Oral Surgery ISSN 1752-2471

ORIGINAL ARTICLE

Noise generation during surgical osteotomies in Oral and Maxillofacial Surgery – is it harmful?

S. Tocaciu[1], A. Liu[1] & N. Rutherford[2]

[1]Monash Health, Clayton, Vic., Australia
[2]Austin Health, Heidelberg, Vic., Australia

Key words:
drill, hearing damage, noise, osteotomy, saw

Correspondence to:
Dr Shreya Tocaciu
Oral and Maxillofacial Unit
Austin Health
145 Studley Rd
Heidelberg
Victoria 3084
Australia
Tel.: +61394965000
email: shreyatocaciu@gmail.com

Accepted: 2 May 2019

doi:10.1111/ors.12423

Abstract

Aim: Oral and maxillofacial surgeons typically spend over 20 h in the operating theatre every week. Many of their procedures involve the use of powered bone and tooth cutting devices, which generate potentially harmful levels of noise. Prolonged exposure to loud noises is associated with hearing loss, increased serum cortisol levels, detrimental cardiovascular outcomes, and poor task performance. This study explores the noise generation of common powered tooth and bone cutting devices in a theatre setting.
Materials and methods: Both compressed air and electric devices were tested. For compressed air devices three burs were tested – jet, round and fissure.
Results: The study found that at the proximity of the patient and surgeon, all tested devices generated noise above the safe threshold of 75 decibels. At the distance of 1 m or more (corresponding to the anaesthetist and scout nursing staff), the Surgairtome and oscillating saw were the only powered osteotomy devices below the safe noise level.
Conclusions: This study explores the impact of noise generation from powered osteotomy devices. This may have health implications for theatre staff, the surgeon, anaesthetist, and the patient.

Clinical Relevance

Scientific Rationale for Study

The health implications of occupational noise have been explored in other industries, but are poorly understood in surgery.

Principal Findings

All powered osteotomy devices tested, generated noise above the safe threshold of 75 decibels. Some devices were found to be safer than others, depending on the cutting interface used, the tissue type, and the distance from the source.

Practical Implications

Noise generation in theatre may have health implications for theatre staff, the surgeon, anaesthetist, and the patient. The factors affecting noise-related damage are explored, as are measures to minimise the detrimental effect of noise during surgery.

Introduction

Historically, hospitals and operating theatres have been areas of calm, control and subdued noises. However, with advances in surgical technologies, many surgical instruments are now powered. These powered instruments are invariably associated with significant noise production, such that the issue of noise-related adverse effect to the health care worker is now a workplace issue[1]. In the realm of Oral and Maxillofacial Surgery (OMS), the source of the noise pollution is most commonly from powered bone and tooth cutting devices.

Although the patient is not exposed regularly to the noise of osteotomy cutting devices, Oral and Maxillofacial surgeons and staff in the operating theatre may be subject to repeated and long-term noise exposure. The Australian Research Centre for Population Oral Health (ARCPOH) reported that Oral and Maxillofacial Surgeons typically spend 15.0 h of private and 5.9 h of public operating time per week[2] for at least 30 years. Of these 20.9 h a week, the majority of cases were reported to be dentoalveolar or orthognathic, both of which involve significant time operating bone or tooth cutting devices. Implants and trauma were also major contributors to the typical OMS case mix. These surgeries also involve cutting of bone, although the proportion to overall operation time is lower.

As well as considering the risk of repetitive loud noises causing sensorineural hearing loss in the surgeon, occupational exposure for the anaesthetic team and nursing staff should also be considered. The implementation of ear protection has sometimes been described as part of the overall personal protective equipment (PPE) used in theatre, but is not in routine use.

The hazards of occupational noise exposure are not limited to surgery. The Unites States National Institute for Occupational Safety and Health has recommended a safe level of 75–85 decibels over an average of 8 h, with a 7.5 min limit to volumes of 103 decibels[1]. This compares to 110 decibels as the volume of a busy highway, and 131 decibels as the peak volume during surgery. The threshold of painful volume has been described as 140 decibels[1].

The sources of noise within the operating theatre include general conversation, electrical or air powered surgical instruments, surgical suction and anaesthetic monitors[1]. Of these, powered surgical instruments contribute as a high volume, intermittent noise source. Unlike the volume of conversation or anaesthetic monitoring machines, powered surgical instruments cannot have their volume turned down.

The detrimental effects of noise to the surgeon, patient and peri-operative staff should not be taken lightly. In the setting of ENT surgery, Shenov *et al*[3]. found patients undergoing procedures involving powered instruments in the mastoid area could experience sensorineural hearing loss on the contralateral side of up to 7 days. Other studies, however, have found no evidence of hearing loss in the patient undergoing head and neck surgery involving powered instruments[4]. The contribution of patient population, duration of powered instrument use, and role of muscle relaxant and its influence on stapedius muscle function, however, have not been specifically explored.

Detrimental health effects of prolonged occupational noise have been studied by Stansfeld *et al*[5]. Most commonly these are reported to be tinnitus and/or hearing loss, and can occur at volumes of as low as 75 decibels. The incidence and severity of noise induced hearing loss is influenced by age, comorbidities, medications, and total cumulative noise exposure. Total cumulative noise exposure itself includes duration, volume and frequency of noise exposure. High level chronic noise exposure has also been linked to tachycardia, hypertension, peripheral vascular disease and ischaemic heart disease[6].

Stansfeld[5] also found that prolonged noise exposure can result in reduced performance, slower task completion and raised serum cortisol. There was also a link between workplace noise levels and reported symptoms of headaches, nausea and anxiety.

Oral and maxillofacial osteotomies are unique in relation to noise production as they are in close proximity to the patient's ears. Temporary hearing loss in patients undergoing head and neck surgery has been reported in the non-operated ear[7] which can be attributed to bone conduction of the noise, which can damage outer hair cells of the inner ear. The role of amplification of noises within the oral cavity has not been specifically studied, and would remain anecdotal. Similarly, patient paralysis during operations would diminish stapedius function, thereby allowing unhampered conduction through the middle ear ossicles. This also has not been specifically studied in the context of iatrogenic sensorineural hearing loss.

The purpose of this article is to investigate the noise generated by various craniofacial osteotomy cutting devices. Any difference in noise generation may help dictate decisions regarding choice of preferred osteotomy cutting device. Level of noise generated may also influence the introduction of noise-specific PPE to protect the surgeon, anaesthetists, nurses and other theatre staff from potential noise related sensorineural hearing loss.

Materials and methods

The study was undertaken in a de-commissioned theatre to accommodate for noise amplification and to replicate the acoustics that would occur in a functioning theatre.

An electronic audiometer was used to measure noise generation (Decibel X, v4.3.0).

The cutting devices measured were powered by compressed air or electricity, as these are used commonly in the Oral and Maxillofacial setting. The devices tested were the Hall micro S-100, the Hall Surgairtome, the Synthes reciprocating saw, and the oscillating saw. The devices were tested with a variety of burs (fissure, jet and round) to see if the interface between device and cutting block would affect noise generation.

The cutting blocks tested were bone (fresh porcine mandible) and tooth (fresh porcine tooth, in mandible). The powered device was also run in air, as a control. Porcine bone was used as it has been shown to be a validated animal model for human bone. As the theatre utilised was decommissioned and no longer for patient care, there were no concerns regarding transmission of animal borne diseases to patients. The investigators wore appropriate PPE. Noise generation was measured at three distances to replicate the effect on the patient (5 cm), surgeon (45 cm) and anaesthetist (100 cm). The noise was measured for 30 s to obtain an average value.

Results

The Hall Micro S-100 was found to be louder than the Surgairtome across all cutting mediums (control, bone and tooth) (Fig. 1). This difference was most apparent in air (100.1 db average compared with 77.1 dB average), with noise levels more comparable when cutting tooth.

When comparing electric saws, the reciprocating saw was louder than the oscillating saw.

As expected, the maximum noise level recorded decreased when distance from the source was increased (Fig. 2). For all devices, noise levels generated were above the threshold for safe occupational noise as described by Stansfield (75 dB) for distances representing the patient and surgeon. The anaesthetist was subjected to lower levels of noise. When considering the Surgairtome and oscillating saw, this was below the threshold for occupational hearing damage.

The type of bur utilised also affected noise generation. When looking at the Surgairtome, three types of bur were tested; the fissure, jet and round burs. At a distance of 5 cm, the three cutting devices were tested in air, bone and tooth (Fig. 3). The type of bur did not matter when testing noise generation in air. All three burs produced more noise when cutting tooth when compared to bone. The jet bur had the lowest maximum noise generation for bone (87.7 dB) whereas the round bur was quietest when cutting tooth (maximum 94.3 dB).

Discussion

The source of noise pollution in theatre can be general conversation, powered surgical instruments, surgical suction, or anaesthetic monitoring equipment. Of these, some can be controlled or adjusted. Powered surgical instruments are a mainstay in the Oral and Maxillofacial Surgeon’s armamentarium, and their potential detrimental effects on patients and the surgical team need to be considered.

The choice of cutting device may have an effect on noise generation, but a direct comparison in noise generation between electric and air powered devices has not yet been done. Piezosurgery was originally

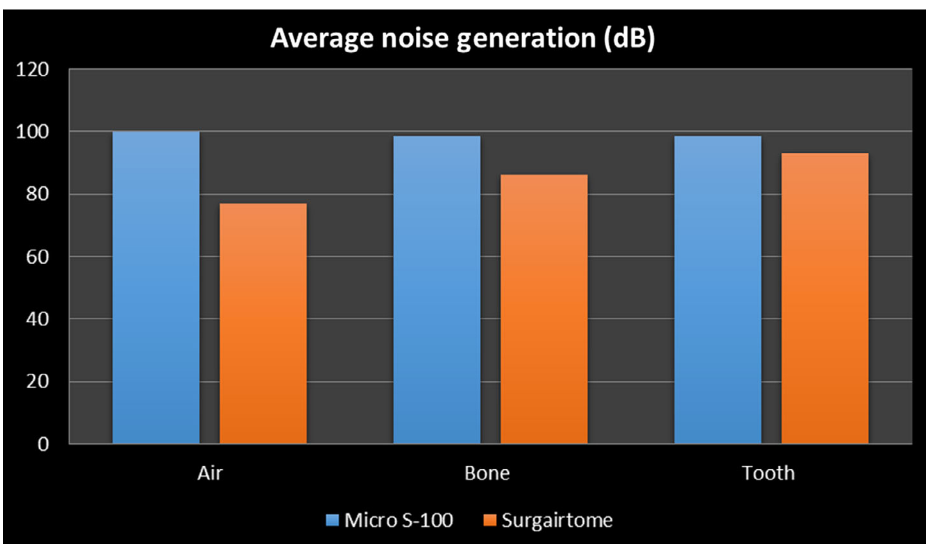

Figure 1 Average noise generation (dB).

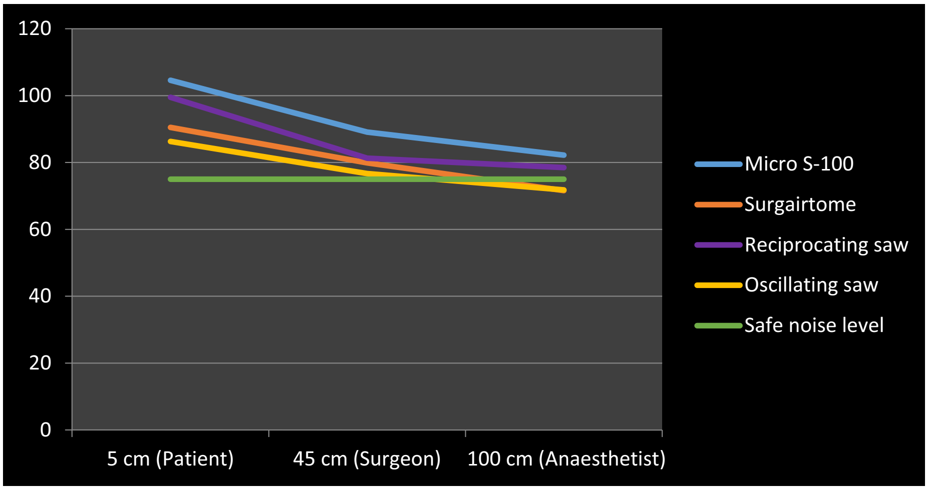

Figure 2 Maximum noise generation versus distance from source (dB).

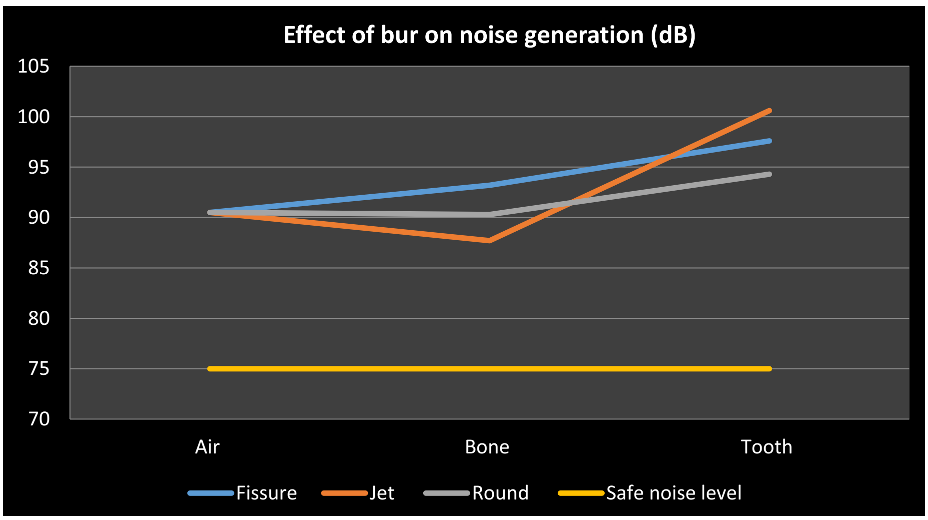

Figure 3 Effect of bur on noise generation.

thought to be advantageous due to its decreased vibration and noise[8], but has since been found to have comparable noise generation to conventional electric or air-powered devices[9]. Secondly, bone cutting with piezoelectric instruments in less efficient, meaning that duration of noise exposure will be longer.

The surgeon can consider additional PPE to protect themselves from prolonged noise exposure. This could include ear plugs or headphones. The anaesthetist has the additional advantage of being able to increase their distance from the cutting device. Changes in design of cutting devices should be considered by the manufacturer, as a quieter (but as efficient) alternative would be more attractive to both the surgeon and the theatre administration, as its staff would be protected. A change is theatre acoustics (e.g. surface finishing on walls and ceiling) could also be considered. The effect of irrigation on noise generation is currently unexplored.

Prolonged occupational noise exposure for Oral and Maxillofacial Surgeons is a previously unexplored topic. This study suggests that powered osteotomy cutting devices may deliver a detrimental level of noise to not only the surgeon, but also to the patient and theatre staff.

Cutting teeth, as is done in many dentoalveolar procedures, generated more noise than cutting bone, although both are above 75 dB, which is considered the safe threshold.

The choice of bur also makes a difference to noise generation, with jet burs generating the least noise on a bone medium, and round bur being the quietest for drilling teeth.

Noise generation is loudest at the level of the patient. The effect of muscle relaxation on the stapedius' ability to dampen noise may further increase this risk, as it may compound the effect of direct bony resonance. The surgeon is also working within a close vicinity to the powered cutting device, and is subjected to detrimental levels of noise with all cutting devices and burs measured. This hazardous noise level applied for all cutting media – control, bone and tooth. The anaesthetist may be spared from hazardous levels of noise if a Surgairtome or oscillating saw is used (rather than the Micro S-100 or reciprocating saw), or if they are more than a metre from the device.

Further studies are required to investigate the effect of powered osteotomy devices on hearing loss or damage. Until then, ear protection should be considered for the surgeon and anaesthetist, as they are subject to prolonged noise exposure.

Acknowledgements

No funding was obtained for this article. All authors have contributed to this article and agree to its submission for publication.

REFERENCES

1. Katz JD. Noise in the operating room. Clinical Concepts and Commentry. Anesthesiology 2014;121:894–8.
2. Singh KA, Brennan DS, Spencer AJ, Goss AN Practice patterns of oral and maxillofacial surgeons in Australia – ARCPOH population oral health series no.3. Aug 2004 Australian Research Center for Population Oral Health.
3. Shenoy VS, Vanka S, Rao RA, Prasad V, Kamath PM, Bhat J. Effect of mastoid drilling on the distortion product otoacoustic emissions in the non-operated ear. Am J Otolaryngol 2015;36:832–6. https://doi.org/10.1016/j.amjoto.2015.07.013
4. Urquhart AC, McIntosh WA, Bodenstein NP. Drill-generated sensorineural hearing loss following mastoid surgery. Laryngoscope 1992;102:689–92.
5. Stansfeld SA, Matheson MP. Noise pollution: non-auditory effects on health. Br Med Bull 2003;68:243–57.
6. Gan WQ, Davies HW, Demers PA. Exposure to occupational noise and cardiovascular disease in the United States: the National Health and Nutrition Examination Survey 1999–2004. Occup Environ Med 2011;68:183–90.
7. Da Crus MJ, Fagan P, Atlas M, McNeill C. Drill-induced hearing in the non-operated ear. Otolaryngol Head Neck Surg 1997;117:555–558.
8. Pavlíková G, Foltán R, Horká M, Hanzelka T, Borunská H, Sedý J. Piezosurgery in oral and maxillofacial surgery. Int J Oral Maxillofac Surg 2011;40:451–7. https://doi.org/10.1016/j.ijom.2010.11.013
9. Kramer FJ, Bornitz M, Zahnert T, Schliephake H. Can piezoelectric ultrasound osteotomies result in serious noise trauma? Int J Oral Maxillofac Surg 2015;44:1355–61. https://doi.org/10.1016/j.ijom.2015.03.004