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Prognostic Factors for Success After Irrigation and Debridement with Modular Component Exchange for Infected Total Knee Arthroplasty

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Abstract

Introduction—Irrigation and debridement with modular component exchange (IDMCE) can treat prosthetic joint infection (PJI) following total knee arthroplasty (TKA). Compared to two-stage revision, IDMCE is associated with lower morbidity, but may carry higher infection recurrence rates. We aimed to identify prognostic factors associated with successful IDMCE following patients with PJI.

Methods—We identified 99 consecutive patients who underwent IDMCE following TKA PJI at a tertiary academic medical center from November 2009 through January 2016. Examined variables included age, gender, symptom duration, body mass index, Charlson Comorbidity Index, total protein, albumin, hemoglobin A1c, erythrocyte sedimentation rate (ESR), C-reactive protein, white blood cell count, gram stain results, final cultures, and use of long-term antibiotic suppression. Success was defined as no further operation on the ipsilateral knee. We used t-tests and chi-squared analyses to determine whether each preoperative factor was associated with IDMCE reoperation.

Results—At mean follow-up of 2.6 years, 64 patients who underwent IDMCE were defined as successful. Thirty-five patients required one or more additional procedures for recurrent infection; of these, 20 patients underwent two-stage revision. Patients with symptom duration of less than

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two days avoided additional surgery in 88% of cases. Elevated ESR >47mm/hr was the only variable associated with reoperation (P=0.005). There were no associations among the other examined variables.

Conclusion—Using IDMCE for PJI after TKA required reoperation in 35% of cases. Elevated preoperative ESR laboratory values and duration of symptoms >2 days were associated with reoperation.

Keywords

Irrigation and debridement with modular component exchange; total knee arthroplasty; infection; prosthetic joint infection; reoperation

Introduction

Two-stage revision is the gold-standard treatment for prosthetic joint infection (PJI) following total knee arthroplasty (TKA) [1, 2]. While two-stage revision successfully treats infection in 89% of PJI cases [2], it presents a significant burden to the patient and hospital [3–5], including two separate operations and an interim period of reduced mobility [1,2]. Two-stage revision is also associated with bone stock degradation [1], soft tissue deformation, and perioperative fracture [6–8].

Irrigation and debridement with modular component exchange (IDMCE) is an alternative to two-stage revision and uses a single operation with potentially lower patient burden and complications. An open debridement with synovectomy is performed followed by copious irrigation. The polyethylene tray is removed and exchanged, which decreases bacterial burden and facilitates posterior soft tissue debridement [9]. Current literature, however, has shown inconsistent results for IDMCE with success rates ranging from 16–83% [7, 8, 10–19]. Additionally, some of these studies have included total hip arthroplasty (THA) infections [12] as well as irrigation and debridement (I&D) without polyethylene exchange [11].

Studies agree that shorter duration of symptoms at presentation, absence of radiographic evidence of component loosening or osteitis, and absence of sinus tracts are all positive indicators of successful eradication with IDMCE [6, 20, 21]. Certain infecting organisms may alter the effectiveness of IDMCE. Deirmengian et al. (2003) found failure rates of 92% and 44% (P=0.007) when comparing *Staphylococcus aureus* to *Staphylococcus epidermidis*, respectively [11]. Odum et al. (2011), however, failed to show significant differences between failure rates when comparing *Staphylococcus* and *Streptococcus* infections [12].

The purpose of this study is to determine prognostic factors that play a role in the success of IDMCE for avoiding reoperation. We believe this to be the largest series of IDMCE TKAs currently available in the literature. All repeat operations were performed for repeat infection or clinical concern for reinfection. Our hypothesis was that shorter duration of symptoms [6, 7], patients with less comorbidities [7, 22], infection with *Streptococcus* [7, 11], and patients prescribed long-term postoperative suppressive antibiotics would have a higher success rate with IDMCE.

Materials and Methods

Our study was conducted at a single American tertiary academic center in the rural Northeast that receives regional referrals. Following approval from the institutional review board, we queried our institutional database for Current Procedural Terminology code 27486, which indicates one-component TKA revision. Surgeries were performed from November 2009 through January 2016 and a total of 303 consecutive patients were identified. A preliminary chart review was then undertaken to identify patients who had a diagnosis of septic arthritis as stated in the post-procedure diagnosis section of the operative note. Patients were then excluded from the study if their revision was performed for any diagnosis other than PJI, including maltracking, aseptic loosening, arthrofibrosis, pain, and laxity (Figure 1). After applying this exclusion criterion, 99 consecutive patients were eligible and included in analyses.

We extracted demographic data and preoperative medical comorbidities to determine the Charlson Comorbidity Index (CCI), in addition to patient heights and weights to calculate the body mass index (BMI) from the electronic medical record. We obtained all data from in-person clinical and hospital records. We collected preoperative white blood cell (WBC) count, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), total protein, albumin, hemoglobin A1c (HgbA1c), Gram stain results, and synovial cell counts. Postoperatively, information about the isolated organism and antibiotic treatment regimen, including any long-term suppressive antibiotics, were collected. We used laboratory values for ESR of 46.5 and CRP of 23.5 to categorize values into binary groups, as used in previous reports [23]. Postoperative antibiotic treatment was at the discretion of the hospital's Infectious Disease team through the Outpatient Parental Antibiotic Treatment (OPAT) program.

We performed analyses using Stata 12MP and 15MP (StataCorp, College Station, TX: StataCorp LP, 2012, 2017). Variable value definitions, such as for age and BMI, were grouped together using standard conventions as data variance allowed. We used t-tests for continuous variables and chi-squared analyses for categorical variables to determine whether each variable was associated with reoperation following IDMCE. Reflecting our counts, we also created multivariable models to determine associations with reoperation following IDMCE for each variable of treatment, while adjusting for age and gender. Treatment failure was defined as any known reoperation on the ipsilateral knee. Statistical significance was defined as $P < 0.05$.

Results

At a mean clinical follow-up of 2.6 years (SD 1.5 years, range 38 days – 6.9 years, 18 patients (18%) with follow-up <1 year), 64 patients (65%) did not undergo further same-knee reoperation after IDMCE, while 35 patients (35%) required reoperation for PJI recurrence. Of these 35, 20 patients had a two-stage revision, 11 patients had a repeat IDMCE, and 4 patients underwent above-knee amputation (AKA).

Of the 20 patients with a two-stage revision reoperation after the initial IDMCE, 6 underwent an additional surgery after the two-stage revision: 3 underwent another IDMCE, 1 had a second two-stage revision, 1 underwent a knee fusion, and 1 underwent a revision for aseptic loosening.

Of the 11 patients who had a repeat IDMCE after the initial IDMCE, 3 patients failed the second IDMCE: 2 patients then underwent a two-stage revision, while the 3rd patient underwent an AKA (separate from the 4 patients with AKAs mentioned previously).

The 4 patients who underwent AKAs following the initial IDMCE included patients with 1.) wound dehiscence with exposed hardware and desiccated patellar tendon, 2.) wound dehiscence with exposed hardware, 3.) post-polio minimal knee function and gastrointestinal distress from antibiotics, and 4.) chronic, severe knee pain who presented with wound breakdown and did well with a contralateral below-knee amputation.

Reoperation occurred within a median of 134 days (mean = 288 days) from the date of initial IDMCE surgery. There was no statistical difference in reoperation rate based on patient age, gender, BMI, or CCI (Table 1). There was statistical significance ($P=0.025$) toward reoperation in patients who had symptom duration >2 days, with reoperation in 45% of cases, versus re-operation in 13% of cases with symptom duration <2 days (Table 1). ESR greater than 46.5mm/hr was the only laboratory value assessed preoperatively that was associated with re-operation for recurrent infection ($P=0.005$). We did not identify significant associations for CRP ($P=0.3078$), WBC ($P=0.155$), aspirate cell count ($P=0.149$), or Gram stain ($P=0.090$) with re-operation. There was no statistically significant difference ($P=0.473$) in reoperation rates between patients who received suppressive antibiotics after IDMCE and those who did not (Table 2). Fourteen of 19 patients (74%) infected with a streptococcal species were treated successfully (Table 3). *Staphylococcus* infections were associated with ESR >46.5 mm/hr ($P = 0.048$), with 72% of the cases falling into this category. Of the 28 patients who had a culture-negative aspirate, 7 went on to have a reoperation after a failed IDMCE. Four of these patients had a two-stage revision, 2 had a repeat IDMCE, and 1 patient had an AKA (Table 3).

Our multivariable models reflected similar results as the earlier bivariate results (Table 4). After adjusting for age and gender, an ESR of 47 or greater was associated with reoperation (OR 4.41, 95% CI 1.58 – 12.36, $P=0.005$). Having symptoms for less than 2 days was protective against reoperation (OR 0.17, 95% CI 0.05 – 0.64, $P=0.008$). No other variable of interest was associated with reoperation. Age and gender were not independently associated with reoperation in any model (results not shown).

Discussion

Guidelines exist for treating certain chronic PJI. Those with a sinus tract, or with radiographic evidence of component loosening, should be treated with two-stage revision [22]. While there is international consensus against arthroscopic irrigation and debridement with retention of components, there is some debate about whether an open IDMCE may be effective in these patients [22]. This study sought to identify which patient factors may be

helpful to the physician who is debating about whether to perform an IDMCE or a two-stage revision for TKA PJI.

Infection with streptococcus species showed a statistical trend towards improved treatment success. Future study direction may include rapid organism speciation based on bacterial DNA polymerase chain reaction results, which would assist surgeons in preoperative decision making [24]. Unfortunately, culture data are usually not available for preoperative planning purposes. Treatment success was not associated with preoperative WBC, CRP, joint aspirate cell count, or Gram stain. A previous study used these variables as part of their nomogram for predicting success rates with IDMCE [7]. While these variables have been used for defining a PJI or assessing risk of developing a PJI [22, 25], we were unable to find any studies showing them to be associated with IDMCE treatment success. We evaluated postoperative suppression antibiotic therapy, which we did not find to be associated with IDMCE outcomes. This is the first study that evaluated this factor for IDMCE outcomes following TKA PJI.

Preoperative ESR levels above 46.5mm/hr were associated with treatment failure following ID-MCE ($P=0.005$), which has not been described previously. While increased reoperation rates after IDMCE have not previously been associated with isolated ESR elevation, there have been descriptions of isolated ESR elevation in low-grade bone and prosthetic infections [26–28]. We suspect that our finding is more reflective of a deeper and more chronic infection, given the longer half-life of ESR compared to CRP [26]. While the CRP may be acutely elevated in the majority of infections, regardless of treatment-resistance status, it often decreases within a few days of initial inflammation [29]. However, an elevated ESR may be more indicative of a persistent, deep-seated joint disease process that is therefore more resistant to the treatment with ID-MCE [28]. Thus, ESR may potentially serve as an unadjusted marker for more resistant infections and identify patients who are more likely to benefit from two-stage revision as opposed to an IDMCE procedure.

While several studies sought to determine the efficacy of IDMCE in the management of prosthetic joint infections, reoperation rates have been inconsistent and many studies had smaller sample sizes that included hip arthroplasty PJI or patients who underwent an irrigation and debridement (I&D) without exchange of the polyethylene component (Table 5) [13, 14, 20]. Additionally, previous studies have included patients with an infected THA in their study analysis as well as patients who did not have exchange of the polyethylene component [12–14, 16, 19]. This study included only TKA patients who had an exchange of their polyethylene component. With regard to the rates of IDMCE failure, our cohort data aligns with the current literature that demonstrates success rates ranging from 16% to 83% [7, 8, 10–19]. When looking at the cohort of patients who underwent a reoperation, 90% of reoperations occurred within 180 days of the initial surgery, thus providing a general timeframe for expected postoperative interventions moving forward. In our series 35% of patients went on to further surgery after IDMCE and the long-term effects of the IDMCE are not clear.

There are several limitations to our study. Manual chart reviews were performed to verify accuracy of data; however, not all variables were available for each patient. There was no

comparison cohort of patients undergoing a two-stage revision. Adjusting variables were limited to age and gender; however, this is the largest known series of IDMCE procedures for TKA PJI, and having 3 variables in models of association would be standard for a series of this size. The suppressive antibiotic regimen around these concerns remains unstandardized. The antibiotic regimen was prescribed at the discretion of the infectious disease attending physician. There were 34 unique treatment regimens among the 54 patients treated with a suppressive regimen. We strongly suggest that further multicenter research be conducted on this issue. The mean follow-up in our study was 2.6 years ($SD=1.5$), thus it is possible that late reinfections were missed in patients seeking care at outside institutions. Of note, four patients in our study who failed an IDMCE underwent AKA as a second procedure. While an AKA may seem to be an unusual second step in managing a PJI after IDMCE, these patients had extenuating circumstances as discussed in the results. All four patients were offered explantation and antibiotic spacer placement, but chose AKA after discussing the risks and benefits with their surgeon. Our cohort was identified by database search to identify patients on whom an IDMCE was performed. Lastly, surgeon preference and selection bias is inherent in any retrospective study.

Further studies including randomized controlled trials of IDMCE and two-stage revision are needed to demonstrate generalizable results. Randomized controlled trials evaluating patient factors that predict success would be valuable in determining whether IDMCE can effectively treat a specific subset of patients.

Conclusion

Our study shows that a preoperative ESR less than 46.5mm/hr and duration of symptoms less than two days are each associated with IDMCE treatment success as defined by reoperation. Infectious organism may also influence treatment results, with more favorable outcomes being seen with *Streptococcus* species, although larger studies may be needed to detect this difference. Surgeons should use these data, when available, to assist with treatment selection and while counseling patients on potential surgical outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Study design

Table 1

Variable differences by whether patient underwent a reoperation

Variable	Count Totals (N=99)	No 2 nd Surgery n (%) (n=64)	Yes 2 nd Surgery n (%) (n=35)	P-Value
Age Group				0.484
42 – 59	28	17 (61%)	11 (39%)	
60 – 69	32	19 (59%)	13 (41%)	
70 – 87	39	28 (72%)	11 (28%)	
Total	99	64 (65%)	35 (35%)	
Sex				0.701
Male	54	34 (63%)	20 (37%)	
Female	45	30 (67%)	15 (33%)	
Total	99	64 (65%)	35 (35%)	
BMI				0.591
< 25	12	9 (75%)	3 (25%)	
25 – 29	24	17 (71%)	7 (29%)	
30 – 34	25	14 (56%)	11 (44%)	
35 – 39	15	11 (73%)	4 (27%)	
40 +	21	12 (57%)	9 (43%)	
Total	97	63 (65%)	34 (35%)	
CCI				0.866
0	35	23 (66%)	12 (34%)	
1	23	14 (61%)	9 (39%)	
2+	40	27 (68%)	13 (33%)	
Total	98	64 (65%)	34 (35%)	
Symptom Duration				0.025
< 2 Days	24	21 (88%)	3 (13%)	
Variable	Count Totals (N=99)	No 2 nd Surgery n (%) (n=64)	Yes 2 nd Surgery n (%) (n=35)	P-Value
2 Days	72	41 (57%)	32 (44%)	
Total	96	62 (65%)	34 (35%)	
Gram Stain				0.090
Negative	51	37 (73%)	14 (27%)	
Positive	48	27 (56%)	21 (44%)	
Total	99	64 (65%)	35 (35%)	
ESR (mm/hr)				0.005
< 46.5	38	32 (84%)	6 (16%)	
47 +	55	31 (56%)	24 (44%)	
Total	93	63 (68%)	30 (32%)	
CRP (mg/L)				0.307
< 23.5	7	6 (86%)	1 (14%)	

Variable	Count Totals (N=99)	No 2 nd Surgery n (%) (n=64)	Yes 2 nd Surgery n (%) (n=35)	P-Value
24 +	85	57 (67%)	28 (33%)	
Total	92	63 (68%)	29 (32%)	
WBC (10³/mcL)				0.155
< 11	48	28 (58%)	20 (42%)	
11 +	50	36 (72%)	14 (28%)	
Total	98	64 (65%)	34 (35%)	
Cell Count cells/mcL				0.149
< 50,000	47	36 (77%)	11 (23%)	
50,000 +	34	21 (62%)	13 (38%)	
Total	81	57 (67%)	24 (44%)	

BMI = Body mass index. CCI=Charlson comorbidity index. ESR=Erythrocyte sedimentation rate. CRP=C-reactive protein. WBC=White blood cell count.

Table 2

Infection recurrence and use of suppressive antibiotics.

Suppressive Antibiotics	Reoperation for infection recurrence		P-Value
	No	Yes	0.473
No	23	10	
Yes	35	19	
Total	58	29	

Table 3

Isolated organism and reoperation

Organism	No reoperation	Two-stage revision	repeat IDMCCE	AKA	Total	P-Value
None	21	4	2	1	28	0.068
<i>Staphylococcus</i>	16	9	7	0	32	
<i>Streptococcus</i>	14	4	1	0	19	
MRSA	6	3	0	2	11	
Other	7	0	1	1	9	
Total	64	20	11	4	99	

Table 4

Multivariable models for associations with repeat surgery (no vs. yes) following IDMCe for TKA PJI. Each variable is a separate model that adjusts for age and sex. For example, the BMI model looks for association for repeat surgery and also adjusts for age and gender, the separate CCI model looks for association for repeat surgery and also adjusts for age and gender, etc. Age and sex were not statistically significant in any of these models and are not displayed.

Model/Variable	Count	Value	Odds Ratio	95% CI Low	95% CI High	P-Value
BMI	97	<25 (ref)				
		25 – 29	1.16	0.23	5.91	0.862
		30 – 34	2.00	0.40	10.03	0.400
		35 – 39	0.92	0.14	5.85	0.929
		40+	1.78	0.32	9.98	0.512
CCI	98	0 (ref)				
		1	1.09	0.36	3.35	0.877
		2+	0.86	0.32	2.32	0.773
Symptom Duration	96	2 or more days (ref)				
		<2 days	0.17	0.05	0.64	0.008
Gram Stain	99	Negative (ref)				
		Positive	1.97	0.82	4.72	0.127
ESR	93	46.5 (ref)				
		47+	4.41	1.58	12.36	0.005
CRP	92	24+ (ref)				
		23.5	0.34	0.04	2.67	0.302
WBC	98	<11 (ref)				
		11+	0.47	0.19	1.15	0.097
Cell count	81	<50,000 (ref)				
		50,000+	2.07	0.70	6.17	0.191

Table 5

Summary of previous literature

Study	Sample size (n)	Treatment(s) performed	Success rate	Follow up
Hartman 1991 (13)	33	31 I&D, 2 arthroscopic I&D	39%	4.5y
Burger 1991 (17)	39	I&D	18%	mean 4.1 y
Mont 1997 (14)	24	21 IDMCE 3 I&D (no poly available)	83% (1/2 of patients had >1 IDMCE)	median 5y range 2–12y
Deirmengian 2003 (11)	31	IDMCE in 10	35%	min 2y
Bradbury 2009 (15)	19	19 IDMCE	16%	min 2y
Byren 2009 (8)	112 (52 hips, 51 knees, 9 other)	IDMCE in 97, arthroscopic in 15	78%	mean 2.3y
Azzam 2010 (16)	106 (53 THA, 53 TKA)	IDMCE in 26 knees, 4 hips remainder = I&D	44.2% (6 had >1 debridements)	min 2y
Koyonos 2011 (19)	138 (70 knees, 60 hips)	I&D alone	35%	min 1y
Gardner 2011 (18)	44	IDMCE	44%	min 1y
Odum 2011 (12)	150 (97 knees, 53 hips)	I&D +/- polyswap (97% of knees had IDMCE)	31%	min 2 y
Buller 2012 (7)	309 (247 knees, 62 hips)	IDMCE	50%	mean 34 months (8 days to 13.9 years)
Duque 2017 (10)	67	IDMCE	69%	mean 4.8y
Trebse 2005 (20)	24 (14 hip, 5 knee, 4 internal fixation, 1 ankle)	I&D (implant retention)	83%	Mean 3.7y (1.8 to 4.7y)