence along medial border of patella	Culture negative
Barbed	39-year-old female	Hypothyroidism, polytrauma	20	Initial twisting injury and sensation of popping with inability to bear weight. Fall later that day resulted in wound dehiscence probing to joint	Wound dehiscence, traumatic arthrotomy, disruption of capsule at tibial plateau, distal mid-substance tear of patella tendon	None taken
Barbed	55-year-old female	None	2	Dehiscence of inferior wound of unclear etiology	Wound dehiscence, 2 cm inferior arthrotomy failure	None taken
Barbed	77-year-old female	Hypertension, hypothyroidism	25	Progressive superficial wound dehiscence after fall	Wound dehiscence, broken barbed suture over proximal arthrotomy	Methicillin-resistant *Staphylococcus aureus*

Table 3. Bivariate associations with 90-day TKA reoperation (any reason, n = 29) and wound-related reoperation (n = 15) among primary TKAs

Variable	All reoperations % (number)	OR	95% CI	p Value	Wound related % (number)	OR	95% CI	p Value	Arthrotomy failure[#,*]
Sutures									
Standard, n = 1598	1% (15)	Ref	Ref	Ref	0% (6)	Ref	Ref	Ref	0
Barbed, n = 884	2% (14)	1.70	0.82–3.53	0.156	1% (9)	2.73	0.97–7.69	0.058	5
Surgery year									
April – December 2011, n = 416	1% (6)	Ref	Ref	Ref	0% (2)	Ref	Ref	Ref	0
2012, n = 644	1% (5)	0.53	0.16–1.76	0.302	0% (3)	0.97	0.16–5.83	0.972	0
2013, n = 657	1% (5)	0.52	0.16–1.73	0.287	0% (3)	0.95	0.16–5.71	0.955	1
2014, n = 465	2% (7)	1.04	0.35–3.12	0.938	1% (4)	1.80	0.33–9.87	0.500	2
January – September 2015, n = 300	2% (6)	1.39	0.45–4.36	0.567	1% (3)	2.09	0.35–12.62	0.421	2
Age group (years)									
< 55, n = 340	1% (4)	Ref	Ref	Ref	1% (4)	Ref	Ref	Ref	1
55–59, n = 351	2% (6)	1.46	0.41–5.23	0.560	1% (4)	0.97	0.24–3.90	0.964	1
60–64, n = 466	1% (5)	0.91	0.24–3.43	0.890	0% (1)	0.18	0.02–1.62	0.127	1
65–69, n = 523	1% (4)	0.65	0.16–2.61	0.541	0% (2)	0.32	0.06–1.77	0.193	0
70–74, n = 378	1% (4)	0.90	0.22–3.62	0.880	1% (3)	0.67	0.15–3.02	0.604	1
75–79, n = 250	2% (4)	1.37	0.34–5.49	0.660	0% (1)	0.34	0.04–3.04	0.332	1
80 +, n = 174	1% (2)	0.98	0.18–5.33	0.978	0% (0)	–	–	–	0
Sex									
Male, n = 1030	1% (9)	Ref	Ref	Ref	0% (4)	Ref	Ref	Ref	1
Female, n = 1452	1% (20)	1.58	0.72–3.49	0.253	1% (11)	1.96	0.62–6.17	0.251	4
Race/ethnicity									
Non-hispanic white, n = 2436	1% (28)	Ref	Ref	Ref	1% (14)	Ref	Ref	Ref	5
Other, n = 46	2% (1)	1.91	0.25–14.43	0.530	2% (1)	3.84	0.49–29.87	0.198	0
Tobacco use preoperative									
Never, n = 1135	1% (13)	Ref	Ref	Ref	1% (7)	Ref	Ref	Ref	2
Quit, n = 1127	1% (14)	1.09	0.51–2.32	0.832	1% (7)	1.01	0.35–2.88	0.989	3
Yes, n = 166	1% (1)	0.52	0.07–3.99	0.532	1% (1)	0.98	0.12–7.99	0.982	0
Charlson score									
0, n = 1469	1% (15)	Ref	Ref	Ref	1% (7)	Ref	Ref	Ref	3
1, n = 513	1% (7)	0.72	0.08–6.40	0.764	0% (3)	1.23	0.32–4.77	0.766	0
2 +, n = 500	1% (7)	1.47	0.27–8.05	0.656	1% (5)	2.11	0.67–6.68	0.204	2
VR-12 PCS preoperative (grouped)									
50 +, n = 159	1% (1)	Ref	Ref	Ref	0% (0)	Ref	Ref	Ref	0
40.00–49.99, n= 343	1% (3)	1.39	0.15–13.38	0.773	0% (1)	0.35	0.02–5.70	0.464	1
30.00–39.99, n = 566	1% (7)	1.98	0.24–16.05	0.523	1% (5)	1.08	0.12–9.31	0.945	0
20.00–29.99, n = 952	1% (11)	1.85	0.24–14.27	0.556	1% (4)	0.51	0.06–4.60	0.549	0
< 20, n = 340	2% (6)	2.84	0.34–23.52	0.334	1% (4)	1.44	0.16–13.02	0.745	3
VR-12 MCS preoperative (grouped)									
60 +, n=993	1% (11)	Ref	Ref	Ref	1% (6)	Ref	Ref	Ref	2
50.00–59.99, n = 528	1% (6)	1.03	0.38–2.78	0.960	1% (4)	1.26	0.35–4.47	0.725	2
40.00–49.99, n = 353	1% (6)	1.54	0.57–4.21	0.396	1% (3)	1.41	0.35–5.67	0.628	0
30.00–39.99, n = 322	1% (2)	0.56	0.12–2.53	0.449	0% (1)	0.51	0.06–4.27	0.537	0
< 30, n = 164	2% (3)	1.66	0.46–5.97	0.435	0% (0)	–	–	–	1
Second primary TKA?									
No, n = 2,367	1% (27)	Ref	Ref	Ref	1% (14)	Ref	Ref	Ref	5
Yes, n = 115	2% (2)	1.53	0.36–6.53	0.563	0% (1)	1.47	0.19–11.31	0.709	0

Table 3. continued

Variable	All reoperations % (number)	OR	95% CI	p Value	Wound related % (number)	OR	95% CI	p Value	Arthrotomy failure[#,*]
BMI preoperative (kg/m^2) (grouped)									
Normal < 25, n = 320	1% (3)	Ref	Ref	Ref	0% (1)	Ref	Ref	Ref	0
Overweight 25 –29, n = 666	1% (7)	1.12	0.29–4.37	0.868	1% (4)	1.93	0.21–17.32	0.558	1
Obese 30–34, n = 548	1% (8)	1.57	0.41–5.93	0.509	0% (2)	1.17	0.11–12.94	0.899	0
Severely obese 35–39, n = 382	1% (4)	1.12	0.25–5.02	0.884	1% (2)	1.68	0.15–18.60	0.673	1
Morbidly obese 40+, n = 360	2% (6)	1.79	0.44–7.22	0.413	1% (5)	4.49	0.52–38.66	0.171	2
Bilateral status									
No, n = 1522	1% (19)	Ref	Ref	Ref	1% (12)	Ref	Ref	Ref	4
Yes, n = 960	1% (10)	0.83	0.39–1.79	0.640	0% (3)	0.39	0.11–1.40	0.150	1
Laterality									
Left, n = 1216	1% (13)	Ref	Ref	Ref	1% (7)	Ref	Ref	Ref	4
Right, n = 1265	1% (16)	1.19	0.57–2.48	0.651	1% (8)	1.10	0.40–3.04	0.855	1
Operating surgeon**									
1, n = 497	1% (6)	Ref	Ref	Ref	1% (3)	Ref	Ref	Ref	1
2, n = 373	1% (3)	0.66	0.16–2.67	0.564	1% (2)	0.89	0.15–5.34	0.896	0
3, n = 455	1% (5)	0.91	0.28–3.00	0.876	1% (3)	1.09	0.22–5.44	0.914	1
4, n = 363	1% (5)	1.14	0.35–3.78	0.827	0% (2)	0.91	0.15–5.49	0.920	1
5, n = 255	2% (6)	1.97	0.63–6.18	0.244	1% (3)	1.96	0.39–9.78	0.412	0
6, n = 233	0% (1)	0.35	0.04–2.95	0.336	0% (0)	–	–	–	0
7, n = 46	0% (0)	–	–	–	0% (0)	–	–	–	0
8, n = 32	3% (1)	2.64	0.31–22.63	0.376	3% (1)	5.31	0.54–52.56	0.153	1
9, n = 2	0% (0)	–	–	–	0% (0)	–	–	–	0
10, n = 223	1% (2)	0.74	0.15–3.70	0.714	0% (1)	0.74	0.08–7.17	0.796	1
11, n = 3	0% (0)	–	–	–	0% (0)	–	–	–	0

n = 2482 surgically treated knees, 2002 TKAs, 1887 patients; using logistic regression techniques, clustered on patient and surgery date to account for bilateral surgeries and some patients having separate unilateral primary TKAs on different dates; only includes variables known preoperatively. Each variable is not adjusted for any other variable in the model. Percentages are rounded. Counts may not add up to total owing to missing data for that particular variable; [#]all 5 arthrotomy failures occurred in surgeries with barbed sutures so logistic regression analyses could not be performed; arthrotomy failures are presented by category for interest, but not analysis; – did not include any cases and could not be calculated; **the actual surgeon performing surgery on the individual knee, not the "attending" surgeon with oversight for the whole surgery; OR = odds ratio; VR-12 = Veterans-RAND 12-Item Survey; PCS = Physical Component Score; MCS = Mental Component Score.

sutures in TKAs [23] and staples with intradermal sutures in THAs [3]. There may be concerns that more "difficult" TKAs were treated with barbed sutures, leading to higher wound complications; however, there were no differences in sutures by preoperative BMI and physical function scores (Table 1), and with only minimal exclusions. There may be a learning curve with barbed sutures, which we have not captured, that may be associated with higher failure rates; however, most study surgeons have extensive experience with both suture types; surgery year and surgeon were not associated with any outcomes and no arthrotomy failures were observed during the first year of barbed suture use. A final limitation of our study is the limited power, as described previously, although this is a frequent issue with rare surgical outcomes. It would be difficult for any individual institution to achieve a power of 0.80 for all-cause reoperations, which we determined to be approximately 4235 knees for each suture group, and this level of surgical detail is generally unavailable in large multisite repositories. We therefore consider our study to be pilot data for larger multicenter trials to conduct further research on the topic.

We found no difference in the rates of 90-day reoperation between the groups, with the numbers available. This metric captures the myriad of complications that necessitate return to the operating room for primary TKA, and suggests that overall there is no difference in the performance of the two closure methods. It is difficult to directly compare our primary and secondary outcomes with previous studies as 90-day overall reoperation rates have not been reported, to the best of our knowledge, in prior barbed suture studies. Our observation of no between-group differences in 90-day reoperation rates between the cohorts is in agreement with previous smaller studies that reported no

differences in overall complications when using barbed sutures to close the arthrotomy and superficial layers [6–8, 19, 20].

When comparing wound-related complications including infections and wound dehiscence, we found no differences. Our observation of differences in wound-related reoperations between the cohorts is in agreement with several studies that specifically noted no differences in wound complications [6–8, 10, 20]. Although Gilliland et al. [7], in their RCT, found no increased complications with use of barbed sutures for arthrotomy and subcutaneous closure in TKA, their 6-week followup would miss potential delayed complications. In our data, three of the 29 reoperations occurred after this period. Studies have highlighted increased risks of infection, particularly when using barbed suture closures for the superficial wound layers [4, 5, 14]. In the study by Chawla et al. [5], highlighting increased risks of wound infection when using barbed sutures in UKA, barbed suture was used for arthrotomy closure in some knees; however, subgroup analysis showed no independent association between infection and barbed suture arthrotomy closure. Some authors have suggested that tightening of the tissue closure resulting in ischemia [5], increased tissue inflammation, or bacterial colonization of the deep barbs may cause wound complications [16]. In our study there were five arthrotomy failures in the barbed suture cohort whereas none was observed in the traditional suture cohort. These findings lend support to a previous case series highlighting arthrotomy failures with barbed sutures [22] in TKAs. Although some studies [4, 8] have not reported arthrotomy failures as a separate outcome, others have noted rates of 0 of 50 for barbed sutures [15], two of 89 for barbed sutures and 0 of 750 in standard sutures [5], and one of 17 for barbed sutures and 0 of 18 with standard sutures [20]. These additional studies highlight that arthrotomy failure following a barbed suture arthrotomy closure warrant further study. Deep infection counts were too low to be compared in our study, and future large-scale studies will be necessary to determine if risks of infection are affected by barbed suture closures.

Our results showed no difference in overall 90-day reoperation rates or wound-related reoperation rates in the barbed suture cohort. However, there were no arthrotomy failures in the conventional suture cohort (0 of 1598) and five (of 884) arthrotomy failures in the barbed suture cohort. Although these differences are not necessarily large enough to change clinical practice in our pilot data, they do warrant further investigation. Future multicenter, high-quality studies with larger sample sizes are needed to definitively determine the safety and efficacy of barbed sutures in TKAs.

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