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Hyperbaric Oxygen Therapy for Promoting Osseointegration Around Dental Implants in Heavy Smokers

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HYPERBARIC OXYGEN THERAPY FOR PROMOTING OSSEOINTEGRATION AROUND DENTAL IMPLANTS IN HEAVY SMOKERS

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ABSTRACT

Objective*:* The purpose of this study is to evaluate the effect of hyperbaric oxygen (HBO) therapy on osseointegration of implants supporting mandibular overdenture in heavy smokers.

Materials and Methods: Following two stage surgical protocol twelve completely edentulous male heavy smokers received implants placed bilaterally in the canine region to support mandibular overdenture. On the second day after the surgery patients were divided randomly into two equal groups. Patients of group I were placed on a protocol of five consecutive sessions of HBO therapy, while patients of group II received no therapy and served as control. Four months following the surgery metallic ball attachments were screwed to the implants upon which mandibular overdentures were fitted. Once patients were comfortable to the prosthesis, they were placed on a zero, six, and twelve months follow-up periods. Radiographic evaluation of peri-implant bony changes was made using cone beam computed tomography(CBCT) . Measurements were taken for bone density and crestal bone height surrounding the implants.

Results: Both groups showed increase in bone density and decrease in crestal bone height through a period of one year follow-up however the group that received HBO therapy showed less crestal bone resorption and more increase in bone density than the control group.

Conclusion: HBO therapy enhanced osseointegration around implants supporting mandibular overdenture in heavy smokers.

KEYWORDS : HBO, implants, overdenture, CBCT.

INTRODUCTION

Edentulism is a debilitating handicap. Zarb[1] described edentulous individuals who could not function as denture cripples. Difficulties with complete denture arise from inability to function with mandibular prosthesis due to its reduced support area, motion of the mandible and thin mucosa lining the alveolar ridge which makes the mandibular denture difficult to manage. Presently most patients feel that complete dentures are below the standard of care and the basic restoration for edentulous mandible should be implant supported

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overdenture with two implants placed in the anterior mandible.[2]

Completely edentulous patients who are heavy smokers are not allowed to have implants specially those of long duration of smoking. The Community Intervention Trial for Smoking Cessation (COMMIT) focused on heavy smokers as those smoking more than 25 cigarettes per day. Nicotine and its metabolites have an inducing effect on bone resorption. They also interfere in early wound healing and bone regeneration around the implant causing early failure. Smoking might also have a damaging effect on osseointegration of the implant on long term leading to inflammation around the implant and late failure of the restoration. [3]

Osseointegration was an innovative treatment in dentistry during the last three decades. The success of osseointegration is related to factors such as material biocompatibility, adequate quality of bone tissues that allows implantation, surgical technique and macro and micro structure of implants.[4-15] Nowadays, the literature suggests different therapies to improve the success of osseointegration as hyperbaric oxygen (HBO) therapy. HBO therapy improved bone formation in non radiated bone and also in irradiated bone to some extent where it presented positive effect on bone maturation and showed satisfactory results with failure rates of 1% to 2% in irradiated bone of mandible.[16,17]

HBO is the inhalation of 100% pure oxygen inside a hyperbaric chamber that is pressurized to greater than 1 atmosphere absolute (ATA) till 3 ATA. The duration of HBO session is typically 90 to 120 minutes however, the frequency and cumulative number of sessions have not been standardized. [18-20] HBO increases dissolved oxygen in the blood and results in high partial pressure of oxygen (PaO_2) in tissues of the body. The increase of oxygen tension in regenerating tissue stimulates the growth of new blood vessels, promotes collagen and adenosine-triphosphate (ATP) synthesis, enhances osteoblastic and osteoclastic activity, [20-22] causes cellular differentiation to osseous tissue, [23] triggers osteogenesis and bone remodeling which accelerates the healing in bone[24,25] and causes a significant increase in bone formation.[26] HBO also accelerates the union of autogenous free bone grafts and the tissue incorporation of commercially pure titanium implants in free autogenous bone grafts.[25,27]

HBO is appropriate for use in several surgical conditions as evidence-based therapy. These are gas gangrene, crush injuries, acute traumatic ischemias, healing in selected problem wounds, exceptional blood loss anemia, necrotizing soft-tissue infections, refractory osteomyelitis, compromised skin grafts, thermal burns and intracranial abscesses. HBO has also been refereed when host compromising factors and/or comorbidities such as diabetes, radiation exposure, soft tissue radionecrosis and osteoradionecrosis are present. [28,29]

From understanding the physiology and mechanism of action of HBO it could be used as a treatment protocol for heavy smokers requiring implants. The purpose of this study is to evaluate the effect of HBO therapy on osseointegration of implants supporting mandibular overdenture in heavy smokers.

MATERIALS AND METHODS

Patient Selection

Twelve completely edentulous male heavy smokers were consecutively admitted for treatment with implant-supported mandibular overdentures at the Department of Proosthodontics, Misr University for Science and Technology. The age of patients at the time of implant placement ranged between 50 to 60 years with mean 55 years. All patients were free from any systemic diseases that may contribute to bone resorption and all of them had normal ridge relationship with adequate bone quality (D2) and

quantity (Type A, B). [30] A consent form signed by the patients participating in the study, as well as passing the requirements of an accurate clinical examination performed by a hyperbaric medical specialist was mandatory. The hyperbaric oxygen treatment contraindications served as exclusion criteria. These contraindications included patients with untreated pneumothorax, upper respiratory infections, high fevers, emphysema with CO_2 retention, history of thoracic surgery, claustrophobia and convulsion associated to toxicity of oxygen. [31,32] All patients were monitored during an observation period of one year and were seen regularly during follow-up visits. Detailed records of all the patients in the study were kept and processed by computer during the entire observation.

Prosthetic Procedures

Patients received their complete dentures prior to implant insertion. Primary impressions were taken using alginate impression (Alginmax, Major Prodotti. Dentari SPA. Moncalieri. Italy) in stock trays. Secondary impressions were taken using medium body rubber base (Swiss TEC, Coltene, Whaledent, Altstatten, Switzerland) in specially constructed special trays. Maxillomandibular relationships were registered following check bite technique. Upper casts were mounted on semi-adjustable articulator (Dentatus type ARH, AB Dentatus, Stockholm, Sweden) according to face bow records (Dentatus face bow Dentatus, Stockholm, Sweden), while the lower casts were mounted using wax wafer centric occluding record. Setting up of modified anatomical cross linked acrylic resin teeth (Vita-pan acrylic teeth, Vita Bad Sackingen-Germany) was done following esthetic tooth evaluation and modified lingualized occlusion scheme. [33] Waxed-up dentures were tried-in and processed into high impact heat cure acrylic resin (Lucitone 199, Dentsply, York, PA-USA). laboratory remounting was done before finishing and polishing. Finished dentures were delivered to the patients after they were clinically remounted. Mandibular dentures were duplicated for fabrication of clear acrylic resin stent (Vertex Rapid Simplified; Vertex-Dental BV, Zeist, The Netherlands) to act as a surgical guide for implant positioning to assure proper implants installation beneath the planned position which was determined by ideal denture contour and esthetics.

Implants

Computerized tomographic scans were employed to calculate the bone height and determine the position of the mental foramen and shape of the bone in the anterior area of the mandible. According to this 15mm length, 3.4mm width titanium alloy, screwed, cylindrical, sand blasted, acid etched implants (TUT 2 Dental Implant, Egyptian CO. for dental implants (ECDI) Cairo Egypt) with internal hex were chosen. The implants were placed in the region between the mental foramina, at the location of the former cuspids following two stage surgical protocol and were left to heal for four months.

Hyperbaric Oxygen Therapy

Patients were divided randomly into two equal groups each of which consists of six patients. On the second day after the surgery patients of group I were placed on a protocol of five sessions of HBO therapy [34] once a day for five consecutive days at the multi place HBO chamber (Fig. 1a,b,c) located at Egyptian Air Force Aero-Medical Institute, Cairo, Egypt under the supervision of hyperbaric medical specialist while, patients of group II received no therapy and served as control. The period of each session was 90 minutes under pressure of 2.4 ATA.[18-20] Each session consisted of three phases: compression pressurization where the room pressure was raised from 1 ATA to 2.4 ATA for 15 minutes, oxygen breathing for one hour at 2.4 ATA and decompression pressurization for 15 minutes from 2.4 ATA to 1 ATA (Fig. 2).

Fig. (1a) Multi place HBO chamber from outside

Fig. (1b) Multi place HBO chamber from inside

Fig. (1c) Application of HBO

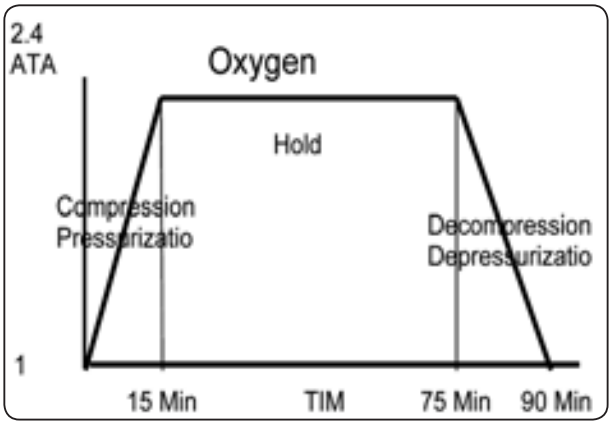

Fig. 2 Histogram showing hyperbaric oxygen session at 2.4 ATA

Loading and Pick-up Procedures

Four months following the surgery, surgical uncovering of the submerged implants was carried out and metallic ball abutment of cuff height 2mm (Tut Dental Implant System;Egyptian Co.for dental implants (ECDI) Cairo, Egypt) were threaded onto the implants Complete seating of ball abutments was verified by radiographing the implant abutment interface. Fitting surface of the mandibular overdenture was relieved to create enough space to accommodate the ball and nylon cap with its metal housing. The denture was tried in the patient's mouth to ensure complete seating. A mix of self cure acrylic resin (Lucitone 199; Dentsply) was applied in the relieved region for direct pick- up of the attachments and the patient was instructed to close in centric during this procedure. Any necessary adjustments were carried out to eliminate occlusal interference and the denture was delivered to the patient and checked after 24 and 72 hrs for any needed adjustment and to ensure that the patient was satisfied with esthetic, stability and retention of the denture.

Follow-up Evaluation Schedule

Patients were instructed to follow strict oral hygiene measures. They were recalled for follow-up visits one week after denture insertion, six and twelve months later on. At these intervals, patients returned for assessment of implant, prosthesis' function and standardized evaluation of their oral health. Cone Beam Computed Tomography (CBCT)

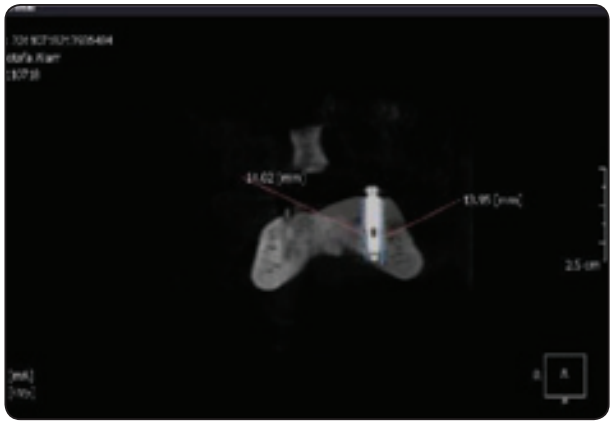

Fig. (3a) Mesial and distal crestal bone height measurements using CBCT

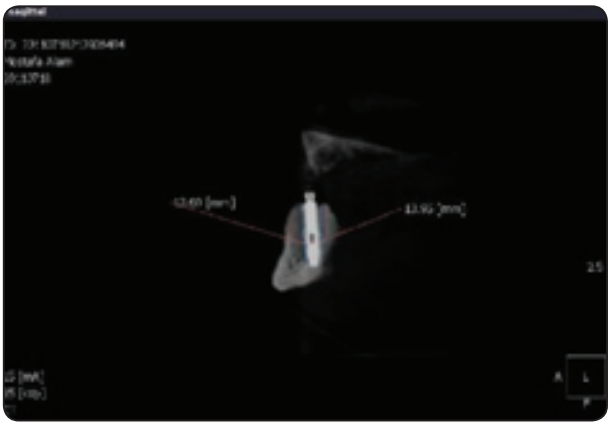

Fig. (3b) Buccal and lingual crestal bone height measurements using CBCT

was used to identify peri-implant radiolucencies, crestal bone levels and bone density.

Radiographic evaluation using CBCT

Images were acquired using the Scanora 3D Imaging system (Scanora 3D, Sorredex-Finland) (voxel size 133um-350 um) which allows the recording of linear bone height and density measurements of images. The personal computer utilized was an Intel Core Duo- 2.13 Mhz-3.25 Gbites-21 inches flat screen 9 Hewlett-Packard Pavilion Elite m9200t series (Hewlett-Packard Pavilion Elite m9200t series USA).

Image Analysis

Linear measurements for evaluation of crestal bone height

Mesial and distal crestal bone levels were calculated from the reconstructed corrected sagittal views by drawing a line parallel to the implant serration extending from the crestal bone to the apical end of the implant (Fig.3a). Similarly, buccal and lingual bone levels were calculated by using cross-sectional views (Fig.3b). Average readings of the four sides at each interval were calculated and tabulated for statistical analysis.

The density measurements were performed by

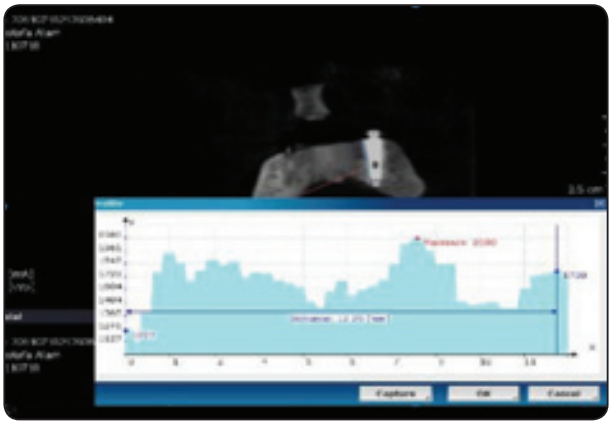

Fig. (4) Assessment of bone density using CBCT

calculating the CT numbers 1 mm away from the surface of each implant at all buccal (B) and lingual (L) sides (cross sectional views) and mesial (M) and distal (D) sides (corrected sagital views). Therefore each implant had four CT numbers (B, L, M, D) indicating the quality (density) of bone engaged with the threads of the implant (Fig 4). Average readings of the four sides at each interval were calculated and tabulated for statistical analysis.

Statistical analysis

The statistical analysis of data was done by using excel program and SPSS program (statistical package for social science) version 16 on windows xp

The description of data as done is

1- Frequency and proportion for qualitative data

2- Mean ± SD for normally distributed quantitative data

The analysis of data done to test statistical significant difference between groups for quantitative data normally distributed (mean ± SD)

Paired and unpaired student t-test was used to compare the two studied groups.

P value is significant if ≤ 0.05 at confidence interval of 95%

RESULTS

Crestal Bone height

There was decrease in mean value of crestal bone height surrounding the implants throughout the study period in both groups. This decrease was highly significant in both groups through all intervals of follow-up period as shown in table I.

There was statistically significant differences between the two studied groups in the decrease of crestal bone height surrounding the implants through all intervals of follow-up period where group I showed less crestal bone resorption than group II as shown in table II.

Bone density

There was increase in mean value of bone density surrounding the implants throughout the study period in both groups. This increase was highly significant in both groups through all intervals of follow-up period as shown in table I.

There was statistically highly significant differences between the two studied groups in the increase of bone density surrounding the implants through all intervals of follow-up period where group I showed more increase in bone density than group II as shown in table IV.

TABLE (I) Effect of time on crestal bone height surrounding the implants in both studied groups at different intervals of follow-up period.

	Group I: HBO Therapy Group		**Group II: Control Group**	
Period	**Mean (mm)**	**SD**	**Mean (mm)**	**SD**
At-insertion	14.31	0.07	14.20	0.10
At- 6 months	14.22	0.08	14.05	0.10
At 12 months	14.03	0.06	13.79	0.05
	paired t- value	**P value**	**paired t- value**	**P value**
0-6 months	9.79	0.001**	13.95	0.001**
0-12months	13.52	0.001**	21.64	0.000**
6-12 months	9.97	0.001**	19.82	0.000**

** p value < 0.05: significant. ** p value < 0.01: highly significant. ns= P value >0.05: non-significant*

TABLE (II) Comparison between crestal bone height changes surrounding the implants in both studied groups at different intervals of follow-up period.

	Group I: HBO Therapy Group		Group II: Control Group		Unpaired t-test	p-value
Period	**Mean difference (mm)**	**SD**	**Mean difference (mm)**	**SD**		
0-6 months	0.09	0.03	0.16	0.04	4.36	0.000**
6-12 months	0.19	0.06	0.26	0.10	2.02	0.049*
0-12 months	0.28	0.07	0.42	0.10	3.38	0.001**

** p value < 0.05: significant. ** p value < 0.01: highly significant. ns= P value >0.05: non-significant*

TABLE (III) Effect of time on bone density surrounding the implants in both studied groups at different intervals of follow-up period.

	Group I: HBO Therapy Group		Group II: Control Group	
Period	**Mean (HU)**	**SD**	**Mean (HU)**	**SD**
At-insertion	1048.17	31.66	959.92	24.50
At- 6 months	1149.83	45.95	1012.67	35.64
At 12 months	1216.25	50.28	1059.08	33.20
	paired t- value	**P value**	**paired t- value**	**P value**
0-6 months	6.32	0.004**	4.23	0.004**
0-12months	9.80	0.007**	8.33	0.006**
6-12 months	3.38	0.003**	3.30	0.003**

** P value < 0.05: significant. ** P value < 0.01: highly significant. Ns= P value >0.05: non-significant*

TABLE (IV) Comparison between changes in bone density surrounding the implants in both studied groups at different intervals of follow-up period.

	Group I: HBO Therapy Group		Group II: Control Group		Unpaired t-test	p-value
Period	**Mean difference (HU)**	**SD**	**Mean difference (HU)**	**SD**		
0-6 months	101.67	28.87	52.75	23.41	4.559563	0.001**
6-12 months	66.42	16.08	46.42	19.41	2.748423	0.010**
0-12 months	168.08	29.99	99.17	22.46	6.37164	0.003**

**P value < 0.05: significant. ** P value < 0.01: highly significant. Ns= P value >0.05: non-significant*

DISCUSSION

Although HBO was used in various researches conducted by several investigators yet, the frequency, and cumulative number of sessions for HBO have not been standardized. In a study by Eid[34] HBO was used to aid in the postoperative stability of orthognathic surgical corrections in patients with severe dentofacial deformities for five consecutive days at the Egyptian Air Force Aero-Medical Institute, Cairo, Egypt. Based on this a protocol of five consecutive HBO sessions was used in this study.

Significant decrease of crestal bone height surrounding the implants for the two groups was found throughout all time intervals during this study. This bone reduction might be due to surgical trauma, bone osteotomy and healing process. Also it might be considered an immediate bone reaction after insertion of the prosthesis which attributed to the healing and reorganization following trauma to the bone and periosteum combined with remodeling due to functional stresses following prosthesis connection.[35,36] Progressive reduction of bone height till the end of the study might be due to cumulative effect of environmental and mechanical factors on the implant[37]. However, in the two groups the amount of reduction was within the acceptable range of implant success which is 1.5-2 mm mean marginal bone loss around dental implant in the first year after prosthetic restoration and 0.1-0.2 mm annually after that.[38,39] This also agrees with the findings of Cox and Zarb [40] who stated that mean crestal bone loss reaching 1.6 mm is accepted as a radiographic sign for implant success during the first year of implant loading. This acceptable range of crestal bone height loss for the two groups until the end of the study period may be attributed to adequate implant length in proportion to the height of the residual alveolar ridge, proper application of oral hygiene measures, proper implant installations and angulation, and restricting the opposing occlusion to complete denture [41,42]

In the results of this study the crestal bone height reduction after one year follow-up was less in the group which received HBO therapy. This might be attributed to the physiologic effects of HBO which includes improved oxygenation, vasoconstriction, increased antimicrobial activity, bactericidal and bacteriostatic effect and modulation of inflammation. Blood and tissue oxygen tensions were documented to remain elevated for over an hour following a single HBO treatment in an experimental rat wound model.[43] The increase in oxygen tension promotes collagen and adenosine-triphosphate (ATP) synthesis, capillary in growth, osteoblastic and osteoclastic activity and has a triggering role in bone remodeling.[20-22,24] There is a parallelism between the increase in oxygen tension and increase in osteoblastic and osteoclastic activity.[20] The increase in oxygen tension causes cellular differentiation to osseous tissue, whereas decreased oxygen tension results in cartilage formation.[23]

The results of crestal bone height in this study agree with the study of Nilsson et al., [26] who proved that HBO treatment causes a significant increase in bone formation. It also agrees with the studies of Sawai et al., [25,27] who showed that there is an acceleration in bone healing and an increase in the amount of new bone formation with HBO therapy.

Statistically significant increase in the mean value of bone density for the two groups was found during all periods of the study. This could be considered as a positive response to the applied forces within the physiologic limit and adaptive capacity. Since the thickness and closeness of the bone trabeculae vary directly with the stresses transmitted to them thus, proper distribution of the load falling on the implants might have enhanced the structural orientation of bone trabeculae and hence increased the bone density around the implants. [44,45] The increase in bone density was more in the group which received HBO therapy. This agrees with the findings of Clark et al., [46] who evaluated the effect of

HBO therapy on bone regeneration during mandible distraction of radiated rabbits and concluded that bone density of the mandible showed a positive relation with the therapy and the percentage of bone into the distracted segments increased with great amount in the non radiated groups in comparison to the radiated groups.

CONCLUSIONS

1- The present study seeks to provide additional evidence regarding the benefits of HBO in enhancing osseointegration around implants supporting mandibular overdenture in heavy smokers.

2- Administration of HBO in heavy smokers improved bone quality and decreased crestal bone resorption around implants.

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