Published online: 2019-09-24

Original Article

Efficiency of gaseous ozone in reducing the development of dry socket following surgical third molar extraction

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ABSTRACT

Objective: The objective of this study was to assess the efficacy of ozone gas (O_3) on the reduction of dry socket (DS) occurrence following surgical extraction of lower jaw third molars, influence of the indication for the extraction, and the difficulty of extraction on the incidence of DS. **Materials and Methods:** This study included thirty patients with bilaterally impacted third molars of mandible requiring surgical procedure for extraction. Following extraction, in the control group, saline solution was used for irrigation of extraction sockets and in the experimental group, intra-alveolar O_3 was applied for 12 s (Prozone, W and H, UK, Ltd.). The surgeries were performed by the same oral surgeon. The follow-up visits were performed at 48 h and on day seven, postsurgery where the symptoms of DS were evaluated and intensity of pain has been recorded using visual analog scale 0–100. **Results:** In this pilot study, DS was present in 16.67% and 3.33% of cases in the control and experimental groups, respectively ($P = 0.20$). **Conclusion:** The application of O_3 may reduce the incidence of DS and accelerates the recovery period after the surgery. Prophylactic use of O_3 may be suggested in all patients, especially in the patients at a risk of development of DS.

Key words: Dry socket, ozone gas, third molar

INTRODUCTION

Dry socket (DS) is one of the most common complications following third molar surgery. Its exact etiology and pathogenesis, despite various approaches to this pathology, are still not known. DS was originally described as a consequence of disintegration of blood clot during days 2–4 after the tooth extraction. Its appearance has been described based on the clinical symptoms, such as a dry alveola covered with a layer of necrotic, yellow-gray tissue, halitosis, and high intensity of pain that radiates to the neck and ear.[1,2] Although rare, other symptoms are lymphadenitis, headache, insomnia, and trismus, as described in the literature.[3,4]

Ozone gas (O_3) is an agent with powerful antimicrobial action.[5,6] It has helpful use as a disinfectant in the field of medicine and dentistry and has been used widely in all fields of dentistry. Atabas D found that treatment with ozone combined with re-mineralizing solution or either alone is very effective to the initial fissural caries lesions.[7] In clinical terms, O_3 can be applied in three basic forms such as gaseous, water, and oil for treating

Access this article online
Quick Response Code:
Website: www.eurjdent.com

How to cite this article: Ahmedi J, Ahmedi E, Sejfija O, Agani Z, Hamiti V. Efficiency of gaseous ozone in reducing the development of dry socket following surgical third molar extraction. Eur J Dent 2016;10:381-5.

DOI: 10.4103/1305-7456.184168

various pathologies. Prozone (W and H, UK, Ltd.,) is a new technology that produces ozone in a gaseous state for use in various dental applications. It generates O_3 and regulates its flow of concentrations, so they do not exceed the permitted therapeutic values. O_3 has several actions in the human body as an antibacterial, anti-inflammatory, and immunostimulatory agents by utilizing the body's oxygen metabolism and also stimulates the antioxidant humoral system of human organisms.[8] Its antibacterial effect is based on its ability to form oxidizing free radicals and destruction of microorganisms.[8] It promotes its antioxidant potential in the destruction of cytoplasmic membranes and cell walls of bacteria, blocking the system enzyme of the cell. This action results in increased permeability of the cell membrane, causing immediate termination of all of its functions and death of microorganisms. This action is selective in microorganisms' cells, but not in human cells because of the human body's greater antioxidant capacity of cells and inhibition, which is vital to stave off the uncontrolled activity of free radicals.[9,10]

The objectives of our study were as follows:

1. To determine the effect of gaseous O_3 in reducing the presence of DS following bilateral surgical lower jaw third molar extraction compared to the control group
2. Influence of the indication for the extraction on the incidence of DS by groups
3. Influence of the difficulty of extraction on the incidence of DS by groups.

MATERIALS AND METHODS

This pilot study was performed in the Department of Oral Surgery in the University Dental Clinical Centre of Kosovo (UDCCK) which included thirty patients addressed in our clinic for surgical extraction in the period of January 2014–June 2014. The Ethics Committee of UDCCK approved the research protocol. Before the surgery, all patients signed an informed consent for participation in the study.

Inclusion criteria were the following: Age 18–30 years; bilateral impacted lower third molars in similar position verified by orthopantomography; and an indication for surgical extraction (pericoronitis, caries, pulpitis, or orthodontic indication). Exclusion criteria included the following: Any systemic disease; smokers; immunocompromised patients; pregnant women; and those who were taking contraceptives.

Surgical procedure

Randomization was used to determine which side would comprise the control group (Gr1) and which would comprise the experimental (O_3) group (Gr2). The patients were not aware of these designations. All the surgeries were performed by the same oral surgeon. Local analgesia was achieved using 4 ml of 2% lidocaine with 1:80,000 adrenalines (Alkaloid, Skopje, Macedonia). A triangular, full-thickness buccal flap was elevated for bone exposure. Bone osteotomy was performed for the section of the tooth if required. Afterward, 5 ml of 0.9% saline solution (Gr1) or O_3 gas (Gr2) was used to irrigate the socket. We used Prozone equipment to supply the O_3 gas, which enabled us to introduce the gas into the socket using plastic attachments for 12 s calibrating the therapeutic dose. This procedure was performed using a surgical suction unit to avoid respiratory aspiration and related complication. Suturing was performed with 3/0 absorbable suture (Ethicon, Somerville, NJ, USA).

The patients were then given postoperative instructions and prescribed ibuprofen 400 mg as an analgesic/anti-inflammatory drug. Postoperative visits were scheduled for 48 h after the surgery and on postoperative day 7. Additional appointments were made as needed. Clinical examination was performed to find evidence of one or more of the following main objective signs of a DS: Absence of a blood clot, bone exposure, or necrotic blood clot. We also recorded the number of analgesic tablets ingested.

Subjective clinical findings included patient data of persistent postoperative pain after the surgery. The degree of pain was recorded on a visual analog scale.

Statistical analysis

Data analysis was performed using Pearson's χ^2 test, Fisher's exact test (P), and McNemar's test. $P < 0.05$ was considered to indicate statistical significance.

RESULTS

The mean age of the patients was 21.87 ± 4.11 years (95% confidence interval [CI]: 20.33–23.40) [Table 1].

Table 1: Age of all participants in the study Group 1/Group 2

Age	Valid *n*	Mean	Confidence−95.00%	Confidence+95.00%	Minimum	Maximum	SD
Years	30	21.87	20.33	23.40	18	33	4.11

SD: Standard deviation

The incidence of DS in Gr1 (n = 5; 16.67%) was higher than that in Gr2 (n = 1; 3.33%), but with no significant difference (P = 0.20) [Table 2].

In the Gr1, the incidence of DS was higher in those who underwent very difficult surgery and in those requiring osteotomy with resection during the tooth extraction compared with those without tooth or root resection. The only case of DS in the Gr2 was recorded in a patient whose tooth extraction was very difficult (osteotomy, root, and tooth resection required) [Table 3].

No adverse reactions were recorded during the study implementation.

According to indications for removing the tooth, the frequency of DS was higher in cases of orthodontic versus pericoronitis indications [Table 4].

Table 2: Incidence of dry socket in the Group 1/Group 2

Group	DS, *n* (%)		Total
	Yes	No	
Group 1	5 (8.33)	25 (41.67)	30 (50.00)
Group 2	1 (1.67)	29 (48.33)	30 (50.00)
Total	6 (10.00)	54 (90.00)	60

DS: Dry socket

The number of consumed analgesics within 48 h after surgery was 3.07 ± 1.96 tablets (95% CI: 2.33–3.80) in Gr1 and 1.20 ± 1.16 tablets (95% CI: 0.77–1.63) in Gr2. The minimum number of consumed analgesics was 0 and the maximum number was 6 in Gr1 and 0 and 4, respectively, in Gr2 [Table 5].

DISCUSSION

Overall complication following third molar surgery rates of about 10%[11] including pain, secondary infection of the head and neck region, dislocation of third molars, excessive bleeding, temporary or permanent damage to the cranial nerves, and mandibular fracture was reported by Yadav *et al*.[12] DS is one of the most challenging complications after surgical extraction of lower third molars. The role of bacteria in the development of DS has been discussed in many clinical and scientific studies. This concept is based on research results that confirmed the increased DS frequency in patients with pericoronitis, poor oral hygiene, and periodontal disease.[13] Potential interference of *Actinomyces viscosus* and *Streptococcus mutans* in DS has been studied by Rozanis *et al*. and it is demonstrated in

Table 3: Influence of the difficulty of extraction on the incidence of dry socket Group 1/Group 2 Difficulty of extraction DS, *n* (%) T

Difficulty of extraction	DS, *n* (%)				Total	
	Yes		No		Group 1	Group 2
	Group 1	Group 2	Group 1	Group 2		
Osteotomy	2 (6.67)	0 (0)	18 (60.00)	20 (66.67)	20 (66.67)	20 (66.67)
Osteotomy and root or tooth resection	2 (6.67)	0 (0)	6 (20.00)	8 (26.67)	8 (26.67)	8 (26.67)
Very difficult extraction (osteotomy, tooth, and root resection)	1 (3.33)	1 (3.33)	1 (3.33)	1 (3.33)	2 (6.67)	2 (6.67)
Total	2 (6.67)	1 (3.33)	25 (83.33)	29 (96.67	30	30

DS: Dry socket

Table 4: Influence of the indication for extraction on the incidence of dry socket Group 1/Group 2

Indication for extraction	DS, *n* (%)				Total	
	Yes		No		Group 1	Group 2
	Group 1	Group 2	Group 1	Group 2		
Pericoronitis	1 (3.33)	0 (0.00)	9 (30.00)	9 (30.00)	10 (33.33)	9 (30.00)
Caries	0 (0.00)	0 (0.00)	4 (13.33)	4 (13.33)	4 (13.33)	4 (13.33)
Pulpitis	0 (0.00)	0 (0.00)	1 (3.33)	1 (3.33)	1 (3.33)	1 (3.33)
Orthodontic indication	4 (13.33)	1 (3.33)	15 (50.00)	15 (50.00)	15 (50.00)	16 (53.33)
Total	5 (16.67)	1 (3.33)	29 (96.67)	29 (96.67)	30	30

DS: Dry socket

Table 5: Number of tablets consumed within 48 h after surgical extraction Group 1/Group 2

Number of tablets in 48 h	Valid *n*	Mean	Confidence−95.00%	Confidence+95.00%	Minimum	Maximum	SD
Group 1 - saline group	30	3.07	2.33	3.80	0	6	1.96
Group 2 - ozone group	30	1.20	0.77	1.63	0	4	1.16

SD: Standard deviation

experimental models of delayed socket recovery after inoculation of these microorganisms.[14] Increasing the number of pyrogenic bacteria as activators of indirect fibrinolysis creates ideal conditions for blood clot disintegration and DS development. Interference of bacteria in the development of DS by introducing preventive antibiotics explains the reduced incidence in many clinical research studies.[15-18] Akota *et al*. demonstrated a significant reduction in the incidence of DS after the application of chlortetracycline-impregnated gauze compared with a control group.[19] Nitzan *et al*. observed increased fibrinolytic activity by *Treponema pallidum* which is present in periodontal disease,[20] explaining why children, who are not colonized by this bacterium, do not develop DS.

The results of our research showed the efficacy of gaseous O_3 in reducing the incidence of DS after surgical extraction of lower third molars compared with the saline solution. Our results also showed that the control patients consumed a large number of analgesic tablets 48 h after tooth extraction compared with the patients who were given O_3, with the difference reaching statistical significance ($P < 0.01$).

Based on our results, intensity of pain following third molar surgical extraction in cases where gaseous O_3 was applied was significantly less than in cases where only saline solution was used for irrigation. This can be explained by the fact that O_3 helps in the synthesis of biologically active substances as leukotrienes, interleukins, and prostaglandins, which are beneficial in reducing inflammation and pain.[21,22] O_3 activates angiogenesis in inflamed tissue[23,24] by reacting with blood elements (erythrocytes, leukocytes, platelets, and vascular system). It also has a positive impact on oxygen metabolism, cellular energy, and the antioxidant defense system in the blood microcirculation, thereby improving oxygen delivery to hypoxic tissues by stimulating its metabolism. In addition, it has been found that ozone could accelerate wound healing and bone reparative processes.[25]

Applying O_3 to the socket following tooth extraction promotes faster healing of the wound without complications.[26] O_3 also reduce the period of recovery by forming a pseudomembrane in the socket that protected it from mechanical and physical insults.[27] It has also been proved to be useful in the treatment of refractory osteomyelitis as a complementary therapy to antibiotics and oxygen hyperbaric application[8,28,29] and promoting the bone healing.[30]

CONCLUSION

According to our findings, O_3 gas has a positive effect on reducing the development of DS and pain following third molar surgery. The microbiological and metabolic capabilities of O_3 for promoting hemostasis, increasing the supply of oxygen, and inhibiting bacterial proliferation increase the opportunities for its use in all fields of surgery. Further clinical trials are needed with larger samples to support our conclusion.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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