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Biopsy in Orthopedics and Risk of Bacterial Contamination During Tissue Sampling: Facts and Strategies

Francisco Rodriguez-Fontan[1,2*], Candace Cephers[2] and Bennie Lindeque[1,2,3]

[1]Department of Orthopedics, University of Colorado, Anschutz Medical Campus, Aurora, Colorado, USA
[2]Colorado Program for Musculoskeletal Research, Department of Orthopedics, University of Colorado Anschutz Medical Campus, Aurora, Colorado, USA
[3]University of Colorado, School of Medicine, Anschutz Medical Campus, Aurora, Colorado, USA

Abstract

Biopsies in the field of orthopedics are used to guide diagnostics and treatment options for the disease process that may be occurring such as a tumor or infection. Skin preparation of these biopsies follows the standard skin preparation for a surgical procedure, with the aim to decrease the amount of microbiota that could lead to contamination of the tissue biopsy and even possible infection. The tissue obtained from the biopsy often undergoes pathology and culture. The reported bacterial contamination rate is roughly below 4%. This review questions how samples from the biopsies are getting contaminated by microbiota that remains on the skin and how it affects infection management. In addition, which techniques or steps can decrease the rate of contamination when performing a biopsy. Our review identified little to no data on investigating bacterial contamination of biopsies. In doing this, the review identified different factors implicated in skin microbiota awareness: skin preparation techniques and solutions, variation of typical microbiota that colonize the skin based on the anatomical region, preoperative withholding versus administrating antibiotics prophylactically and using different scalpel blades for superficial and deep incisions, among others. Although we failed to identify any data that provided answers to our original question and quantify each factor individually, most studies in different orthopedic fields provided significant findings to some extent. We outline some practical recommendations based on consensus and theoretical effectiveness in decreasing the contamination rate. Further research entailing skin microbiota contamination of a biopsy is needed in the field of orthopedics.

Keywords: Biopsy contamination, Infection, Microbiota, Prepping, Sampling

[*]***Correspondence to:*** Francisco Rodriguez-Fontan**,** Department of Orthopedics, University of Colorado, Anschutz Medical Campus, Aurora, Colorado, USA and Colorado Program for Musculoskeletal Research, Department of Orthopedics, University of Colorado Anschutz Medical Campus, Aurora, Colorado, USA.

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Introduction

A biopsy is sampling of tissue to identify the presence, cause, and degree of a disease. The goal is to obtain an accurate diagnosis in the context of a growing or aggressive appearing lesion and/or to rule out an infection [1]. Biopsies are sent standardly to the lab as fresh or frozen samples for evaluation of pathology, cytology, and culturing (i.e., aerobic, anaerobic, acid fast bacterial, and fungal) [1, 2].

There are several ways to perform a biopsy and choosing the approach is based on the reasoning, surgeon preference, anatomic location, and, in the case of a malignant lesion, on anticipation of possible mass excision and including this in the planned future surgical field [1]. Fine needle aspiration (FNA) is used to obtain cells within the lesion, primarily used for diagnoses of carcinomas; core biopsy is used to evaluate both the structural and the cellular aspects of a lesion, and is primarily used to diagnose sarcomas; incisional biopsies, historically the gold standard, allows for access to deeper lesions without seeding the surrounding structures through an incision of the skin; and an excisional biopsy is the removal of an entire lesion or mass, primarily for small and superficial [1]. Incisional biopsies have been shown to be more accurate in diagnoses with 94 - 95% success rate as compared to FNA (83% - 100% success rate) [1, 2].

Of note, there is a 1.2 - 3.8% reported risk of contamination of the biopsy culture which in the context of ruling out an infection, can compromise or delay appropriate treatment if misleading or misinterpreted in either way [3]. Whether a contaminant or not, it is often challenging to distinguish and direct treatment (e.g., antibiotic therapy and staged revision arthroplasties) [3]. Main questions around this issue are how to minimize contamination, what is the constitution of the remaining skin flora after skin preparation, scalpel change during deep dissection, and to what extent is this a tolerable finding in biopsies. The focus of this review is to identify literature looking at factors implicated in bacterial contamination or surgical site infection (SSI) with a narrowed focused scope into the risk of contaminating an incisional biopsy with remaining human skin microbiota after decolonizing the skin with standard solutions.

Prepping Solutions and Contamination Rate

All approaches begin with decolonization or decontamination of the surgical point of entry during prepping. This is standardly done with the goal of minimizing the amount of skin flora colonization and prevent post-operative infection. There are many different decolonization solutions and techniques which include different concentrations and combinations of isopropyl alcohol (IPA), povidone iodine, IPA with acetone, or chlorhexidine gluconate (CHG) [4]. Many studies attempt to compare which technique is most effective at eliminating the most amount of skin microbiota, however infections can still occur [5].

It was found that in orthopedic surgeries 1 - 5% of wounds develop a superficial or deep infection, increasing mortality 2 - 3x and cost burden to hospitals and patients [5, 6]. The most common contaminants depend on the location of surgery, and most include but are not limited to: *Staphylococcus aureus*, *Staphylococcus epidermis*, coagulase negative *Staphylococcus*, *Propionibacterium* (e.g., *Propionibacterium acnes*), and sometime *Enterococcus* (e.g., *Enterococcus faecalis*) [5]. For this reason, besides standard skin preparation, prophylactic antibiotics are given in most orthopedic surgeries, typically a 2nd or 3rd generation cephalosporin, depending on surgery location or type of surgery [6-9].

Some studies investigated anatomy based prepping techniques differences. For instance, specifically focusing on hand surgery, Xu et al. [3] showed that 0.7% iodine povacrylex with 74% IPA (Duraprep: 3M Health Care, MN, USA) and povidone iodide (Betadine) were more effective than 2% CHG with 70% IPA (ChloraPrep; Becton Dickinson, NJ, USA) because of a different composition of microbiota of the hand compared to other locations of the body [3]. The post-preparation culture positivity for ChloraPrep was significantly higher as opposed to the other two solutions, yet they advocate that the clinical relevance must be further investigated given that the most commonly encountered species were Bacillus and these rarely cause post-operative infection [3]. The composition of hand microbiota is dependent on the patient's environment or activity. For example, 'homemakers' were found to have more *Acinetobacter lwoffii*, *Enterobacter cloacae*, *Klebsiella pneumoniae*, *Pseudomonas* (e.g., *Pseudomonas aeruginosa, Pseudomonas fluorescens/putida*), and *S. aureus* as compared to neonatal-intensive-care-unit nurses who had more *E. faecalis*, *Staphylococcus epidermidis* and *Staphylococcus warneri* [10]. Another study, contrasting Savage et al. [11] but favoring the concept of different microbiota composition shows that duraprep and ChloraPrep are equally effective in decolonization of common pathogens found on the lumbar spine. In the same trend of theoretical anatomical region based differential solution prepping effectiveness, Saltzman et al. [12] showed ChloraPrep to be superior to duraprep and betadine at eliminating bacteria from the shoulder, predominantly *S. aureus*.

Another study ventured in comparing single versus double skin preparation of the shoulder, and this showed that 1% povidone alone, versus 4% CHG followed by 1% povidone preps significantly and equally decrease positive cultures [13]. Coagulase negative *Streptococci* were reduced from 92.7% to 40% and 7.2% with single and double preps, respectively. The reduction of *P. acnes* and *S. aureus* showed no significant difference in reduction of these bacteria between the two preparations [13]. There have been several studies that show the use of hydrogen peroxide (H_2O_2) show high efficacy of reducing the amount of *Propionibacterium* on the skin which has attracted shoulder surgeons into its use [14, 15]. In this regard, Hernandez et al. [14] showed that after 5 min, 3% H_2O_2 has complete eradication of the bacteria on the skin prior to surgical skin preparation for shoulder surgery.

The same issue has been investigated in looking at the rate of false positive blood cultures after comparing different skin cleaning solutions prior to venipuncture [16]. In this regard, Caldeira et al. [16] metanalysis has shown that alcohol-based solutions were superior to non-alcoholic ones in minimizing false positive rate, with the exception of iodine which had no difference. CHG and iodine comparison was not conclusive, but alcoholic CHG was superior as compared to non-alcoholic povidone-iodine. Another study found consistent similar results, showing significantly higher contaminated blood cultures with the use of povidone-iodine and when femoral venipuncture was performed [17].

From the aforementioned, ChloraPrep (2% CHG and 70% IPA) seems to safely reduce skin flora significantly in most circumstances and minimizes false positiveness the most.

Field Animal Models, Techniques, and Other Practices

Multiple tissue sampling from reinsertion of the needle seems to be a risk for contamination. Mellish et al. [18] took skin cultures, deep needle biopsies of pectoralis and longissimus dorsi, and cultures of the biopsy pathway. It was identified that a positive skin sample did not correlate to deep biopsy contamination. Their conclusion was that despite the use of sterile technique, the contamination of the deep biopsies was most likely due to reinsertion of needle while multiple samplings were taken [18]. An interesting practice is switching blades after skin cut, for deep dissection to prevent carrying skin bacteria to deeper layers. Lioce et al. [19] studied the risk of SSI due to scalpel blade contamination gained from the superficial incision of dog abdomens. Many surgeons switch scalpel blades between superficial and deep incisions because of the theory that this decreases the risk of causing infection. It was found that out of the 75 scalpel blades used, only 2 of them had positive cultures, and of the 69 dogs who survived the surgery, six of them got an SSI. However, those cultures did not match the bacteria of the two scalpel cultures, suggesting there was no contamination from the skin into the surgical field [19]. Their finding was recently supported by Smith et al. [20] group which found no difference in culture positive rate (predominantly *Staphylococcus* species) of the skin scalpel blade used in orthopedic procedures versus control blades, which were not used during the surgery (4.9% vs 5.2%, respectively). This study advocates that there is no theoretical advantage in switching blades after skin incision. On the contrary, favoring scalpel switching, another study looking at *P. acnes* contamination for shoulder surgeries found 11.8% positive culture rate in skin scalpel, even after using ChloraPrep and H_2O_2 for surgical field preparation [21].

Another common practice is the use of iodine-impregnated drapes to theoretically prevent contamination or infection, which to the date are not mandatory given no significant evidence to support its use [9, 22, 23]. In this regard, Scheidt et al. [24] found skin incision scalpels to have a significantly lower skin flora contamination rate when using the iodine-impregnated drapes (3.8%) as opposed to its omission (12.2%). Yet, this did not reflect in a higher SSI rate as in concordance to other studies finding no significant difference in skin colonization and SSI with the use of iodine drapes [9, 22, 24-26].

Some concerns have been raised around the relation of time of preoperative antibiotics and sensitivity of tissue cultures. In this regard, prosthetic joint infections (PJI) are worth mentioning. Of significant morbidity and mortality, efforts have been performed into the diagnosis and management. In a prospective study, the prophylactic administration of antibiotics pre vs Post tissue culturing yielded no significant difference in diagnostic sensitivity for low grade undiagnosed PJI [27]. Yet, a review article discourages such thought showing that tissue cultures can have a significantly higher sensitivity in patients with PJI when the antibiotics are withheld pre- and intra-operatively until after tissue sampling (95% vs 88%) [28]. However, on further analysis, they mention that this would affect about 7% of the patient's undergoing revision for PJI, and though seemingly low, in those with low probability of PJI could be significant in preventing an acute infection if withholding antibiotics [28]. The postponing of antibiotics until culture would mean a higher risk of infection in revision surgeries when placing new implants in the setting of low probability of PJI [28]. Overall, it seems reasonable and cautious to maintain pre-operative antibiotics if the patient has a low probability of infection and to weigh pros and cons of withholding antibiotics based on each case.

Despite proper standard protocols for infection control, post-operative infections continue to variedly occur approximately 0.5 - 11% (i.e., depending on the procedure and type of surgery), and the same can be accounted for risk of tissue sample contamination [9, 29]. Half of the cases can be partially explained by airborne or shed bacteria coming from the patient or healthcare providers, predominantly *Staphylococcus* [30]. For instance, the perineum, thighs and feet shed more bacteria than any other part in the body and this ends up in the operating room air, which inevitably can end up in the surgical field or instruments [29, 31]. In addition, Krueger et al. [29] brings up an important concern, which is the amount of time scrubs are worn by physicians. The extent of skin flora found in these was directly correlated with the amount of time spent in the hospital, hence they recommend donning fresh scrubs before entering the operating room to help minimize risk of contamination or infection [29].

Senior Author's Recommendation for Tissue Sampling

- Patient education on skin cleaning techniques in a preoperative visit.
- Donning fresh scrubs for each case.
- Alcoholic CHG for prepping the surgical field ± hydrogen peroxide (if shoulder region).
- Pre-operative antibiotics are to be given in all cases and consider withholding prior to tissue sample in cases with high probability of infection.
- Consider using a blade for skin incision and discard it. Use a second blade for deep dissection. Mostly for shoulder, perineum, thigh, and foot regions.
- For arthrocentesis, FNA or core biopsies, perform a small skin incision to dermis with an 11-size blade, retract skin with skin hooks and proceed to perform the aspirate or the core biopsy. Avoid touching incisional edges, and minimize the number of re-entries, changing the needle every single time for multiple samples.
- Minimize traffic and number of personnel in the operating room.

Conclusion

The original question of this review was what the risk of is contaminating a biopsy with remaining skin microbiota. During our review of the literature, we focused on types of skin preparation, the type of microbiota found on different parts of skin based on anatomical region, and animal and human models of biopsy tract contamination, as well as theoretical techniques to minimize contamination and infection. Although we failed to identify any research that has been done specifically to address our question, we outline some recommendations based on multifactorial facts, consensus, and theoretical effectiveness in decreasing the contamination rate. Future studies to aid in addressing this question could involve a comparative cohort of culturing skin prior and after surgical preparation, considering the most common procedures practiced to date.

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Conflict of Interest

None.

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