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Original Article

The efficacy of ozone therapy on free gingival graft augmentation around dental implants

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Abstract

Aim: The implants exhibiting lack of keratinized mucosa (KM) may be more prone to the early stage of peri-implant infection. The aim of the present study was to evaluate topical ozone therapy on free gingival graft (FGG) healing in terms of augmenting KM around the implants during 6-month follow-up.

Material and methods: Thirty patients (16 women and 14 men) with inadequate KM around their implants were randomly allocated to either the ozone group (FGG + Ozone therapy) or the control group (FGG alone). The width and thickness of KM, plaque index (PI), gingival index (GI), probing depth (PD), mucosal recession (MR) and clinical attachment level (CAL) were evaluated at baseline, 1, 3 and 6 months. During 14 days postoperatively, patient's pain perception was analyzed by using a visual analog scale analog scale (VAS). At 14 days, quality of life was also assessed via the Oral Health Impact Profile-14 (OHIP-14).

Results: No significant differences were found between ozone and control groups with respect to KM dimensions at any study follow-up periods ($p>0.05$). Ozone group provided significantly higher CAL and MR values at 6 months compared to baseline values. Moreover, ozone group exhibited significantly lower GI values compared to the control group at 6 months ($p<0.05$). No significant difference was observed between the groups for postoperative VAS values and total OHIP-14 scores ($p>0.05$).

Conclusion: Adjunctive ozone therapy did not provide any beneficial impact on the dimension of obtained KM around the implants at 6 months. However, ozone therapy may give rise to less mucosal inflammation around the implants compared to spontaneous healing.

Keywords: Autografts; Dental Implants; Inflammation; Keratinized Mucosa; Ozone Therapy.

INTRODUCTION

The maintenance of long-term implant function and peri-implant tissues in a healthy aesthetic state depends on a balance between soft and hard tissues (1). Local predisposing factors such as inadequate bone volume and insufficient presence of stable and healthy soft tissue may jeopardize the success of dental implant rehabilitation (2). Keratinized mucosa (KM) has been investigated as one of the local risk indicators influencing the success of implant therapy (3-5). It has been demonstrated that the composition and structural organization of the peri-implant KM differ from the periodontal tissues (6). The peri-implant connective tissue fibers run in a parallel direction to the surface of the transmucosal part of the implants (7). However, the peri-implant connective tissue consist of fewer fibroblasts and more collagen fibers and has a comparable structure to that of scar tissue (7,8). Compared to teeth, the supra-crestal soft connective tissue near the implant contains only few blood vessels than the similar location of the periodontium at teeth (8). The influence of the structural-biological characteristics of peri-implant soft tissue could make peri-implant tissue more susceptible to an inflammatory process caused by plaque accumulation (9). On the other hand, a number of clinical studies suggested that insufficient width and thickness of KM was associated with increased levels of plaque accumulation (10,11) and mucosal inflammation, (12,13) and was observed with a further mucosal recession, (11) clinical attachment loss (14) and marginal bone resorption (11). Therefore, there is a need to augment the KM around implants in cases with an inadequate width (6). Surgical soft tissue augmentation aimed to increase the width of KM has been suggested to facilitate oral hygiene, (15) to enhance the quality of soft tissue (16) and to minimize mucosal recessions around the implants (15).

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Apically positioned flap (APF) in combination with free gingival graft (FGG) has been indicated a predictable and effective treatment modality increasing the width of KM (6). The histological evaluation demonstrated that the healing of FGG can be divided into three organized and consecutive time-dependent phases, including the initial healing phase (0 to 3 days) which consist of avascular plasmic circulation from the recipient site, revascularization phase (4 to 11 days) which is characterized by completely covering of the graft with an epithelial layer and vascularization and capillary ingrowth at the base of the graft and tissue maturation phase in which (11 to 42 days) the pattern of vascularization does not exhibit major changes after 14 days (17). Hence, the use of new techniques and therapeutic strategies, as well as devices to accelerate wound healing in these processes could provide more thicker and wider zone of KM and allow more predictable results.

Ozone which appears attractive as possible therapeutic agent for inflammatory diseases has been suggested to bio-stimulate and accelerate soft and bone tissue healing (18,19). The wound healing following surgery procedures involves several biological events that can be induced by ozone therapy, such as activated neuroprotective systems, improved blood circulation and oxygen delivery, stimulated proliferation of immunocompetent cells and synthesis of immunoglobulins and enhanced the release of growth factors (20,21). Tasdemir et al. (18) evaluated effect of ozone therapy on early healing of de-epitheliazed gingival grafts and they reported that a higher increase in the blood perfusion units was found in the ozone therapy group compared to control group in the first week, moreover ozone therapy showed to increase quality of life postoperatively and to decrease post-operative pain sensation.

Although it is known that ozone therapy accelerates soft tissue wound healing, the influence of ozone therapy on autogenous graft healing around implants has not been studied previously. Therefore, the present study tested the hypothesis that the ozone therapy would enhance wound healing and increase the width and thickness of KM around implants. In this study, the primary aim was to evaluate topical ozone therapy on FGG healing around implants during 6-month follow-up. Secondary objectives were the effects of ozone therapy on postoperative pain and surgery-related quality of life.

MATERIAL and METHODS

Study design, population and randomization

The present study was a parallel, randomized controlled clinical design with 6-month follow-up. Thirty patients (16 women and 14 men, aged 31 to 62 years, mean age: 52 ± 2.3) with inadequate KM around their implants, were selected from the patients included in maintenance programs of the Periodontology Department of Gazi University, between February 2017 and January 2018. Informed consent was obtained from all participants, based on the study approval of the Institutional Review Board at Ankara University, Faculty of Dentistry, Ankara, Turkey (Protocol ID: 36290600/25).

Patients were randomly allocated to either the ozone group (FGG + Ozone therapy) or the control group (FGG alone) using a computer-generated randomization scheme by the statistician. Allocation concealment was achieved using a sealed, coded opaque envelope containing the treatment procedure. Each envelope was assigned a number identifying a patient to receive the respective treatment, which was only revealed immediately after the surgical procedure was completed. An examiner who was not involved in the surgical procedures and postoperative examinations opened the envelopes and informed the surgeon for which procedures would be done.

The patients were included based on the following inclusion criteria: 1) age > 18 years, 2) having one implant region presenting inadequate attached mucosa (<1 mm), 3) non-smoking, 4) not having any systemic disease that could compromise wound healing, and 5) no contraindications for periodontal surgery and ozone therapy.

At least 1 month before the surgery, all the subjects received oral hygiene instructions with the initial periodontal therapy including scaling and root planning at teeth and mechanical debridement with titanium curettes (ImplaMate, Nordent Mfg Inc., Elk Grove Village, IL, USA) at implant sites. Patients were re-valuated at least 8 weeks after initial therapy and full-mouth plaque score <20% and full mouth bleeding score < 15% were scheduled for surgical procedure.

Primary and secondary outcome variables

The primary outcome variable was the assessment of width and thickness of the KM around the implants. The secondary outcome variables included the assessment of the periodontal parameters of the affected implants, patient morbidity and surgery-related quality of life.

Clinical periodontal measurements

The following clinical parameters were assessed immediately before surgery (baseline), after 1, 3 and 6 months using a manual periodontal probe (Williams periodontal probe, Hu-Friedy, Chicago, IL, USA): 1) plaque index (PI); (22) 2) gingival index (GI); (23) 3) bleeding on probing (BOP); (24) 4) probing depth [PD] was measured as the distance between the margin of the peri-implant mucosa and the base of the peri-implant sulcus, and were recorded at four sites (mesio-buccal, mid-buccal, distobuccal and palatal); 4) mucosal recession [MR] was measured at mid-buccal aspect of the implant sites as the distance between the level of the implant-abutment junction and the margin of the peri-implant mucosa; 5) clinical attachment levels (CAL) was measured from the implant-abutment junction to the base of the peri-implant sulcus; 6) width of KM (KMW) at the buccal sites of the implants was measured from the margin of the peri-implant mucosa to the mucogingival junction; 7) thickness of KM (KMT) was measured at mid-buccal aspect of the implant sites, 1 mm apical to the peri-implant mucosal

margin within keratinized mucosa using a 15 endodontic reamer (Merkez Diş Malz, Ankara, Turkey) attached to a rubber stopper under the local anesthesia. The distance between the tip of the reamer and the rubber stopper was measured with a digital caliper with 0.05 resolutions (Alpha Tools, Mannheim, Germany).

Surgical procedure

All the operations were performed by the same periodontist under local anesthesia. A horizontal split-thickness incision was made at the mucogingival border with a #15c blade (Swann-Morton, Sheffield, England) and a mucosal partial thickness flap was raised. The mucosal flap was sutured to the apical region of the periosteum to create vestibular depth with 5-0 resorbable sutures (Dogsan Surgical Sutures, Trabzon, Turkey). A FGG was obtained from the donor site in the region between the first premolars and second molars and sutured in the recipient site with interrupted sutures using 5-0 non-resorbable silk sutures (Dogsan Surgical Sutures, Trabzon, Turkey). When necessary, to stabilize the graft, a horizontal mattress suture was anchored to the periosteum apical to the graft and suspended around the lingual aspect of the implants (Figure 1).

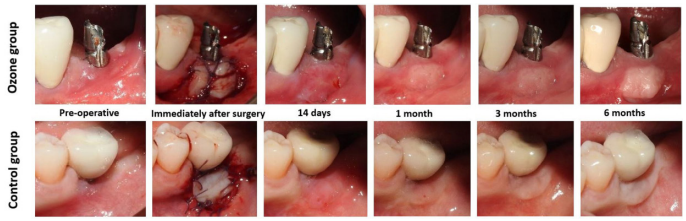

Figure 1. Clinical views of the ozone and control groups at study follow-up periods

The graft length (horizontal), width (vertical) and thickness (mean of each corner and middle of the graft values) were recorded immediately after harvesting the graft. The surface area of FGG was calculated using the following formula: graft surface area (mm^2):

graft length (mm) x graft width (mm). FGG dimensional changes between postoperative follow-up periods were calculated based on the following formula: the percentage of graft contraction (graft shrinkage): 100 x ([baseline dimension–postoperative dimension]) /baseline dimension (25)

Ozone protocol

The patients allocated for the ozone group received the following protocol for ozone application: The ozone delivery system (Ozone DTA Ozone Generator (DentaTec Dental AS, Norway) was used according to the manufacturer's information. Ozone was applied on recipient sites at a fixed concentration of 2100 p.p.m. through a connected handpiece, using a sterile, specially formed perio-tip with 80% oxygen for 30 seconds (Figure 2). The applications were performed immediately after surgery and at days 1, 3, 7 and 14 post-surgery. The patients allocated to the control group received ozone application without starting the ozone generator.

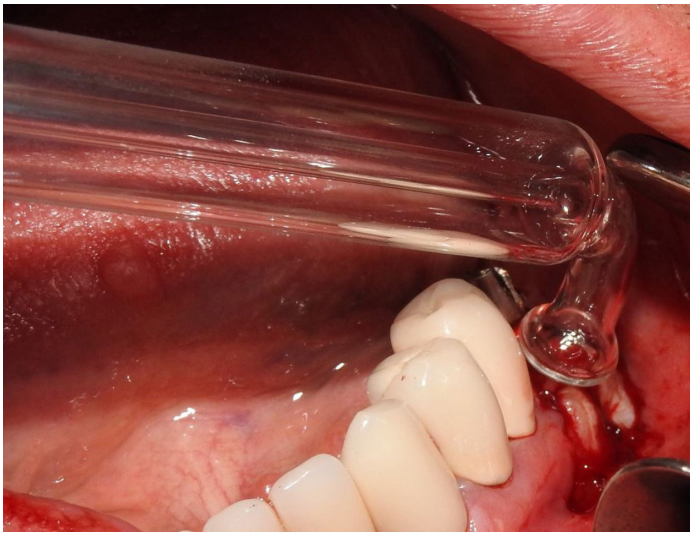

Figure 2. The application of topical ozone therapy

Postoperative instructions

The patients were instructed to provide plaque control using 0.12% chlorhexidine rinse used twice a day during 2 weeks and to take 100 mg flurbiprofen (Majezik, Sanovel Pharmaceuticals INC, Istanbul, Tukey) in case of pain or swelling. The patients were prompted to record the number of analgesic tablet taken. The sutures were removed after 14 days.

Moreover, to assess the patient's pain perception, they were instructed to record their pain experience by pointing in a visual analog scale (VAS) from 0 (absence of pain) to 10 (severe pain) at day 1, 3, 7 and 14 postoperatively. The patients were also given a self-administered questionnaire, the Turkish version of the Oral Health Impact Profile (OHIP)-14 (26) to evaluate the impact of the surgical procedures on quality of life at day 14 postoperatively. The questionnaire was consisted of 14 items arranged in seven conceptual domains of impact: Functional limitation (trouble pronouncing words and worsened taste), physical pain (painful aching in mouth and uncomfortable eating foods), psychological discomfort (feeling self-conscious and tense), physical disability (interrupted meals and unsatisfactory diet), psychological disability (difficulty in relaxtation and embarrassment), social disability (irritability and difficulty in performing usual jobs) and handicap (life less satisfying and total inability to function) (27). The patients were instructed to answer in a five-point scale having scores as 'never' (0), 'hardly ever' (1), 'occasionally' (2), 'fairly often' (3), and 'very often' (4)

Statistical analyses

The sample size calculation was performed to detect the value of 0.9 mm considering the increase in width of the KMW value which was defined as the main outcome variable. The sample size was calculated using $\alpha = 0.05$ and the power of 80%, as previously described (28). On the basis of these data, 12 subjects would be necessary for each group. To allow for possible dropouts, 15 patients were included in the final analysis of this study. The single implant site was assigned as the unit of statistical analysis.

Descriptive data were reported for all outcome variables as the mean ± standard deviation (mean ± SD). The Shapiro-Wilk test was performed for multivariate normality. The Levene test was used to examine the homogeneity of variance. For comparisons of the differences between the groups, Mann-Whitney U and Student t tests were used to analyze non-parametric and parametric data, respectively. For comparisons of the differences within the groups, the Paired t-test was used if the assumptions of normal distribution were provided, and the Wilcoxon Sign Ranks test was used in cases where the assumptions were not provided. The VAS value was examined by repeated measures of ANOVA to evaluate the differences within and between groups, followed by Bonferroni post hoc tests. Data analysis was performed using statistical software (Version 24; IBM SPSS, Inc., Chicago, IL, USA). A level of significance was defined as $p \leq 0.05$.

RESULTS

Study population and implants' characteristics

Of the totally 32 patients recruited for this study, two patients did not attend the follow up visits exactly. Thus, complete data were available consisting of 15 patients in each treatment group.

The mean age of patients was 50.6 ± 2.62 years in the ozone group and 53.42 ± 3.9 years in the control group. None of the patients in any group suffered any significant complication and all the surgical sites healed uneventfully. Thirty single-unit rough-surfaced implants from six different manufacturers were included in this study. From all the affected implant sites, 2 implants were located in maxillary posterior area, 6 implants were located in mandibular anterior area, whereas the highest prevalance rates of implants were seen in mandibular posterior area (n=22). The mean functional loading time of the implants were 5.42 ± 1.65 years in the ozone group and 5.23 ± 1.38 years in the control group. The mean graft length and width was 7.6 ± 1.18 mm and 9.13 ± 1.24 mm for the ozone group, 7.8 ± 1.52 mm and 9.46 ± 1.5 mm for the control group, respectively. The mean graft thickness was 1.17 ± 0.21 mm in the ozone group and 1.18 ± 0.21 mm in the control group.

Clinical examinations

In terms of the keratinized mucosa dimensions, statistically significant increases were observed for the 1-, 3- and 6-month measurements compared to baseline measurements for the mean KMW and KMT values in both treatment methods ($p<0.05$), while there were no significant differences regarding to these values between the ozone and control groups at any study follow-up periods ($p>0.05$) (Table 1).

Table 1. Intra- and Intergroup Comparisons of Clinical Parameters for the Treatment Groups

Parameters		Baseline	1 Month	3 Month	6 Month	P value (Baseline - 6 Months)
PI	Ozone Group	0.28 ± 0.38	0.35 ± 0.45	0.30 ± 0.27	0.21 ± 0.26	0.527[a]
	Control Group	0.40 ± 0.42	0.36 ± 0.43	0.23 ± 0.29	0.28 ± 0.33	0.230[a]
	P value	0.805[c]	0.390[c]	0.443[c]	0.642[c]	
GI	Ozone Group	0.04 ± 0.06	0.20 ± 0.41	0.03 ± 0.08	0.00 ±-	0.317[b]
	Control Group	0.05 ± 0.14	0.23 ± 0.41	0.03 ± 0.08	0.01 ± 0.06	0.414[b]
	P value	0.875[d]	0.797[d]	1.000[d]	0.040[d]	
BOP (%)	Ozone Group	13.33 ± 15.99	33.33 ± 22.49	26.66 ± 17.59	15.26 ± 18.21	0.627[a]
	Control Group	20.00 ± 19.36	38.33 ± 29.68	31.66 ± 34.76	35.00 ± 31.05	0.090[a]
	P value	0.340[c]	0.620[c]	0.913[c]	0.094[c]	
PD (mm)	Ozone Group	3.20 ± 1.09	3.06 ± 0.99	2.81 ± 0.88	2.98 ± 0.97	0.139[a]
	Control Group	3.21 ± 1.22	3.18 ± 1.32	2.98 ± 1.17	3.31 ± 1.58	0.474[a]
	P value	0.901[c]	0.884[c]	0.835[c]	0.560[c]	
MR (mm)	Ozone Group	0.53 ± 0.67	0.18 ± 0.29	0.12 ± 0.39	0.12 ± 0.39	0.017[b]
	Control Group	0.51 ± 0.65	0.28 ± 0.55	0.40 ± 0.59	0.31 ± 0.54	0.075[b]
	P value	0.457[d]	0.158[d]	0.217[d]	0.271[d]	
CAL (mm)	Ozone Group	3.73 ± 1.15	3.25 ± 1.00	2.94 ± 0.85	3.10 ± 0.92	0.030[d]
	Control Group	3.73 ± 1.05	3.46 ± 1.30	3.36 ± 1.20	3.66 ± 1.55	0.752[d]
	P value	0.967[c]	0.429[c]	0.278[c]	0.212[c]	
KMW (mm)	Ozone Group	0.33 ± 0.61	5.66 ± 1.39	5.33 ± 1.17	5.13 ± 1.30	<0.001[b]
	Control Group	0.46 ± 0.85	5.10 ± 1.83	4.50 ± 1.95	4.20 ± 1.78	<0.001[b]
	P value	0.443[d]	0.485[d]	0.125[d]	0.311[d]	
KMT (mm)	Ozone Group	0.24 ± 0.41	3.02 ± 0.72	2.96 ± 0.85	2.92 ± 0.84	<0.001[a]
	Control Group	0.37 ± 0.61	2.88 ± 0.91	2.75 ± 0.85	2.56 ± 0.68	<0.001[a]
	P value	0.590[c]	0.506[d]	0.553[c]	0.334[c]	

a:Wilcoxon Signed Ranks Test, b:Paired-t test, c:Mann-whitney U test, d:Student-t test, PI: plaque index, GI: gingival index, BOP: bleeding on probing, PD: probing depth, MR: mucosal recession, CAL: clinical attachment level, KMW: keratinized mucosal width, KMT: keratinized mucosal thickness

A marked graft contraction was found in both groups between surgery and the 1-month follow-up (baseline contraction), while less percentage of contraction was seen between 1st and 3rd months and 3rd and 6th months of examinations compared to baseline contraction levels. There were significant differences between the groups for baseline contraction and the contraction between 1st and 3thmonths of examinations favor of ozone group (p<0.05) (Table 2).

Table 2. The Mean Graft Contraction in the Treatment Groups

	0- 1 month	1 – 3 months	3 – 6 months
Ozone Group (%)	23.78 ± 20.91	5.96 ± 12.11	5.21 ± 9.13
Control Group (%)	37.75 ± 17.25	13.95 ± 17.67	9.28 ± 12.01
P value	0.046[b]	0.043[a]	0.271[a]

a: Student-t test , b: Mann Whitney U test

The mean PI, GI and BOP values were lower for both groups at 6th month compared to baseline values but the differences were not statistically significant (p>0.05). At 6 months postoperatively, the mean PI and BOP values did not reveal a statistically significant difference between the groups, whereas ozone group exhibited lower GI values compared to control group at the same study period (p<0.05) (Table 1).

When considering the mean PD values, a slight decrease was observed at 6 months compared to baseline for the ozone group, however this difference was not statistically significant (p>0.05). Contrarily, there was an insignificant increase at 6th month compared to baseline for the control group in terms of the mean PD value (p>0.05). Ozone group demonstrated a mean decrease of about 0.4 mm of MR value at 6 months and this difference was statistically significant compared to baseline value (p<0.05), while the corresponding decrease was about 0.2 mm at 6th month for the control group, although not significantly (p>0.05). Similar to the mean MR values, ozone group exhibited a statistically significant decrease in the mean CAL value (p<0.05), however the increase was not statistically significant for the control group (p>0.05). Between group comparisons, statistical analysis failed to reveal any significant difference in the mean MR and CAL values at all follow-up periods (p>0.05).

Postoperative discomfort and quality of life

Significant differences were observed between the groups at 14th day regarding the subjects of physical and social disability in the quality of life favor of ozone group (p<0.05), while there was no statistically significant difference in terms of Total OHIP scores between the groups (p>0.05) (Table 3).

The mean VAS scores exhibiting postoperative pain showed no statistically significant differences between the groups for all study periods (p>0.05) (Figure 3). The amounts of systemic analgesic consumption were 2.06 ± 1.89 tablets and 2.66 ± 1.98 tablets in the ozone and control groups, respectively and the difference between the groups was not statistically significant (p>0.05).

Table 3. Comparisons of the Mean of the Seven Major Subscales of the OHIP-14 TR Scale Between the Groups

OHIP-14		N	Mean±SD	Min	Max	P value
Functional limitation	Ozone Group	15	2.08 ± 1.78	0.00	5.00	0.072[a]
	Control Group	15	3.41 ± 1.67	0.00	6.00	
Physical pain	Ozone Group	15	1.75 ± 0.96	0.00	4.00	0.149[b]
	Control Group	15	2.66 ± 1.77	0.00	5.00	
Psychological discomfort	Ozone Group	15	1.58 ± 1.88	0.00	4.00	0.927[b]
	Control Group	15	1.66 ± 1.61	0.00	4.00	
Physical disability	Ozone Group	15	0.66 ± 1.30	0.00	4.00	0.030[b]
	Control Group	15	3.00 ± 1.90	0.00	6.00	
Psychological disability	Ozone Group	15	1.16 ± 1.11	0.00	3.00	0.257[b]
	Control Group	15	1.75 ± 1.28	0.00	4.00	
Social disability	Ozone Group	15	0.58 ± 0.90	0.00	2.00	0.033[b]
	Control Group	15	1.83 ± 1.58	0.00	5.00	
Handicap	Ozone Group	15	0.41 ± 0.90	0.00	3.00	0.110[b]
	Control Group	15	1.00 ± 1.12	0.00	3.00	
TOHIP	Ozone Group	15	8.25 ± 5.49	2.00	21.0	0.543a
	Control Group	15	15.33±6.59	4.00	27.0	

a: Student-t test , b: Mann Whitney U test, TOHIP: Total OHIP score

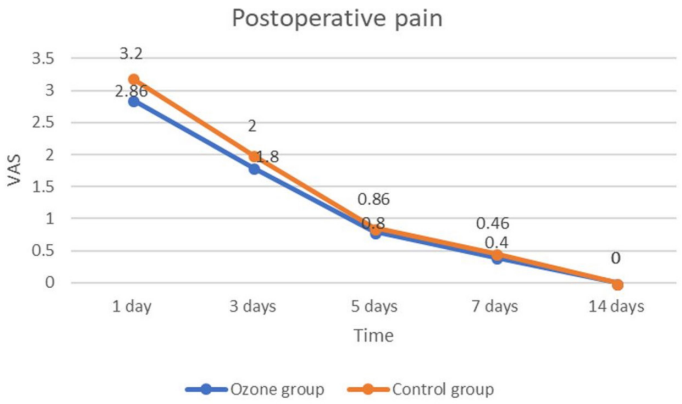

Figure 3. Comparison of postoperative measurements in terms of postoperative pain between the groups. *, p<0.05 considered statistically significant, Mann-Whitney U test

DISCUSSION

The present study was evaluated the effect of ozone therapy on the FGG healing around the implants exhibiting inadequate KM at a 6th month postoperative duration. The findings of the study demonstrated that ozone therapy provided significant benefit in the mean CAL and MR values at the end of the study compared to baseline values. At 6th month, the implant sites treated with ozone showed significantly lower mucosal inflammation.

It has been stated that KM augmentation using FGG around the implants provides to reduce mucosal inflammation, to increase attachment gain and to and to maintain crestal bone level (6,29). Oh et al. (29) has reported that FGG procedure is a predictable treatment option compared to oral prophylaxis without augmentation especially for

managing the early stages of peri-implant infection in sites with inadequate KMW. Similar outcomes were also noted in the study by Askin et al, (30) demonstrating significant improvements in clinical and inflammatory parameters around the implants with FGG procedures.

Recent evidence has suggested ozone therapy as a safe adjunct treatment modality that facilitates wound healing and cell proliferation and improves the supply of blood (18,31,32). After surgical procedures, a diverse range of biological events in relation to the wound healing can be improved by ozone therapy such as rapid keratinization and enhanced blood circulation and neovascularization (18,31). Patel et al. (31) stated better gingival healing when applied ozonized oil on FGG grafted sites compared to spontaneous healing. Similarly, Tasdemir et al. (18) indicated that ozone therapy can have improvements in FGG wound healing by increasing blood perfusion.

In this study, a statistically significant amount of keratinized mucosa achieved with both treatment procedures. At 6th month postoperatively, the mean KMW and KMT values were higher in the ozone group compared to control group which differences were not statistically significant (5.13 ± 1.30 mm and 2.92 ± 0.84 mm for the ozone group and 4.20 ± 1.78 mm and 2.56 ± 0.68 mm for the control group, respectively). The mean KMW obtained with the present treatment procedures is consistent with the results of the previous studies (between 3.10 mm and 4.40 mm) (29,30,33). However, the contractions of the grafted area between baseline and 1 month and between 1st and 3th months were significantly lower in the ozone group compared to spontaneous healing. It was stated that the transplanted FGGs demonstrated about 38–45% of graft shrinkage during 1 month postoperatively (34). Similarly, in our study, the graft contraction at a 1-month follow-up period was 37.75% in the control group, while ozone therapy showed less graft shrinkage at the same time point (23.78%).

In the present study, applied ozone therapy protocol showed significant clinical attachment gain and recession reduction, however control group did not reveal significant improvements for these parameters. Although mucosal coverage for exposed implant threads was not the primary purpose of the FGG procedure, adjunctive ozone therapy combined with FGG surgery provided significant mucosal coverage at the end of the study. The application of ozone therapy provided almost 0.4 mm mucosal coverage, while 0.2 mm mucosal coverage was obtained in the control group at 6 months postoperatively. These findings are in agreement with data presented in the study by Oh et al., (29) which reported a reduction of MR values in the FGG grafted sites around the implants at the end of their study. Moreover, the present study findings presented significantly lower GI values for ozone therapy at 6th month postoperatively. This finding could be explained by the fact that ozone group had higher mucosal coverage that was related with improved mucosal texture and lower mucosal inflammation. On the other hand, it could also be related with antimicrobial property of ozone therapy and the effects of it on the immune response (18).

Several studies have highlighted that periodontal plastic surgeries affects the quality of life negatively (35-37). It was also reported that FGG transplantation can give rise to major complications, such as postoperative pain, bleeding and sensation loss, which can cause severe disturbances to patient's quality of life (38). Moreover, it has been suggested that ozone therapy is an effective treatment procedure that improve quality of life through the stimulation of the neuroendocrine system and releasing of endorphins possibly increasing release of seratonin (20). Taşdemir et al. (18) demonstrated that the patients received ozone therapy declared significantly lower total OHIP score than control group at a postoperative 6th day. On the contrary, no significant difference was found between ozone and control group regarding to the mean total OHIP score at a postoperative 14th day in our study. However, when considering the conceptual domains of impact, ozone-treated group showed significantly lower scores in terms of physical and social disability. Paralleling to the mean total OHIP score, ozone group did not reveal a significantly lower VAS score exhibiting postoperative pain.

Within the limitations of the study, the present results indicate that adjunctive ozone therapy to the FGG procedures did not provide any beneficial impact for the dimension of obtained KM around the implants at 6th month. However, ozone therapy may give rise to less graft shrinkage during the healing period and moreover, to have less inflammation around the mucosal margin. Ozone therapy also indicated better results in terms of physical and social features during postoperative period.

Competing interests: The authors declare that they have no competing interest.
Financial Disclosure: There are no financial supports
Ethical approval: The present study design was approved by the Institutional Review Board at Ankara University, Faculty of Dentistry, Ankara, Turkey (Protocol ID: 36290600/25)

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