Does Pooled Intraoperative Sampling Improve the Diagnosis of Periprosthetic Joint Infection? A Paired Diagnostic Accuracy Study

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Introduction

- Periprosthetic Joint Infection (PJI) represents a severe clinical complication of arthroplasty, and a leading indication for surgical revision.
- A comprehensive tissue sampling regime, collecting from distinct anatomical locations, is key to PJI diagnosis and organism detection —organisations such as EBJIS[3] and MSIS[4] recommend at least 3 samples be taken.
- It is unclear what role intraoperative prearthrotomy fluid samples play in PJI diagnosis.
- Significant heterogeneity exists in the literature regarding the relative performance of intraoperative fluid culture and tissue culture.

Research Questions

QUESTION ONE — What is the incremental value of adding fluid sampling onto an existing comprehensive tissue sampling regime?

QUESTION TWO — Can a fluid sample substitute a tissue sample as part of a comprehensive sampling regime without compromising diagnostic yield?

Key Definitions

Microbiological Yield — The proportion of samples which identified a plausibly pathogenic organism.

Diagnostic Yield — The proportion of cases in which the microbiology results increased the EBJIS classification.

Fluid Sample — A sample of synovial fluid drawn intraoperatively prior to arthrotomy

Methodology

- Retrospective observational study.
- Screened all consecutive revision hip and knee arthroplasties (DAIR & implant replacement) conducted at a single specialist orthopaedic centre in the UK between Nov 2024 & Nov 2025.
  - 397 cases screened — 165 excluded (53 cancelled, 112 no paired fluid and tissue samples)
- Tissue samples collected according to surgeon discretion (number and location).
- Microbiology processed by a single on-site laboratory; aerobic & anaerobic incubation up to 10 days.

Three levels of analysis:

1. Diagnostic & Microbiological yield — overall concordance, single-modality detections, polymicrobial discordance.
2. Diagnostic performance (sensitivity, specificity, PPV, and NPV) calculations. EBJIS classification binarised to enable calculation. Paired comparison using McNemar's test ($\alpha = 0.05$).
3. Resampling of cases with ≥4 tissue samples to enable comparison of tissue-only and tissue+fluid simulated sampling strategies at different overall sample counts. 5% non-inferiority margin used.

Diagnostic Feature	Infection Unlikely	Infection Likely	Infection Confirmed
Joint Space Purulence	-	✓	
Communicating Sinus	-		✓
Preoperative Aspiration	-	✓	
Intraoperative Microbiology	-	1 positive sample	≥2 identical positive samples
Intraoperative Histology	-	"features of active infection"	"visible organisms"

Table 1: The modified EBJIS 2021 used to classify infection likelihood. Modifications reflect data captured within the study institution. "Infection likely" classification requires ≥2 positive criteria.

Headline Findings / Conclusions

- Tissue culture uniquely detects more organisms than fluid culture
- Fluid and tissue cultures perform similarly well at diagnosing infection
- Swapping a single tissue sample for a fluid sample only works when very few samples are taken overall

Conclusion: Fluid sampling adds clinically meaningful value when used in addition to comprehensive tissue sampling, especially given the substantial impact of PJI

Results

1 Diagnostic & Microbiological Yield

- 232 cases included: 68 "infection confirmed", 6 "infection likely", 154 "infection unlikely".
- Among 74 "infection confirmed" & "infection likely", 47 were monomicrobial (63.5%), 15 (20.3%) polymicrobial, 12 (16.2%) culture-negative.
- Overall diagnostic concordance: 91.9%.
- Five monomicrobial cases were discordant; tissue uniquely identified the plausible pathogen in four cases, and fluid in 1 case.
  - All uniquely grown organisms were CoNS.
- Five polymicrobial cases were discordant; tissue identified additional organisms in 4 cases, and fluid in 1 case (Table 2).

Case Number	Fluid Culture	Tissue Culture
#2024-7461	Streptococcus dysgalactiae	Streptococcus dysgalactiae **Proteus mirabilis**
#2025-1009	Enterobacter cloacae	Enterobacter cloacae **Corynebacterium striatum**
#2025-2191	Staphylococcus epidermidis	Staphylococcus epidermidis **Escherichia coli** **Pseudomonas aeruginosa**
#2025-5516	Bacteroides fragilis **Bacteroides faecis**	Bacteroides fragilis
#2050-6030	Enterococcus faecium	Enterococcus faecium **Klebsiella pneumoniae**

Table 2: Discordant polymicrobial cases. Highlighted cells indicate which culture uniquely identified the additional organism(s), with the additional organisms formatted in bold.

2 Modality Sensitivity, Specificity, PPV, & NPV

- No statistically significant difference was found in diagnostic performance across all 4 performance metrics between both modalities (table 3).
  - No difference when reference standard classified PJI-positive as "infection confirmed" + "infection likely" versus "infection confirmed" alone.
- Exclusion of microbiology from reference standard decreased PPV for both modalities (Fluid: -24.2%, Tissue: -21.7%), and decreased fluid specificity (-8.5%), no other statistically significant changes were found.

	Sensitivity		Specificity		PPV		NPV	
Fluid Culture	**78.4%**	67.7—86.2	**97.5%**	93.7—99.0	**93.6%**	84.6—97.5	**90.6%**	85.3—94.1
Tissue Culture	**82.4%**	72.2—89.4	**94.9%**	90.3—97.4	**88.4%**	78.8—94.0	**92.0%**	86.8—95.3

Table 3: Sensitivity, specificity, PPV, and NPV for fluid and tissue culture calculated against an EBJIS classification inclusive of microbiology results — binarised such that "infection confirmed" and "infection likely" equate to PJI-positive, and "infection unlikely" equates to PJI-negative. Data presented as % point estimate and 95% confidence intervals (Wilson's).

3 Resampled Simulated Sampling Strategies

- Resampling showed that substituting one tissue sample with a fluid sample was only non inferior at an overall sample count of two (Figure 1A).
- At higher sample counts, tissue-only strategies consistently outperformed strategies substituting tissue for fluid .
- Addition of fluid sampling to tissue sampling regimes was found to be superior at low tissue sample counts (≤2), and non-inferior at higher tissue sample counts(Figure 1B).

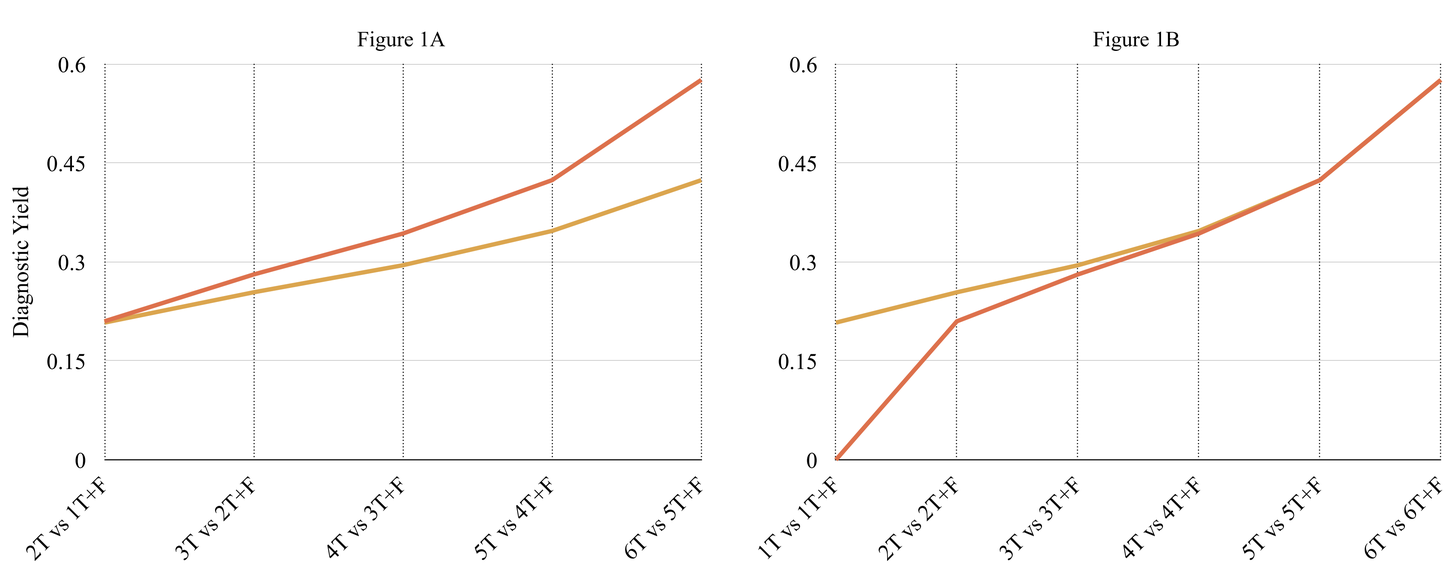

Figure 1: Comparison of simulated sampling strategies to (A) explore the substitutive potential of fluid sample for a single tissue sample, and (B) the incremental diagnostic value of adding fluid sampling on top of tissue sampling. T = tissue, F = fluid.

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