



Top 100 Most Cited Articles on the use of Ozone in Dentistry: Bibliometric Analysis

Olga Beatriz Lopes Martins ^a, Marco Túllio Becheleni ^{a*},
Ricardo Grillo ^b, Endi Lanza Galvão ^c
and Saulo Gabriel Moreira Falci ^a

^a Department of Oral and Maxillofacial Surgery, School of Dentistry, Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, MG, Brazil.

^b Department of Oral and Maxillofacial Surgery, Faculdade São Leopoldo Mandic, Campinas, SP, Brazil.

^c Department of Physical Therapy, School of Biological and Health Sciences, Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, MG, Brazil.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/acri/2024/v24i8845>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/122415>

Systematic Review Article

Received: 20/06/2024
Accepted: 28/08/2024
Published: 01/09/2024

ABSTRACT

Introduction: c density (number of citations per year), first author's country, year of publication, study design and subject. VOSviewer software was used to create graphical bibliometric maps.

*Corresponding author: Email: marco.becheleni@ufvjm.edu.br;

Cite as: Martins, Olga Beatriz Lopes, Marco Túllio Becheleni, Ricardo Grillo, Endi Lanza Galvão, and Saulo Gabriel Moreira Falci. 2024. "Top 100 Most Cited Articles on the Use of Ozone in Dentistry: Bibliometric Analysis". *Archives of Current Research International* 24 (8):14-34. <https://doi.org/10.9734/acri/2024/v24i8845>.

Results: The total number of citations papers which from 13 to 180, and only eight were cited more than 100 times. Papers were published from 1997 to 2022, mainly in dentistry journals. The studies originated from 30 different countries and the most papers were from Germany (16%) and Turkey (15%). In total, 250 keywords were used and the most used were ozone 50 (20%), dentistry 8 (3,2%) and periodontitis 7 (2,8%).

Conclusions: 1) Germany was the main country that contributed to field research on the use of ozone in dentistry 2) The University of Basel was the most productive university in the researched field; 3) Clinical Oral Investigations was the journal that led the ranking with the most articles published, 4) The keyword ozone was the most used in the articles; 5) Oral and maxillofacial surgery was the research area most addressed by the 100 most cited articles.

Keywords: Bibliometrics; citation analysis; ozone; dentistry.

ABBREVIATIONS

AD	: Annals of Dermatology
ADJ	: Australian Dental Journal
AJD	: American Journal of Dentistry
AMR	: Archives of Medical Research
AMS	: Advances in Medical Sciences
AO	: Angle Orthodontist
ASB	: Applied Sciences- Basel
B	: Biomaterials
BF	: Biofactors
BOH	: BMC Oral Health
BOR	: Brazilian Oral Research
BRI	: Biomed Research International
CA	: Collegium Antropologicum
CDSR	: Cochrane Database Of Systematic Reviews
COI	: Clinical Oral Investigations
COIR	: Clinical Oral Implants Research
CR	: Caries Research
DM	: Dental Materials
DMJ	: Dental Materials Journal
DT	: Dental Traumatology
EJPS	: European Journal of Oral Sciences
HTA	: Health Technology Assessment
IEJ	: International Endodontic Journal
IJER	: International Journal of Environmental Research and Public Health
IJOMI	: International Journal of Oral & Maxillofacial Implants
IJOMS	: International Journal of Oral and Maxillofacial Surgery
IJP	: International Journal of Prosthodontics
IN	: Interventional Neuroradiology
JAD	: Journal of Adhesive Dentistry
JAOS	: Journal of Applied Oral Science
JBO	: Journal of Bone Oncology
JCPD	: Journal of Clinical Pediatric Dentistry
JCS	: Journal of Craniofacial Surgery
JD	: Journal of Dentistry
JDR	: Journal of Dental Research
JDS	: Journal of Dental Sciences
JE	: Journal of Endodontics
JERD	: Journal of Esthetic and Restorative Dentistry
JFMA	: Journal of the Formosan Medical Association
JP	: Journal of Periodontology
JPIERD	: Journal of Prosthodontics-Implant Esthetic and Reconstructive Dentistry

JPIS : *Journal of Periodontal and Implant Science*
JPR : *Journal of Periodontal Research*
JPRE : *Journal of Pain Research*
LMS : *Lasers in Medical Science*
LSM : *Lasers in Surgery and Medicine*
MGR : *Medical Gas Research*
MSE : *Materials Science & Engineering C-Materials for Biological Applications*
NM : *New Microbiologica*
O : *Odontology*
OMI : *Oral Microbiology and Immunology*
OO : *Oral Oncology*
OSE : *Ozone- Science & Engineering*
QUADO: *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology*
PLS : *Photomedicine and Laser Surgery*
PPT : *Photodiagnosis and Photodynamic Therapy*
QI : *Quintessence International*
SDJ : *Swedish Dental Journal*
SR : *Scientific Reports*
STAM : *Science and Technology of Advanced Materials*

1. INTRODUCTION

Ozone is an immunostimulant, antimicrobial, and biocompatible agent [1], and there is evidence of its effectiveness as a therapeutic agent in both medicine and dentistry [2].

In dentistry specifically, it is used through various indirect application methods, including gaseous ozone generators, ozonated water, and ozonated oil [3]. These diverse applications are being studied across several specialties, such as endodontics [4-6], restorative dentistry [2,7,8], oral medicine [9-11], surgery [12-14], periodontics [3,15,16], implantology [17-19], among others.

Although laboratory studies suggest a favorable potential for ozone use in dentistry, clinical evidence supporting its routine application as a treatment modality remains limited. Therefore, well-designed studies are essential to assess the efficacy and safety of this therapeutic approach [20].

Generally, studies with the highest methodological rigor are published in journals with the greatest impact. Consequently, bibliometric analyses have emerged to identify significant articles that influence medical practice and inspire new research ideas [21]. These bibliometric methods evaluate the quality, credibility, and impact of studies [22,23] through citation analyses, which assess research performance [24] and determine whether it has achieved its objectives in a specific area of health research [25]. As a result, they assess

numerous publications from institutions across different countries [26].

In 2021, the PubMed database recorded over three hundred bibliometric review articles in the health field, focusing on evaluating the top 100 cited articles within their areas of interest, many of which were related to Dentistry [27]. However, a search using the MeSH descriptors 'Bibliometrics' AND 'ozone therapy' AND 'dentistry' yielded no results in this database. Consequently, a bibliometric study on the use of ozone therapy in dentistry could significantly contribute to the scientific literature by guiding future research and publications. It would enable researchers to track the progress of studies in this area and deepen their understanding.

Thus, the objective of this bibliometric analysis was to identify and classify the 100 most cited articles related to the clinical use of ozone in dentistry.

2. MATERIALS AND METHODS

"The literature search was conducted following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, using the Clarivate Analytics Web of Science database. This methodology is similar to that described in a previous study, which analyzed the ranking of the 100 most cited articles related to orthognathic surgery, and another study, which focused on the 100 most cited articles concerning third molar surgery. As a review, this study is exempt from research ethics board approval" [27-28].

2.1 Search Strategy

A search was conducted on October 10, 2022, using Clarivate Analytics' Web of Science database. The search terms included "ozone" or "ozone therapy" or "ozonized" combined with "dentistry" or "dental" in the title and/or abstract. The results were extracted into a table using Microsoft Excel and organized in descending order of citation count. Manuscripts were selected by two independent, previously calibrated researchers.

To be included in this study, publications needed to mention ozone in the title and/or abstract. Publications unrelated to the topic were excluded. There were no restrictions on the year of publication, journal impact factor, study design, or manuscript language.

The most cited articles were manually analyzed for the following information from the Clarivate Analytics Web of Science database: number of citations, year of publication, journals, keywords, authors, contributing institutions, countries, and research fields in dentistry. The country of origin and contributing institution of each article were determined based on the address provided for the first corresponding author.

The number of articles and citations per article were graphed using the Statistical Package for the Social Sciences (SPSS version 22.0). The relationship between authors was determined

based on how frequently they cited each other, using network visualization created with VOSviewer software (Leiden University, Netherlands).

3. RESULTS

The initial search identified 743 articles in the database. After reviewing titles and abstracts, the 100 most cited manuscripts involving ozone in dentistry were listed in Table 1, ordered by citation count. The study selection process, including the search strategy used in the database, is summarized in a flow diagram (Fig. 1).

3.1 Authors Publications and Citations

The number of authors ranged from one to twelve, with a mean of 4.80 ± 2.23 . The authors and co-authors with the highest number of publications among the top 100 were Edward Lynch (8), Reinhard Hickel (5), and Hakki Oguz Kazancioglu (5). Fig. 2 provides a graphical representation of the network between the authors.

The articles with the highest number of citations among the top 100 were by Fliefel R (2015) with a total of 180 citations, Azarpazhooh A (2008) with 158 citations, and Baysan A (2000) with 146 citations. The number of citations ranged from 13 to 180, with a mean of 38.56 ± 33.06 . Only 8 articles reached 100 citations (Table 1).

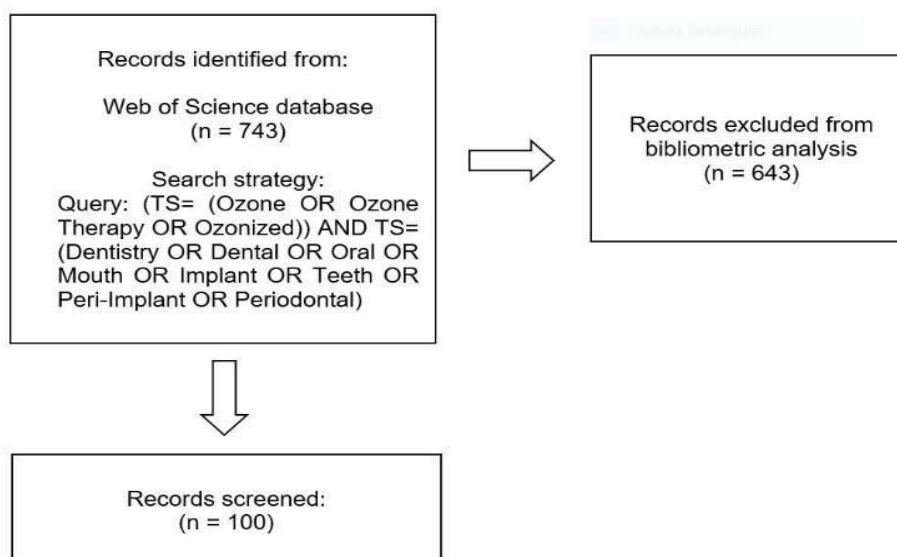


Fig. 1. Flow diagram of the study selection process and search strategy

Table 1. The top 100 cited studies about ozone in dentistry

Rank	Author	Title	Publication year	Journal	Institution	Citations
1	Fliefel R et al	Treatment strategies and outcomes of bisphosphonate-related osteonecrosis of the jaw (BRONJ) with characterization of patients: a systematic review	2015	IJOMS	Universitat Munich	180
2	Azarpazhooh A, Limeback H	The application of ozone in dentistry: A systematic review of literature	2008	JD	University Toronto	158
3	Baysan A et al	Antimicrobial effect of a novel ozone-generating device on micro-organisms associated with primary root carious lesions in vitro	2000	CR	Royal London School of Medicine and Dentistry	146
4	Nagayoshi M et al	Efficacy of ozone on survival and permeability of oral microorganisms	2004	OMI	Kyushu Dental College	136
5	Muller P et al	Efficacy of gasiform ozone and photodynamic therapy on a multispecies oral biofilm in vitro	2007	EJPS	University of Zurich	113
6	Kuhl S et al	Bisphosphonate-related osteonecrosis of the jaws - A review	2012	OO	University of Basel	104
7	Wierichs R, Meyer-Lueckel H	Systematic Review on Noninvasive Treatment of Root Caries Lesions	2015	JDR	RWTH Aachen University	104
8	Huth KC et al	Effect of ozone on oral cells compared with established antimicrobials	2006	EJPS	Ludwig- Maximilians University	101
9	Estrela C et al	Antimicrobial efficacy of ozonated water, gaseous ozone, sodium hypochlorite and chlorhexidine in infected human root canals	2007	IEJ	Universidade Federal de Goiás	99
10	Baysan, A; Lynch, E	Effect of ozone on the oral microbiota and clinical severity of primary root caries	2004	AJD	University Birmingham	97
11	Foschi F et al	Photodynamic inactivation of Enterococcus faecalis in dental root canals in vitro	2007	LSM	The Forsyth Institute	97
12	Ripamonti CI et al	Efficacy and safety of medical ozone (O-3) delivered in oil suspension applications for the treatment of osteonecrosis of the jaw in patients with bone metastases treated with bisphosphonates: Preliminary results of a phase I-II study	2011	OO	National Cancer Institute of Milan	78

13	Huth KC et al	Effectiveness of ozone against endodontopathogenic microorganisms in a root canal biofilm model	2009	IEJ	LudwigMaximilians University	65
14	Polydorou O et al	Antibacterial effect of an ozone device and its comparison with two dentin-bonding systems	2006	EJPS	Albert-Ludwigs University Freiburg	59
15	Stubinger S et al	The use of ozone in dentistry and maxillofacial surgery: A review	2006	QI	University of Basel	59
16	Agrillo A et al	Ozone therapy in the treatment of avascular bisphosphonate-related jaw osteonecrosis	2007	JCS	University of Rome La Sapienza	56
17	Huth KC et al	Effect of ozone on non-cavitated fissure carious lesions in permanent molars. A controlled prospective clinical study	2005	AJD	University Munich	50
18	Kazancioglu HO et al	Comparison of the influence of ozone and laser therapies on pain, swelling, and trismus following impacted third-molar surgery	2014	LMS	Bezmi Alem Vakif University	49
19	Rapone B et al	The Effect of Gaseous Ozone Therapy in Conjunction with Periodontal Treatment on Glycated Hemoglobin Level in Subjects with Type 2 Diabetes Mellitus: An Unmasked Randomized Controlled Trial	2020	IJER	Aldo Moro University of Bari	46
20	Duangthip D et al	Non-surgical treatment of dentin caries in preschool children - systematic review	2015	BOH	University of Hong Kong	42
21	Cardoso MG et al	Effectiveness of ozonated water on Candida albicans, Enterococcus faecalis, and endotoxins in root canals	2008	QUAD O	University of Taubaté	42
22	Hayakumo S et al	Clinical and microbiological effects of ozone nano-bubble water irrigation as an adjunct to mechanical subgingival debridement in periodontitis patients in a randomized controlled trial	2013	COI	Tokyo Medical and Dental University	41
23	Bitter K et al	Bond strength of fiber posts after the application of erbium: yttrium-aluminum-garnet laser treatment and gaseous ozone to the root canal	2008	JE	Charité-Universitätsmedizin Berlin	41
24	Polydorou O et al	The antibacterial effect of gas ozone after 2 months of in vitro evaluation	2012	COI	University Medical Center Freiburg	41
25	Agrillo A et al	New therapeutic protocol in the treatment of avascular necrosis of the jaws	2006	JCS	University of Rome La Sapienza	41

26	Case PD et al	Treatment of Root Canal Biofilms of <i>Enterococcus faecalis</i> with Ozone Gas and Passive Ultrasound Activation	2012	JE	The University of Queensland	41
27	Schmidlin PR et al	Effect of ozone on enamel and dentin bond strength	2005	JAD	University of Zurich	41
28	Kazancioglu HO et al	Effects of ozone therapy on pain, swelling, and trismus following third molar surgery	2014	IJOMS	Bezmialem Vakif University	39
29	Kazancioglu HO et al	Effects of Laser and Ozone Therapies on Bone Healing in the Calvarial Defects	2013	JCS	Bezmialem Vakif University	38
30	Hayakumo S et al	Effects of ozone nano-bubble water on periodontopathic bacteria and oral cells - in vitro studies	2014	STAM	Tokyo Medical and Dental University	37
31	Krozer A et al	Chemical treatment of machined titanium surfaces - An in vitro study	1999	COIR	Lund University	37
32	Al Habashneh R et al	Ozone as an adjunct to conventional nonsurgical therapy in chronic periodontitis: a randomized controlled clinical trial	2015	JPR	Jordan University of Science and Technology	37
33	Ebensberger U et al	PCNA-expression of cementoblasts and fibroblasts on the root surface after extraoral rinsing for decontamination	2002	DT	University of Basel	37
34	Ozgul BM et al	Clinical Evaluation of Desensitizing Treatment for Incisor Teeth Affected by Molar- Incisor Hypomineralization	2013	JCPD	Ankara University	36
35	Raeissadat SA et al	Intra-articular ozone or hyaluronic acid injection: Which one is superior in patients with knee osteoarthritis? A 6-month randomized clinical trial	2018	JPRE	Shahid Beheshti University	35
36	Cho H et al	Postoperative interventions to reduce inflammatory complications after third molar surgery: review of the current evidence	2017	ADJ	The University of Queensland	35
37	Kustarci A et al	Bactericidal effect of KTP laser irradiation against <i>Enterococcus faecalis</i> compared with gaseous ozone: an ex vivo study	2009	QUAD	Cumhuriyet University	34
38	Rollason V et al	Interventions for treating bisphosphonate-related osteonecrosis of the jaw (BRONJ)	2016	CDSR	Geneva University Hospitals	34
39	Yilmaz S et al	Evaluation of the Clinical and Antimicrobial Effects of	2013	PLS	Yeditepe University	34

the Er:YAG Laser or Topical Gaseous Ozone as Adjuncts to Initial Periodontal Therapy						
40	Kronenberg O et al	Preventive Effect of Ozone on the Development of White Spot Lesions during Multibracket Appliance Therapy	2009	AO	University of Bern	34
41	Huth KC et al	Effectiveness of ozone against periodontal pathogenic microorganisms	2011	EJPS	Ludwig Maximilians University	34
42	Rapone B et al	The Gaseous Ozone Therapy as a Promising Antiseptic Adjuvant of Periodontal Treatment: A Randomized Controlled Clinical Trial	2022	IJER	Aldo Moro University of Bari	33
43	Dahnhardt JE et al	Treating open carious lesions in anxious children with ozone. A prospective controlled clinical study	2006	AJD	University of Bern	33
	Hauser-Gerspach I et al	Influence of gaseous ozone in peri-implantitis: bactericidal efficacy and cellular response. An in vitro study using titanium and zirconia	2012	COI	University of Basel	32
45	Shi XL et al	Partial oxidation of TiN coating by hydrothermal treatment and ozone treatment to improve its osteoconductivity	2016	MSE	Jiangsu University of Science and Technology	31
	Chidambaranathan AS et al	Comprehensive Review and Comparison of the Disinfection Techniques Currently Available in the Literature	2019	JPIERD	SRM Dental College	30
47	Matsumura, K et al	Surface modification of poly(ethylene-co-vinyl alcohol): hydroxyapatite immobilization and control of periodontal ligament cells differentiation	2004	B	Kyoto University	30
	Bezirtzoglou E et al	A quantitative approach to the effectiveness of ozone against microbiota organisms colonizing toothbrushes	2008	JD	Democritus University of Thrace	30
49	Manton DJ et al	Effect of ozone and Tooth Mousse (TM) on the efficacy of peroxide bleaching	2008	ADJ	The University of Melbourne	30
50	Magni E et al	Effect of ozone gas application on the mechanical properties of dental adhesives bonded to dentin	2008	DM	University of Siena	29
	Montevecchi M et al	Comparison of the antibacterial activity of an ozonated oil with chlorhexidine digluconate and povidone-iodine. A disk diffusion test	2013	NM	University of Bologna	29
	Kazancioglu HO, Erisen M	Comparison of Low-Level Laser Therapy versus Ozone Therapy in the Treatment of Oral Lichen Planus	2015	AD	Bezmialem Vakif University	28
	Azarpazhoob A et al	Evaluating the Effect of an Ozone Delivery System on the Reversal of Dentin Hypersensitivity: A Randomized, Double-blinded Clinical Trial	2009	JE	University of Toronto	28
	Skurska A et al	Evaluation of the influence of ozonotherapy on the clinical parameters and MMP levels in patients with chronic and aggressive periodontitis	2010	AMS	Medical University of Bialystok	28
	Hauser-Gerspach I et al	Comparison of the immediate effects of gaseous ozone and chlorhexidine gel on bacteria in cavitated carious lesions in children in	2009	COI	University of Basel	25

	vivo				
Suh Y et al	Clinical utility of ozone therapy in dental and oral medicine	2019	MGR	Stony Brook University Renaissance School of Medicine	25
Noguchi F et al	Ozonated Water Improves Lipopolysaccharide-induced Responses of an Odontoblast- like Cell Line	2009	JE	Kyushu Dental College	24
McKenna DF et al	The Effect of Subgingival Ozone and/or Hydrogen Peroxide on the Development of Peri-implant Mucositis: A Double-Blind Randomized Controlled Trial	2013	IJOMI	University of Warwick	24
Cadenaro M et al	Enamel and Dentin Bond Strength Following Gaseous Ozone Application	2009	JAD	University of Trieste	24
Butera A et al	Ozonized Water Administration in Peri-Implant Mucositis Sites: A Randomized Clinical Trial	2021	ASB	University of Pavia	23
Tasdemir Z et al	Effects of Ozone Therapy on the Early Healing Period of Deepithelialized Gingival Grafts: A Randomized Placebo-Controlled Clinical Trial	2016	JP	Erciyes University	23
Al-Omiri MK et al	Randomized controlled clinical trial on bleaching sensitivity and whitening efficacy of hydrogen peroxide versus combinations of hydrogen peroxide and ozone	2018	SR	University of Jordan	22
Almaz ME, Sonmez IS	Ozone therapy in the management and prevention of caries	2015	JFMA	Kırıkkale University	22
Knight GM et al	The inability of Streptococcus mutans and Lactobacillus acidophilus to form a biofilm in vitro on dentine pretreated with ozone	2008	ADJ	The University of Adelaide	22
Sadatullah S et al	The antimicrobial effect of 0.1 ppm ozonated water on 24-hour plaque microorganisms in situ	2012	BOR	King Khalid University	21
Agrillo A et al	Ozone therapy in extractive surgery on patients treated with bisphosphonates	2007	JCS	University of Rome La Sapienza	21
Lynch E, Swift EJ	EVIDENCE-BASED EFFICACY OF OZONE FOR ROOT CANAL IRRIGATION	2008	JERD	Queen's University	20
Daif ET	Role of intra-articular ozone gas injection in the management of internal derangement of the temporomandibular joint	2012	QUAD O	Cairo University	20
Samuel SR et al	Effect of ozone to remineralize initial enamel caries: in situ study	2016	COI	Thai Moogambigai Dental College	19
Brazzelli M et al	Systematic review of the effectiveness and cost-effectiveness of HealOzone for the treatment of occlusal pit/fissure caries and root caries	2006	HTA	University of Aberdeen	19

Bayer S et al	Comparison of laser and ozone treatments on oral mucositis in an experimental model	2017	LMS	Bezmaiem Vakif University	18
Pires PT et al	Effect of ozone gas on the shear bond strength to enamel	2013	JAOS	University of Porto	18
Dalkilic EE et al	Effect of different disinfectant methods on the initial microtensile bond strength of a self-etch adhesive to dentin	2012	LMS	Yuzuncu Yil University	18
Swift, EJ	Evidence-based caries reversal using ozone	2008	JERD	Queen's University	18
Isler SC et al	The effects of ozone therapy as an adjunct to the surgical treatment of peri-implantitis	2018	JPIS	Gazi University	18
Tasaki T et al	Plasma-treated water eliminates Streptococcus mutans in infected dentin model	2017	DMJ	Tsurumi University School of Dental Medicine	18
Noites R et al	Synergistic Antimicrobial Action of Chlorhexidine and Ozone in Endodontic Treatment	2014	BRI	Catholic University of Portugal	18
Ripamonti CI et al	Efficacy and tolerability of medical ozone gas insufflations in patients with osteonecrosis of the jaw treated with bisphosphonates-Preliminary data Medical ozone gas insufflation in treating ONJ lesions	2012	JBO	Istituto Nazionale dei Tumori	18
Grootveld M et al	High resolution H-1 NMR investigations of the oxidative consumption of salivary biomolecules by ozone: Relevance to the therapeutic applications of this agent in clinical dentistry	2006	BF	London South Bank University	18
Dukic W et al	The Influence of Healozone on Microleakage and Fissure Penetration of Different Sealing Materials	2009	CA	University of Zagreb	17
Anzolin AP et al	Ozonated oil in wound healing: what has already been proven?	2020	MGR	Universidade de Passo Fundo	17
82 Ximenes M et al	Antimicrobial activity of ozone and NaF-chlorhexidine on early childhood caries	2017	BOR	Universidade Federal de Santa Catarina	17
83 Noetzel J et al	Efficacy of calcium hydroxide, Er:YAG laser or gaseous ozone against Enterococcus faecalis in root canals	2009	AJD	Charité-Universitätsmedizin Berlin	17
84 Domb WC	Ozone Therapy in Dentistry A Brief Review for Physicians	2014	IN	Inland Institute of Aesthetic Dentistry	17
85 Erdemci F et al	Histomorphometric evaluation of the effect of systemic and topical ozone on alveolar bone healing following tooth extraction in rats	2014	IJOMS	Akdeniz University	16
86 Loncar B et al	Ozone Application in Dentistry	2009	AMR	University Zagreb	16
87 Al Shamsi AH et al	The effects of ozone gas application on shear bond strength of orthodontic brackets to enamel	2008	AJD	Queen's University	16

88	Eick S et al	Effect of ozone on periodontopathogenic species-an in vitro study	2012	COI	University of Bern	16
89	Grocholewicz K et al	Effect of nano-hydroxyapatite and ozone on approximal initial caries: a randomized clinical trial	2020	SR	Pomeranian Medical University	15
90	Matys J et al	Effect of ozone and diode laser (635 nm) in reducing orthodontic pain in the maxillary arch-a randomized clinical controlled trial	2020	LMS	Medical University	15
91	Egusa H et al	Clinical Evaluation of the Efficacy of Removing Microorganisms to Disinfect Patient- Derived Dental Impressions	2008	IJP	Osaka University Graduate School of Dentistry	15
92	Filippi, A	Ozone in oral surgery - Current status and prospects	1997	OSE	Justus-Liebig- Universität Gießen	15
93	Camacho-Alonso, F et al	Effects of photodynamic therapy, 2 % chlorhexidine, triantibiotic mixture, propolis and ozone on root canals experimentally infected with Enterococcus faecalis: an in vitro study	2017	O	University of Murcia	15
94	Fagrell TG et al	Effect of ozone treatment on different cariogenic microorganisms in vitro	2008	SDJ	University of Gothenburg	15
95	Uraz A et al	Ozone application as adjunctive therapy in chronic periodontitis: Clinical, microbiological and biochemical aspects	2019	JDS	Gazi University	15
96	Bal FA et al	Effects of photodynamic therapy with indocyanine green on Streptococcus mutans biofilm	2019	PPT	Abant Izzet Baysal University	14
97	Al-Omiri MK et al	Improved tooth bleaching combining ozone and hydrogen peroxide-A blinded study	2016	JD	The University of Jordan	14
98	Nardi G et al	Mouthwash Based on Ozonated Olive Oil in Caries Prevention: A Preliminary In-Vitro Study	2020	IJER	Sapienza University of Rome	13
99	Silva E et al	The effect of ozone therapy in root canal disinfection: a systematic review	2020	IEJ	Universidade Grande Rio	13
100	Boch T et al	Effect of gaseous ozone on Enterococcus faecalis biofilm-an in vitro study	2016	COI	University Medical Center Freiburg	13

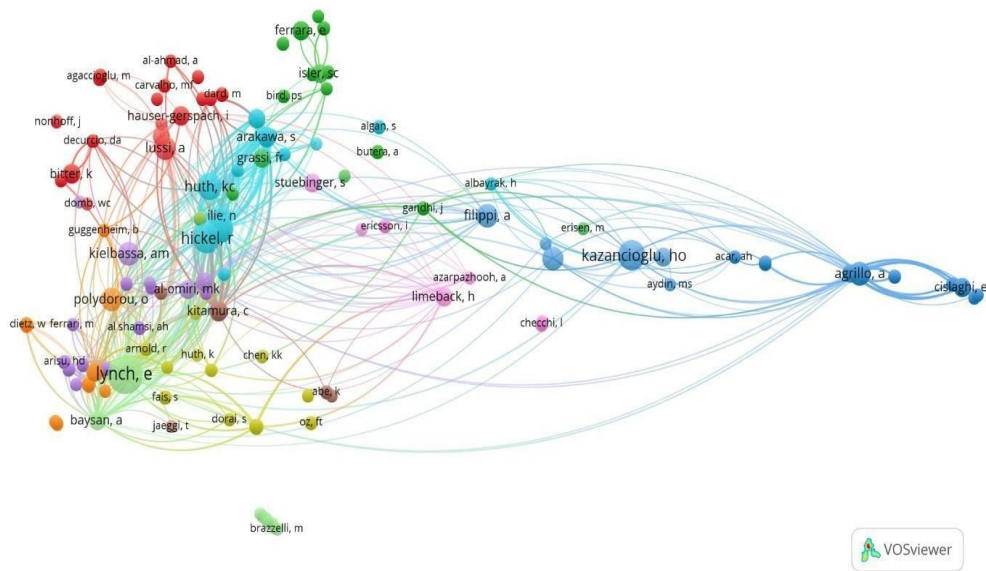


Fig. 2. The network of authors and citations of the bibliographic research “ozone in dentistry”

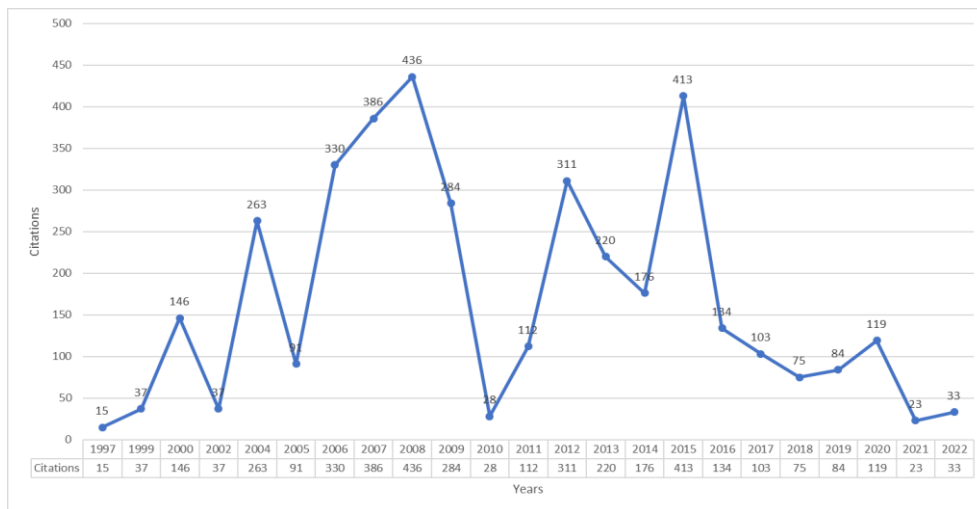


Fig. 3. Correlation between the number of citations and the year of publication of the studies

The earliest manuscript in this bibliometric analysis was published in 1997 by Filippi A in Ozone: Science & Engineering (OSE) and was cited 15 times. The most recent article was published in 2022 by Rapone B in International Journal of Environmental Research and Public Health (IJER) and was cited 33 times.

Fig. 3 illustrates the correlation between the number of citations and the year of publication of the studies. The citation distribution shows significant peaks in the years 2008 and 2015, with the top 100 studies receiving 436 and 413 citations, respectively.

3.2 Institutions and Countries

A total of 76 different international institutions are associated with these studies. The University of Basel led the list with 5 manuscripts published among the top 100 most cited, followed by Bezmialem Vakif University with 4 articles.

The studies originated from 30 different countries. The leading countries were Germany with 16 manuscripts, Turkey with 15 articles, Italy with 12 articles, and Switzerland with 11 manuscripts. England, Japan, and the USA each contributed eight manuscripts to the top 100 articles (Fig. 4 and 5).

3.3 Journals

The 100 most cited articles involving ozone in dentistry were published in 59 different journals. *Clinical Oral Investigations* (COI) led the list with 7 articles, followed by *American Journal of Dentistry* (AJD) with 5 articles. European Journal of Oral Sciences (EJPS), Journal of Craniofacial Surgery (JCS), Journal of Endodontics (JE), and Lasers in Medical Science (LMS) each published four articles (Fig. 6).

3.4 Keywords

A total of 250 keywords were used across the top 100 articles. The five most frequently used keywords were: ozone (50 times, 20%), dentistry (8 times, 3.2%), periodontitis (7 times, 2.8%), ozone therapy (6 times, 2.4%), and disinfection (5 times, 2%). The most frequently used keyword appeared in 50 studies, with the frequency of keywords ranging from one to fifty occurrences. Fig. 7 provides a graphical representation of the keywords in map form.

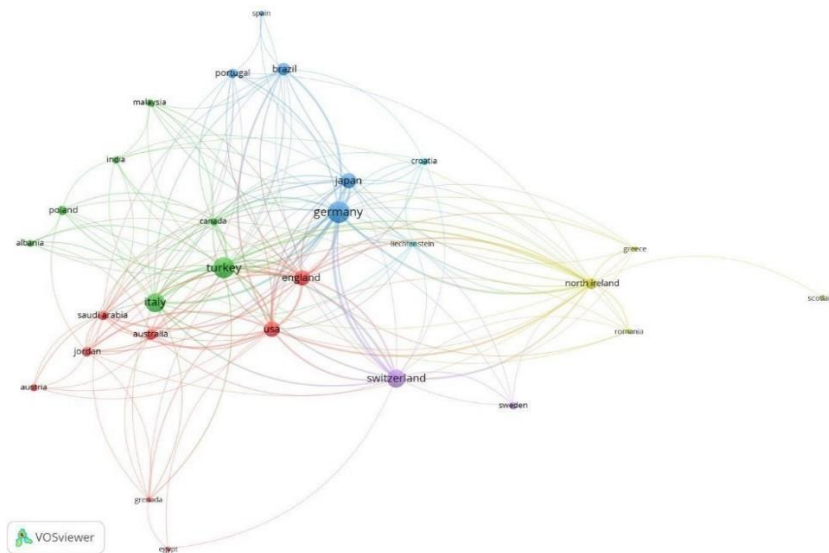


Fig. 4. Network analysis of countries from “ozone in dentistry” bibliographic search. Circle sizes are related to countries and their number of publications

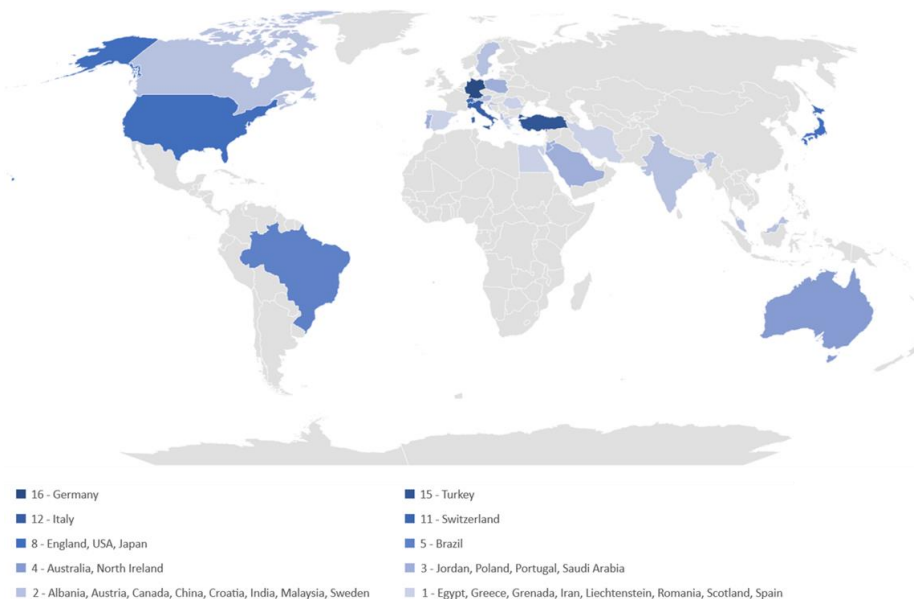


Fig. 5. Countries of origin of top 100 articles

3.5 Research Field

Fig. 8 displays the research fields covered by the 100 most cited articles on ozone in dentistry. The leading fields were Oral and Maxillofacial Surgery (OMFS) and Operative Dentistry, each with 19 studies, followed by Microbiology with 18 studies.

Another significant finding from this bibliometric analysis is that 9 studies within the top 100 evaluated ozone as an alternative treatment for medication-related osteonecrosis of the jaw (MRONJ).

3.6 Time-Pattern of Publications

Based on the distribution of the 100 articles over the years, 2008, followed by 2009 and

2012, were the years with the highest concentration of publications, with 12, 10, and 9 studies respectively (Fig. 9).

4. DISCUSSION

This paper aims to conduct a bibliometric analysis of ozone therapy in dentistry. Given the considerable growth in scientific publications over time, bibliometric methods can assist researchers and clinicians in identifying key factors to consider when choosing where to publish their work or where to search for information on a field. Thus, a list of the top 100 most-cited articles on ozone therapy in dentistry was compiled, accompanied by graphic data visualizations to provide researchers and academics with a better understanding of the subject.

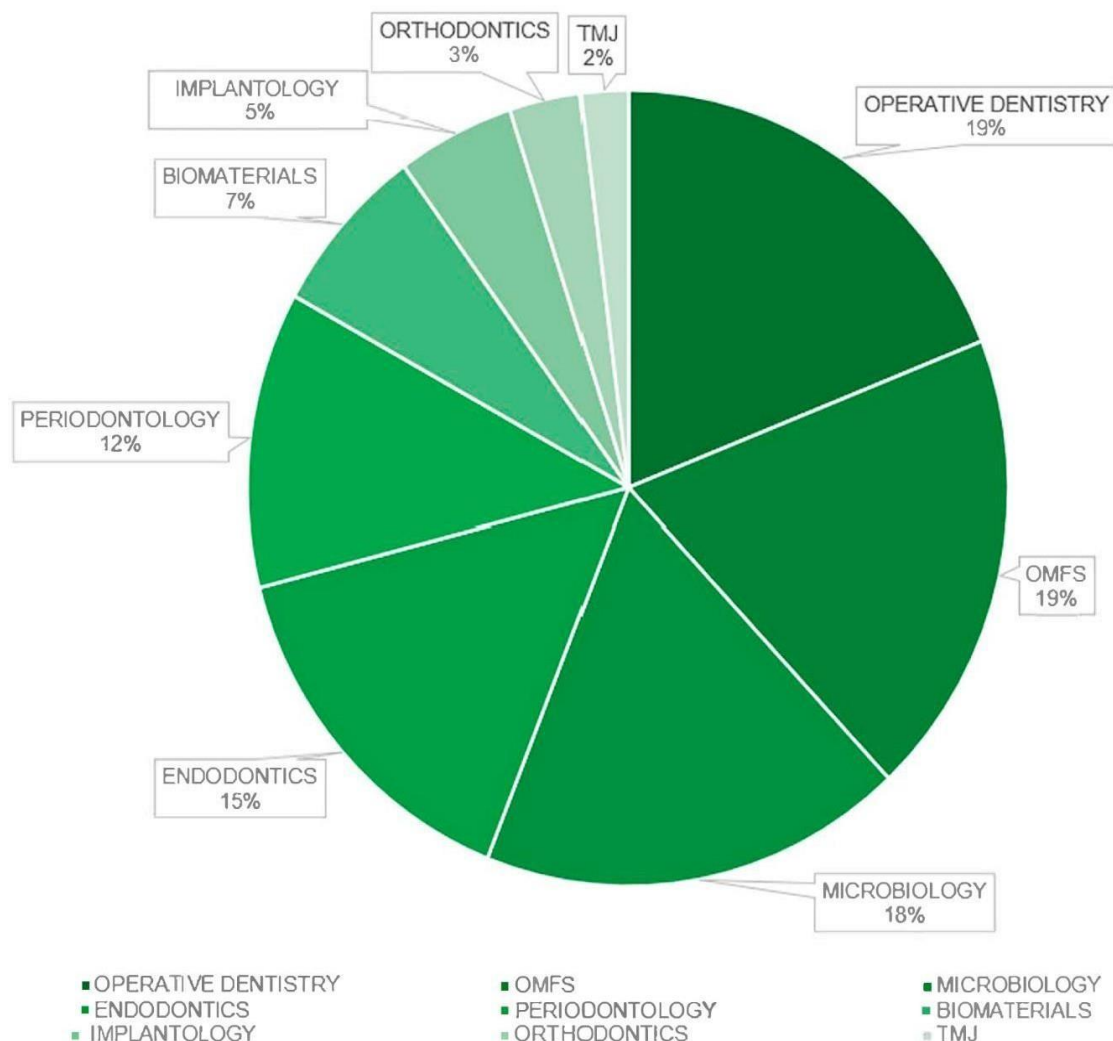


Fig. 8. Top-100 ozone in dentistry - research fields of included studies

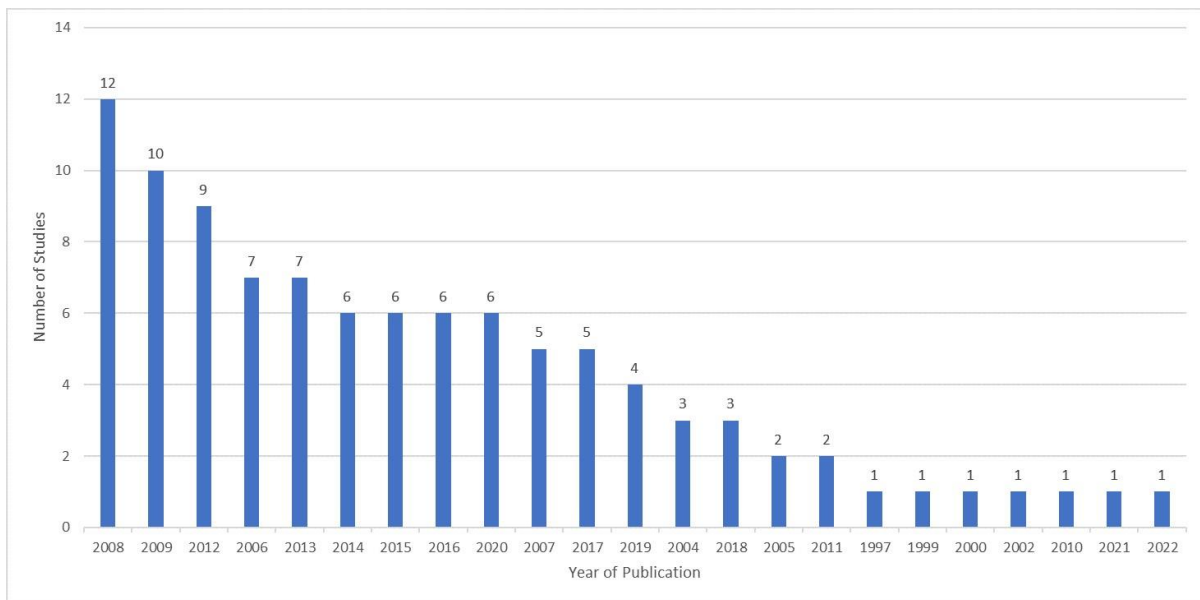


Fig. 9. Time-pattern distribution of the 100 most-cited studies on ozone in dentistry over the years

One important parameter in bibliometric analyses is the total number of citations, with articles receiving over 100 citations often classified as classics [25]. While studies with high citation rates are generally considered influential in their field, a low citation count does not necessarily indicate poor quality [29], as citation patterns can vary greatly depending on the type of publication, research, and discipline, and their significance can evolve over time [26].

The two most cited articles on ozone in dentistry were systematic reviews. The most cited study discussed ozone as an adjunctive treatment for bisphosphonate-related osteonecrosis of the jaws [9], while the second most cited article systematically reviewed the clinical application and potential of ozone remineralization in dentistry [20]. The third most cited article featured an in vitro study designed to evaluate the antimicrobial effect of ozone from a new ozone-generating device on primary root caries lesions, specifically targeting *Streptococcus mutans* and *Streptococcus sobrinus* [2].

In terms of disciplines, Oral and Maxillofacial Surgery (OMFS) and Operative Dentistry lead the ranking. The high number of citations in these areas can be attributed to the success of ozone therapy in decontaminating both surgical and clinical environments. Ozone therapy has established itself as an extremely effective alternative treatment for challenging conditions such as medication-induced osteonecrosis of the

jaws (MRONJ) [9,30-34]. Additionally, other surgical procedures benefit from ozone therapy, including third molar extractions [13,14], oral pathology [11], temporomandibular disorders [35], and dental implants [17-19,36].

Decontamination of caries is also a well-established procedure [7,37-43], including root caries decontamination and its use as an endodontic irrigation solution [2,4-6,44-49].

Bibliometrics provides a tool that can be scaled from the micro level (institutions) to the macro level (countries) [26]. In this analysis, the diverse range of studies is evident, with contributions from over 70 institutions, notably the University of Basel, and 30 different countries, with Germany being prominent.

Ozone generation is considered a cost-effective and efficient method. Although most leading countries are high-income economies, Turkey, a middle-income country, stands out as a significant contributor to research on this topic. The subject of ozone therapy is taken seriously by researchers, as evidenced by the high impact factors of several journals listed in the top 100, such as *Clinical Oral Investigations* [17, 50-55] and *Journal of Endodontics* [47, 50,56,57]. Increased international collaborations and the use of the Internet could further expand the volume of publications and foster knowledge exchange among researchers.

As noted in the literature, using appropriate keywords is crucial for extensive article dissemination [28,58]. The keyword ozone was used in only half of the most-cited articles, often alongside related terms such as dentistry or periodontitis. Despite its relevance, ozone therapy is not listed among MeSH keywords. The authors suggest adopting MeSH keywords for standardization and broader use [59].

In conclusion, the application of ozone in dentistry and medicine has increased in recent years due to its recognized benefits [36]. However, the bibliometric data from this study indicate that the years 2008, 2009, and 2012 were the most productive, with peaks in citations observed in 2008 and 2015. Despite the expected rise in publications over the last five years, the oldest article in the analysis was published in 1997 [60,61] and the most recent in 2022 [7]. It is important to consider that the ranking of the 100 most cited articles represents the current landscape, and ongoing scientific advancements necessitate periodic updates to reviews.

A major limitation of this study is the reliance on the Web of Science for bibliometric analysis. Other bibliometric databases, such as Medline, Embase, and Cochrane Library, were not included. However, Web of Science is widely used due to its established metrics for comparing journal impact within disciplines through Journal Citation Reports (JCR; Clarivate Analytics). Factors such as journal and author self-citations, incomplete citing, and manuscript availability can affect citation rates[62,63] Thus, while many journals report on ozone in dentistry, this reflects growing interest in the topic rather than necessarily indicating high-quality research.

5. CONCLUSION

This bibliometric analysis can lead us to conclude that: 1) Germany was the main country that contributed to field research on the use of ozone in dentistry 2) The University of Basel was the most productive university in the researched field; 3) Clinical Oral Investigations was the journal that led the ranking with the most articles published, 4) The keyword ozone was the most used in the articles; 5) Oral and maxillofacial surgery was the research area most addressed by the 100 most cited articles.

The bibliometric list helps locate studies on specific topics and highlights trends in the research over time.

These results can guide authors on where to consider submitting their research on ozone therapy in dentistry.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dourado ALT, Santos AFL, Rocha RC. Aplicações clínicas do ozônio na odontologia: revisão de literatura. Rco revista ciências e odontologia. 2019;5(1):46-56.
2. Baysan A, Whiley RA, Lynch E. Antimicrobial effect of a novel ozone-generating device on Micro-organisms associated with primary root carious lesions *In vitro*. Caries Research. 2000;34(6):498– 501. DOI: 10.1159/000016630
3. Rapone B, Ferrara E, Santacroce L, Topi S, Gnoni A, Dipalma G, Mancini A, Di Domenico M, Tartaglia GM, Scarano A, Inchingolo F. The gaseous ozone therapy as a promising antiseptic adjuvant of periodontal treatment: A randomized controlled clinical Trial. Int J Environ Res Public Health. 2022;19(2):985. DOI: 10.3390/ijerph19020985. PMID: 35055807; PMCID: PMC8775443.
4. Noetzel J, Nonhoff J, Bitter K, Wagner J, Neumann K, Kielbassa AM. Efficacy of calcium hydroxide, Er:YAG laser or gaseous ozone against Enterococcus faecalis in root canals. Am J Dent. 2009;22(1):14-8. PMID: 19281107.
5. Camacho-Alonso F, Salmerón-Lozano P, Martínez-Beneyto Y. Effects of photodynamic therapy, 2 % chlorhexidine, triantibiotic mixture, propolis and ozone on root canals experimentally infected with Enterococcus faecalis: An *In vitro* study. Odontology. 2017;105(3):338-346. DOI: 10.1007/s10266- 0160271-4. Epub 2016 Oct 22. PMID: 27771807.

6. Silva EJNL, Prado MC, Soares DN, Hecksher F, Martins JNR, Fidalgo TKS. The effect of ozone therapy in root canal disinfection: a systematic review. *Int Endod J.* 2020;53(3):317-332. DOI: 10.1111/iej.13229. Epub 2019 Nov 3. PMID: 31587303.
7. Almaz ME, Sönmez IŞ. Ozone therapy in the management and prevention of caries. *J Formos Med Assoc.* 2015;114(1):3-11. DOI: 10.1016/j.jfma.2013.06.020. Epub 2013 Aug 19. PMID: 23969041.
8. Al-Omiri MK, Al Nazeh AA, Kielbassa AM, Lynch E. Randomized controlled clinical trial on bleaching sensitivity and whitening efficacy of hydrogen peroxide versus combinations of hydrogen peroxide and ozone. *Sci Rep.* 2018;8(1):2407. DOI: 10.1038/s41598-018-20878-0. PMID: 29402954; PMCID: PMC5799293.
9. Fliefel R, Tröltzsch M, Kühnisch J, Ehrenfeld M, Otto S. Treatment strategies and outcomes of bisphosphonate-related osteonecrosis of the jaw (BRONJ) with characterization of patients: A systematic review. *Int J Oral Maxillofac Surg.* 2015;44(5):568-85. DOI: 10.1016/j.ijom.2015.01.026. Epub 2015 Feb 26. PMID: 25726090.
10. Kazancioglu HO, Erisen M. Comparison of Low-Level Laser Therapy versus Ozone Therapy in the Treatment of Oral Lichen Planus. *Ann Dermatol.* 2015;27(5):485-91. DOI: 10.5021/ad.2015.27.5.485. Epub 2015 Oct 2. PMID: 26512161; PMCID: PMC4622881.
11. Bayer S, Kazancioglu HO, Acar AH, Demirtas N, Kandas NO. Comparison of laser and ozone treatments on oral mucositis in an experimental model. *Lasers Med Sci.* 2017;32(3):673-677. DOI: 10.1007/s10103-0172166-1. Epub 2017 Feb 11. PMID: 28190112.
12. Erdemci F, Gunaydin Y, Sencimen M, Bassorgun I, Ozler M, Oter S, Gulses A, Gunal A, Sezgin S, Bayar GR, Dogan N, Gider IK. Histomorphometric evaluation of the effect of systemic and topical ozone on alveolar bone healing following tooth extraction in rats. *Int J Oral Maxillofac Surg.* 2014;43(6):777-83. DOI: 10.1016/j.ijom.2013.12.007. Epub 2014 Jan 31. PMID: 24491848.
13. Kazancioglu HO, Ezirganli S, Demirtas N. Comparação da influência das terapias com ozônio e laser na dor, inchaço e trismo após cirurgia de terceiro molar impactado. *Lasers Med Sci.* 2014;29(4):1313-9. DOI: 10.1007/s10103-013-1300-y. Epub 2013 14 de março. PMID: 23494104.
14. Cho H, Lynham AJ, Hsu E. Postoperative interventions to reduce inflammatory complications after third molar surgery: review of the current evidence. *Aust Dent J.* 2017;62(4):412-419. DOI: 10.1111/adj.12526. Epub 2017 Jun 14. PMID: 28498604
15. Al Habashneh R, Als Salman W, Khader Y. Ozone as an adjunct to conventional nonsurgical therapy in chronic periodontitis: a randomized controlled clinical trial. *J Periodontol Res.* 2015;50(1):37-43. DOI: 10.1111/jre.12177. Epub 2014 Mar 25. PMID: 24665871.
16. Rapone B, Ferrara E, Corsalini M, Converti I, Grassi FR, Santacroce L, Topi S, Gnoni A, Scacco S, Scarano A, Delvecchio M. The effect of gaseous ozone therapy in conjunction with periodontal treatment on glycated hemoglobin level in subjects with type 2 diabetes mellitus: An unmasked randomized controlled trial. *Int J Environ Res Public Health.* 2020;17(15):5467. DOI: 10.3390/ijerph17155467. PMID: 32751340; PMCID: PMC7432743.
17. Hauser-Gerspach I, Vadaszan J, Deronjic I, Gass C, Meyer J, Dard M, Waltimo T, Stübinger S, Mauth C. Influence of gaseous ozone in peri-implantitis: bactericidal efficacy and cellular response. An in vitro study using titanium and zirconia. *Clin Oral Investig.* 2012;16(4):1049-59. DOI: 10.1007/s00784-011-0603-2. Epub 2011 Aug 13. PMID: 21842144.
18. McKenna DF, Borzabadi-Farahani A, Lynch E. The effect of subgingival ozone and/or hydrogen peroxide on the development of peri-implant mucositis: A double-blind randomized controlled trial. *Int J Oral Maxillofac Implants.* 2013;28(6):1483-9. DOI: 10.11607/jomi.3168. PMID: 24278915
19. Isler SC, Unsal B, Soysal F, Ozcan G, Peker E, Karaca IR. The effects of ozone therapy as an adjunct to the surgical treatment of peri-implantitis. *J Periodontol Implant Sci.* 2018;48(3):136-151. DOI: 10.5051/jpis.2018.48.3.136. PMID: 29984044; PMCID: PMC6031764.
20. Azarpazhooh A, Limeback H. The application of ozone in dentistry: a

- systematic review of literature. *J Dent.* 2008;36(2):104-16.
DOI: 10.1016/j.jdent.2007.11.008. Epub 2007 Dec 31. PMID: 18166260.
21. Brandt JS, Hadaya O, Schuster M, Rosen T, Sauer MV, Ananth CV. A Bibliometric Analysis of Top-Cited Journal Articles in Obstetrics and Gynecology. *JAMA Netw Open.* 2019;2(12):e1918007. DOI: 10.1001/jamanetworkopen.2019.18007. PMID: 31860106; PMCID: PMC6991228.
 22. Luukkonen T. Bibliometrics and evaluation of research performance. *Ann Med.* 1990;22(3):145-50. DOI: 10.3109/07853899009147259. PMID: 2393549.
 23. Ellegaard O, Wallin JA. The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics.* 2015;105(3):1809-1831. DOI: 10.1007/s11192-015-1645-z. Epub 2015 Jul 28. PMID: 26594073; PMCID: PMC4643120.
 24. Cooper ID. Bibliometrics basics. *J Med Libr Assoc.* 2015;103(4):217-218. DOI: 10.3163/1536-5050.103.4.013
 25. Heldwein FL, Rhoden EL, Morgentaler A. Classics of urology: A half century history of the most frequently cited articles (1955-2009). *Urology.* 2010;75(6):1261-8. DOI: 10.1016/j.urology.2009.09.043. Epub 2009 Dec 4. PMID: 19962736.
 26. Wallin JA. Bibliometric methods: pitfalls and possibilities. *Basic Clin Pharmacol Toxicol.* 2005;97(5):261-75. DOI: 10.1111/j.1742-7843.2005.pto_139.x. PMID: 16236137
 27. Falci SGM, Guimarães MTBÁ, Al-Moraissi EA, Firoozi P, Galvão EL. Top 100 cited publications in the field of third molar surgery: A bibliometric analysis. *J Stomatol Oral Maxillofac Surg.* 2022;123(5):e489-e498. DOI: 10.1016/j.jormas.2022.07.007. Epub 2022 Jul 22. PMID: 35878752.
 28. Grillo R. Orthognathic surgery: A bibliometric analysis of the Top 100 Cited Articles. *Journal of Oral and Maxillofacial Surgery.* 2021;79(11):2339-49. DOI: 10.1016/j.joms.2021.06.004
 29. Chew FSA. Relyea-Chew: How research becomes knowledge in radiology: An analysis of citations to published papers. *Amer. J. Roentgenol.* 1988;150:31-37.
 30. Kühl S, Walter C, Acham S, Pfeffer R, Lambrecht JT. Bisphosphonate-related osteonecrosis of the jaws--a review. *Oral Oncol.* 2012;48(10):938-947. DOI: 10.1016/j.oraloncology.2012.03.028. Epub 2012 Apr 21. PMID: 22525606.
 31. Ripamonti CI, Cislighi E, Mariani L, Maniezzo M. Efficacy and safety of medical ozone (O₃) delivered in oil suspension applications for the treatment of osteonecrosis of the jaw in patients with bone metastases treated with bisphosphonates: Preliminary results of a phase I-II study. *Oral Oncol.* 2011;47(3):185-90. DOI: 10.1016/j.oraloncology.2011.01.002. PMID: 21310650.
 32. Agrillo A, Ungari C, Filiaci F, Priore P, Iannetti G. Ozone therapy in the treatment of avascular bisphosphonate-related jaw osteonecrosis. *J Craniofac Surg.* 2007;18(5):1071-5. DOI: 10.1097/scs.0b013e31857261f. PMID: 17912085.
 33. Rollason V, Laverrière A, MacDonald LC, Walsh T, Tramèr MR, Vogt-Ferrier NB. Interventions for treating bisphosphonate-related osteonecrosis of the jaw (BRONJ). *Cochrane Database Syst Rev.* 2016;2(2):CD008455. DOI: 10.1002/14651858.CD008455.pub2. PMID: 26919630; PMCID: PMC7173706.
 34. Ripamonti CI, Maniezzo M, Boldini S, Pessi MA, Mariani L, Cislighi E. Efficacy and tolerability of medical ozone gas insufflations in patients with osteonecrosis of the jaw treated with bisphosphonates-Preliminary data: Medical ozone gas insufflation in treating ONJ lesions. *J Bone Oncol.* 2012;1(3):81-7. DOI: 10.1016/j.jbo.2012.08.001. PMID: 26909261; PMCID: PMC4723354.
 35. Daif ET. Role of intra-articular ozone gas injection in the management of internal derangement of the temporomandibular joint. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2012;113(6):e10-4. DOI: 10.1016/j.tripleo.2011.08.006. Epub 2012 Feb 28. PMID: 22677023.
 36. Butera A, Gallo S, Pascadopoli M, Luraghi G, Scribante A. Administração de água ozonizada em locais de mucosite peri-implantar: Um ensaio clínico randomizado. *Ciências Aplicadas.* 2021;11(17):7812. Available: <https://doi.org/10.3390/app11177812>
 37. Duangthip D, Jiang M, Chu CH, Lo EC. Non-surgical treatment of dentin caries in

- preschool children- systematic review. BMC Oral Health. 2015;15:44. DOI: 10.1186/s12903-015-0033-7. PMID: 25888484; PMCID: PMC4403709.
38. Brazzelli M, McKenzie L, Fielding S, Fraser C, Clarkson J, Kilonzo M, Waugh N. Systematic review of the effectiveness and cost-effectiveness of HealOzone for the treatment of occlusal pit/fissure caries and root caries. Health Technol Assess. 2006;10(16):iii-iv, ix-80. DOI: 10.3310/hta10160. PMID: 16707073
 39. Pires, Patricia Teixeira et al. Effect of ozone gas on the shear bond strength to enamel. Journal of Applied Oral Science. 2013;21(2):177-182. Available:<https://doi.org/10.1590/1678-7757201302362> ISSN 1678-7765. Available:<https://doi.org/10.1590/16787757201302362>.
 40. Dalkilic EE, Arisu HD, Kivanc BH, Uctasli MB, Omurlu H. Effect of different disinfectant methods on the initial microtensile bond strength of a self-etch adhesive to dentin. Lasers Med Sci. 2012;27(4):819-25. DOI: 10.1007/s10103-011-0987-x. Epub 2011 Sep 14. PMID: 21915687.
 41. Lynch E. Evidence-based caries reversal using ozone. J Esthet Restor Dent. 2008;20(4):218-22. DOI: 10.1111/j.1708-8240.2008.00183.x. PMID: 18767993.
 42. Ximenes M et al. Antimicrobial activity of ozone and NaF-chlorhexidine on early childhood caries. Brazilian Oral Research. 2017;31:e2. Available:<https://doi.org/10.1590/1807-3107BOR-2017.vol31.0002>. Epub 05 Jan 2017. ISSN 1807-3107. Available:<https://doi.org/10.1590/1807-3107BOR-2017.vol31.0002>.
 43. Nardi GM, Fais S, Casu C, Mazur M, Di Giorgio R, Grassi R, Grassi FR, Orrù G. Mouthwash based on ozonated olive oil in caries prevention: a preliminary *In-vitro* Study. Int J Environ Res Public Health. 2020;17(23):9106. DOI: 10.3390/ijerph17239106. PMID: 33291253; PMCID: PMC7730335.
 44. Wierichs RJ, Meyer-Lueckel H. Systematic review on noninvasive treatment of root caries lesions. J Dent Res. 2015;94(2):261-71. DOI: 10.1177/0022034514557330. Epub 2014 Nov 14. PMID: 25398366; PMCID: PMC4438727.
 45. Estrela C, Estrela CR, Decurcio DA, Hollanda AC, Silva JA. Antimicrobial efficacy of ozonated water, gaseous ozone, sodium hypochlorite and chlorhexidine in infected human root canals. Int Endod J. 2007;40(2):85-93. DOI: 10.1111/j.1365-2591.2006.01185.x. PMID: 17229112.
 46. Baysan A, Lynch E. Effect of ozone on the oral microbiota and clinical severity of primary root caries. Am J Dent. 2004;17(1):56-60. PMID: 15241911.
 47. Bitter K, Noetzel J, Volk C, Neumann K, Kielbassa AM. Bond strength of fiber posts after the application of erbium: Yttrium-aluminum-garnet laser treatment and gaseous ozone to the root canal. J Endod. 2008;34(3):306-9. DOI: 10.1016/j.joen.2007.12.011. PMID: 18291282.
 48. Case PD, Bird PS, Kahler WA, George R, Walsh LJ. Treatment of root canal biofilms of *Enterococcus faecalis* with ozone gas and passive ultrasound activation. J Endod. 2012;38(4):523-6. DOI: 10.1016/j.joen.2011.12.020. Epub 2012 Feb 2. PMID: 22414842.
 49. Lynch E. Evidence-based efficacy of ozone for root canal irrigation. J Esthet Restor Dent. 2008;20(5):287-93. DOI: 10.1111/j.1708-8240.2008.00195.x. PMID: 18837750.
 50. Hayakumo S, Arakawa S, Mano Y, Izumi Y. Clinical and microbiological effects of ozone nano-bubble water irrigation as an adjunct to mechanical subgingival debridement in periodontitis patients in a randomized controlled trial. Clin Oral Investig. 2013;17(2):379-88. DOI: 10.1007/s00784-012-0711-7. Epub 2012 Mar 17. PMID: 22422082.
 51. Polydorou O, Halili A, Wittmer A, Pelz K, Hahn P. The antibacterial effect of gas ozone after 2 months of *in vitro* evaluation. Clin Oral Investig. 2012;16(2):545-50. DOI: 10.1007/s00784-011-0524-0. Epub 2011 Feb 18. PMID: 21331635.
 52. Hauser-Gerspach I, Pfäffli-Savtchenko V, Dähnhardt JE, Meyer J, Lussi A. Comparison of the immediate effects of gaseous ozone and chlorhexidine gel on bacteria in cavitated carious lesions in children *In vivo*. Clin Oral Investig. 2009;13(3):287-91. DOI: 10.1007/s00784-008-0234-4. Epub 2008 Nov 26. PMID: 19034538.

53. Samuel SR, Dorai S, Khatri SG, Patil ST. Effect of ozone to remineralize initial enamel caries: in situ study. Clin Oral Investig. 2016;20(5):1109-13. DOI: 10.1007/s00784-016-1710-x. Epub 2016 Jan 12. PMID: 26759338.
54. Eick S, Tigan M, Sculean A. Effect of ozone on periodontopathogenic species--an *In vitro* study. Clin Oral Investig. 2012;16(2):537-44. DOI: 10.1007/s00784-011-0515-1. Epub 2011 Feb 2. PMID: 21287208.
55. Boch T, Tennert C, Vach K, Al-Ahmad A, Hellwig E, Polydorou O. Effect of gaseous ozone on Enterococcus faecalis biofilm-an *In vitro* study. Clin Oral Investig. 2016;20(7):1733-9. DOI: 10.1007/s00784-015-16671. Epub 2015 Dec 4. PMID: 26637463.
56. Azarpazhooh A, Limeback H, Lawrence HP, Fillery ED. Evaluating the effect of an ozone delivery system on the reversal of dentin hypersensitivity: A randomized, double-blinded clinical trial. J Endod. 2009;35(1):1- 9. DOI: 10.1016/j.joen.2008.10.001. Epub 2008 Nov 8. PMID: 19084115.
57. Noguchi F, Kitamura C, Nagayoshi M, Chen KK, Terashita M, Nishihara T. Ozonated water improves lipopolysaccharide-induced responses of an odontoblast-like cell line. J Endod. 2009;35(5):668-72. DOI: 10.1016/j.joen.2009.01.016. PMID: 19410080.
58. Mondal H, Mondal S, Mondal S: How to choose title and keywords for manuscript according to medical subject headings. Indian J Vasc Endovasc Surg. 2018;5(3):141.
59. Principles of MEDLINE Subject Indexing. U.S. National Library of Medicine. Available: <https://www.nlm.nih.gov/bsd/disted/meshtutorial/principlesofmedlinesubjectindexing/principles/index.html>. Accessed Dec 15, 2022.
60. Filippi A. Ozone in oral surgery - Current status and prospects. Ozone: Science and Engineering. 1997;19(5):387–393. DOI: 10.1080/01919512.1997.1038286
61. Naderi M, Ebrahimzadeh G, Alimohammadi M, Past V. Effect of ozone on the inactivation of indoor airborne viruses with the COVID-19 virus approach: A systematic review. Tehran Univ Med J. 2022;80(2):82-90.
62. Past V, Naderi M, Saremi G, Azizi P, Javadzadeh M, Shahveh S, Bayat Z. The application of ozone gas in inactivation of surface and airborne sars-cov-2 in hospitals: A systematic review. Ozone: Science and Engineering. 2024;1–21. Available: <https://doi.org/10.1080/01919512.2024.2360438>
63. Past V, Naderi M. The applications of ozone gas in hospitals for disinfecting and sterilizing the air, surfaces and equipment contaminated with the COVID-19 Virus: A Comprehensive Review. Virus; 9.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2024): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:

<https://www.sdiarticle5.com/review-history/122415>