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Original Article

Noise Exposure in TKA Surgery; Oscillating Tip Saw Systems vs Oscillating Blade Saw Systems

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ABSTRACT

Background: Historically it has been suggested that noise-induced hearing loss (NIHL) affects approximately 50% of the orthopedic surgery personnel. This noise may be partially caused by the use of powered saw systems that are used to make the bone cuts. The first goal was to quantify and compare the noise emission of these different saw systems during total knee arthroplasty (TKA) surgery. A second goal was to estimate the occupational NIHL risk for the orthopedic surgery personnel in TKA surgery by quantifying the total daily noise emission spectrum during TKA surgery and to compare this to the Dutch Occupational Health Organization guidelines.

Methods: A conventional sagittal oscillating blade system with a full oscillating blade and 2 newer oscillating tip saw systems (handpiece and blade) were compared. Noise level measurements during TKA surgery were performed during cutting and hammering, additionally surgery noise profiles were made.

Results: The noise level was significantly lower for the oscillating tip saw systems compared to the conventional saw system, but all were in a range that can cause NIHL. The conventional system handpiece produced a considerable higher noise level compared to oscillating tip handpiece.

Conclusion: NIHL is an underestimated problem in the orthopedic surgery. Solutions for decreasing the risk of hearing loss should be considered. The use of oscillating tip saw systems have a reduced noise emission in comparison with the conventional saw system. The use of these newer systems might be a first step in decreasing hearing loss among the orthopedic surgery personnel.

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Historically, it has been suggested that noise-induced hearing loss (NIHL) affects approximately 50% of the orthopedic surgery personnel [1–3]. One study has shown that the operation theater of the Department of Orthopaedic Surgery was subject to the loudest noises in a hospital [4]. This is partly caused by the noise generated from the powered bone saws during bone cutting [5–10]. Another factor is the hammering used to position implants, which is associated with very high impact peak noises [5–10]. A combination of

these 2 different types of noise is a major cause for the high incidence of NIHL among the orthopedic surgery personnel [3].

Bone saws are available in different design concepts (Fig. 1A). The current conventional design features a fully oscillating blade shaft (Fig. 1A, upper). A newer design features an oscillating tip powered through an internal mechanism of a stationary, hollow shaft (Fig. 1A, middle and lower). Since the bony cuts in total knee arthroplasty (TKA) are often made by guiding the blade shaft through a slot in a metal guiding block, one of the proposed advantages of the latter design is a lower noise emission due to decreased blade-block interaction with less chance for soft tissue damage. However, no quantitative acoustic information from this new saw blade design is available from a clinical setting.

Sydney et al (2007) [11] have performed noise measurements in a laboratory setting, using both a conventional oscillating blade saw and an oscillating tip saw in simulated TKA surgeries on porcine knees. Although they concluded that the oscillating tip saw

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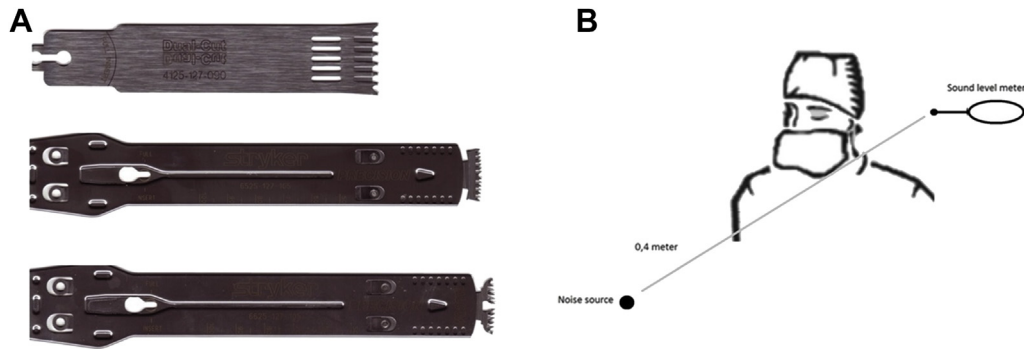


Fig. 1. (A) The 3 different saw blades used in this study. Upper: oscillating blade sagittal saw, Middle: oscillating tip precision saw, and lower: oscillating tip falcon blade. (B) The measurements that were performed during cutting or hammering at surgeon ear distance, which was approximately 0.4 m distance.

featured reduced noise exposure in their experiment, different factors may have influenced their results compared to regular TKA surgeries on human patients. In particular, differences in working place environment and the properties of cadaveric porcine bone may have affected the results.

The first goal of this study therefore was to quantify and compare the noise emission of these different saw systems (blade and handpiece) when used in a standard operating room during TKA surgery. Our hypothesis is that the newer oscillating tip saw systems produce significantly less noise during cutting than the conventional oscillating blade saw system. A second goal was to estimate the occupational NIHL risk for the orthopedic surgery personnel in TKA surgery by quantifying the total daily noise emission spectrum, also including impact noises due to hammering, during TKA and to compare this to the Dutch Occupational Health Organization (ARBO) guidelines.

Materials and Methods

Bone Saw Instruments

A conventional sagittal oscillating blade saw (Dual-Cut, Stryker, MI) and 2 oscillating tip saws (Precision Saw and Falcon Blade, Stryker) were selected for comparison in this study (Fig. 1A). The Stryker system 5 handpiece with built-in motor unit was used to power the sagittal oscillating blade saws. The oscillating tip saws were powered by a newer precision handpiece system 7.

Therefore, 3 different saw systems were examined during cutting: (1) sagittal oscillating blade saw with system 5 hand piece (SAG), (2) precision saw with precision handpiece system 7 (PRE), and (3) the falcon blade with precision handpiece system 7 (FAL). In addition, the system 5 and system 7 hand pieces alone were examined on noise emission. Different types of cuts were made during each TKA surgery: the tibia cut, the distal femur cut, and the 4-in-1 chamfer cut. For each cut, the same type of closed-slot metal cutting block (Scorpio, Stryker) was used to ensure guidance of the blade when cutting through the bone.

Measuring Noise Levels

Four different kinds of noise measurements were performed in this study: measurements of the saw systems during cutting and of the hand piece alone, TKA surgery noise profiles and impact noise measurements during metal-on-metal hammering. All these noise measurements were performed with a calibrated sound level meter (2260 Investigator, Brüel & Kjær, Narum, Denmark). When used,

the sound level meter was calibrated daily and has a measurement error of <0.1 dB. The 3 different measurements are explained separately in the following section.

All measurements were carried out during TKA surgeries. All cuts during surgery were performed by 2 experienced surgeons, both skilled in all saw systems used. Inclusion criteria were patients with primary osteoarthritis requiring TKA. Excluded were patients with diseases that could negatively impact bone quality (osteoporosis, Paget disease, multiple myeloma, malignant bone tumors, and rheumatoid arthritis).

Saw Blade Cutting Measurements

During the tibia cut, distal femur cut and 4-in-1 chamfer cut in TKA surgery, the sound level meter was held over the shoulder of the surgeon, with the microphone tip next to the surgeon's ear while pointing toward the sound source at approximately 40 centimeters distance from the noise source (Fig. 1B). This ensured that representative measurements were obtained while maintaining surgical sterility. In addition, measurements of the hand pieces alone were performed at approximately 40 centimeters distance from the noise source. In this way, an estimation of the influence of the handpiece on the total noise emission of the saw system during cutting can be made.

During cutting, the noise levels were measured on an A-weighted scale. This is a logarithmic measure of the measured sound intensity in comparison to a reference level, which is set to the threshold of human hearing, $I_0 = 10^{-12}$ [W/m²]. The A-weighted scale [dB(A)] closely reflects the loudness perceived by the human ear.

To check whether potential hearing loss in the range of normal speech would be expected, full frequency spectra were measured for a limited number of cases: 9 frequency spectra for PRE, 6 for SAG, and 4 for FAL. Analyses were performed in line with Sydney et al [11].

The selection of used saw type was randomized for each patient.

TKA Surgery Profile Measurements

The ARBO guidelines state that during an 8-hour working day, the averaged noise level ($L_{Aeq, 8hour}$) should be below 85 dB(A) whereas a noise level below the 80 dB(A) is recommended [12]. The $L_{Aeq, 8hour}$ is a good measure of a subject's daily occupational noise exposure [12]. Therefore, entire TKA surgery profiles were made to calculate the $L_{Aeq, 8hour}$ which includes all noises generated in TKA surgeries.

Four noise profiles of TKA surgeries were measured at 1.4 meter distance of the saw system (Fig. 1B). This was the closest distance where the sterility could be maintained, while keeping the noise

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