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Original article

Usefulness of sonication for diagnosing infection in explanted orthopaedic implants

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ABSTRACT

Background: Orthopaedic implant infection is a rare but serious complication whose optimal treatment requires an accurate microbiological diagnosis. The objective of this study was to determine whether culturing sonicated explants improved sensitivity compared to culturing standard sonicated soft-tissue samples.
Hypothesis: Cultures of explant sonication fluid are more sensitive than cultures of soft-tissue sonication fluid in patients with implant infection.
Methods: This single-centre retrospective study included all sonication fluid samples from implants explanted in orthopaedic surgery theatres for any reason. The microbiological results of the implant sonication fluid cultures were compared to those of cultures of sonicated soft-tissue and bone samples taken during the same procedure. The primary evaluation criterion was the difference in microorganisms recovered from explant sonication fluids versus fluid/tissue cultures.
Results: The study included 187 explants removed between September 2009 and June 2015. Of the definite infections, 83% were identified by explant sonication, 86% by fluid/tissue cultures, and 91% by both techniques combined. Explant sonication recovered causative organisms in 10 patients with definite infection but negative fluid/soft tissue cultures. Antibiotic therapy prior to explantation was associated with lower sensitivity of explant sonication (57% vs. 67% for fluid/soft tissue cultures).
Conclusion: Explant sonication improved the diagnosis of infection when combined with fluid/soft tissue cultures.
Level of evidence: IV, retrospective single-centre study.

1. Introduction

In situ infection of orthopaedic implants, although rare (< 1% to 2%) [1] is dreaded by both surgeons and patients [2–5]. When infection is suspected, identifying the causative organisms and testing their susceptibility to antibiotics are crucial to the development of an effective treatment strategy [6]. Cultures of soft-tissue and bone samples may be negative [7–10]. Bacteria form biofilms that adhere to the surface of inert implants [11–14]. Within biofilms, pathogenic organisms are sheltered not only from the host immune response, but also from antibiotics [15], which have limited ability to penetrate biofilms. The adherent bacteria acquire the small-colony variant phenotype and are isolated from the surrounding tissues by the biofilm, making them difficult to identify [10,16–19].

Sonication consists in sending sound waves in the ultrasound spectrum through a fluid. Sonication disrupts intercellular connections, thereby disorganizing the biofilm and releasing the quiescent bacteria it contains. Another effect of sonication is deagglomeration and lysis of cell adhesion proteins. Thus, sonication increases the likelihood of identifying bacteria responsible for infection [20]. Adding mechanical vortex mixing of the sonication fluid further increases the ability to recover microorganisms [21].

Work by Tunney et al. reported in 1998 showed better sensitivity of sonication compared to conventional cultures of hip prostheses [22,23]. In 2010, the French Microbiology Society issued a recommendation that sonication be used [24]. An evaluation of sonication results obtained since then is timely.

The objective of this study was to determine whether cultures of sonicated explants improved sensitivity compared to cultures of standard fluid/tissue samples. The hypothesis was that cultures of

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explant sonication fluid would prove more sensitive than cultures of fluid/tissue samples in patients with implant infection.

2. Material and method

2.1. Study design

Partial and total orthopaedic implant removal procedures performed from September 2009 to June 2015 for any reason in the orthopaedic and traumatology operating theatres of our department and followed by explant sonication were identified retrospectively. The primary evaluation criterion was the identification of micro-organisms by explant sonication. The other samples taken during the explantation procedure served as controls.

2.2. Sample collection and processing

Among explants, only those identified as such by the microbiology department and processed using sonication were included. In addition to the explants, deep fluids, soft-tissues, and bone were sampled. All samples were collected in the operating theatre at the site of suspected infection. Exclusion criteria were inaccurate sample labelling and absence of concomitant implant and fluid/tissue samples.

Routine sonication of explants removed in our orthopaedic and traumatology operating theatres was introduced in September 2009. This study included all explants removed from that date to June 2015. Fig. 1 is the flow chart. Several samples were harvested during each procedure. In addition, some patients had several explants removed, and the total number of explants is therefore greater than the number of patients and procedures. Thus, of the 167 procedures, 16 involved the removal of two explants and two of three explants processed by sonication, for a total of 187 explants.

The samples fell into three categories: fluids, soft tissues, and implants. The study compared the implant samples to the fluid and soft tissue samples used as controls. The control-group samples were also subjected to sonication as recommended by the French Microbiology Society (SFM).

All samples were studied at our microbiology department according to a protocol based on recommendations issued in 2010 by the French Microbiology Society (SFM) [24]. The explants were placed in sterile bottles and taken to the microbiology laboratory at room temperature within 2 hours after removal.

2.3. Data collection

The following data were collected for each patient: type of explant, side and date of implantation; diagnosis, symptoms, and symptom duration; serum C-reactive protein (CRP) level; antibiotic exposures within 2 weeks before explantation; and microbiological findings.

2.4. Study groups

Pre-operatively, three groups of patients were distinguished based on the likelihood of infection [10,25]: definite infection defined either as a draining track or as a CRP level above 100 mg/L plus at least two of the following three signs of infection: local inflammation, fluid collection, and fever; suspected infection leading to explantation with sample collection; and no evidence of infection with routine samples collected during explantation for a non-infectious complication [10,12].

Post-operatively, two groups of patients were distinguished: confirmed infection defined as at least one intra-operative sample positive for a pathogenic organism or at least two intra-operative samples positive for the same non-pathogenic species exhibiting the same antibiotic susceptibility profile; and no confirmed infection when the above-listed criteria were not met. A single sample containing a non-pathogenic organism was taken to indicate contamination that did not require treatment. Table 1 reports the demographic features of the patients according to the final diagnosis.

The number of samples taken during the procedure was five or more for 154 (82.3%) explants and less than three for only 1

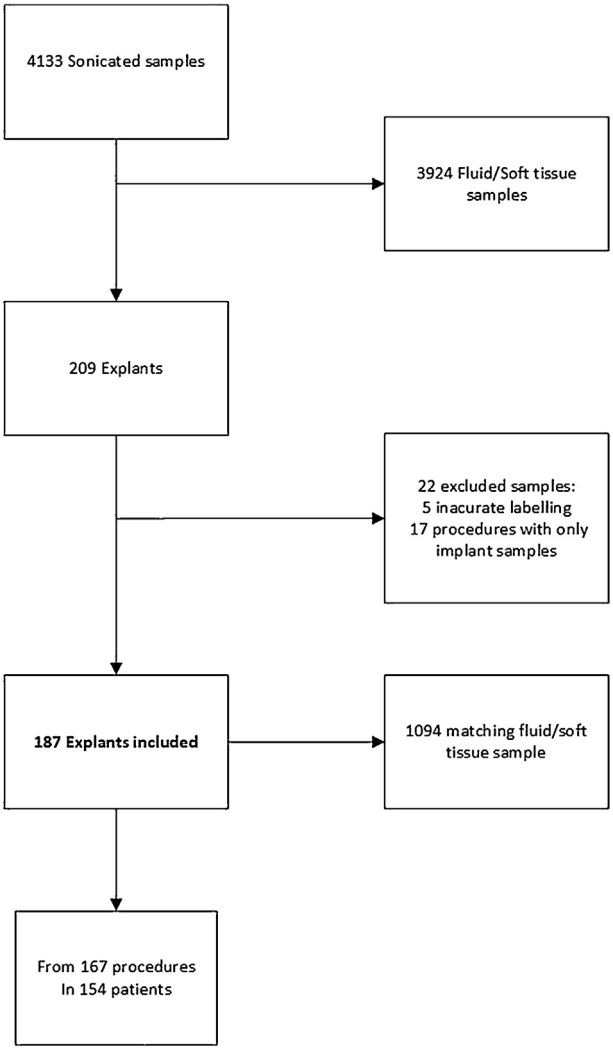

Fig. 1. Flow chart.

Table 1
Main patient characteristics.

	Infection confirmed	Infection not confirmed	Total	*p* value
	131 (70.1%)	56 (29.9%)	187	
Prosthetic material	102 (69.4%)	45 (30.6%)	147	
Hip prosthesis	70 (64.2%)	39 (35.8%)	109	
Knee prosthesis	27 (84.4%)	5 (15.6%)	32	
Other prostheses	5 (83.3%)	1 (16.7%)	6	
Other material	29 (72.5%)	11 (27.5%)	40	0.052
Internal fixation	27 (84.4%)	5 (15.6%)	32	
Cement	2 (25.0%)	6 (75.0%)	8	
Age, years, mean ± SD	67.8 ± 16.0	68.9 ± 13.5	68.1 ± 15.3	0.66
Cemented prosthesis				
Yes	75 (64.1%)	42 (35.9%)	117	
No	56 (80.0%)	14 (20.0%)	70	**0.02**

The value in bold indicates significative value.

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