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Suction Tip Colonization during Orthopedic Surgery: A Review

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Abstract

Surgical site infections are clinically and epidemiologically critical in orthopedic surgery, as they lead to several complications affecting the quality of life of patients. Contamination may occur during the surgery, through instruments directly inserted into the wound acting as reservoirs for microorganisms. This study aimed to review the literature on suction tip colonization during orthopedic surgery, with an aim toward setting guidelines for its management during surgical procedures. Suction tips can be colonized primarily in two ways. The first is through direct contact with a surgical wound or poor handling by surgical staff and the second is through continuous airflow through the tip of the suction. Colonization rate between studies has decreased in the last years reporting in recent papers a 7.3% suction tips colonization rates in clean orthopedic. The most common germs isolated are *S. epidermidis*, *S. aureus* and *E. cloacae*. Suction tip colonization has a direct relationship with the duration of the surgical procedure, with a higher rate of colonization with longer surgeries. Multiple strategies have been proposed to reduce the risk of colonization of the suction tips used during a surgical procedure including systematically changing suction cannula after 1 hour of surgery or strategies to reduce active suction time. It is unclear if suction tip colonization is directly related to surgical site infection rates. Further studies are needed to corelate infection and colonization of the suction canula.

Introduction

Surgical site infections (SSIs) are clinically and epidemiologically critical in orthopedic surgery, as they lead to several complications affecting the quality of life of patients[1].

In orthopedics, infections require prolonged treatments due to the need for several interventions, implant removal, antibiotic therapy, and hospitalization. These frequently result in compromised functional outcomes of patients, successively causing high rates of morbidity and mortality, with increased health costs[1-4].

Multiple studies highlighted the importance of hygiene in the operating room by showing the colonization of surgical tools and airborne particles[9-12] and their association with SSIs[13-15]. Therefore, ventilation management guidelines were presented by the German Society for Hospital Hygiene[16].

Therefore, the growing concern with SSIs generated initiatives to reduce the risks of healthcare-associated infections, such as the Surgical Care Improvement Program (SCIP)[5], the guidelines of the Centers for Disease Control and Prevention (CDC)[6], and the global guidelines for the prevention of surgical site infection by the World Health Organization (WHO)[7].

Suction tips, frequently used in orthopedic surgeries, are susceptible to colonization similar to other surgical tools. Contamination may occur during the surgery, through instruments directly inserted into the wound or suction catheter tips, acting as reservoirs for microorganisms[8]. Suction tip contamination during surgery may cause surgical wound inoculation with pathogenic microorganisms and thus, a risk factor for late infections in clean surgical procedures[17].

This study aimed to review the literature on suction tip colonization during orthopedic surgery, with an aim toward setting guidelines for its management during surgical procedures.

How is a Suction tip colonized?

Suction tips can be colonized primarily in two ways. The first is through direct contact with a surgical wound or poor handling by surgical staff[18] and the second is through continuous airflow through the tip of the suction, creating turbulent flow and favoring the fixation of microorganisms at the site[1,17-19].

The effect of the environment on the operating room has been investigated for several decades as a factor associated with SSIs and suction tip colonization due to airflow during the procedure[17,20,21]; however, turbulence and the presence of airborne particles vary during the surgery. Chaveaux found an up to four times increase in contamination during limb preparation[22], while Brown demonstrated a 4.4 times increase in contamination during dressing the patient[23]. These are the periods of highest risk of suction tip colonization through aspiration of airborne particles.

How many Suction tips are colonized?

Similar to the other medical specialties, multiple studies have been conducted on suction tip colonization in orthopedic surgery. In 1978 Meals and Knoke[12] made the first attempt to quantify colonization of the suction tips finding a 35% colonization rate.

Greenough[27] corroborated Meals and knoke results with a 35% contamination rate, but this time he added another group where he used the cannula only for femoral canal preparation and evidenced a lower rate of colonization, suggesting that the time of exposure of the cannula was a risk factor for colonization.

Later Knoke in 1988, Strange-Vognsen and colleagues, reported a 54% contamination rate of suction tips used in orthopedic procedures when preparing cultures of surgical suction tips, identifying different types of *Staphylococcus* in their study[24].

Similarly, Robinson and colleagues conducted a study with 39 joint replacements performed in an operating room with ultra-clean air and found 41% of the suction tips showing evidence of bacterial contamination[25].

More recently, Givissis aimed to identify the common factors associated with colonization by studying 50 patients who underwent elective trauma surgery. At the end of each surgery, the suction tips were sent for culture and microbiological analysis and contamination was found in 54% of the tips, with *Staphylococcus* accounting for 77.8% contaminations[20].

Studies have mostly shown a high percentage of suction tip colonization. However, in 2011, Dr. Insull published a study with 51 suction tips, reporting colonization in only 7.8% cases. The most common strain was, once again, *Staphylococcus*[8].

González et al. reported a colonization rate of 7.3% in 546 suction tips, studied after use in clean orthopedic arthroplasty and osteosynthesis surgeries at an orthopedic and trauma center in Colombia, in this paper there is a surprisingly high rate of E. cloacae isolated without any clear explanation, we think it could related with surgical site location but is only a theory[26].

Table 1: Overview of colonization percentage in suction cannula studies

Authors	Date	Sample	Percentage of colonization	Most Frequent Microorganism	Prevention Strategies
Meals and Knoke[12]	1978	20	35%	Staphylococcus epidermidis, Coryne-bacterium, Propionibacterium	Standard sterile protocol, cephalothin or lincomycin prophylaxis and Positive pressure air conditioning
Greenough[27]	1986	Group 1: 30 Group 2: 31	Group 1: 35% Group 2: 3,2%	Staphylococcus epidermidis, Group C Streptococcus, Streptococcus faecalis	Standard sterile protocol, cephalosporin prophylaxis + Positive pressure airflow + Cannula exchange 2-3 times
Strange Vognsen[24]	1988	22	54%	Coagulase- negative Staphylococcus, Acine-tobacter calcoacaticus, Coryneform rods	Standard sterile protocol, cloxacillin or cefuroxime prophylaxis + conventional airflow
Robinson[25]	1993	39	41%	Coagulase- negative Staphylococcus, Diphteroids, Micrococci	Standard sterile protocol, amoxicillin or flucloxacillin prophylaxis + Vertical laminar flow and air sampling
Givissis[20]	2008	50	54%	Staphylococcus coagulasa negativo, Staphylococcus aureus, Diphtheroids	Standard sterile protocol, cefuroxime prophylaxis + non-ultra-clean air operating theatre
Insull and Hudson[8]	2012	51	7.8%	Staphylococcus coagulasa negativo, Streptococcus alpha haemolityc	Standard sterile protocol
González Edery[26]	2020	546	7.3%	Staphylococcus epidermidis, Staphylo-coccus aureus, Enterobacter cloacae.	Standard sterile protocol, cephalosporin prophy-laxis

Germs

All authors agree that the most frequently isolated microorganisms are *Staphylococcus*, highlighting the importance of direct contamination of the skin or surgical wound and behavior during the surgery[8,20,21,24,25].

In the most recent study, the most common germ was *S. epidermidis* (27.5%), followed by *S. aureus* (12.5%), and *E. cloacae* (10.0%)[26].

Risk factors for Catheter infection

Byrne et al., in 2007, reported suction tip colonization to be associated with longer surgery time. The contamination rate was 17% in surgical procedures shorter than 90 minutes and 33% in those longer than 90 minutes[28].

Givissis showed a key difference between surgeries lasting less than one hour versus those longer than one hour, with percentages of 9.1% versus 66.7%, respectively[20].

The study conducted by González et al. also highlighted the duration of use during surgery as a risk factor associated with suction tip colonization, showing that the possibility of suction tip colonization doubled after 60 minutes of its use in surgery, and was eight times higher after 90 minutes of surgery[26].

Colonization prevention strategies

The dramatic decrease in colonization levels between the studies by Givissis and Insull stands out[8,20]. This difference may be correlated with the WHO guidelines published in 2008[7], highlighting checklists and adequate intraoperative behavior, as previously stated by Dr. Knobben, as being essential to reduce intraoperative contamination[29]. Dr. Sartini showed a marked decrease in the number of *S. aureus* isolated from airborne particles of the operating room by applying an intraoperative behavior protocol[30]. Therefore, the best strategy for decreasing suction tip and surgical environment colonization is to behave adequately within the behavioral protocol.

Furthermore, multiple strategies have been proposed to reduce the risk of colonization of the suction tips used during a surgical procedure.

Alsadaan, in the most recent infection consensus, recommended changing the suction tip after one hour of surgery to reduce the incidence of its contamination[18].

Greenough found a significant difference in suction tip colonization between changing it when aspirating the femoral canal and using the suction tip throughout the surgery[27]. Considering this difference, the suction tip should be replaced before executing critical steps of the procedure, such as implant fixation[21,27].

Time is the most important variable associated with colonization. Therefore, another strategy has been developed, to decrease the effective suction time of the suction tip[26,28]; this strategy involves first suctioning only after all surgical personnel are fully dressed and prepared for the intervention. Thus, the periods with the greatest amount of airborne particles are avoided[22,23]. Next, suction is suspended during the operative act and is used only when aspiration is required in the operative field[18]. However, this also generates concerns as the material aspirated may backflow through the duct and generate contamination.

The contact between the suction tip and the patient's skin and surgical wound may be prevented by keeping it inside a plastic container for exclusive use. This could be evaluated as a strategy to reduce the risks of suction tip colonization; however, no studies are available in the reviewed literature.

No comparable studies were found for the colonization of reusable versus disposable suction tips, although a few studies have compared the use of disposable and reusable clothing, without difference in infection[31]. The risk of failure of sterilization of surgical instruments and the risk of infection associated with using poorly sterilized material is well-established[32].

Unanswered questions about Catheter colonization

Although a significant percentage of suction tips used in orthopedic surgery become contaminated during the procedure and the duration of use of the suction tips is directly correlated with the percentage of colonization, the relationship of suction tip colonization to the percentage of infections at the operative site remains unclear. Givissis reported a case in which operative site infection was associated with suction tip colonization[20].

The 2019 Infection Consensus recommends changing the suction tip after one hour of surgery[18]. However, this measure is only based on expert recommendations, and to date no studies have shown, with a sufficient level of evidence, whether suction tip colonization is directly related to SSI rates.

Changing the suction tip every hour during orthopedic surgeries implies an economic cost. SSI treatment is expensive[2] and could exceed the cost of routinely replacing suction tips. The cost-effectiveness of systematically changing suction tips depends on the existence of a relationship between SSI and its colonization because, without this the costs of a clean orthopedic surgery would increase without a real benefit.

Occluding the suction tip or shutting down the suction system to avoid the continuous airflow through the suction tip decreases the active suction time and therefore the percentage of colonization, without requiring a replacement. Although, this strategy is a cost-effective

measure with a clinical impact comparable to changing the suction tip, no studies have confirmed its effect.

Under the hypothesis of suction tip colonization by aspiration of a similar wound, the possibility of routinely preparing cultures of suction tips in septic surgeries or in surgeries with a high risk of infection is crucial.

Conflict of Interest

Authors from this manuscript have no conflict of interest to disclose and counted with no funding from governmental or private industry

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