Antibiotic Delivery via Hickman Catheter for the Treatment of Prosthetic Joint Infection

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abstract

Infection rates for total joint arthroplasty range from 1% to 2%, and infection carries significant risk. The traditional course of treatment is irrigation and debridement, but historically, success rates have been variable. The goals of this study were to evaluate the safety and efficacy of Hickman catheterization in the treatment of prosthetic joint infection and to assess its value as an alternative to irrigation and debridement. The authors retrospectively analyzed 26 Hickman catheterizations in the treatment of acute early, acute late, and chronic late infections of primary and revision hip and knee arthroplasty. Initial arthroplasty procedures were performed between 2006 and 2018, with all cases followed for a minimum of 1 year postoperatively. The authors evaluated surgical data, clinical outcomes, and success rates, and they compared their success rates with reported values for cases treated with irrigation and debridement. The authors' success rate was 100% for acute early hip infection, 100% for chronic knee infection, and 80.0% for chronic hip infection. They reported a 75.0% success rate in the treatment of acute late infection for hip arthroplasty and a rate of 62.5% for knee arthroplasty. Postoperative clinical outcomes were significantly improved for both hips and knees for all infection types. The success rates for the treatment of acute early prosthetic joint infection and chronic late prosthetic knee infection were superior to available reported rates on irrigation and debridement. The authors also reported the highest success rate for the treatment of acute late infection. The current data suggest that Hickman catheterization is a promising safe and effective alternative to irrigation and debridement for the treatment of prosthetic joint infection. [*Orthopedics*. 2021;44(3):e395-e401.]

Prosthetic joint infection (PJI) occurs in approximately 1% to 2% cases of knee and hip arthroplasty, often leading to significant rates of morbidity and mortality.[1,2] To avoid complete revision of the joint, irrigation and debridement (I&D) has long been the traditional route of treatment. In this course of treatment, systemic antibiotics are typically administered for 4 to 6 weeks before operative debridement of the joint. However, the success of this procedure varies widely, with rates ranging from 0% to 90%.[3-7] With such significant rates of failure, morbidity is a major concern, especially when the infection becomes resistant to traditional antibiotics. Patients who have unsuccessful I&D often undergo multiple subsequent surgeries, which further increases the risk of complications and the cost of treatment.[8-10]

Many studies suggest that the high failure rates with I&D are associated with a low local intra-articular concentration of antibiotics.[11,12] Antony et al[13] described a method of delivering high concentrations of local intra-articular antibiotics via Hickman catheters and reported a microbiologic cure rate of 100% and a success rate of 89.5% within 11 months of follow-up. Given these

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Table 1

Demographic Characteristics

Variable	Hips	Knees
Date range	2/2006-3/2018	5/2008-1/2017
Cases, No.	12	14
Deceased, No.[a]	0 (0.0%)	2 (15.4%)
Female, No.	8 (53.3%)	7 (53.8%)
Follow-up, mean±SD, y	2.9±1.8	2.9±2.6
Age, mean±SD, y	57.7±18.1	69.3±7.7
Body mass index, mean±SD, kg/m^2	29.6±5.7	35.9±7.1

[a]*Cause of death unrelated to surgery.*

encouraging results, the current authors have adopted the Hickman catheterization (HC) method in their practice for the treatment of PJI.

The authors report success rates with the use of HC in a single-surgeon cohort for the treatment of acute and chronic PJI in hip resurfacing arthroplasty, total hip arthroplasty, and total knee arthroplasty. The goal was to evaluate the safety and efficacy of HC by reporting success rates and clinical outcomes. The authors further assessed the value of HC as an alternative to I&D by comparing the rate of implants saved via HC with similar cases treated with I&D. This retrospective review of de-identified patient data was reviewed by an institutional review board and deemed exempt.

Materials and Methods

Patient Information

The primary surgeon (T.P.G.) has maintained a prospective database of more than 6000 primary hip arthroplasties, more than 1200 primary total knee arthroplasties, and more than 500 total joint revisions. The authors retrospectively analyzed this database to identify PJIs and found 35 total cases (0.4% rate of infection), with 26 of these treated with HC. These procedures were performed between February 2006 and March 2018, and all had a minimum of 1-year follow-up. Patient demographic information is shown in **Table 1**.

Diagnosis

Diagnosis of joint infection is generally identified by, but not limited to, patient presentation with pain, restriction of joint motion, pain with joint motion, and/or clinical signs, such as a red, hot, swollen joint. Criteria for diagnosis are defined by the Musculoskeletal Infection Society.[14-16] Additionally, laboratory evaluation shows positive aspiration findings, elevated erythrocyte and C-reactive protein values, purulence of the joint fluid, and white blood cell count of the joint fluid greater than 10,000/µL.

Procedure and Treatment

An intra-articular Hickman catheter (IAC) (C.R. Bard, Inc) is inserted through the fascia, and a subcutaneous tunnel is initiated with a laparoscopic Allis clamp (Medline Industries, Inc). The intra-articular antibiotic exits through a small puncture wound. Care is taken to use the smallest puncture wound to avoid leakage. The catheter is positioned through the skin in the anterior thigh. The cuff is placed 2 inches from the insertion site and secured with 2-0 nylon suture. The IAC is tested for flow both open and occluded to check for leaks. The catheter is cut off at the appropriate length and threaded down into the joint. Osteoset beads (Wright Medical Technologies, Inc) are prepared with 1 pack of fast set with 1.2 g tobramycin at the beginning of the case to allow cure time. The cured beads are placed into the deep wound. Then 1 g vancomycin powder is placed deep within the subcutaneous tissue as the layers are closed with absorbable Quill suture (Surgical Specialties Corp). A sterile dry dressing is placed over the wound at the IAC site. The IAC is flushed with 2 mL heparinized saline at the end of the procedure and again every 2 days until the start of the infusion of vancomycin. The fibrous cuff of the catheter provides soft tissue ingrowth, which seals the surface of the tube, preventing tracking along the catheter. Treatment with intra-articular antibiotics is started approximately 2 weeks after insertion of the IAC, or when the catheter site is completely dry.

The intra-articular antibiotics are determined based on cultures of the synovial fluid and tissue and polymerase chain reaction analysis. If the findings are negative or are not available, antibiotics are empirically selected based on the most likely pathogens. Concomitant systemic antibiotics are not used during the administration of intra-articular antibiotics, which are delivered for 6 weeks.

Antibiotics are administered as a bolus followed by a 1-mL heparinized saline flush (100 units/mL). This includes 500 mg vancomycin in 5 mL saline daily and 2 g cefazolin in 5 mL saline daily. The drug dosage and administration schedule is based on the pharmacokinetics of the antibiotic. The dose of vancomycin is based on random levels in the serum. These levels are monitored weekly while the patient is receiving antibiotic therapy. Vancomycin levels are kept at less than 10 µg/L. The dose of other antibiotics is calculated according to the protocol of Antony et al,[13] in which the dose is reduced from 50% of the serum dose to achieve high local concentration. Baseline blood work is obtained, including complete blood count, comprehensive metabolic panel, erythrocyte

sedimentation rate, C-reactive protein level, and tests specific to the chosen antibiotic. Vancomycin levels are obtained weekly, and dosage is adjusted based on the random vancomycin trough.

Once intra-articular antibiotic therapy is completed, the IAC is removed in the operating room. For chronic late infection, the authors perform total joint revision during the same procedure. The authors selected oral antibiotics based on pathogen resistance and prescribed them for 6 months postoperatively.

Follow-up

For hip procedures, office or remote follow-up was requested at 6 weeks, 1 year, and 2 years, and every other year thereafter. For knee procedures, follow-up was requested at 4 weeks, 3 months, 1 year, and 2 years, and every other year thereafter. A clinical questionnaire, radiographs, and a physical examination testing range of motion and strength were obtained at each visit. After 1 year, the authors no longer requested physical examination on remote follow-up. The OrthoVault database (Midlands Orthopaedics) supported the authors' collection and analysis of the demographic, clinical, and radiographic data for all patients. Clinical scores included the Harris Hip score to test hip function and the Knee Society Score to test knee function (both function scores measured on a scale of 0-100), University of California Los Angeles (UCLA) score to assess activity level, and visual analog scale (VAS) score to measure pain on regular and worst days. Patients were informed of possible adverse reactions and instructed to contact the office if any adverse reactions occurred.

Table 2

Surgical Information

	Mean±SD	
Variable	**Hips**	**Knees**
Length of incision, in	4.6±0.9	5.7±1.5
Operation time, min	93.0±34.2	68.4±28.2
Estimated blood loss, mL	283.3±204.0	82.5±47.2
Hospital stay, d	3.1±1.5	2.5±0.7
American Society of Anesthesiologists score	2.6±0.5	2.9±0.4

Table 3

Infection Categories

	No.	
Hickman type	**Total**	**Revisions**
Acute early hip	3 (25.0%)	0 (0.0%)
Acute late hip	4 (33.3%)	1 (25.0%)
Chronic hip (2 stage)	5 (41.6%)	1 (20.0%)
Acute late knee	8 (57.1%)	3 (37.5%)
Chronic knee (2 stage)	6 (42.9%)	0 (0.0%)

Results

Of the 17 infected hips, 12 were treated with HC. In **Table 2**, cases are classified by infection category. The specific infection/culture and antibiotics used for each case are shown in **Table 3**. Three hips (25.0%) had acute early infection, 4 (33.3%) had acute late infection, and 5 (41.6%) had chronic infection and were treated with 2-stage revision. The success rate for hips treated with HC was 100%, with acute early infection by 2 years. There was 1 revision for 2-stage chronic infection (80.0% success rate), and there was 1 revision for acute late hip infection (75.0% success rate). Overall, the success rate for HC in hip arthroplasty was 83.3%.

Of the 20 total infected knees, 14 were treated via HC. There were 8 cases of acute late knee infection (57.1%) and 6 cases of chronic knee infection (42.9%) treated with 2-stage revision. The success rate for knees with chronic infection treated with HC was 100% by 2 years. There were 3 revisions of knees with acute late infection (62.5% success rate with HC). Overall, the success rate for HC for knee infection was 78.6%, and the total success rate for HC for all joint infections was 80.8%.

Postoperative clinical outcomes are shown in **Table 4**. Patients with infected hips treated with HC reported mean Harris Hip score of 85.7 at 1-year follow-up, whereas those with infected knees treated with HC reported mean Knee Society Score of 70.0. Mean UCLA score at 1 year was 7.0 for hips and 3.6 for knees. Mean regular VAS pain score was 1.2 for hips and 3.2 for knees, whereas mean worst VAS pain score was 4.7 for hips and 6.2 for knees.

Discussion

This study reported the outcomes of HC for the treatment of PJI in primary and revision hip resurfacing arthroplasty, total hip arthroplasty, and total knee arthroplasty in a large, single-surgeon cohort. The rate of success was 100% for acute early hip infection, 100% for chronic knee infection, and 80.0% for chronic hip infection. Acute late infection is the most

Table 4

Clinical Outcomes

Variable	Mean±SD Hips	Knees
Preoperative		
Function score	39.3±18.5	47.9±37.8
Postoperative		
Function score	85.7±14.9	70.0±19.0
UCLA score	7.0±2.0	3.6±2.0
Visual analog scale score pain: regular	1.2±1.3	3.2±3.7
Visual analog scale score pain: worst	4.7±2.9	6.2±4.5

Abbreviation: UCLA, University of California Los Angeles.

difficult to treat[4,7]; with HC, the authors reported a 75.0% success rate for acute late infection in hip arthroplasty and a 62.5% success rate in knee arthroplasty.

Postoperative function scores at 2-year follow-up were significantly improved from preoperative scores for both hips and knees. Mean UCLA score for hips was 7.0, which is the equivalent of regularly participating in active events (eg, bicycling). Mean UCLA score was lower for knees, at 3.6, which is approximately equivalent to regularly participating in mild activity (eg, walking). Patients undergoing hip treatment typically tend to be younger and more active preoperatively compared with those undergoing knee treatment, which may explain this difference in scores. Similarly, those undergoing knee procedures had a mean regular VAS score of 3.2 (slight to mild pain), whereas the mean regular VAS score for patients undergoing hip procedures was 1.2 (nearly no pain). Postoperative UCLA and VAS scores were significantly improved from preoperative scores for both hips and knees.

Late acute infection presents many challenges and typically is more difficult to treat than other joint infections.[4,7] In this study cohort, 4 acute late hip infections occurred, and 3 of these were treated successfully with HC. The other patient had a late infection 12 years postoperatively after a case of pneumonia. Of the other 3 patients, 1 had late infection 1 year postoperatively after a fall and fracture; 1 had a persistent recurrent fungal infection 1 year postoperatively and could not tolerate medication; and the other patient had a late infection 6 months postoperatively for unknown reasons. Of the 8 acute late knee infections, 5 were treated successfully (62.5%). The causes of late infection in these cases were abscessed tooth and complications of diabetes 9 years postoperatively, pneumonia 5 years postoperatively, cut on the treated knee 15 years postoperatively, urinary tract infection 5 years postoperatively, and an unknown cause 7 years postoperatively. Of the 3 unsuccessful cases, 1 patient had acute late infection as a result of rapid cellulitis growth 2 years postoperatively. The other 2 patients had late infections from unknown causes, both 2 years postoperatively.

Little information is available on acute late PJI. Success rates for treatment of these infections are typically low.[4,7] Few studies have reported on acute late infections. **Table 5** shows a comparison of success rates for acute late infections in the authors' practice with those of other published reports. A study by Wouthuyzen-Bakker et al[7] reported a 55.0% success rate with I&D in the treatment of acute late infection in 340 hips and knees. Blom

Table 5

Literature Comparison of Acute Late Joint Infections

	Current study				
Acute late	Hip	Knee	All	Wouthuyzen-Bakker et al[7]	Blom et al[4]
Joint type	Primary hip	Primary knee	All hips and knees	All hips and knees	Primary hip
Treatment	Hickman catheterization	Hickman catheterization	Hickman catheterization	Irrigation and debridement	1 irrigation and debridement, 2 antibiotics only
Date range	2/2006-3/2018	5/2008-1/2017	2/2006-3/2018	1/2005-12/2015	1/1993-12/1996
Rate of infection, No./total no.	3/6350 (<0.1%)	0/244 (0.0%)	4/7146 (<0.1%)		3/1567 (0.2%)
Success rate, No./total no.	3/4 (75.0%)	5/8 (62.5%)	7/12 (58.3%)	187/340 (55.0%)	0/3 (0.0%)

Table 6

Literature Comparison of Acute Early Joint Infections

Acute early	Current study: Hip	Current study: Knee	Current study: All	Blom et al[4]	Blom et al[4]	Manrique et al[6]	Manrique et al[6]	Chung et al[17]	Chung et al[17]
Joint type	Primary hip	Primary knee	All hips and knees	Primary hip	Primary hip	Primary hip	Primary knee	Primary hip	Primary knee
Treatment	Hickman catheterization	Hickman catheterization	Hickman catheterization	Irrigation and debridement	Antibiotics only	Irrigation and debridement	Irrigation and debridement	2-stage irrigation and debridement	2-stage irrigation and debridement
Date range	2/2006-3/2018	5/2008-1/2017	2/2006-3/2018	1/1993-12/1996	1/1993-12/1996	1/2000-2/2016	1/2000-2/2016	1/2002-12/2016	1/2002-12/2016
Rate of surgical site infection, No./total no.	3/6350 (<0.1%)	0/1282 (0.0%)	4/7146 (<0.1%)	14/1567 (0.9%)	14/1567 (0.9%)				
Surgical site infection success rate, No./total no.	3/3 (100%)		3/3 (100%)	2/6 (33.3%)	7/8 (87.5%)	92/118 (78.0%)	40/58 (69.0%)	16/17 (94.1%)	29/31 (93.5%)
Total rate of infection (all types), No./total no.	9/6350 (0.1%)	14/1282 (1.1%)	35/7146 (0.5%)						
Total success rate (all infection types), No./total number	10/12 (83.3%)	11/14 (78.6%)	21/26 (80.8%)						

et al[4] reported 3 primary hip procedures with acute late infection. They used I&D in 1 case and antibiotics only in the remaining 2 and reported a 0.0% success rate. The current study results are markedly improved, with a 75.0% success rate in primary hip procedures, a 62.5% success rate in primary knee procedures, and a 66.6% success rate overall.

Table 6 provides a comparison of acute early infections treated at the authors' practice with those of other published reports. For both primary and revision hip procedures with acute early infection treated with HC, the authors reported a 100% success rate by 2 years. This rate is significantly higher than other available published outcomes. Other studies have shown a success rate of 33.3% to 94.1%.[4,6,17] To the current authors' knowledge, Chung et al[17] reported the highest success rate in the treatment of acute early infection with 2-stage I&D, with rates of 94.1% for 17 primary hip procedures and 93.5% for 31 primary knee procedures.

Table 7 provides a comparison of chronic late infections treated in the authors' practice with 2-stage HC with those of other published reports. The authors reported a 90.9% overall success rate for all chronic PJIs with 2-stage HC, whereas published success rates with 2-stage I&D ranged from 70.1% to 97.8%.[5,18-20] The authors found 2 reports on 1-stage I&D for the treatment of chronic late infection, but the results varied greatly. Crockarell et al[5] had a 0.0% success rate for 19 primary hip procedures with 1-stage I&D, whereas Klouche et al[19] reported a 100% success rate for 38 primary hip procedures with 1-stage exchange and a 97.8% success rate for 46 primary hip procedures with 2-stage exchange.

The most notable limitation of the current study was the small sample (n=26); the authors experience low rates of infection in their practice, and correspondingly, the sample is relatively small. The authors reported only 12 cases of acute late infec-

Table 7

Literature Comparison of Chronic Late Joint Infections

Chronic late	Current study: Hip	Current study: Knee	Current study: All	Manrique et al[6]	Crockarell et al[5]	Berend et al[18]	Klouche et al[19]	Klouche et al[19]
Joint type	Primary hip	Primary knee	All hips and knees	All hips and knees	Primary hip	Primary hip	Primary hip	Primary hip
Treatment	2-stage Hickman catherization and reimplantation	2-stage Hickman catherization and reimplantation	2-stage Hickman catherization and reimplantation	2-stage debridement and reimplantation	1-stage debridement and reimplantation	2-stage debridement and reimplantation	2-stage debridement and reimplantation	1-stage debridement and reimplantation (select cases)
Date range	2/2006-3/2018	5/2008-1/2017	2/2006-3/2018	1/1999-6/2015	1/1975-12/1991	1/1996-12/2009	8/2002-6/2006	8/2002-6/2006
Rate of chronic infection, No./total no.	3/6350 (<0.1%)	0/244 (0.0%)	4/7146 (<0.1%)		19/17,285 (0.1%)	205/8725 (2.3%)		
Chronic infection success rate, No./total no.	4/5 (80.0%)	6/6 (100%)	10/11 (90.9%)	405/570 (70.1%)	0/19 (0.0%)	157/186 (83.0%)	45/46 (97.8%)	38/38 (100%)

tion; however, because they could find only 2 other reports on this type of PJI in hips and knees, they believe that these results are invaluable. The authors plan to conduct studies after a longer period of data collection to further understand the outcomes of HC, and they encourage other practices to publish their results to strengthen the collective understanding of PJI treatment. Another notable limitation was that the HC and intra-articular antibiotic technique is not widely used, and as a result, expertise may be limited. Thus, these results may not be easily reproducible in the short term.

Conclusion

These early results, which showed an overall success rate of 80.8% for the treatment of all infections, are encouraging. The authors reported a 100% success rate with HC in the treatment of acute early hip infection and chronic knee infection. They also reported a 75.0% success rate for treatment of acute late infection in the hip and a 62.5% success rate for treatment of acute late infection in the knee. Larger samples and results from multiple centers are necessary to establish a greater understanding of outcomes after HC, but the current data suggest that treatment of PJI with appropriate intra-articular antibiotic appears to be a safe and effective alternative to I&D.

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