TECHNICAL NOTE

Acta Orthop Traumatol Turc 2012;46(6):455-459
doi:10.3944/AOTT.2012.2794

Domestic electric drills in the service of orthopaedic surgery: a potential and preventable source of surgical site infections

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Objective: We aimed to assess the contamination potential of the exhaust air from venting ports of running domestic electric drills which are commonly used in orthopaedic surgeries by means of both microbiological sampling and particle counting.

Methods: In an empty operating room, the exhaust air from five running sterile domestic electric drills measured using a particle counter and microbiological sampling was made via aspirating isolator with colony formations noted for a 2-week period. International Organization for Standardization (ISO) 14644 criteria were implemented with respect to the sterility standards.

Results: All of the drills produced statistically significantly higher levels of particles than the ambient air ($p<0.01$). There was no statistically significant difference in the number of collected particles among drills ($p>0.05$). No bacterial growth was detected in microbiological sampling via blood agar medium in the ambient air. Conversely, *Staphylococcus epidermidis*, *Micrococcus luteus*, and *Staphylococcus capitis* were isolated from the exhaust air of all running drills. There was no correlation between the number of particles produced by drills and the microbiological sampling.

Conclusion: Domestic electric drills are not safe and may be a direct source of surgical site infection, as the use or re-use of these drills during orthopaedic surgery increases the risk of infection with contaminated aerosols that are produced by these devices.

Key words: Domestic drill; microbiological sampling; particle count; surgical site infection.

Sterilization of surgical equipment constitutes an important part of infection control. Inadequate sterilization of surgical instruments has resulted in surgical site infection (SSI) outbreaks or severe complications such as osteomyelitis which can be persistent and lead to functional deficiency of the extremities.[1]

Power tools are essential surgical equipment for fixation in orthopaedic surgery and electric drills are usually used for bone perforation. Although specific electric drills for medical-surgical use are produced, domestic electric drills (DED) produced for non-medical purposes may be used in developing countries due to their low cost and easy accessibility.

Medical electric drills for surgical use, in general, enable appropriate cleaning procedures to assure the sterilization process. However, appropriate cleaning of

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Submitted: December 14, 2011 **Accepted:** March 1, 2012

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Available online at
www.aott.org.tr
doi:10.3944/AOTT.2012.2794
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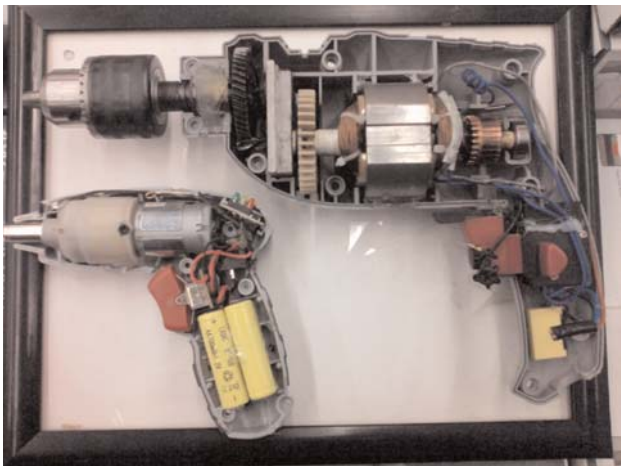

Fig. 1. Inner parts of electric drills. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

the internal parts of domestic drills is not possible due to the impossibility of soaking the equipment into a detergent solution or washing their inner parts (Fig. 1). Only the external surface of the DED can be cleaned.[2] DEDs have venting ports on their bodies which discharge exhaust air from around the surgical site during surgery. Therefore, when a DED is activated during surgery, contaminated aerosols and particles are discharged from the venting ports. With the drill's proximity to the wound and surgeons' hands, the nearby surgical fields which should remain clean may be contaminated.

There are only few studies addressing the use of DEDs in orthopaedic surgeries. However, surprisingly, none of these studies identify their use as a risk factor for SSI.[2,3] Although these studies could not demonstrate their infectious potential, they do not recommend the use of DEDs in orthopedic surgeries.

The aim of this study was to evaluate the contamination potential of the exhaust air from venting ports of running DED through microbiological sampling and particle counting.

Materials and methods

Five DEDs (Bosch RT-2P; Robert Bosch GmbH, Stuttgart, Germany) (Fig. 2) with venting ports which were previously used and sterilized with ethylene oxide (EtO) were included in this randomized, experimental study. The experiment was carried out on a standard surgical table with a sterile table cover. Sampling were performed using a portable airborne particle counter (PAPC 3400 Series, Hach Ultra Analytics© 2005; Hach Company, Loveland, OH, USA) for one minute in the empty operating room (OR) at a distance of 10 cm from the venting ports of the running DEDs (Fig. 3). These measurements were repeated in the same setting 5 times sequentially with one minute break between each measurement. Particles were automatically recorded quantitatively by a PAPC device. Subsequently, microbiological sampling was made using a blood agar containing petri dish for 5 minutes via an aspirating isolator (DUO-SAS-360 Isolator; VWR International PBI Srl, Milan, Italy) device, again in the empty OR at a distance of 10 cm from the running ports (Fig. 4). Properly marked blood agar plates were incubated in a microbiological heater for culture (Orion®, Model 502; Fanem, São Paulo, Brazil) for 96 hours at a temperature of 37°C.

Fig. 2. DED used in our study. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

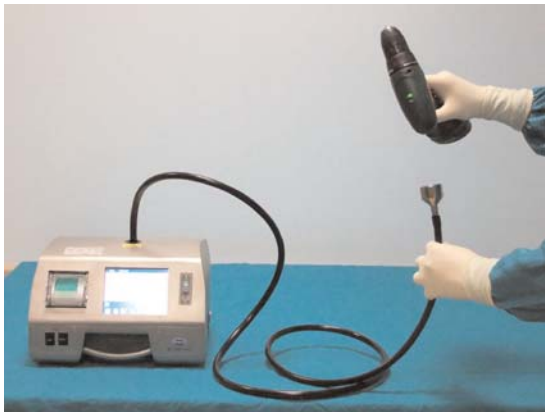

Fig. 3. Particle counting from the venting ports of the electric drill. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Fig. 4. Microbiological sampling from the venting ports of the electric drill. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Table 1. Clean room standards according to ISO 14644 criteria.

Classification	Maximum concentration limits for particles equal to and larger than 0.5 µm (particle/m³ of air) in size
ISO 1	
ISO 2	4
ISO 3	35
ISO 4	352
ISO 5	2,520
ISO 6	35,200
ISO 7	352,000
ISO 8	3,520,000
ISO 9	35,200,000

Colony formations were followed up for two weeks with daily observation for growth and gram stain was performed if necessary. International Organization for Standardization (ISO) 14644 criteria were implemented with respect to the sterility standards (Table 1).

The Kruskal-Wallis test was used for the comparison of particle values measured in the running DEDs and ambient air. The post-hoc Dunn test was used for comparison between DEDs. The association between particle values and growing colony count was evaluated using the Spearman's rank correlation coefficient.

Results

The median values of particles collected from venting ports of DEDs and ambient air in the OR was 433,962 (range: 313,201 to 546,177) and 75,877 (range: 73,423 to 85,020), respectively (Table 2). All DEDs produced statistically significantly higher levels of particles than the ambient air ($p<0.01$). There was no statistically significant difference in number of collected particles among drills ($p>0.05$). No bacterial growth was detected in the microbiological sampling via blood agar medium in the ambient air. In contrast, *Staphylococcus epidermidis*, *Micrococcus luteus*, and *Staphylococcus capitis* were isolated from the collected air from venting ports of all running DEDs in the microbiological sampling (Table 3). There was no correlation between the number of particles produced by the DEDs and the microbiological sampling.

Discussion

Domestic electric drills are frequently used in developing countries for orthopaedic surgeries.[2,4] These DEDs have venting ports to discharge the air from inside the motor. Due to the impossibility of internal cleaning, these drills have raised suspicion of contamination of the surgical field. Very limited studies have been performed to identify the risks of DEDs on SSIs and none of these studies have been able to demonstrate their potential risk to trigger SSIs.

Infection complicates up to 5% of clean procedures and 30% of clean contaminated procedures and leads to significant increases in length of stay, cost of care, need for physician visits after surgery, readmissions, intensive care unit admissions, subsequent surgeries, and long-term surgical site complications and enhances the adjusted risk of death by 1.6 times.[1,5] To reduce prolonged morbidity and aforementioned healthcare costs associated with these infections, airborne bacteria and other sources of contamination

Table 2. Quantitative analysis of particles (0.5 µm/min) counted from venting ports of DEDs.

Instance	DED 1	DED 2	DED 3	DED 4	DED 5	OR
1′	702,063	546,177	128,614	582,881	132,297	85,020
2′	608,239	387,502	189,745	383,812	76,451	77,388
3′	410,644	349,552	102,093	433,962	96,240	75,877
4′	489,949	467,102	166,205	485,951	101,965	73,423
5′	313,201	457304	98,720	386,954	80,011	74,012

Table 3. Microbiological sampling of exhaust air from venting ports of DED's with colony counts (CFU/m³) in blood agar medium.

Microorganism	DED 1	DED 2	DED 3	DED 4	DED 5	OR
Staphylococcus epidermidis	43	73	70	32	60	-
Micrococcus luteus	50	50	50	40	37	-
Staphylococcus capitis	40	37	53	50	57	-
Total	133	160	173	122	154	

must be reduced to the minimum.[6] It is estimated that 40 to 60% of SSIs are preventable.[1]

Contamination of ambient air in the OR is thought to be a risk factor for infections of the surgical site in clean surgery.[7] Few countries have set bacterial threshold limits for conventionally ventilated ORs and there is no international consensus on the methods, types of sampling and tolerable limits of bioburden in ORs. The main parameters associated with environmental biocontamination in ORs are discussed with a special emphasis on air quality and its control. Assessment of air quality in the OR can be performed routinely by microbiological sampling and particle counting.[6,7] For this reason, we performed not only microbiological sampling of DEDs but also particle counting from the exhaust air.

Infection depends on several factors, such as microbial contamination at the surgical field, amount of inoculated microorganisms, virulence of the pathogen, and the patient's general health and immunologic status.[3,8] It is assumed that higher bacterial counts in the air correlate with a higher risk for SSI. In the United Kingdom, the limit is 35 CFU/m^3 (colony forming unit per cubic meter) for an empty OR and 180 CFU/m^3 for an average period of 5 minutes in an active one.[6] During our testing, there were no surgical activity, instruments or staff which are considered additional sources which increased bacterial counts. According to our measurements, although the ambient air in the OR did not contaminate the agar plates and the cultures were all negative, the bacterial counts in the samples obtained from DEDs were much higher than the acceptable limits.

The same microorganism species were detected in the cultures of exhaust air emanated from all DEDs with different amount of CFUs in the same OR. The origin of microorganisms is not possible to detect with the methods used in current studies. While in previous studies blood spills and skipped debris were addressed as the source of contaminated content, this was not proven. On the other hand, the rotor itself produces metal splinters and blows oil aerosols which may be another source of contaminated particles. While the DED is on, it takes the ambient air around its rotor and blows it out through the venting ports in order to cool the rotor. Mobilization of air to the operative field increases the rate of flow facing per unit area. This may increase the ambient air facing the sterile field in a certain time period, and may be enough to increase the amount of bacterial load. Sagi et al.[9] reported positive cultures in repeated experiments with two separate sterile drills when the exhaust air from the drill was directed at agar plates, compatible with our study. However, there was no bacterial growth in the control agar plates left open in the ambient air for the same duration of time. The authors hypothesized that localized air currents generated by the high-speed exhaust resulted in deposition of bacteria onto the agar plates. However, further studies are needed to detect the origin of microorganisms colonized in the samples of exhaust air.

Goveia et al.[3] assessed the efficacy of sterilization procedures of ordinary drills and found that EtO was effective in eliminating inoculated microbial load inside DEDs. However, in contrast to their results, they pointed out that their study did not validate the use and re-use of DEDs in surgical procedures. Our results are not compatible with those of Goveia et al., as we found the microbiological load of DEDs to exceed acceptable limits. In their study, they intentionally inoculated *Bacillus atrophaeus* spores to DEDs. However, Staphylococci, in particular *Staphylococcus aureus*, are the predominant cause of bone infections worldwide.[10] *S. aureus* accounts for 37 to 67% of septic arthritis isolates in studies from different nations.[10,11] Additionally, *S. epidermidis* is the most common coagulase negative *Staphylococcus* species in many types of bone infections, including prosthetic joint infections and osteomyelitis.[11,12] Other species such as *S. capitis*, *S. hominis*, *S. simulans*, *S. caprae* and *S. lugdunensis* have all been reported as etiological agents for bone infections.[9,10] Implant-associated infections are typically caused by the two leading microorganisms, *S. aureus* and *S. epidermidis*.[9,12] In our study, *S. epidermidis*, *S. capitis* and *Micrococcus spp.*, important agents regarding orthopaedic SSIs, were colonized. Moreover, while Goviea et al. used new DEDs in their study, microbiological load may be cumulative inside these equipment. For this reason, we employed previously used DEDs in our study.

It is well-known that the use of ultra-clean air removed of particles has been shown to decrease infection rates significantly in orthopaedic implant surgery. Seal and Clark reported that particles are significantly correlated with microbiological contamination during surgery performed in an ultra-clean theatre.[13] In our study, all the DEDs produced a large amount of particles much higher than the acceptable limit. Some studies have found no association with an increase in air microbiological counts and high particle counts.[7] The clinical significance of an increase in such air particle counts is therefore likely to be minimal. The lack of this correlation was attributed to the non-contaminated origin of the particles.[7] However, the particles from DED

venting ports are blown from the internal motors where the contamination is highly suspicious. Although particle counts are not linearly proportional to CFU/m^3, our results demonstrate that when particle counts are detected over the acceptable limits, bacterial counts are also over the normal limits. While no statistically significant difference was found between the power tools, all were observed to generate too many particles for sterility standards.

In conclusion, our results demonstrate that DEDs are not safe and may be a direct source of SSIs. The use or re-use of DEDs and the contaminated aerosols they produced increases the risk of SSI during orthopaedic surgery.

Conflicts of Interest: No conflicts declared.

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