HYPERBARIC OXYGEN THERAPY (HBOT) AND PERIDONTAL HEALTH

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This study has tested the effects of hyperbaric oxygen in periodontal structures in agreement with the theories supported by literature research. Eight patients, from 30 to 50 years-of-age, were tested with pure oxygen inhalation, at the 2.5 ATA absolute pressure. Main approved tests of periodontal health were evaluated before and after HBOT's cycles. The results in all patients treated with HBOT, have founded clear improvement of clinical and instrumental parameters.

Hyperbaric oxygen therapy (HBOT) has many uses. The Undersea and Hyperbaric Medical Society sets standards for the use of hyperbaric medicine, currently there are several indications for hyperbaric oxygen therapy in medicine and many more unapproved conditions where HBOT may be useful.

The surrounding ambient pressure at sea level is 1 ATM, each additional ATM of pressure is equal to 33 feet of depth of sea water or 14.7 pounds per square inch (psi). HBOT consists of placing a patient into a pressurized chamber of up to 3 atmospheres (ATM) of pressure, in which the elevated pressure combined with exposure to 100% oxygen has many physiologic effects on the body. The normal oxygen concentration of plasma at sea level is 3 mL/L, instead at the level at a pressure of 3 ATM breathing 100% oxygen, it approaches 60 mL/L.

The literature shows that this is enough to keep swine alive after all of their red blood cells have been removed and is sufficient to supply the resting oxygen requirement for most tissues. HBOT can potentiate antibiotics (such as aminoglycosides and quinolones), and at higher concentrations it can be bacteriostatic and bactericidal. HBOT also neutralizes alfa exotoxins, produced by bacteria such as Clostridium. Hyperbaric oxygen therapy promotes neutrophil mediated bacterial killing ability in hypoxic tissue, it also prevents the release of proteases and free radicals in certain injuries, thereby decreasing vasoconstriction, edema, and cellular damage (1).

The conditions approved by the Undersea and Hyperbaric Medical Society for hyperbaric oxygen therapy include (2):

1. decompression sickness
2. acute arterial gas emboli
3. necrotizing fasciitis
4. gas gangrene
5. refractory osteomyelitis
6. acute blood loss anemia

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7. failed skin grafts
8. chronic radiation injury
9. carbon monoxide poisoning
10. acute thermal injury
11. compartment syndromes
12. compression injury
13. cranial abscess
14. arterial insufficiency
15. acute sensory hearing loss

There are numerous off label indications such as autism, stroke and attention deficit hyperactivity disorder (ADHD) that did not respond clearly to hyperbaric oxygen therapy. A specific indication for HBOT is in cases of Wagner grade 3 diabetic wounds refractory to at least 30 days of conventional therapy (2).

Most contraindications to hyperbaric oxygen therapy are related to issues of barotrauma. Barotrauma is physical injury to an area where there is a closed air filled space such as the lung or middle ear. Injury results from expansion of trapped gases with the changing pressure from the hyperbaric dive resulting in rupture of the compartment (perforation of a tympanic membrane or pneumothorax) (1).

Cakmak T. et al. think that, additionally to these concerns, barotraumatic lesions can occur in any trapped air e.g. dental abscess after failed filling or in periodontitis and subgingival anaerobes that may cause gaseous lesions. These lesions can cause a very strong sharp pain particularly in the ascent phase of the hyperbaric oxygen therapy when the pressure decreases and volume begins to re-expanse (3).

More relative contraindications are the presence of pulmonary blebs and emphysema with carbon dioxide retention. Administration of certain drugs is a relative contraindication (Disulfiram, Cisplatinum, Sulfamylon, Bleomycin). Sinusitis, seizures, pregnancy, implanted devices such as pacemakers and epidural pumps are relative contraindications. Claustrophobia, especially in cases of the monoplace chamber, can be an issue. The only true absolute contraindication is an untreated pneumothorax. Diving a patient in this situation will lead to fast progression of a tension pneumothorax and certain death.

In reference to theoretical aspects supported by literature research, the study has tested the effects of hyperbaric oxygen in periodontal structures through a specific experimentation in order to confirm what is explained in literary texts.

Nogueira-Filho et al, evaluate the effect of hyperbaric oxygen therapy (HBO2) as an adjunct to scaling and root planing (SRP) in the treatment of severe cases of chronic periodontitis. Their data suggest that hyperbaric oxygen therapy had a short-term beneficial effect on pocket reduction and bacterial elimination, and may be considered a potential adjunct therapeutic option to improve the clinical outcomes of scaling in severe cases of chronic periodontitis (4).

In our research, the hygienic maintenance of the dental arches was intentionally not improved during the whole research period with other additional treatments, this to test only HBOT's effects by clinical and instrumental data.

MATERIALS AND METHODS

For our research, we selected eight divers in training, non-smokers, with a hygienic maintenance of the dental arches that was intentionally not improved during the whole research period. The informed consent was signed by all the participants prior to the study.

The trial was randomized, controlled and double-blind. Eight subjects without periodontal disease (5 males

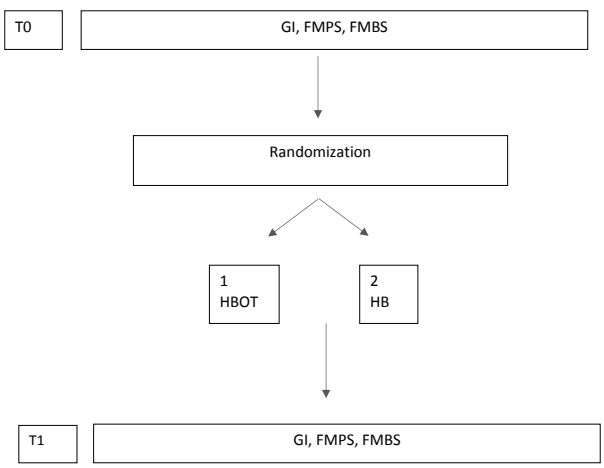

Fig. 1. *Flow-chart of the study.*

and 3 females) aged 29-50 years, were randomly divided into two groups based on oxygen hyperbaric therapy (HBOT): a groups treated with 100% oxygen, and a group without oxygen (HB placebo).

Inclusion criteria for patients:
Patients with following characteristics:
- at least 20 teeth, to exclusion of 3rd molars
- PSR with values of 1 or 2
- PPD ≤3 mm

Exclusion criteria:
Patients with following characteristics:
- Last 6 months < periodontal treatment
- Patients with systemic diseases or any contraindications to HBOT
- Presence of orthodontic appliances
- Patients with periodontal disease PPD > 3 mm
- 6 months taking antibiotics <
- Taking 3 months < anti-inflammatory, cortisone
- Pregnant or taking contraceptive hormones
- The absence of consent to the study

In the first group the oxygen hyperbaric therapy was carried out with pure oxygen inhalation, at the 2.5 ATA absolute pressure, through rubber gold-nasal mask, and making the patient breathe with open mouth in order to get advantage from both the indirect oxygen action by endogenous, and the direct action in perfusion contact, on the exposed gum tissues. The treatment provided a 25 +/- 5 cycle of HBOT sessions, according to the scheme: 30'- 3' break time - 30'. In the second group, the dive was carried out without inhalation of pure oxygen, but always with rubber gold-nasal mask.

Table I. *Data at T0.*

Data at T0	Patient	GI	FMPS %	FMBS %
Group 1 - HBOT	1	1.6	65	59
	2	2	99	76
	3	1.6	73	54
	4	1.9	100	69
Group 2 - HB (Placebo)	1	1.7	88	60
	2	1.4	82	45
	3	1.6	69	65
	4	1.7	55	63

Table I. *Data at T1.*

Data at T1	Patient	GI	FMPS %	FMBS %
Group 1- HBOT	1	1.3	62	32
	2	1.5	92	47
	3	1.2	74	19
	4	1.5	97	48
Group 2- HB (Placebo)	1	1.5	90	51
	2	1.3	78	32
	3	1.4	67	52
	4	1.5	43	39

Clinical parameters were assessed at baseline (T0) up to 6 months (T1) for the 2 groups (5-10): Gingival Index (GI), Full Mouth Plaque Score (FMPS) (11), Full Mouth Bleeding Score (FMBS) (6). All tests were repeated after a few days at the end of hyperbaric treatment and achieved data. In order to get a simple and comfortable reading, data has been reported on a folder specially created for this research. Each patient was tested by the same operator.

RESULTS

The clinical data collected during the first visit (T0) of the subjects of the various groups, are collected in the table I. The clinical data collected during the last visit (T1) of the subjects of the various groups, are collected in the table II.

As shown in Tables I and II, in all patients treated with HBOT we found a massive improvement of both clinical and instrumental parameters. From a clinical point of view, we found a significant improvement of the gingival health with an important recovery of the mucosa tropism, highlighted especially from the decreasing of bleeding. Indeed instrumental analysis have shown in all patients a significant reduction of

Full Mouth Bleeding Score. No essential increase or decrease of the plaque index has been found, this in agreement hygienic maintenance of the dental arches that was intentionally not improved during the research period.

Because of this whole series of improvements at gingival mucosa's tropism and capillary fragility, in all cases we found an increase of periodontal health.

DISCUSSION

The analysis of the obtained results from this study shows several interesting data. After the application of our protocol of 25 +/- 5 HBOT sessions a clear improvement of the clinical parameters related to gingival tropism has been shown. In the improvement of the gingival mucosa tropism, we can mention the capillary neoangiogenesis due to oxygen "plasma", and anti-inflammatory effects (1).

The clinical efficacy relative to the bactericidal and bacteriostatic action can be explained through the mechanism of oxygen action itself. Furthermore, we supposed that the important improvement of data is also connected to the sequential HOB effect carried on the neocollagen synthesis in the periodontal structures.

In agreement with the neo synthesis action, the effects of daily exposure to HBO on the proliferation and differentiation of human osteoblasts *in vitro* were also evaluated; the data suggest that the exposure of osteoblasts to HBO enhances differentiation toward the osteogenic phenotype, providing cellular evidence of the potential application of HBO in fracture healing and bone regeneration (12).

CONCLUSION

Based on all the considerations previously exposed, we can be optimistic about the possibilities offered by the HBO therapy, as future support for the traditional treatment of periodontal disease.

In fact, with this study we do not want to reach a dogmatic result. Rather, we would like to stimulate further dentistry research into good results achieved by the hyperbaric oxygen therapy in the treatment of other diseases. We are also motivated by the excellent clinical feedback and by the non-invasive nature of this therapy.

In conclusion, hyperbaric oxygen therapy provides the most tissues with vessels, which have good blood flow, and the anatomical structure of the mouth with its rich vascular beds has the advantage to benefit from this treatment. Therefore, this study supports the idea of using this treatment mode in dentistry. However, even if the data agree in utilizing HBOT in dentistry, the proposed work is to be considered a pilot study given the small sample size. To obtain more statistically significant data, it is important to conduct further studies with a larger sample to determine the HBOT's clinical and instrumental benefits in dentistry.

REFERENCES

1. Jones MW, Cooper JS. Hyperbaric, Wound Healing. In: (ed.^(eds. StatPearls. Treasure Island (FL): 2017.
2. Undersea and Hyperbaric Society website. Definition of Hyperbaric Oxygen Therapy. Retrieved from
3. Cakmak T, Metin S, Balta S, Sen A, Akin A. The Use of Hyperbaric Oxygen Therapy in Dentistry. J Clin Diagn Res 2015; 9(9):ZL01.
4. Hampson NB. Hyperbaric Oxygen Therapy 1999 Committee Report. Place: 1999.
5. Silness J, Loe H. Periodontal Disease in Pregnancy. Ii. Correlation between Oral Hygiene and Periodontal Condtion. Acta Odontol Scand 1964; 22:121-35.
6. Newbrun E. Indices to measure gingival bleeding. J Periodontol 1996; 67(6):555-61.
7. Lang NP, Adler R, Joss A, Nyman S. Absence of bleeding on probing. An indicator of periodontal stability. J Clin Periodontol 1990; 17(10):714-21.
8. Page RC, Eke PI. Case definitions for use in population-based surveillance of periodontitis. J Periodontol 2007; 78(7S):1387-99.
9. Nield-Gehrig JS. Fundamentals of Periodontal Instrumentation and Advanced Root Instrumentation. Place: Wolters Kluwer/Lippincott Williams and Wilkins,
10. Grace AM, Smales FC. Periodontal control: an

effective system for diagnosis, selection, control and treatment planning in general practice Quintessence Int Dent Dig 1989;

11. Loe H, Silness J. Periodontal Disease in Pregnancy. I. Prevalence and Severity. Acta Odontol Scand 1963; 21:533-51.
12. Wu D, Malda J, Crawford R, Xiao Y. Effects of hyperbaric oxygen on proliferation and differentiation of osteoblasts from human alveolar bone. Connect Tissue Res 2007; 48(4):206-13.