



## ■ ARTHROPLASTY

# Improving outcomes in acute and chronic periprosthetic hip and knee joint infection with a multidisciplinary approach

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## Aims

Periprosthetic hip and knee infection remains one of the most severe complications following arthroplasty, with an incidence between 0.5% to 1%. This study compares the outcomes of revision surgery for periprosthetic joint infection (PJI) following hip and knee arthroplasty prior to and after implementation of a specialist PJI multidisciplinary team (MDT).

## Methods

Data was retrospectively analyzed from a single centre. In all, 29 consecutive joints prior to the implementation of an infection MDT in November 2016 were compared with 29 consecutive joints subsequent to the MDT conception. All individuals who underwent a debridement antibiotics and implant retention (DAIR) procedure, a one-stage revision, or a two-stage revision for an acute or chronic PJI in this time period were included. The definition of successfully treated PJI was based on the Delphi international multidisciplinary consensus.

## Results

There were no statistically significant differences in patient demographics or comorbidities between the groups. There was also no significant difference in length of overall hospital stay ( $p = 0.530$ ). The time taken for formal microbiology advice was significantly shorter in the post MDT group ( $p = 0.0001$ ). There was a significant difference in failure rates between the two groups ( $p = 0.001$ ), with 12 individuals (41.38%) pre-MDT requiring further revision surgery compared with one individual (6.67%) post-MDT inception.

## Conclusion

Our standardized multidisciplinary approach for periprosthetic knee and hip joint infection shows a significant reduction in failure rates following revision surgery. Following implementation of our MDT, our success rate in treating PJI is 96.55%, higher than what current literature suggests. We advocate the role of a specialist infection MDT in the management of patients with a PJI to allow an individualized patient-centred approach and care plan, thereby reducing postoperative complications and failure rates.

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**Keywords:** PJI, multidisciplinary team, infected arthroplasty, revision surgery

## Introduction

Joint arthroplasty numbers continue to grow exponentially with an ever-increasing ageing population. Over the past five years, the UK National Joint Registry has witnessed a growth in lower limb arthroplasty procedures of up to 5,000 cases/year.<sup>1</sup> Unsurprisingly, it is projected that the number of

revision procedures will increase dramatically over the coming ten years.<sup>2,3</sup>

Despite an increasing understanding with regards to periprosthetic knee and hip infection, it remains one of the most severe complications following a total knee or

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total hip arthroplasty, with an incidence usually quoted between 0.5% to 1% in the literature.<sup>4-6</sup>

Individuals diagnosed have a five-year survival less than those with certain cancers, including breast, prostate, and melanoma.<sup>7</sup> This statistic, coupled with the mean cost of revision treatment for an infected knee arthroplasty quoted as three-times the cost of treatment for an aseptic knee at £30,000,<sup>6</sup> and the mean cost for revision hip treatment at £50,000,<sup>6</sup> highlights the extent and severity of this condition.

Although in recent years steps have been made to provide pathways and guidance for individuals with a periprosthetic joint infection (PJI), there remains a lack of evidence and therefore consensus across many facets of patient care.<sup>8</sup> This may partly explain the variability of success rates in revision surgery for PJI across the literature.<sup>9-12</sup>

Current principles recommend a multidisciplinary approach, along with a defined pathway, with new British Orthopaedic Association Standards for Trauma and Orthopaedics (BOAST) guidelines steering uniformity across units.<sup>13</sup> Although there are promising results in the literature regarding the usage of a multidisciplinary team (MDT) for the treatment of PJI in prosthetic hips,<sup>14,15</sup> there is limited evidence available for the effectiveness of an MDT in the management of infected knee arthroplasties, in particular in those individuals who undergo a debridement antibiotics and implant retention (DAIR) or a one-stage procedure.<sup>16</sup>

An infection MDT was established in our unit in November 2016 with criteria for diagnosis and treatment options adapted continuously in line with the latest guidelines, up to date literature and developing clinical experience. We postulated that following implementation of our MDT, our rate of recurrent infection following revision surgery for PJI would decrease. This study was therefore designed to compare the rate of recurrent infection in those individuals undergoing a DAIR procedure, one- or two-stage revision for acute and chronic PJI following hip and knee arthroplasty, prior to and after implementation of a specialist PJI MDT with a minimum follow-up of two years.

## Methods

After obtaining local ethical approval, and as per Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, data was retrospectively analyzed from an orthopaedic trauma centre. In all, 58 consecutive infected joints requiring treatment were analyzed. This composed of 29 infected joints prior to the implementation of an infection MDT in November 2016, along with 29 infected joints subsequent to the MDT conception. Exclusion criteria was: 1) Joints that had historically already undergone any prior revision procedure; 2) Any joints with a previous PJI; 3)

**Table 1.** Patient demographics and comorbidities.

Variable	Pre-MDT (n = 29)	Post-MDT (n = 29)	p-value
Skin condition, n (%)	4 (13.79)	2 (6.90)	0.670*
Rheumatoid arthritis, n (%)	2 (6.90)	3 (10.34)	1.000*
Smoker, n (%)	0 (0.0)	1 (3.45)	1.000*
Previous cancer, chemotherapy, n (%)	2 (6.90)	4 (13.79)	0.670*
Diabetes mellitus, n (%)	6 (20.69)	9 (31.03)	0.550*
BMI > 35 kg/m <sup>2</sup> , n (%)	3 (10.34)	5 (17.24)	0.706*
Preoperative revision albumin < 30, n (%)	13 (44.83)	13 (44.83)	1.000*
Age, yrs, mean (SD)	64.95 (15.51)	63.72 (13.52)	0.821†

\*Fisher's exact test.

†Unpaired t-test.

MDT, multidisciplinary team; SD, standard deviation.

Did not receive all treatment at our hospital for example if the DAIR was performed elsewhere; 4) Any patient that was treated primarily with suppressive antibiotics; and 5) Died of unrelated causes before the end of the two-year follow-up.

**Diagnosis and demographics.** A diagnosis of a peri-prosthetic joint infection was defined as per the Musculoskeletal Infection Society (MSIS) 2011 criteria, with the part modification at the International Consensus Meeting in 2013.<sup>17,18</sup> Retrospectively, data was analyzed to ascertain if the infected joints met the new criteria set out by the European Bone and Joint Infection Society (EBJIS).<sup>19</sup> An acute PJI was defined as an infection less than one month after primary surgery, with a chronic infection occurring at any time one month post-surgery. A joint was deemed to be infected by haematogenous spread if there was an obvious infective source elsewhere in the body, confirmed by clinical findings or/and positive blood cultures, with an infection in the prosthetic joint by a similar organism occurring within one month.

If there was clinical suspicion of a PJI when reviewed, routine radiographs and bloods including a white blood cell count, ESR, and CRP were performed. However, even if these markers were normal but clinical suspicion remained high, an aspiration in theatre was performed.<sup>17-20</sup> Preoperative aspirations were collected in blood culture bottles, and were sent to the laboratory for synovial white blood cell count, differential and extended culture. Fungal and acid-fast bacillus cultures were only utilized if the initial results showed no growth.<sup>21</sup> Intraoperative further aspirates were acquired and again sent in blood culture bottles to the laboratory. In addition, a specific set of tissue samples were obtained intraoperatively from the hip and knee, as set out by a specific 'PJI' set on our electronic Trak-care system.

Age, sex, comorbidities, and confounding factors, along with laboratory values, investigations, length

**Table II.** Breakdown of initial revision procedure performed in each group.

Variable	Pre-MDT (n = 29), n	Post-MDT (n = 29), n
DAIR	Knee: 5	Knee: 3
	Hip: 0	Hip: 0
Single-stage	Knee: 7	Knee: 5
	Hip: 2	Hip: 4
Two-stage	Knee: 3	Knee: 7
	Hip: 12	Hip: 10

DAIR, debridement antibiotics and implant retention; MDT, multidisciplinary team.

**Table III.** Indication for initial revision procedure.

Variable	Pre-MDT (n = 29)	Post-MDT (n = 29)
Acute infection	Knee: 4	Knee: 3
	Hip: 2	Hip: 1
Chronic infection	Knee: 9	Knee: 10
	Hip: 12	Hip: 10
Haematogenous spread	Knee: 2	Knee: 2
	Hip: 0	Hip: 3

MDT, multidisciplinary team.

of hospital stay, organism, duration of antimicrobial therapy, time to formal microbiology advice, and complications/failure were recorded from reviewing digital patient notes. Table I shows the baseline preoperative demographic data of the series.

**MDT.** The MDT included a consultant microbiologist (PW), a consultant in infectious diseases (NDR), along with a number of orthopaedic consultants (RMDM, BPR, WL, MM, SP, MK, BR, SH, AG) with an interest in PJI and revision surgery. The team would meet routinely once a week throughout the year for a face-to-face discussion with regards to individuals currently being treated, or about to be treated for a PJI. Notes from the MDT were uploaded to online patient archives.

**Surgery antibiotics and follow-up.** All revision operations were performed by a consultant (RMDM, BPR, WL, MM, SP, MK, BR, SH, AG) with a specialist interest in revision arthroplasty. The decision as to what revision procedure was performed was at the surgeon's discretion pre-MDT, it was team based following the MDT implementation. Generally in our institution (Queen Elizabeth University Hospital, UK), a DAIR procedure was the preferred treatment in those patients presenting with an acute infection. In patients with chronic infection, patient comorbidities, wound, bone stock, and microorganism factors were taken into consideration as to whether a one- or two-stage revision arthroplasty was performed.<sup>20,22,23</sup> There was roughly an equal spread of performing surgeon across the two groups.

All individuals undergoing a DAIR procedure had at least six litres of washout, thorough debridement and exchange of any polyethylene components. In those who received a one-stage procedure, the revision components were all cemented into place with revision cement, which contained antibiotics at an appropriate concentration depending on any microorganism identified. Individuals requiring a two-stage revision had a thorough debridement during their first stage, followed by implantation of a temporary prosthesis with antibiotic loaded cement. At least six weeks of antibiotics were administered in the interstage period. Reimplantation

in our cohort was performed when there were no clinical or paraclinical signs of infection.

As there remains limited evidence published with regards to many aspects of antibiotic treatment in PJI, antibiotic therapy was tailored to each individual patient. Pre-MDT, this was less reliable, depending on personal consultant to consultant contact between the orthopaedic team and the microbiology and or infectious diseases department. Post-MDT, plans were often made in advance of any revision procedure and weekly discussions between all members of the MDT were documented.

Follow-up with a specialist consultant was a minimum 24 months, in the post-MDT group this was along with regular MDT input if required. Standard follow-up was at three, six, and 12 months, and then annually.

**Outcome measures.** The definition of successfully treated PJI was based on the Delphi international multidisciplinary consensus.<sup>24</sup> Success was defined as infection control at a minimum of 24 months, with or without long-term antibiotics. Failure was defined as the need for reoperation or further revision surgery due to ongoing infection, spacer retention, or death-specifically related to the PJI or complications arising from its management.

**Statistical analysis.** Statistical analysis was performed using SPSS version 20 software (SPSS, USA). Fisher's exact test and unpaired *t*-test were used, with a significance value set at  $p < 0.05$ .

## Results

A total of 58 consecutive patients with a PJI were analyzed, 29 (15 knees, 14 hips) prior to and 29 (15 knees, 14 hips) post-implementation of the specialist MDT. No patients were lost to follow-up. Infection was confirmed as per the MSIS at the time the patients presented, however we have retrospectively reviewed the patients clinical data to ascertain if they would have met the new criteria published by the EBJIS.<sup>19</sup> In 21 cases pre-MDT (ten knees, 11 hips), the infection was confirmed, and infection was likely in the remaining eight cases (five knee, three hip). Post-MDT,

**Table IV.** Length of hospital stay, time between primary and revision procedure, time to microbiology advice, and failure rates.

Variable	Pre-MDT Knee (n = 15) Hip (n = 14) Combined (n = 29)	Post-MDT Knee (n = 15) Hip (n = 14) Combined (n = 29)	p-value
Total length of hospital stay, days, mean (SD)	Knee: 40.67 (57.81) Hip: 38.79 (25.14) Combined: 39.76 (27.83)	Knee: 45.87 (30.98) Hip: 47.29 (43.69) Combined: 46.55 (50.57)	0.761* 0.527* 0.530*
Time between primary and revision procedure, months, mean (SD)	Knee: 27.60 (37.63) Hip: 38.50 (41.53) Combined: 32.86 (39.24)	Knee: 31.80 (30.91) Hip: 95.36 (75.99) Combined: 62.48 (64.83)	0.736* 0.022* 0.042*
Time to formal micro advice, days, mean (SD)	Knee (13): 11.15 (11.05) Hip (12): 6.50 (6.16) Combined (25): 8.52 (6.04)	Knee: 3.93 (2.34) Hip: 3.43 (3.74) Combined: 3.07 (3.25)	0.021* 0.128* 0.0001*
Failure rate, n (%)	Knee: 7 (46.67) Hip: 5 (35.71) Combined: 12 (41.38)	Knee: 1 (6.67) Hip: 0 Combined: 1 (3.45)	0.035† 0.041† 0.001†

\*Unpaired *t*-test.

†Fisher's exact test.

MDT, multidisciplinary team; SD, standard deviation.

**Table V.** Microorganism identified in total knee arthroplasty.

Variable	Pre-MDT (n = 15), n	Post-MDT (n = 15), n
<i>Staphylococcus aureus</i>	4	2
Coagulase negative <i>staphylococcus</i>	4	5
Group B <i>streptococcus</i>	1	2
<i>Pseudomonas aeruginosa</i>	1	
<i>Enterococcus faecalis</i>		2
<i>Bacillus licheniformis</i>		1
<i>Micrococcus sp.</i>	1	
Polymicrobial	1	1
Culture negative	3	2

MDT, multidisciplinary team.

**Table VI.** Microorganism identified in total hip arthroplasty.

Variable	Pre-MDT (n = 14), n	Post-MDT (n = 14), n
<i>Staphylococcus aureus</i>	5	4
Coagulase negative <i>staphylococcus</i>	3	5
<i>Streptococcus mutans</i>	1	
Group B <i>streptococcus</i>	1	1
<i>Escherichia coli</i>	1	1
<i>Enterococcus faecalis</i>		1
<i>Bacteroides uniformis</i>	1	
Polymicrobial	1	2
Culture negative	1	

MDT, multidisciplinary team.

similar results were seen with 22 cases (11 knees, 11 hips), confirmed as per the EBJIS definition, and the remaining seven cases (four knees, three hips) likely. Table II demonstrates the breakdown of initial revision procedure performed in the pre- and post-MDT groups. There was roughly an equal spread of indication for revision surgery between the two groups, with the majority of patients undergoing revision surgery for a chronic infection (Table III).

Failure was defined as Tier 3 or 4 based on the consensus from the second ICM infection meeting.<sup>25</sup> There was a significant difference in failure rates between the two groups ( $p = 0.001$ , Fisher's exact test), with 12 individuals (41.38%) pre-MDT requiring further surgery compared with one individual (6.67%) post-MDT inception, as presented in Table IV.

There was one death in the pre-MDT group; an 89-year-old female who had undergone a two-stage revision for an infected total hip arthroplasty six years previously. The cause of death was not related to the revision hip procedure. Two individuals in the pre-MDT

era and one post-MDT required an above knee amputation. All three patients had undergone a DAIR as their initial revision procedure for a knee PJI. One individual in the pre-MDT group required a girdlestone for ongoing infection following a two-stage revision for an infected hip arthroplasty. All remaining failures were due to ongoing infection post revision, requiring further surgery.

There was no significant difference ( $p = 0.530$ , unpaired *t*-test) in length of overall hospital stay for initial revision procedure between the two groups. (Table IV) Of note, the time taken for formal microbiology advice was significantly shorter in the post MDT group for knees ( $p = 0.021$ , unpaired *t*-test) and in combination with hips ( $p = 0.0001$ , unpaired *t*-test). In the pre-MDT group, one patient was discussed with microbiology/infectious diseases preoperatively, four patients were not discussed at all, and 11 patients post-MDT were discussed prior to revision surgery.

The organism was identified in 52 cases (89.66%). The most common organism identified was *Staphylococcus*

*spp.* Four patients grew multiple organisms. For four patients in the pre-MDT group and two in the post-MDT group, no organism was identified (see Tables V and VI).

## Discussion

Revision surgery for periprosthetic joint infection remains unpredictable, with variable success rates in the literature ranging from 76% to 91%.<sup>26–29</sup> What defines success in the treatment of PJI is in itself inconsistent, with further operations, requirement of long-term antibiotics, infection markers, clinical signs, and osteolysis all being used as outcome measures.

The 2018 2nd International consensus meeting, among other meetings and evolving guidelines and trials such as the Oral versus Intravenous Antibiotics for Bone and Joint Infection (OVIVA) have begun to help us better shape care for patients with a PJI.<sup>13,25,30,31</sup> However, many questions are still left unanswered and uncertainty remains in particular with regards to antibiotic treatment. There remains limited evidence for intravenous (IV) only versus oral (PO) only regimes, when to perform an IV-PO switch, results of extended PO antibiotic treatment following reimplantation, and outcomes following long-term PO antibiotic suppression.<sup>25</sup> To help overcome some of these difficulties, current principles recommend a multidisciplinary approach, with over 98% of delegates at the international consensus meeting voting that patients with a PJI should be treated in centres that can offer an MDT service.<sup>13,24</sup>

Although the concept of an MDT is not a new one, it is relatively novel in the treatment of PJI. There is a lack of prospective randomized studies in the area, as logistics and ethical approval presents difficulties, however their benefit is apparent in the few retrospective studies that have been published.<sup>12,15,32,33</sup> The majority of these studies focus on the benefit of the MDT in the treatment of infected hip arthroplasties with a two-stage revision,<sup>12,15</sup> and there remains limited available evidence with regards to the role of the MDT in the treatment of knee PJI, or with regards to hips undergoing a single-stage revision for infection.

Our centre provides a framework that allows all prosthetic joints to be discussed at a weekly meeting, and the benefit is apparent in the results above. Although our sample size is small, following implementation of an infection MDT our success rate in treating PJI is 96.55%; higher than what the current literature suggests. PJI is often associated with a high mortality, even if the infection is eradicated.<sup>34</sup> Our current mortality rate is 1.72% with a minimum follow-up of 24 months. We are aware of the high failure rate pre-MDT in our study. For a period of this time, a number of hospitals merged to form our large trauma and arthroplasty unit. Perhaps new equipment, new hospital and new colleagues contributed to the higher failure rate during this time. Our sample size is

also small, which may account for the high rate of failure in the pre-MDT cohort.

With a focus on ‘getting it right first time’ in orthopaedics<sup>35</sup> and throughout medicine, the same can be said most definitely for PJI as we know that as the number of revision surgeries increases, the chance of success decreases.<sup>25</sup> There is also the financial and economic burden to take into consideration.<sup>36,37</sup> The cost of further surgery following reinfection is estimated to be four times that of a two-stage revision procedure for a PJI and this does not even take into consideration indirect costs such as lost income.<sup>38</sup>

The study is not without its limitations. It is retrospective in nature, with only 29 patients in each cohort. Follow-up was a minimum of two years, and although a significant portion of septic failures occur in the first two years, the rate remains high up to five years.<sup>39–41</sup> Some intricacies of surgery were difficult to determine from operation notes such as washout volume, what liquid was used for the washout and if drapes were changed intra-operatively. Although the study comes from one unit, a number of revision surgeons perform the operations and therefore there is variability in their practice. Finally, with an ever-progressive understanding regarding PJI, perhaps the statistically significant change cannot be fully attributable to the infection MDT.

Although the MDT in our unit is well established, there is room for growth and the addition of other healthcare professionals. From April 2019, a pharmacist has been attending on a regular basis. The addition of more subspecialties to help determine the best course of treatment for the patient could further improve the care and optimization of these often difficult to manage patients, ultimately minimizing patient morbidity and mortality.

In conclusion, our standardized multidisciplinary approach for periprosthetic knee and hip joint infection shows a significant reduction in failure rates at a minimum of 24 months follow-up. We advocate the role of a specialist infection MDT in the management of these patients to allow an individualized patient-centred approach and care plan and thereby reducing recurrence and reoperation rates.



### Take home message

- Following implementation of our multidisciplinary team (MDT), our success rate in treating periprosthetic joint infection (PJI) is 96.55%, higher than what current literature suggests. We advocate the role of a specialist infection MDT in the management of patients with a PJI.

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