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Aerosol spread during maxillary sinus floor elevation: Piezosurgery vs conventional rotary system. A cadaver study

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ABSTRACT

Aims Infectious diseases have been always a major concern for world population; therefore, particular attention should be paid on any precautions for prevention of infectious disease transmission. The aim of this study was to compare the aerosol spread created by conventional rotating handpiece and piezosurgery during sinus lift procedure.

Materials and Methods Twelve fresh human cadavers were used for this study. Bilateral osseous windows were created on the lateral wall of the maxillary sinus using either piezosurgery or conventional high-speed rotary device under copious irrigation with methylene blue mixed saline solution. Aerosol spread was scored by scoring the count of droplets on graph papers placed next to the operating table before each surgical procedure.

Results Aerosol spread was significantly higher in piezosurgery group for the first 7 distances (70 cm from the head level), while no significant difference was found in further distances.

Conclusions The findings of this study suggest that utilizing conventional rotary handpiece instead of piezosurgery for sinus lifting osteotomy may provide benefit in decreasing aerosol spread.

KEYWORDS Aerosols; Piezosurgery; Sinus Floor Augmentation

INTRODUCTION

Infectious diseases have always been a major concern for world population causing significant impacts on health, economy, and social life. Although advances in antibiotics and vaccines, new pathogens are constantly emerging such as novel coronavirus disease (Covid-19) which is defined as global health crisis of our time. Therefore, particular attention should be paid on any precautions for prevention of infectious disease transmission.

Traditionally, three routes of infectious disease transmission have been defined including contact, droplet, and airborne transmission, with respect to the particle size and distance from the infectious source (1). Apart from these, aerosol transmission has gained attention in recent years as another possible route of infection transmission. Several researchers have reported that aerosols generated from many bodily processes and medical procedures may contain pathogens in conjunction with body fluids (2-5).

Almost all dental and oral surgical procedures create bioaerosols because of highspeed rotating instruments with water coolant. It is therefore believed that there is an increased risk of spread of infectious pathogens in a dental setting (6-8). Along with the following the principle of universal precaution, any attempt to reduce bioaerosols generated during oral and maxillofacial interventions would play a vital role in infection control.

Nowadays, there is an ongoing fight against Covid-19 outbreak worldwide, but in the meantime, the need for rehabilitation of patients still exists within the specialty of oral and maxillofacial surgery. In this context, dental implant therapies have priority considering the association between edentulism and inadequate nutrient intake which may lead to weight loss, malnutrition, and ultimately increased morbidity and mortality (9,10).

Maxillary sinus augmentation is one of the most common procedures in implant rehabilitation of maxillary posterior region and most cases require a lateral antrostomy to elevate sinus membrane. Antrostomy could be performed by

using a conventional high-speed rotating handpiece, or an ultrasonic device (piezosurgery). Several publications have appeared in recent years documenting that, compared to conventional handpiece, use of piezosurgery in sinus lift procedures may decrease the risk for membrane perforation and enhance patient comfort while increasing the duration of the surgery (11). Given the disparate working principles of these devices, it is conceivable that there may be difference between the amount and spread of aerosols produced between them. To the authors´ best knowledge, no single study exists which evaluated the amount of aerosol created by conventional rotating handpiece and piezosurgery during sinus lift procedure.

This study therefore set out to compare the amount of aerosol created by conventional rotating handpiece and piezosurgery during sinus lift procedure and thus to contribute in precautions to reduce bioaerosol transmission of infectious diseases.

MATERIALS AND METHODS

Twelve fresh adult cadavers, without any history of trauma, surgery, defect, or pathology involving the maxillofacial region, were examined on left and right sides at the laboratory of the Department of Anatomy, Akdeniz University School of Medicine.

This study was granted permission from the local ethics committee of the University with the approval number 70904504/558.

The cadavers were randomly allocated into two groups (6 cadavers per group): piezosurgery (P) and conventional surgery (C). Prior to the surgical procedure, a board covered with 1/2" graph papers were placed next to the operating table (Figure 1).

Following the incision and mucoperiosteal flap elevation, an osseous window was created on the lateral wall of the maxillary sinus bilaterally using a piezosurgery device (NSK® VarioSurg Ultrasonic Bone Surgery, USA) or a conventional bur with a high-speed rotary device (NSK® Surgic AP, USA) under copious irrigation with a mixture of saline and methylene blue solution (Contranea, Zurich Veterinaire, Switzerland) (Figure 2).

At the end of the osteotomy of each cadaver, graph papers were replaced with the new ones. The graph papers were divided into distances with reference to the points determined at 10 cm intervals starting from the head level (Figure 3). To evaluate the quantity and intensity of aerosol spread, total count of droplets for each interval were recorded and scored. Total count of droplets was identified as 0 to 10, 11 to 20, 21 to 50, 51 to 70 and above 70 and graded as 1, 2, 3, 4, 5, respectively.

Statistical analysis

Descriptive statistics, including median and interquartile range were used to analyze the data. Considering the small sample size, the Kruskal-Wallis test was performed, followed by the Mann-Whitney U test and Wilcoxon signed rank test as post hoc tests (differences were considered significant at $P < .05$) using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp, Armonk, NY).

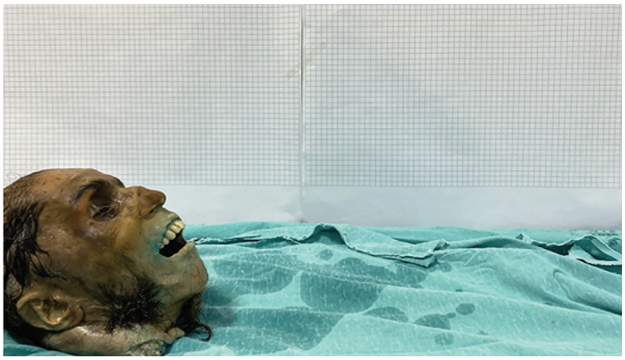

FIG. 1 Before each procedure, graph papers were placed next to the operating table.

FIG. 2 Bone osteotomy was performed with piezosurgery (A) or conventional rotating handpiece (B) for lateral maxillary sinus lift

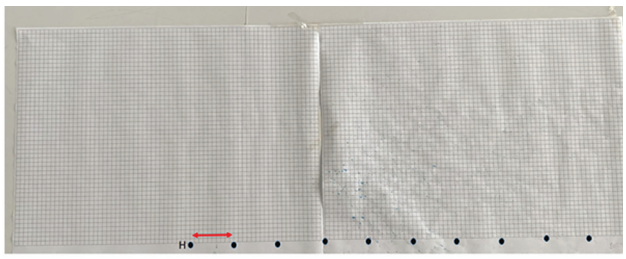

FIG. 3 The graph papers were divided into distances with reference to the points (black points) determined at 10 cm intervals (red arrow) starting from the head level (H).

RESULTS

Table 1 summarizes the descriptive analysis of aerosol spread in piezosurgery and conventional high-speed handpiece groups at all distances measured. When comparing the average scores of two groups, it was observed that aerosol spread was significantly higher in piezosurgery group for the first 7 distances (70 cm from the head level), while no significant difference was found in further distances (Table 2).

DISCUSSION

Oral and maxillofacial procedures have always been associ-

	D1		D2		D3		D4		D5		D6		D7		D8		D9		D10	
	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Median	4.5	2.5	4	2.5	4	2	3.5	1.5	3.5	2	3	1.5	2.5	1	1	1	1	1	1	1
IQR	1	1	1	1	0	1	1	1	1	1	1	1	2	1	2	0	1	0	1	0

D: distance, P: piezosurgery, C: conventional surgery, N: sample size, IQR: Interquartile range.

TABLE 1 Average aerosol spread in conventional and piezosurgery groups at all distances

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Chi-Square	7,923	6,548	10,286	4,083	7,663	7,627	7,857	1,000	,000	,000
df	1	1	1	1	1	1	1	1	1	1
Asymp. Sig.	,005*	,011*	,001*	,043*	,006*	,006*	,005*	,317	1,000	1,000

D: distance, df: degree of freedom, Asymp. Sig: Asymptotic significance, '' indicates significant difference (p<.05).*

TABLE 2 Kruskal-Wallis analysis for comparison of average scores of aerosol spread between conventional and piezosurgery groups for each distance.

ated with high risk of exposure to infectious diseases since aerosols or droplets induced during the oral interventions have comparable risk with those that occur during medical procedures (12). This paper is a modest contribution to the current knowledge on infection control measures for aerosol generating oral surgical procedures regarding the risk of transmission of acute respiratory infections.

Implant therapy in the posterior maxilla often poses a problem due to insufficient bone volume and lateral maxillary sinus floor elevation (LMSFE) is one of the most common procedures performed to overcome this limitation (13). Till date, various techniques and devices have been proposed for LMSFE using piezoelectric devices and conventional rotary instruments (14).

A growing body of literature has compared the efficiency of piezosurgery and conventional rotary instruments in terms of membrane perforation, operating time, and implant outcomes. In a study by Wallace et al., it was concluded that sinus elevation surgery using piezoelectric techniques had several advantages including improved intraoperative visibility and reduction in membrane perforation rate, intraoperative bleeding, and surgical trauma (15). Similarly, Barone et al. also reported that membrane perforation rate was lower with piezosurgery, however, the time required for window osteotomy was higher compared to the conventional method (16). There is a general agreement in the literature regarding the longer period required for operations with the piezosurgery device (17-19). In a systematic review, Atieh et al. reported that there was no significant difference between piezoelectric surgery and rotary instruments regarding the risk of sinus membrane perforation and implant failure while a statistically significant difference was found in the operating time between the two techniques with more time required for piezosurgery (14). In a more recent systematic review by Stacchi et al., it was reported that while not significant, a lower incidence of membrane tearing occurred when using piezosurgery, and there was moderate evidence suggesting that piezosurgery prolongs the surgery duration compared with conventional rotary instruments (20).

While debate continues about the above-mentioned limitations and advantages of both techniques, no research has been found that investigated piezosurgery and rotary instruments from the point of view of aerosol production and spread which could be a risk factor for the transmission of the various infections including COVID-19.

The generalizability of much published research on infection transmission from dental aerosols is problematic. Few researchers have investigated the aerosol transmission of infectious diseases in dental settings. In a study by Harrel et al., it was reported that high-powered electric tools may produce aerosols that would be a potential route for disease transmission for both bloodborne and airborne viruses (21). In 2017, Zemouri et al. reported that bio-aerosols in dental settings could be hazardous to both patients and healthcare workers (22).

Although great effort has been paid on research on antiviral therapy, and vaccines, the COVID-19 pandemic is not quite over yet, and it has utmost importance to improve precautions alternative to imposed lockdowns and social distancing for preventing the spread of the disease (23,24).

It is common knowledge that coronavirus has a potential for nosocomial transmission during aerosol-generating procedures performed on infected patients (25). In a recent paper, Gandolfi et al. reported that the face-to-face contact (within 0.5 m) between patients and dental care workers in the dental clinic represents a high-risk condition and there is a need for novel protection measurements from droplets spray for dental staff and patient as well as new operative approaches (26).

In the same vein, several studies also emphasized the po-

tential risk for COVID-19 inhalation transmission of dental procedures since high-speed handpieces with irrigation may increase the diffusion of aerosol particles (27,28).
In reviewing the literature, high-speed instruments have been reported to have a higher risk for bioaerosol transmission of infectious diseases (28,29). Rautemaa et al. investigated the spread of airborne bacteria and the level of contamination during dental treatment and observed significant contamination of the room at all distances sampled when high-speed instruments were used (8). However, no single study exists which compared different dental high-speed instruments in terms of aerosol production and spread. The present study demonstrated, for the first time, that sinus lifting surgery using piezosurgery caused significantly increased aerosol spread when compared with a conventional rotating handpiece. This result could be attributed to working principle of piezosurgery based on vibration and increased operation time.

CONCLUSION

The results of the present study suggest that utilizing conventional rotary handpiece instead of piezosurgery for sinus lifting osteotomy may provide benefit in decreasing aerosol spread. However, further research is recommended to determine the actual risk of infection transmission associated with dental aerosol generating procedures.

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Conflict of Interest and Funding
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Author contributions
Conceptualization: Sindel A, Sindel M. Formal Analysis: Ozalp O, Altay MA. Investigation: Simsek Kaya G, Erkal M. Methodology: Ozalp O, Rasljanin E. Project Administration: Sindel A, Altay MA, Ozalp O. Writing – Original Draft: Erkal M, Rasljanin E, Ozalp O. Review & Editing: Sindel A, Simsek Kaya G, Sindel, Altay MA.

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