Unexpected positive intraoperative cultures (UPIC) in revision Hip and knee arthroplasty- A review of the literature

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ABSTRACT

Unexpected positive intraoperative culture (UPIC) in revision hip and knee arthroplasty has a prevalence of 10.5%, there is no consensus in the literature on how to interpret them and how to treat them. Our literature review showed that most authors would consider two or more positive cultures as significant and usually treat them with culture specific antibiotics for 4–6 weeks. A single positive intraoperative culture can or cannot be significant depending on the virulence of the organism, hence taking multiple tissue samples in and around the joint is recommended. All failed arthroplasty cases must be evaluated preoperatively according to musculoskeletal infection society criteria (MSIS) to rule out the possibility of infection as an etiology for failure of the arthroplasty. Most authors reported that large majority of these UPIC were from a low virulence organism. Our review showed that the implant survival is more than 85% with 4–6 weeks of antibiotic treatment.

1. Introduction

Revision hip and knee arthroplasties are done due to multiple reasons. Data from worldwide joint registries had shown that about 12% of hip and knee arthroplasties undergo revision arthroplasty within 10 years from the index surgery.¹ It is imperative to rule out infection as the possible etiology preoperatively because the treatment of two groups is significantly different. Roberts et al. reported that the prosthetic joint infection (PJI) is the second most common cause of implant failure.² However, infection rates probably are underestimated, since many cases of presumed aseptic failure may be due to unrecognized infection.³ There is no gold standard method for diagnosing prosthetic joint infection. Different criteria have been used for the diagnosis of prosthetic joint infection preoperatively.^{4–7} Clinical findings, laboratory investigation for infection parameters, and microbiology findings are often insufficient for diagnosis of prosthetic joint infection. Culture negative prosthetic joint infection has been estimated to occur in 7%⁸ to 18%⁹ of the cases, similarly false positive cultures have been reported to occur ranging between 3% and 52%.¹⁰ In a recent publication, Parvizi et al. outlined a new evidence based and validated criteria for the diagnosis of prosthetic joint infection preoperatively.¹¹

Unexpected positive intraoperative culture (UPIC) is the presence of

positive culture from intraoperative samples, indicating the possibility of infection in a case of revision arthroplasty which was presumed to be of aseptic etiology. UPIC is important as it can lead to prosthetic joint infection (PJI) if not treated properly. There is no consensus in the literature on how to interpret these positive cultures and how to treat them. Different treatments have been recommended including watchful waiting to varying periods of intravenous antibiotic treatment to chronic antibiotic suppression.^{3,12–15} Previous studies have reported high rates of implant survival ranging from 85 to 100% in infections diagnosed by positive intraoperative cultures.^{15–19} Some authors have questioned the significance of these positive intraoperative cultures in presumed aseptic revisions.^{18,20} In addition to this the cultures are subject to errors in sampling, transportation and contamination.

We conducted a literature review to assess the prevalence of UPIC among aseptic revision surgeries and to answer following questions 1) what is the incidence of PJI following UPIC? 2) What are the common microorganisms found in cultures? 3) What is the commonly followed treatment protocol and the effectiveness of the treatment protocol 4) what are the special techniques and advances in diagnosis of PJI and their effectiveness.

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Table 1
Patient characteristics.

Study	No of UPIC/No of Aseptic revisions	Mean follow up in months	Male Female	Age Mean	BMI	Immunosuppression	Joint involved with UPIC Hips Knees	Prevalence of UPIC
Saleh et al.	155/1540	43	1540 patients	62.7	31.5	3.9% immunosuppressed	Hips-62 Knees-41 52 excluded < 1yr follow-up	10%
Berend et al.	7/103	31.6	M- 50 F- 51	70.8	NA	NA	H- 7	6.8%
Jacobs et al.	43/406	50.5	M- 133 F-273	64.5	29.5	7 diabetics and Rheumatoid arthritis	H-26 K-17	10.6%
Ribera et al.	34/89		M-49 F- 50	74	NA	14 diabetics, 2 cirrhosis	H - 25 K - 9	38%
Moojen et al.	49/176	12	M- 49 F - 127	72	NA	NA	H - 49	27.8%
Barrack et al.	41/692	53.35	692 patients	NA	NA	NA	K - 41	5.9%
Fernandez-Sampedro et al.	27/198	31	M - 86 F - 112	68.9	30.7	30 diabetics, 6 on immunosuppression 6 on steroids	K - 1 H - 23	13.6%
Ince et al.	1/24	19	M - 5 F - 19	69	NA	NA	H - 1	4%
Kemphorne et al.	8/54	9.7	M - 33 F - 21	72.3	NA	NA	K - 2 H - 6	15%
Parvizi et al. ³⁰	14/323 314 patients	11	M-133 F - 181	67	28	NA	H - 14	4.3%

2. Material and methods

After thorough search through medical databases we identified 10 studies since 2000 which reported on unexpected positive intraoperative cultures and their outcomes. We included only those studies which reported on results of intraoperative cultures in presumed aseptic failures. Any studies which included preoperatively suspected prosthetic joint infections were excluded. We collected data on patient demographics, preoperative evaluation criteria, incidence of UPIC, type of organisms isolated from cultures, details of treatment and any additional techniques used for intraoperative evaluation.

3. Results

3.1. Patient demographics and prevalence of UPIC among aseptic revisions

There were 3605 aseptic revision cases, of which unexpected positive intraoperative cultures were found in 379 cases with a prevalence of 10.5%. The prevalence of UPIC varied significantly from 4% reported by Ince et al. to 38% reported by Ribera et al.¹³ (Table 1). The mean age was 69 years; there were 538 (39%) men and 834 (61%) female patients out of the available data on 1372 patients. The mean follow-up was 26.1 months from the time of revision surgery. There were 111 (34%) knees and 213 (66%) hips involved with a UPIC (Table 1).

3.2. Preoperative evaluation

Along with clinical evaluation most studies used laboratory screening with erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) and some studies documented complete blood count with white cell differential. Further evaluation with aspiration of the joint was done routinely by some authors and selectively by some authors.^{10,12,21} After a successful aspiration, the fluid was cultured. When there was enough fluid, a differential count was performed to record number of nucleated cells and the percentage of polymorphonuclear cells¹⁰ (Table 2).

Fernandez-Sampedro³ used a preoperative algorithm including a history and physical examination, determination of ESR and CRP within 2 weeks before surgery, a plain radiograph and a technetium-99-labeled leukocyte scintigraphy. Pre-operative synovial fluid culture was obtained at the surgeon's discretion. Parvizi et al.²² also used a standard algorithmic approach after 2004 for the workup of failed arthroplasties. The algorithm included preoperative ESR and CRP for all patient's and intraoperative cultures. ESR greater than 30 mm/h and CRP greater than 1 mg/dL were considered abnormal. The mean ESR among the patients who required surgery for PJI and those who had positive cultures was 38 mm/h compared to 30 mm/h among patients who did not require any surgery. CRP was found to be 2.1 mg/dL in the first group compared to 1.2 mg/dL in the second group.

Marculescu et al.¹⁵ reported on 16 prosthetic joint infections which were diagnosed from unexpected positive intraoperative cultures. Pre-operative sedimentation rate was done in seven patients and was normal in 5 patients. Preoperative synovial fluid cultures done in the two patients with an elevated sedimentation rate yielded negative results. No patient had a C-reactive protein test (CRP) done.

3.3. Prophylactic antibiotic administration

There was variability in the use of antibiotics among the studies. Berend et al.²¹ administered an intra-operative dose of cephalosporin and gentamycin after the cultures were obtained. Ribera et al.¹³ also administered Cefazolin or Teicoplanin plus ceftazidime one or two doses depending on the duration of the operation (less or more than 6 h), immediately after culture samples were collected.

Parvizi et al.²² in their study routinely administered intravenous first-generation cephalosporin (or vancomycin for those with a history

Table 2
Summary of preoperative and intraoperative evaluation.

Study	ESR (mm/hr)	CRP (mg/dl)	Other pre-op evaluations	Positive Frozen section	Surgeries performed
Saleh et al.	21.8	0.5	Aspiration, Serum WBC	3	Revision THA and TKA
Berend et al.	NA	NA	Aspiration and radionuclide imaging as needed	Not done	62 isolated acetabular revisions, 13 stem revisions, 5 liner exchanges for wear, 22 complete revisions, and 1 hardware removal of a loose trochanteric apparatus.
Jacobs et al.	> 30 in 10 patients	> 10 mg/L in 5 patients	Aspiration, Serum WBC	NA	Both components revised in 95% TKA and 27% THA, remaining were single component revisions
Ribera et al.	NA	NA	Aspiration	NA	Revision THA and TKA
Moojen et al.	17	0.5	Aspiration and arthrography in 30% and scintigraphy in 55%	19	In 63 patients both components revised; in 76 only acetabular cup and in 37 only femoral stem
Barrack et al.	29.15	2	WBC count, Aspiration routinely in 1 center, selectively in other 2	Not done	Revision TKA
Fernandez-Sampedro et al.	NA	NA	technetium-99-labeled leukocyte scintigraphy and pre-operative synovial fluid culture	13	Partial revisions in 118, total revisions in 77, two stage in 1 and girdlestone in 1
Ince et al.	11.6	5.5	All had aspiration	Not done	Revision of the cup in all
Kemphorne et al.	NA	Elevated in 3 patients	Aspiration if there was clinical concern	Not done	Single stage revision in all
Parvizi et al.	34	1.6	Aspiration	Not done	Revision THA

of allergy to penicillin or cephalosporins) before skin incision and continued for the first 48 h after surgery or until the intraoperative culture results became available. Fernandez-Sampedro³ also administered standard peri-operative prophylaxis with cefazolin or vancomycin in cases of penicillin allergy; which was continued for 24 h after surgery. Jacobs et al.²³ administered prophylactic antibiotic with cefazolin 1 gm, 3 times a day for 5 days after the collection of the tissue samples or until the culture results were available.

The present consensus is that the antibiotics should be administered prior to skin incision and re-dosed as needed intra-operatively.²⁴

3.4. Intraoperative cultures and frozen section

There was significant variability in the number of specimens obtained intraoperatively for cultures. Barrack et al.¹⁰ obtained at least one culture of the joint fluid in addition to one tissue culture from behind the implants. Positive intraoperative cultures were found in 41 of the 692 cases; of these 29 were single positive with no other evidence of infection and they were considered false positive. Remaining 12 were classified as true positives based on preoperative and intraoperative findings including two positive cultures. Moojen et al.¹⁴ obtained 14-20 samples and used them for intraoperative cultures, pathological analysis and 16S rRNA PCR with reverse line blot hybridization (PCR-RLB) test. Based on these tests they classified 7 as true positive infections and 15 more patients were suspected of having infection.

Fernandez-Sampedro et al.³ collected 2 to 6 samples per patient and used the Del Pozo²⁵ criteria to diagnose prosthetic joint infection postoperatively. Out of the 198 patients 24 were diagnosed to have prosthetic joint infection, three out of the 24 PJI cases were diagnosed by histopathological findings; 8 had histopathology and positive peri-prosthetic tissue and sonicate fluid cultures; 8 had positive peri-prosthetic tissue and sonicate fluid cultures; 4 had histopathology and positive sonicate fluid cultures; and 1 had positive sonicate fluid culture.

Jacobs et al.²³ classified less than two cultures as aseptic and two or more positive intraoperative cultures were grouped in to the PJI.

3.5. Microorganisms isolated

Most infections diagnosed with unexpected positive intraoperative cultures were caused by low virulence organisms. Coagulase-negative staphylococci were the main pathogens encountered in the series reported by Segawa et al.¹⁶ and Tsukayama et al.¹⁷ In the series of Marculescu et al.¹⁵ eight patients (50%) had positive intraoperative cultures with coagulase-negative staphylococci and four patients (25%) had positive cultures with *Propionibacterium* spp. Saleh et al.¹² reported 67% of the infections caused by indolent organisms, primarily coagulase negative staphylococci and *Propionibacterium* *acne*, and 21% by virulent organisms. Berend et al.²¹ reported 5 positive cultures in 103 revision total hip arthroplasty cases, 1 *Staphylococcus* *epidermidis*, 1 methicillin-resistant *Staph* *epidermidis*, 2 methicillin resistant *Staphylococcus aureus*, and 1 *Enterococcus faecalis*.

3.6. Treatment protocols used and their effectiveness

Saleh et al.¹² in their study managed the unexpected positive intraoperative cultures primarily based on the type of the isolated organism. They treated patients with the 4-6 weeks of IV antibiotics or oral antibiotics if at least one of the following criteria was present: (1) one or more positive cultures for a virulent organism or fungal/acid fast bacilli; (2) two or more positive cultures for an indolent organism; or (3) one culture positive for an indolent organism with positive perioperative laboratory findings or history of more than two revisions.

Marculescu et al.¹⁵ in their study considered a patient to have positive intraoperative cultures when at least two intraoperative specimens obtained at the time of revision arthroplasty yielded the same microorganism on culture, with an identical in vitro susceptibility

profile. The treatments were the decisions of the orthopedic and infectious disease clinicians caring for those patients and there was no standard protocol. Of the 16 prosthetic joint infections, 12 received intravenous treatment for a median duration of 28 days, 2 of these received antibiotics for 45 days. 8 patients had oral antibiotic suppression for a median duration of 876 days, one patient was treated with antibiotic suppression alone. 3 patients received no antibiotic treatment. They reported five-year implant survival of 89%.

Berend et al.²¹ obtained a single swab culture intraoperatively and considered all intraoperative positive cultures and gram stains as significant and treated the positive culture patients with intravenous antibiotics and empirically treated the patients with positive gram stains with oral antibiotics as per the direction of the infectious disease specialist. They reported no prosthetic joint infections and 100% implant survival at the time of final follow-up. Fernandez-Sampedro et al.³ treated 11 of the 24 (45.8%) patients with diagnosis of PJI with antibiotic therapy post revision arthroplasty. Six of these 11 patients (54.6%) who received antibiotics post revision had implant failure whereas only 3 of 13 patients (23.1%) with PJI who did not receive antibiotics had implant failure.

3.7. Advances in the diagnosis of PJI and their effectiveness

Ribera et al.¹³ used sonication of the implants to increase the yield of microorganisms. A total of 89 patients were included in the study, they were divided into 4 groups according to the findings from conventional cultures and sonication cultures. Group 1 had two or more positive concordant tissue culture results, sonication results were disregarded. These were diagnosed to have definitive prosthetic joint infection postoperatively. Group 2 had one positive culture and 1 concordant culture from the sonication fluid, and some of these were treated with long-term antibiotics or were left untreated according to the criteria by the clinician. Group 3 had one positive culture or a non-concordant culture from either conventional or sonication and some of these were treated with long-term antibiotics or were left untreated according to the criteria by the clinician. Group 4, all cultures were negative. Their results from prosthesis sonication among patients with presumed aseptic loosening showed good correlation in cases of PJI diagnosed by conventional tissue cultures. Based on this they consider that several cases of single positive tissue cultures were significant. In the literature there is no consensus regarding the sonication protocol to be used and the number of microorganisms that is to be isolated to diagnose an infection from the sonication fluid.^{9,26}

Moojen et al.¹⁴ reported on using multiple criteria for the diagnosis of prosthetic joint infection from intraoperative specimens. They used cultures, pathological analysis and broad-range 16S rRNA PCR with reverse line blot hybridization (PCR-RLB) technique to improve the diagnostic accuracy. Based on their strict criteria true infection was diagnosed in 7 patients out of 176, intraoperative cultures were positive in 3 out of 7, pathological analysis was positive in 5 out of 7, all seven patients were found to be positive with PCR- RLB technique. These infections were from low virulence bacteria like coagulase negative staphylococci for which the PCR-RLB was found to be more sensitive than the routine cultures.

3.8. Implant survival after the diagnosis of prosthetic joint infection

Treatment was considered to be a failure when there was a relapse of infection, sinus and purulence at any time during the follow-up and reinfection with a different strain or a different microorganism.²⁷ The implant survival among the studies we reviewed varied from 85% reported by Saleh et al.¹² to 100%^{14,21,27–29} (Table 3). Higher survival seen in some studies could be because small study size and shorter follow up.

Tsukayama et al.¹⁷ had 90% success with 6 weeks IV antibiotic treatment in 31 THAs which were diagnosed to have prosthetic joint

Table 3
Intraoperative and treatment details.

Study	Number of Culture specimens taken	Special techniques utilized	Common Organisms isolated	Antibiotic treatment	Chronic antibiotic suppression	Diagnosis of post-op PJI	Revision surgeries in patients diagnosed with PJI	Implant survival until recent follow up
Saleh et al.	Multiple	None	Coag negative Staph (CONS), P acne	IV-39 Oral-10 Both-10 None –44	35	16/103	16	85%
Berend et al.	1	None	Staph Epidermidis Staph Aureus	IV-5 patients Oral – 2 patients	37	None	1	100%
Jacobs et al.	3–9	None	Staph Epidermidis P Acne	9 TKA, 17 THA- 3-month post op antibiotics	NA	43	NA	TKA-88% THA-92%
Ribera et al.	5 or more	Sonication of the implants	Coag Neg staph (CONS), Corynebacterium species.	NA	NA	12	NA	NA
Moojen et al.	14–20	16S rRNA PCR with reverse line blot hybridization	CONS, P Acne	Prolonged antibiotics in 2	NA	7	none	100%
Barrack et al.	2–3	None	Staph Epidermidis	4–6 wks IV – 17 patients	none	12	2	95%
Fernandez-Sampedro et al.	2–6	Sonication of the implant	Staph Epidermidis	Prolonged antibiotics in 11	1	24	9 of 24 and 1 of 174 AL needed two stage revision	95%
Ince et al.	2	rRNA PCR	P acne	None	None	None	None	100%
Kemphorne et al.	Multiple	Sonication of the implant	CONS	1 oral 3 IV antibiotics	None	4 treated	None	100%
Parvizi et al.	Minimum 3	None	NA	NA	NA	14	14 (4.3%) 20 Non-infected failures	89%

infections from intraoperative cultures. Marculescu et al.¹⁵ reported 5-year survival rate of 89% in 16 cases of prosthetic joint infections diagnosed from intraoperative cultures. Jacobs et al.²³ reported three out of 17 cases TKA failures at two years due to reinfection in the PJI group compared with 5/173 in the aseptic group. The two-year infection free implant survival was 88% in the PJI group compared to 98% in the aseptic group. Three of the 26 THAs failed at two years as compared to 11/188 in the aseptic group. The two-year infection free implant survival was 92% in the PJI group compared to 94% in the aseptic group.

4. Discussion

In this systematic review of the literature we analyzed importance of unexpected positive intraoperative cultures in presumed aseptic prosthetic joint revision surgeries. The reported prevalence of unexpected positive intraoperative culture varies from 4% to 38%, this could be due to differences in preoperative evaluation, the selected cohort of aseptic revisions, definition of positive cultures, number of culture samples taken, contamination rates during transportation and in the laboratory, smaller study group. The mean prevalence was found to be 10.5% among the patients included in this review. We included studies published after 2000 because the studies published prior to reported intraoperative cultures results in patients with prosthetic joint infections.^{15–17} This made it difficult to accurately describe the rate of UPIC. The incidence of UPIC was almost twice more common in the hips as compared to the knees.

Most of the studies we reviewed predated the diagnostic criteria for prosthetic joint infection put forth by the Musculoskeletal infection society (MSIS) in 2011.²⁴ Without a proper pre-operative criterion some of the prosthetic joint infections may have been missed by these studies. Jacobs et al.²³ in their study included revision arthroplasties which were done between January 2011 to November 2013. They did evaluate the patients with preoperative ESR, CRP, serum WBC and joint aspiration but strict MSIS criteria was not adopted.

The newer definition¹¹ is a validated and updated version of the MSIS criteria based on a multicenter prospective study of patients undergoing revision total joint arthroplasty. It has two major criteria as before. The minor criteria include the pre-operative ESR, CRP, D-dimer, synovial fluid evaluation and intraoperative histological findings, cultures and presence of purulence. The new criteria demonstrated a higher sensitivity of 97.7% compared to the MSIS (79.3%), with a similar specificity of 99.5%.

We found considerable variability in the literature regarding the significance of single positive intraoperative culture and the decision to treat it with antibiotics. Segawa et al.¹⁶ described the diagnosis of deep prosthetic joint infection in revision TKA based on finding of two positive intra-operative cultures and these were termed type 1 deep prosthetic joint infections. Single positive cultures were considered not enough evidence to diagnose PJI. The cultures which were positive in broth only were disregarded. Berend et al.²¹ obtained a single swab culture intraoperatively and considered all positive cultures and positive Gram stains as significant and treated them with antibiotics. They recommended obtaining multiple cultures including the tissue and fluid cultures during the revision arthroplasty cases thereby a single positive culture can more easily be regarded as non-significant and perhaps antibiotic treatment can be avoided in those cases.

Saleh et al.¹² grouped their patients with positive intraoperative cultures into 3 groups. The group 1 did not meet institutional criteria for antibiotic treatment. They also applied the MSIS criteria retrospectively to divide the patients who were treated with antibiotics into group 2, who did not meet the criteria and group 3 who met the MSIS criteria for the diagnosis of prosthetic joint infection. The group 1 patients were presumed to have contaminated cultures, 9% of these were later readmitted for diagnosis of prosthetic joint infection but all of them were infected with a different organism than isolated originally. Whereas 20% of the group 2 and 3 patients developed prosthetic joint

infection of which 58% were caused by the same organism. Although patients in group 2 did not meet MSIS definition for PJI at the index revision, higher subsequent rates of PJI were noted in this group compared to group 3 (22% vs. 14%) but this difference was not statistically significant. Their study also showed higher infection recurrence rate in patients with single positive intraoperative culture, indicating that even patients with a single positive culture for a virulent microorganism may truly be infected and require antibiotic treatment.

Kamme and Lindberg,³⁰ defined the presence of 1 or 2 positive cultures out of 5 as representative of probable contaminants and suggested 3 positive cultures out of 5 as the threshold for defining infection. In a large consortium study, Atkins et al.³¹ agreed with 3 of 5 positive intraoperative cultures as the recommended threshold for defining infection. But this criterion was not fool proof either, there was 8% chance that only one of the 5 cultures could be positive in an infected case.

Barrack et al.¹⁰ reported no prosthetic joint infections in 29 patients with single positive cultures and no other evidence of infection, only 5 of these were treated with 4–6 weeks of IV antibiotics. They classified these as false positive cultures and none of these developed any signs of infection at an average of 45 months follow-up. Based on this they concluded that not all positive intraoperative cultures require treatment and a 4–6 weeks course of antibiotic treatment has a degree of risk and cost that would not be justified on a routine basis. So, they concluded that the treatment of a single positive intraoperative culture is not necessary in the absence of any other evidence of infection.

In a study by Fernandez-Sampedro et al.,³ antibiotic therapy post-revision surgery in patients with PJI was not related to a better outcome. There was no statistically significant difference in functional status between PJI patients with antibiotic and those with no antibiotic treatment. In fact, PJI patients who were treated with antibiotics developed implant failure more often than those who were not treated with antibiotics. They also didn't treat 11 patients with single positive cultures with any antibiotics because they did not meet any other criteria for PJI.

Diagnosis of aseptic loosening of the prosthetic joint remains challenging, and the pathogenesis of aseptic loosening is poorly understood. It is postulated that some of these cases of aseptic loosening could be secondary to the bacteria living on and around the implants producing the chronic inflammation leading to implant failure without any clinical signs and symptoms of infection.³² These bacteria may be over looked if standard culture techniques are used. This hypothesis of bacterial infection as one of the unrecognized or occult etiology for aseptic loosening is further supported by detection of bacterial DNA using highly sensitive techniques like PCR.³³

One of the reasons for not able to isolate the organisms is due to the presence of biofilm. This has led some investigators to use biofilm disruption techniques like sonication of the implants.^{33–35} Fernandez-Sampedro et al.³ found positive sonicate cultures in 10.6% of the patients. They showed that the sensitivity of sonicate fluid culture, which requires a single specimen, was higher than peri-prosthetic tissue culture in detecting PJI. Zhai et al.²⁷ in a metaanalysis of sonication fluid samples from prosthetic components for the diagnosis of infection found that the sonication fluid culture has high sensitivity and specificity in diagnosing PJI. Kempthorne et al.²⁹ used a control revision arthroplasty group for comparison for assessing the rate of infection in revisions for aseptic loosening. They also used sonication of the implants, they consistently had more positive cultures from conventional sampling methods than the sonication. They concluded ultrasound sonication of the removed prosthesis was less sensitive than conventional sampling techniques. This could be due to ultra-sonication in solid containers as opposed to plastic bags to reduce the contamination risk.

PCR of the 16S rRNA segment of the bacterial genome offers a highly sensitive assessment for the presence of bacteria. The 16S rRNA segment is very common to most bacteria causing the PJI; therefore, its use is associated with increased sensitivity.³⁶ Tunney³⁷ et al. reported

an overall 72% positive rate of PCR in their study of sonicated fluid culture. Based on this they assume that the occult infection is more common in aseptic revision surgeries than previously thought. Ince et al.²⁸ in their study of 24 patients with acetabular cup loosening undergoing revision surgery found that PCR for detection of 16S rRNA in tissue specimens obtained from hip joints is not superior to routine bacteriologic culture techniques for detection of low-grade infections. Their finding contradicts finding by many other investigators. They observed, this could be because of meticulously performed and extended processing of the bacteriologic cultures in preoperative aspiration samples, thereby ruling out most of the prosthetic joint infections preoperatively.

5. Conclusion

According to this study the incidence of UPIC varies from 4 to 38% with a mean prevalence of 10.5%. The most common microorganisms found are indolent organisms like coagulase-negative staphylococci and *Propionibacterium* acnes. Virulent organisms like *Staphylococcus aureus* and enterococci are less common. UPIC is treated with culture specific antibiotics intravenously or orally for a period of 4–6 weeks. Single positive intraoperative culture can or cannot be significant depending on the virulence of the organism, hence taking multiple tissue samples in and around the joint can be helpful in determining the presence of infection. Thorough preoperative evaluation using the MSIS criteria to rule out prosthetic joint infection can reduce the incidence of UPIC. Newer techniques like ultrasound sonification of implant shows high to equal sensitivity but low specificity.

Declarations of interest

All the authors disclose that there are no conflicts of personal or financial interests with other people or organizations which may inappropriately influence this work.

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