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Original article

Dair approach in 7 infected total hip arthroplasties: our experience and current concepts of the literature

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Abstract. *Introduction:* Periprosthetic joint infection (PJI) is one of the most challenging complications following total hip arthroplasty. In early infection, within four to twelve weeks from surgery, debridement, antibiotics and implant retention (DAIR) can be the initial treatment. The aim of this study is to report our case series and review current concepts reported in the literature about this topic. *Materials and Methods:* This was an observational cohort study that included 7 patients managed with DAIR for PJI following primary total hip replacement (THR) between 2014 and 2020. Inclusion criteria were a primary THR, direct anterior or lateral approach, DAIR procedure, and PJI. Exclusion criteria were a PJI following a revision total hip replacement or hemiarthroplasty, posterolateral approach, 1-stage revision, 2-stage revision, and Girdlestone procedure without prior DAIR. For each patient demographic characteristics, laboratory values, microorganisms involved, antibiotic therapy and outcome at one-year follow-up were registered. *Results:* The mean duration between THR and DAIR was 19 days. In all cases only one DAIR procedure was performed. Most infections were caused by Staphylococcus aureus (4 cases) [one methicillin resistant (MRSA)]. The other infections were caused by Streptococcus agalactiae, Staphylococcus coagulase negative and Escherichia coli. At the final follow-up, the procedure was considered as successful in 6 out of 7 patients (85%). The one with unsuccessful outcome underwent to a two-stage revision. *Discussion:* Our results were comparable with those of a recent systematic review of the literature. Factors that have been postulated to influence the outcome of DAIR in the management of PJIs include the timing and numbers of debridement, the exchange of components, the responsible microorganism and the duration of antibiotic treatment. In conclusion, the outcomes following DAIR are better as the indications are refined and risk factors identified. PJI prevention remains the key but the current literature still lacks well documented and effective PJI prevention protocols. (www.actabiomedica.it)

Key words: hip, arthroplasty, prosthesis, infection, DAIR

Introduction

Total hip arthroplasty (THA) provides reliable outcomes for patients suffering from end-stage degenerative hip osteoarthritis (OA) in terms of pain relief, functional restoration, and overall improved quality of life (1–4). Its high rate of cost effectiveness has allowed to be widely distributed in all mid- to advanced healthcare systems to such an extent that more than 1 million THA are performed worldwide yearly (5,6). One of the causes that provokes its failure is the development of PJI, which has an incidence, following primary THA, of 1–2% approximately. This complication is the leading cause of revision in many published registers and large cohort studies (7,8) and it is considered one of the most difficult complications to manage (9).

In early infection, within four to twelve weeks of surgery DAIR can be the initial treatment (10,11).

This type of treatment of acute infections was first reported in 1974 by Müller (12) and then by Coventry (13) in 1975 with a rate of success of 80% and 20%, respectively.

As for some type of fracture (14) also for PJI the approach has progressively changed during years.

With further reports, factors thought to improve treatment include onset of PJI within the first four post-operative weeks (15), debridement initiated early after the onset of symptoms of infection (16), the absence of a sinus tract or radiographic signs of loosening (16) and the type and duration of antibiotic therapy (18-21).

However, the proportion of patients that responds to DAIR ranges between 14% (22) and 100% (23-25)

The aim of this study is to report our case series and review current concepts reported in literature about DAIR for PJI following primary THR.

Materials and Methods

This was an observational cohort study which included patients managed with DAIR for PJI following primary THR between 2014 and 2020 at the University Hospital of Parma. Our institutional ethics committee approved the study.

Inclusion criteria were a primary THR performed through a direct anterior or lateral approach, DAIR procedure, and PJI. Exclusion criteria were a PJI following a revision surgery or hemiarthroplasty, posterolateral approach, 1-stage revision, 2-stage revision, and Girdlestone procedure without prior DAIR.

DAIR was considered for patients with suspected PJI (figure 1) in the early postoperative period or suspected hematogenous (late) infection with symptoms for less than 4 weeks as suggested by Zimmerli criteria (10). The diagnosis of PJI was made according to the following major MSIS (Musculoskeletal Infection Society) criteria (26,27) (2 or more positive cultures, presence of a sinus tract, or presence of intraoperative

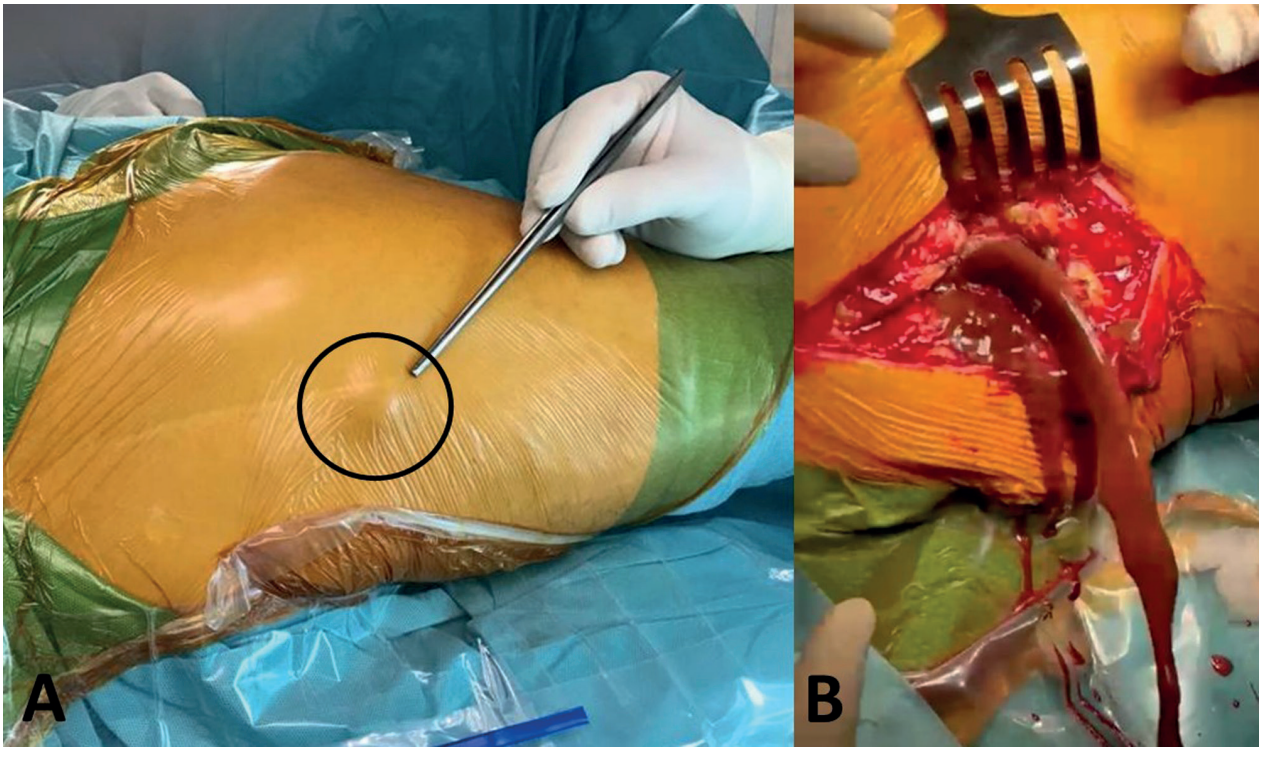

Figure 1. PJI following right primary THR performed through lateral approach. Clinical view before incision with distal swelling (circle) (A) and intraoperative view with discharge of purulent material (B).

pus). During our routine weekly multidisciplinary meeting with infectious disease specialists the minor MSIS criteria were also considered [elevated C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), positive histological analyses of periprosthetic tissue, or a single positive culture] (26,27).

Data of included patients were prospectively collected. For each patient demographic characteristics, laboratory values, microorganisms involved, antibiotic therapy and outcome one-year follow-up were registered.

The DAIR procedure consisted of removing all infected tissues, obtaining specimens for microbiology testing, and irrigating the wound with 6 to 12 L of saline solution using pulse-lavage equipment. The hip was dislocated to allow complete debridement. Empirical intravenous antibiotic treatment with vancomycin combined with carbapenem was started intraoperatively after the tissue for cultures were obtained. The treating surgeon decided intraoperatively to retain or exchange the modular components. The components were retained if the exposure precluded their exchange, if excessive force (which risked loosening the femoral stem) was needed, or if component removal would cause substantial damage to the trunnion or the surrounding soft tissue, muscles, or bone. Specific antibiotic therapy consisted of 2 weeks of intravenous antibiotic administration followed by various number of weeks of oral antibiotic administration. The duration of intravenous antibiotic administration could be prolonged if needed given the clinical situation. The empirical therapy was adjusted when the causative microorganism was identified, and rifampicin was added if the causative microorganism was sensitive to it.

Failure of treatment with DAIR was defined as follows (26-28): (1) removal of the hip prosthesis as part of a 1-stage, 2-stage, or Girdlestone procedure; or (2) failure to cure the infection, leading to antibiotic suppression therapy and/or a chronic sinus tract because patient's comorbidities precluded removal of the prosthesis.

Table 1. Demographic data of the 7 patients.

Patients	**7**
Age	73.8 +/- 9.2
BMI	31.7 +/- 5,3
Male: Female	4:3
Smoker	6/7
Alcohol	6/7
Diabetes	7/7
Kidney failure	5/7

Results

A total of 7 cases with complete data were included. Demographic data were reported in Table 1 and characteristics of infection were summarized in Table 2.

The underlying joint disease was osteoarthritis in 5 hips and osteonecrosis in 2. All infected implant were cementless THAs performed in 4 cases via lateral approach and in 3 via direct anterior approach. The DAIR procedures were performed through the same surgical approach of the first implant.

The mean duration of surgery for the first implant of the THA was 113 +/-22 minutes thus documenting a longer time than those usually registered in our Clinic.

Table 2. Characteristics of infection and of DAIR procedure.

Patients	**Surgical approach**	**DAIR after primary THA (days)**	**Microorganism**	**CRP preop**	**Duration of DAIR procedure (min)**
1	Lateral	21	Staph. Aureus	248	55
2	Direct anterior	13	Escher. Coli	250	64
3	Lateral	26	MRSA	194	70
4	Lateral	11	Strept. Agalactiae	205	50
5	Direct anterior	15	Staph. Aureus	226	75
6	Direct anterior	28	Staph. Aureus	215	62
7	Lateral	19	Staph. Coag. Neg	196	80

The mean duration between THA and DAIR was 19 days. In all reported cases only one DAIR procedure was performed, within 5 days of the onset of the symptoms in 6 patients out of 7. All the infections were classified as acute (within 6 weeks from the original surgery) or early hematogenous (within 7 days from clinical onset) infections.

Most infections were caused by Staphylococcus aureus species (4 cases) and one of them was methicillin resistant (MRSA). The other patients developed infection caused by Streptococcus agalactiae infection, Staphylococcus coagulase negative and Escherichia coli.

The mean values of laboratory examinations before DAIR procedure were the following: 219 for CRP, 98,5 for ESR and 17.000 WBC.

At the final follow-up, the procedure was considered successful in 6 out of 7 patients (85%).

The modular liner component was exchanged in all cases except one in which the surgeon decided not to remove a ceramic liner because of the risk of its fragmentation with possible creation of infected foreign bodies. The ceramic head was exchanged in all cases.

The mean number of days before bacterial growth was 3.5 +/- 1.5 days. Antibiotic susceptibilities were available after a mean of 2.7 +/- 1.3 days. Specific antibiotic therapy started after a mean of 4.8 +/- 1.7 days of empirical intravenous antibiotic administration. Intravenous antibiotic therapy was performed for a mean of 24.2 +/- 7.5 days followed by oral antibiotic administration for a mean of 36 +/-18 days.

The patient with unsuccessful outcome developed early wound problems with continuous secretion and persistent altered level of laboratory examinations. In this case, a two-stage revision were performed 2 months after DAIR procedure. In the other cases, a regular healing of surgical wound was registered with progressive normalization of laboratory examinations. All these patients underwent to immediate weight bearing after DAIR. At one-year, follow-up six patients reported the absence of any symptoms of infection with good functional outcome and normalization of specific laboratory tests. The mean Harris Hip Score in this group of patients was 82.4 +/- 7,9.

The current data had not sufficient power for statistical analysis.

Discussion

The results of this study show a successful outcome after DAIR in 85% of patients at midterm follow-up. Our results are comparable with those of a recent systematic review of other surgical approaches showing that the pooled success of DAIR was around 80% for studies published between 2011 and 2015 (29).

A previous recent metanalysis reported an overall proportion of success of 64.7% associated with DAIR in the treatment of infected THAs (29). An earlier and smaller meta-analysis by Romano et al (30) reported a lower proportion of success with a pooled mean success of 55.9% and 52.0% after single or multiple debridements and irrigation procedures respectively. However, Romano et al (30) included mixed cohorts of infected THAs and total knee arthroplasties (TKAs) treated between 1970 and 2011. Overall, there is a wide range, between 14% and 100%, (31,32) of success following DAIR in the management of an infected THA. The proportion of success appeared to improve with the passage of time ($p < 0.0001$).

Factors which have been postulated to influence the outcome of DAIR in the management of PJIs include the timing of debridement (33), the number of debridements (34), the exchange of components (10,11), the responsible microorganism who causes infection (35-37) and the duration of antibiotic treatment (25,34,38,39).

Some studies from the Mayo clinic (16,33) found that the duration of symptoms and the time from the initial procedure influenced the proportion of success following DAIR. Brandt et al (16) reported that if debridement took place more than two days after the onset of symptoms there was a four-fold increase in failure of treatment. Other authors have reported similar findings.

Tattevin et al (40) reported 100% success when debridement was performed within five days of the onset of symptoms. A recent case-control study by Grammatopoulos et al (41) also reported an improved ten-year survival (87% versus 65%) when DAIR was performed with less than one week between the onset of symptoms and debridement. The importance of the timing of debridement is thought to be related to the "race to the surface" as described by

Gristina and Costerton (42) and subsequent maturation of the biofilm.

Complete maturation of the biofilm is thought to occur within two to four days of bacterial attachment (43,44). It is thought that, once maturation has taken place, irrigation is largely ineffective with re-establishment of the biofilm on the retained prosthesis within 24 hours (45).

In this case series 6 patients underwent DAIR within 5 days of onset of infection's signs. The only subject who underwent revision was the one who had DAIR 10 days after the onset of infection.

In this study Authors reported a high rate of modular component exchange. Grammatopoulos et al. showed that exchange of modular components was of benefit, particularly in cases of late PJI, and improved the 10-year survival (41). On the contrary, Sendi et al (46) previously stated that exchange of modular components during DAIR in total hip replacement was based on empirical reasoning only.

In a recent large study, Svensson et al (47) reported their analysis on 575 patients treated with DAIR for a first-time PJI at the site of a primary THA: 364 underwent component exchange and 211 did not. The exchange of components was associated with a lower rate of reoperations due to PJI after DAIR (28.0%) compared with non-exchange (44.1%). The Kaplan-Meier analysis estimates implant survival for exchange was 71.4% compared with 55.5% for non-exchange. With the analysis adjusted for confounders, DAIR with exchange was associated with a significantly decreased risk of another reoperation due to PJI compared with non-exchange.

Only few previous studies have provided specific recommendations on the optimal empiric antibiotic treatment while considering this antimicrobial susceptibility. For example, Moran et al. recommended the use of vancomycin combined with carbapenem, whereas Fulkerson et al. had previously recommended the specific use of either vancomycin or a 3rd or 4th generation cephalosporin (48,49). Two studies that are more recent also recommended vancomycin as the designated empiric agent; however, the common denominator regarding these studies is a relatively high incidence of MRSA (50,51). The generalizability of these recommendations to regions with low incidences of MRSA is therefore questionable (52). Recently, a Dutch study recommended the use of cefazolin for the empiric treatment after PJI (53). However, only 3 different potential empiric antibiotic agents were incorporated in their analysis and vancomycin was not investigated. Taken together, there is no consensus on the optimal choice of empiric antibiotic treatment. From the studies presented there is a tendency toward vancomycin as the empiric treatment of choice also in regions with MRSA but vancomycin's disadvantages such as increased toxicity compared to beta-lactam antibiotics, necessity for blood level measurements, its decreased effectiveness against methicillin-sensitive Staphylococcus aureus and its suboptimal activity in biofilms should be considered (54).

It is important to note that a high coverage does not necessarily imply high efficacy. Reaction with the components of the biofilm matrix reduces the ability of several antibiotics to penetrate the biofilm that results in a reduced exposure of bacteria to the antibiotics and a subsequent decrease in antibiotic action (55).

In literature are reported unfavorable results for application of gentamicin beads in association to DAIR procedure (56). Deijkers et al (56) in a recent study confirm that patients managed with gentamicin beads had a 3.7-fold greater risk of DAIR failure compared with those not managed with gentamicin beads. Since gentamicin beads have to be explanted at some point, there were more DAIR procedures performed in individuals managed with gentamicin beads (mean, 2.9 DAIRs per hip) compared with individuals managed without gentamicin beads (mean, 1.3 DAIRs per hip). In this study, gentamicin beads were never used and Authors believe that empirical intravenous antibiotic therapy has to be changed as soon as possible with specific medications. This choice and duration of antibiotic treatment has to be prescribed and followed by infectious diseases specialists.

Finally, in the present report only a single DAIR procedure was performed but Authors believe that, when necessary (persistent signs of infection and of altered values of blood exams) multiple surgeries are indicated.

In conclusion, the outcomes following DAIR appear to be improving as the indications are refined

and risk factors identified. The most influential determinants of outcome are the timing of debridement from the onset of symptoms and the exchange of modular components at the time of the initial debridement.

PJI prevention remains the key but the current literature still lacks well-documented and effective PJI prevention protocols.

Conflict of interest: Each author declares that he/she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article. Due to the retrospective and observational nature of the study, approval of the ethics committee was not required.

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