Original article
https://doi.org/10.18019/1028-4427-2025-31-4-452-462

The role of microbiological methods in diagnosis of periprosthetic joint infection in patients with aseptic loosening of total hip arthroplasty

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Abstract

Introduction Instability of the total hip arthroplasty is a common complication and an indication for revision arthroplasty. The implant instability is diagnosed as aseptic with no microbiological culture growth to be obtained through preoperative synovial aspiration. Etiological interpretation of intraoperative findings in cases of so-called "aseptic instability" is critical for determining subsequent treatment strategies.

The **objective** was to determine the role of microbiological methods in diagnosing periprosthetic joint infection (PJI) of the hip.

Material and methods A bacteriological analysis was produced for 173 patients with aseptic instability of total hip replacement. The patients aged 27 to 82 years. Based on laboratory, clinical and microbiological (MB) findings, the patients were divided into two groups. The first group consisted of 118 (68.2 %) patients who underwent one-stage revision and had a favorable postoperative prognosis. The second group consisted of 55 (31.8 %) patients with elevated hematological parameters, local signs of inflammation, positive MB findings and had unfavorable prognosis. These patients underwent two-stage revision arthroplasty. Biopsy samples were tested using polymerase chain reaction (PCR) in cases of minimal microbial load.

Results Positive MB results were registered in 5.1 % of patients in the first group and in 25.5 % of patients in the second group. Intraoperative biopsies revealed positive results in 20.3 % of the first group and 30.9 % of the second group. PCR identified PJI in 7.5 % of MB biopsies and in 19.6 % of aspirates.

Discussion The findings indicated low diagnostic value of microbiological cultures with PCR improving diagnostic accuracy by 7.5 %. Detection of low-virulence microorganisms including coagulase-negative staphylococci required specific evaluation criteria.

Conclusion Microbiological culturing demonstrated moderate sensitivity, in low-virulence infections, in particular, while PCR in low-virulence infections was essential in establishing the microbial etiology of PJI.

Keywords: joint replacement, periprosthetic joint infection, coagulase-negative staphylococci, hip joint, joint instability, microbiological studies, polymerase chain reaction

For citation: Linnik SA, Orishak EA, Ermakov AM, Kucheev IO, Nilova LYu, Fadeev EM, Karagezov G, Korshunov DYu, Tsololo YaB, Usikov VV, Polikarpov AV. The role of microbiological methods in diagnosis of periprosthetic joint infection in patients with aseptic loosening of total hip arthroplasty. *Genij Ortopedii*. 2025;31(4):452-462. doi: 10.18019/1028-4427-2025-31-4-452-462.

INTRODUCTION

Total hip arthroplasty (THA) in the treatment of patients is an effective and safe orthopedic procedure in foreign and Russian surgical practice [1, 2]. With an increase in joint replacement surgeries, the number of complications increases. the most severe of which and Periprosthetic joint infection (PJI) is one of the most challenging and devastating modes of failure following arthroplasty procedures. PJI is estimated to occur in approximately 5–10 % of the replacements [2–7]. Aseptic loosening is a common late complication (20.0–50.3 % of cases) and the most common reason for revision THA [8, 9]. Instability of one or both endoprosthetic components is the predominant cause of aseptic revision THA in 38.1 % of cases according to the registry of the EP of the Vreden Russian Research Institute of Traumatology and Orthopedics. Aseptic loosening of THA reaches 50.3 % of primary revisions and ranks second in frequency after infectious complications and amounts to 20.8 % of re-revisions [8, 10–12].

Preoperative differential diagnosis of PJI and aseptic instability is challenging, especially in the presence of low-virulence pathogens and biofilm-associated infections [13–15]. Cases of suspected aseptic instability of THA can be caused by an undetected infection, which can be verified by in-depth microbiological testing (MBT). An individual reaction of the body to the implant is one of the reasons for aseptic loosening of the implant.

PJI manifests as instability in the operated joint and pain without changes in biochemical parameters, blood cellular reactions or signs of inflammation. The so-called “aseptic instability” of THA may be caused by a subclinical infection caused by low-virulent pathogens, representatives of the patient’s or staff’s microbiota [16–19]. Due to a vague clinical picture and the absence of early laboratory hematological parameters, MBI is prescribed only at the stage of manifestation of signs of exacerbated infectious process, when the microbial component is obvious. Intraoperative infection is one of the reasons for PJI which manifests during the period from several weeks to several months after surgery.

Examination of periprosthetic tissue samples and synovial fluid is the "gold standard" of MBI. The sensitivity is the key limitation of the bacteriological method which usually requires a content of at least 10^3 CFU of microbial cells in the material. Growth of microorganisms can be absent with use of standard bacteriological methods which may be associated with the insignificant quantity and with antibacterial therapy administered before sampling [20–23].

Gram-positive bacteria *S. aureus* and *S. epidermidis* are common etiological agents of PJI with an incidence rate of 60 %. Much less frequently (up to), Gram-negative bacteria and their associations are described as less common causative agents of PJI with reported incidence of 17 % [24–26]. Virulence factors of staphylococci, which include surface proteins that promote tissue colonization, a polysaccharide capsule, protein A, carotenoids, exotoxins, etc., are most characteristic of *S. aureus*.

The presence of a clinical equivalent allows the authors to suggest that a significant portion of the infection is caused by weakly virulent pathogens with a characteristic subclinical course of the infectious process. In such cases, it seems logical to discuss the etiological role of coagulase-negative staphylococci, among which S. *epidermidis, S. simulans, S. hominis, S. capitis, S. caprae* and *S. lugdunensis* were of isolated [27–30].

Instability of the implant after THA is a common complication and serves as an indication for revision THA. Growth of weakly virulent microflora have been recently reported with deep MBI of removed implants, and the implant instability cannot be considered aseptic. Diagnostic

algorithms for identifying this pathology continue to be developed and improved because of the lack of a diagnostic test that would allow 100 % detection of PJI.

The **objective** was to determine the role of microbiological methods in diagnosing PJI of the hip.

MATERIAL AND METHODS

The results of different diagnostic methods for PJI were evaluated in 173 patients with aseptic instability of endoprosthestic components, including 61 (35.3 %) male and 112 (64.7 %) female patients aged 27 to 82 years (53.7 ± 7.4). The patients were treated at the Trauma and Orthopedic Clinic of the I.I. Mechnikov North-Western State Medical University between 2020 and 2023. Primary THA was performed for osteoarthritis, femoral neck fractures, and aseptic necrosis of the femoral head. Instability of the endoprosthetic components developed at 1 to 12 years (5.8 on average) after primary endoprosthetic procedures.

Postoperative wounds healing was examined after primary arthroplasty, during postoperative period, the nature and frequency of pain at the operation site prior to instability signs. Signs of inflammation (edema, hyperemia, hyperthermia), the joint function were locally evaluated at the operation site. Preoperative history of 55 patients with endoprosthetic instability showed increased body temperature (up to 38°), greater leukocyte, ESR, CRP count. Diagnostic significance of screening results, including preoperative MBI in the period of re-endoprosthetics, was assessed based on laboratory and clinical findings.

Patients were divided into two groups for prognosis, the choice of treatment strategy and diagnostic findings depending on laboratory, clinical data and MBI evaluated with the EBJIS 2021 criteria. The first group consisted of 118 (68.2 %) patients showing no increase in hematological parameters (leukocytosis, CRP, ESR, neutrophilia, etc.) after primary arthroplasty, no inflammation at the operating site having negative MBI results, i.e. patients with a prognostically favorable postoperative course. These patients underwent one-stage re-arthroplasty. The second group, prognostically unfavorable, consisted of 55 (31.8 %) patients with elevated hematological parameters and local signs of inflammation, an unfavorable postoperative course after primary THA and positive MBI results. Patients in this group underwent two-stage re-arthroplasty upon admission to the clinic.

All patients underwent a comprehensive clinical, hematological and microbiological examination before revision arthroplasty according to the algorithms of international professional societies (Musculoskeletal Infection Society MSIS 2018, European Bone and Joint Infection Society EBJIS 2021).

Clinical and laboratory findings including ESR, CRP counts, leukocytosis, erythrocyte and polymorphonuclear neutrophils synovial count were used to predict PJI. Ultrasound-guided MBI punctures were produced by three-fold puncture from the joint cavity before revision arthroplasty that was performed in all 173 patients with unstable THA: 118 patients of the first group with a favorable prognosis underwent one-stage re-arthroplasty, and 55 patients of the second group underwent two-stage re-arthroplasty.

Removal of unstable components, collection of biopsies for MBI, thorough washing of the surgical wound using pulse lavage, ultrasonic treatment of the surgical wound and installation of a revision implant were performed for patients of the first group. Revision arthroplasty system was selected individually depending on local changes in the operated joint (presence of bone defects, osteoporosis, condition of soft tissues). Patients with an unfavorable prognosis underwent two-stage re-arthroplasty. Debridement was produced first. Biopsy samples (at least five) were taken for MBI after removal

of unstable endoprosthetic components, bone cement and other foreign bodies (screws, wire, etc.)., an articulating spacer was normally placed after thorough washing of the surgical wound and the ultrasound treatment. Special molds were used to prepare a two-component spacer with the size selected individually depending on the diameter of the acetabulum and the bone canal of the femur. An antimicrobial composition of prolonged action was used to manufacture the spacer (patent No. 2019109897). The final re-arthroplasty was performed after 3–4 months using revision systems.

Patients of the first group received antibiotic (cefazolin) for prophylaxis for 3–5 postoperative days. Patients of the second group received a course of parenteral antibacterial therapy (approved by a clinical pharmacologist, depending on the microflora identified during MBI) for 7–10 days, followed by oral antibiotic therapy for 6–8 weeks.

MBI of biomaterial obtained intraoperatively is a diagnostically significant method in PJI, especially when identifying microorganism strains of the same phenotype from two or more intraoperative samples [29–32]. Intraoperative extraction of several samples for MBI was performed in all patients. Unstable endoprosthetic components (cup, liner, stem, head) removed, underlying altered tissues, material from the femoral canal and acetabulum, synovial fluid, periprosthetic membrane (if present), smears from the wound and bone pieces were examined.

The samples were cultured on an extended set of nutrient media to isolate aerobic, facultative anaerobic and obligate anaerobic microorganisms and micromycetes. A generally accepted semi-quantitative method with sieving was used, which does not allow for accurate weighing of the material and reliable calculation of the concentration of the pathogen. The growth was assessed according to the categories “from enrichment medium”, “sparse”, “moderate”, “abundant”, “confluent”, which implied the following criteria: when isolating on a dense nutrient medium, growth of 10 colonies of microorganisms of a certain type was assessed as scanty; rated as moderate with 10 to 100 colonies and abundant with greater than 100 colonies.

With continuous growth of microorganisms being not countable, the growth was designated as "confluent". A reserve enrichment seeding was performed on thioglycollate and sugar broths, followed by seeding on solid media. After washing, the prosthetic fragments (cup, liner, stem, head) were aseptically placed either in wide-necked bottles with liquid nutrient medium or (depending on size) in specially prepared sterile containers with liquid media that ensure complete immersion of the components. The standard method of incubating enrichment cultures involved seeding on solid media after 16–18 hours. In cases of incubating prosthetic components, cultivation in a liquid nutrient medium was prolonged to 72 hours.

Standardized biochemical systems, the MALDI TOF mass spectrometry method were used for identification of various groups of microorganisms.

A cultural study of the material obtained before and during revision arthroplasty does not fully resolve the problem of interpreting the results and assessing the etiological significance of findings with an extremely low microbial load, and does not always allow a diagnosis of PJI. Additional microbiological methods are essential for similar results obtained by different methods interpreting the findings as significant. Therefore, samples obtained during revision arthroplasty were examined with in the polymerase chain reaction (PCR). The theoretical sensitivity of PCR is 1 microbial cell in the test material; the sensitivity of PCR measures 10^2–10^3 microbial cells.

Prior to inoculation into nutrient media, the study material was aliquoted by selecting pieces of tissue and taking swabs from native material and prosthetic components, followed by freezing at a temperature of –80 °C for PCR testing.

Native material was examined for microbial genes, including resistance genes using a programmable amplifier with a real-time fluorescent signal detection system CFX96 Touch (Bio-Rad). The results were analyzed using the software of the device used for PCR with real-time detection. The graphs of fluorescent signal accumulation were analyzed in the corresponding channels, indicating accumulation of the amplification product of gene fragments of the corresponding microorganisms and/or resistance enzymes. The clinical interpretation of positive PCR results was assessed as a significant component of the inflammatory process.

Genes of methicillin-resistant staphylococci were detected in native material using a set of reagents for identification and quantification of DNA of methicillin-sensitive and methicillin-resistant *S. aureus*, methicillin-resistant coagulase-negative *Staphylococcus spp*. in biological material with the PCR method with hybridization-fluorescence detection AmpliSens® MRSA-screen-titer-FL. The presence of *S. aureus* DNA and the mecA gene DNA were analyzed. The samples with established *Staphylococcus spp*. DNA were additionally examined for the presence of vanA and vanB genes using the AmpliSens® MDR VRE-FL reagent kit.

The kit is intended for the qualitative determination of *Enterococcus spp*. DNA and vanA and/or vanB genes detected to identify vancomycin-resistant enterococci (VRE) strains. However, vanA and vanB genes can be detected in Staphylococcus spp. in some rare cases aggravating the course of the disease and limits resources for therapy [16, 22, 28].

The study was approved by the Ethics Committee of the Mechnikov North-Western State Medical University and was conducted in accordance with the ethical standards set out in the Declaration of Helsinki. Informed consent for publication of the findings was obtained from all patients.

STATISTICA 10 software was used for statistical processing of the results. Quantitative parameters were determined using nonparametric methods χ^2, Fisher and Mann – Whitney tests. Differences between groups were considered statistically significant at $p < 0.05$.

RESULTS

Patients were representative in terms of gender in both groups. The average age of patients was 57 years (IQR 49–70) in the first group and 61 years (IQR 48–67) in the second group ($p > 0.05$). The median levels of leukocytosis, ESR, and CRP did not differ significantly between the groups prior to re-arthroplasty and measured: 7.8×109/L and 8.1×10^9/L; 15.8 mm/h (IQR 13–28) and 19 mm/h (IQR 13–32); 5.0 mg/mL (IQR 1.52–6.7) and 3.5 mg/mL (IQR 1.9–6.1) ($p > 0.05$) in the first and second groups, respectively.

Of 173 patients, positive results of MBI punctures prior to re-arthroplastic surgery were detected in 20 (11.6 %) patients including six (5.1 %) patients in the first group and 14 (25.5 %) cases in the second group. Positive results were mainly represented by coagulo-negative staphylococci ($n = 14$; 70.0 %), gram-negative ($n = 3$; 15.0 %) and microbial associations ($n = 5$; 25.0 %).

Intraoperatve MBI of tissue biopsies is essential for the diagnosis of PJI. Positive results were detected in 41 (23.7 %) patients, which is twice as often ($p < 0.05$) as from those taken preoperatively (OR = 2.0; 95 % CI 13.4–22.3). Positive results were obtained in 24 (20.3 %) patients of the first group and in 17 (30.9 %) cases of the second group, which is ($p < 0.05$) twice as high as from preoperative punctures (Table 1).

Table 1

Inoculation with MBI prior to, during and after arthroplasty

Groups of patients	Number of positive MBI results (culturing)					
	Preoperative punctures		Intraoperative biopsy		Post-op	
	abs.	%	abs.	%	abs.	%
Group I	6	5.1	24	20.3	7	5.9
Group II	14	25.5	17	30.9	6	10.9

The patients with positive MBI puncture results had positive intraoperative MBI biopsy results. The microbial landscape in 31 (75.6 %) patients with positive punctures coincided with the microbiota obtained during joint puncture in patients with unstable implant.

According to the EBJIS 2021 criteria, PJI was diagnosed in 20.3 % of cases in the first group, and was 1.5 times more common in the second group of patients (30.9 %) ($p < 0.05$).

DNA of significant microorganisms was detected with PCR indicating the presence of PJI in 54 (31.2 %) patients, including 24 (43.6 %) patients in the second group and 30 (25.4 %) patients in the first group. On average, the PCR test could improve the diagnosis of PJI with MBI biopsy by 5.1 % in the first group and by 12.7 % in the second group.

The PCR method allowed us to identify 7.5 % more cases of PJI than with MBI biopsy in both groups, and by 19.6 % greater ($p < 0.05$) than with MBI punctates. The PCR method significantly improved ($p < 0.05$) detection of PJI by 20.3 % after MBI punctures and by 5.1 % after MBI biopsies in the first group, and, PJI was determined ($p < 0.05$) more often in the second group, by 18.1 % and 12.7 %, respectively (Tables 2, 3).

Short-term results (up to 6 months) were reveiwed in the patients of both groups (Table 4).

Table 2

Results of culturing and molecular biological research methods

Groups of patients	Number of patients with positive results					
	Preoperative punctures		Intraoperative biopsy		PCR	
	abs.	%	abs.	%	abs.	%
Group I ($n = 118$)	6	5.1	24	20.3	30	25.4
Group II ($n = 55$)	14	25.5	17	30.9	24	43.6
Total ($n = 173$)	20	11.6	41	23.7	54	31.2

Table 3

Quantification of *S. aureus* DNA and mecA, vanA, vanB gene in the diagnosis of PJI

Groups of patients	Description	Quantification					
		DNA MSSA	DNA MRCoNS	DNA MRSA	DNA MRS spp.	vanA	vanB
Group I	cases of detection of staphylococcal DNA	6	21	2	1	–	–
	copies/ml sample	$1.1–2.7×10^4$	$2.4–9.0×10^5$	$5.8–8.8×10^3$	$1.2×10^3$		
Group II	cases of detection of staphylococcal DNA	–	18	3	3	–	–
	copies/ml sample	–	$1.0–9.4×10^4$	$1.4–3.1×10^4$	$1.2–7.7×10^3$		
Total	6	6	39	5	4		

Table 4

Healing of surgical wounds after re-arthroplasty

Groups of patients	Number of patients					
	Healing by primary intention		Healing by secondary intention		Infected, fistulas	
	abs	%	abs	%	abs	%
Group I (n = 118)	94	79.7	8	6.8	16	13.5
Group II (n = 55)	36	65.4	9	16.4	10	18.2

Postoperative wounds healed by primary intention in 94 (79.7 %) patients of the first group, which was more common ($p < 0.05$) than that in the second group amounting to 36 (65.4 %) patients. Surgical wound got infected and sinuses developed in 26 (15.0 %) patients including 13.5 % in the first group and was less common ($p < 0.05$) than that in the second group (18.2 %).

Infection was observed in three patients in each group (12.5 % and 16.7 %, respectively). Low-virulent staphylococci were cultured postoperatively with positive PCR results and negative MBI punctures and biopsies. In two cases in each group, in addition to the gram-positive microorganisms identified during the MBI, new gram-negative non-fermenting bacteria *Pseudomonas aeruginosa* were detected.

A significant limitation of MBI (cultural research) includes the limited sensitivity from the standpoint of the need for a sufficient microbial load per unit volume of the material to be able to interpret the results. If a negative result is obtained in culturing, the lower limit of the method's sensitivity is determined by the seeding dose. With seeding on dense nutrient media microbial growth can be detected only under a microbial load of at least 100–1000 microbial cells per ml of the material being examined. New, more sensitive, molecular biological methods are to be introduced. A complex microbiological diagnosis will help to expand diagnostic capabilities and determine the significance of microorganisms with the low virulence and small quantity. The newly approved clinical guidelines "Infection associated with orthopaedic implants" highlights the importance of culture testing indicating the advantage of molecular biological methods over traditional culture testing in examination of patients with infection caused by low-virulence pathogens.

Long-term outcomes (one year after re-arthroplasty) were reviewed in 103 patients of the first and 47 patients of the second groups. Positive results were obtained in 96 (95.0 %) patients of the first group, which was ($p < 0.05$) 10.8 % higher than that in the second group amounting to 38 (80.5 %). Local infectious complications in the form of PJI were detected in 17 (11.3 %) patients, which is nine less than in the period of 6 months after surgery. It can be associated with stable remission after debridement in the cases. Pathogens identified after arthroplasty in 10 (62.5 %) PJI patients of both groups coincided with pathogens obtained during MBI of preoperative punctures and intraoperative MBI of biopsies. Microorganisms were additionally identified with PCR in six patients (37.5 %).

The findings indicated a low significance of preoperative MBI of punctures. Biopsies taken during re-arthroplastic surgery in patients with aseptic instability of implant allow to detect microbiota twice as often. The use of PCR testing facilitated identification of microflora in 7.5 % of cases in patients with negative MBI results preoperatively and during re-arthroplasty surgery indicating the role of PCR testing in patients with a poor prognosis for PJI with a small number of bacteria (10^2 CFU) or their absence.

Clinical instance

A 54-year-old female patient was treated for instability of the right THA at the trauma and orthopedic clinic. In the anamnesis, before the development of instability of the endoprosthes is components, The patient repeatedly developed signs of inflammation at the site of the operated joint that were arrested by antibiotic therapy. Microorganisms were not detected during MBI of the hip aspirate. Revision arthroplasty was performed for the right hip joint. Microbiological examination of biopsies (periprosthetic tissues, synovial fluid, endoprosthetic components) revealed no growth of microorganisms. PCR of biopsies showed methicillin-resistant coagulase-negative *Staphylococcus spp*. The patient developed an increased body temperature of 37.7°, fever, signs of systemic inflammatory response and postoperative wound inflammation at two weeks. The postoperative wound puncture demonstrated pus and *S. epidermidis* cultured with PJI developed.

Therefor, complex microbiological and PCR (if there are less than 10^3 CFU in 1 cm^3) studies allowed us to diagnose PJI and choose the optimal treatment strategy for patients with unstable endoprosthetic components.

DISCUSSION

MBI is a significant diagnostical test [16, 32, 33]. However, the key limitation of MBI is the sensitivity, which normally requires a content of at least 10^2–10^3 CFU in 1 cm^3 of the test material. In most cases, standard bacteriological methods show no growth of microorganisms, which may be due to the small number or antibacterial therapy before sampling. PCR study was performed for the 55 patients of the second group with a poor prognosis for PJI, and for the 118 patients of the first group. The material was characterized by weak bacterial contamination mainly from the enrichede medium. There was a scanty growth or the absence from conditionally abiotic objects (prosthetic components) and significant contamination (from moderate to confluent growth) in some biomaterial samples (joint fluid, smears, tissue fragments).

The quantitative equivalent in terms of the copies/mL of sample appears to be an important component in the development and definition of criteria for the etiologic significance of low-virulence microorganisms including coagulase-negative staphylococci, in the development of PJI. The minimum number of copies (at the level of sensitivity of the bacteriological method) is observed exploring endoprosthetic components with the number of copies corresponding to the etiologically significant number of microorganisms studying muscles, tissues and synovial fluid with the PCR method. The fact may indicate “lost” findings with bacteriological testing as the only method and identification of additional positive findings during a parallel study of the material, including material from endoprosthetic components, using the PCR method. We were able to detect 15 additional cases of staphylococci, which is 14.8 % of additional findings from the staphylococcal isolates previously found during bacteriological examination (101 strains).

According to modern algorithms, opportunistic pathogens isolated from one sample of biomaterial in the absence of other signs of infection do not indicate PJI, while the highly virulent microorganisms isolated even from one sample is diagnostically significant. Opportunistic pathogens isolated from only one sample and absence of pathogen growth in intraoperative biomaterial do not rule out PJI [20]. Inagaki et al. reported 80 % of cases of confirmed PJI with the pathogen being identified in the two samples of biological material, 8.3 % of cases in one sample and the pathogen was not identified in 11.7 % of cases. Recurrent PJI are reported in 21 % of cases [34].

With the century-long history of the bacteriological method, the technology remains relevant and reliable for the majority of clinical scenarios. The bacteriological (cultural) method allows for verification of the pathogen assessing the quantity, sensitivity to antimicrobial drugs using several standardized methods. Although the bacteriological method remains the "gold standard" for validating other modern methods of microbiological diagnosis, it has some limitations including relatively low sensitivity, the exacting nature of individual groups of bacteria that would result in unrepresentative results, lack of confidence in the complete interpretation in case of a positive result or a false negative test [20, 31]. The bacteriological examination of the biomaterial and washings from the endoprosthetic components demonstrated no bacterial growth in 76.3 % of cases in the series. In such cases, joint instability is considered aseptic. With weakly expressed inflammation indicators, low virulence of the prevailing pathogens of PJI, postoperative complications are assessed as aseptic loosening of the construct and does not lead to adequate treatment strategy with mandatory antibiotic therapy. The empirical antibiotic therapy can result in low efficiency of bacteriological examination. The PCR method allowed for identification of microorganisms in 54 (31.2 %) of 173 patients, which was ($p < 0.05$) 7.5 % higher than that from intraoperative biopsies and 19.6 % higher than from preoperative punctures. More significant results were obtained in patients of the comparison groups. The PCR improved diagnosis with puncture from 5.1 % to 25.4 % in the first group, from 11.6 % to 43.6 % in the second group. The MBI biopsy improved diagnosis from 20.3 % to 25.4 % in the first group and from 30.9 % to 43.6 % in the second group.

The material examination detected microorganism DNA with a negative culture result that could be interpreted as etiologically significant with the clinical equivalent being the decisive factor in the case requiring revision operations.

The advantage of the combined methods includes the ability to assess the significance of preoperative findings and provide earlier interpretation rather than repeated bacteriological examination determining the surgical strategy for patients with unstable endoprosthetic components. The PCR method introduced into the examination of intraoperative material would facilitate faster etiological decoding, timely application of targeted antibiotic therapy and selection of surgical strategy.

CONCLUSION

Microbiological test in the diagnosis of PJI demonstrated moderate or high sensitivity (43.5–100.0 %) and high specificity (81.2–100.0 %). The use of microbiological (cultural) testing in preoperative material (punctures) allowed for identification of PJI in 5.1–11.6 % and in 23.7–31.2 % of intraoperative biopsies.

The native material examined with the PCR method can facilitate detection of PJI even in the presence of a low-virulence infection with the microbial cell content being less than 10^3 CFU per 1 cm^3 or absent with MBI of the "pre-revision" puncture or intraoperative "revision" biomaterial. Microbiological (culturing) testing demonstrates moderate sensitivity, in low-virulence infections, in particular, with the molecular biological testing (PCR) playing a leading role in establishing the microbial etiology of PJI.

Comprehensive microbiological diagnosis would help expand diagnostic capabilities and determine the significance of microorganisms, even with low virulence and small quantities.

Conflict of interest *None of the authors has any potential conflict of interest.*

Funding *The authors received no financial support for the research and/or authorship of this article.*

Ethical standards *The study was approved by the Ethics Committee of the Mechnikov North-Western State Medical University and was conducted in accordance with the ethical standards set out in the Declaration of Helsinki*

Informed consent *All patients gave informed consent for publication of the study results.*

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The article was submitted 11.11.2024; approved after reviewing 06.05.2025; accepted for publication 05.06.2025.

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