

Effect of Microgravity on Oral Cavity: A Review

¹Dr. Achint Garg, ²Dr. Annu Saini

¹(Department of Oral Medicine and Radiology, ITS Dental College & Research Centre, India)

²(Department of Oral Medicine and Radiology, ITS Dental College & Research Centre, India)

Abstract: Microgravity is the condition in which people or objects appear to be weightless. The effects of microgravity can be seen when astronauts and objects float in space. Microgravity can be experienced in other ways, as well. Our planet earth is the third planet of the solar system and exerts a force called gravitational force on living and non living things present on its surface or also on the objects come in contact with this pull. As we leave Earth's surface and escapes its gravitational pull, the microgravity we have in space forces various changes in our body. Due to exposure of astronauts to the stimulated microgravity they experience several uncommon and unfavorable environmental conditions, which lead to innumerable injurious health effects. Microgravity affects almost all the systems and physiological activities including cardiovascular system, skeletal system, renal system, nervous system, respiratory system, hormonal imbalance etc. The main focus of this review is the effect of the microgravity on the oral cavity and temporomandibular joint.

Keywords: Microgravity, Astronaut, Barotraumas, Odontocrexia, Barodontalgia

I. Introduction

The universe has its secrets. Extra dimensions of space might be one of them. If so, the universe has been hiding those dimensions, protecting them, keeping them coyly under wraps. From casual glance, you would never suspect a thing. - Lisa Randall

Human physiological adaptation to the conditions of space is a challenge faced in the development of human spaceflight. Microgravity causes various physiological changes in astronauts during space flight. Whether we realized it or not, the mankind has evolved a number of structures, mechanisms, controls and reactions that are adapted to the constant stress of gravities. Exposure to zero or microgravity conditions during space flights induces drastic changes in the human body that may threaten the safety of astronauts and inhibit their activities. While humans have little difficulty surviving in space for short periods in time, it is still unknown whether long-term exposure to microgravity may be detrimental to human health.¹ Weightlessness consist of a cascade of interrelated adaptations that modulate the various physiological processes of human body by altering fluid redistribution, change of weight bearing structures and dysfunction of gravity receptors, circadian related problems involving sleep & performance, increased flatulence, loss of muscle mass, bone loss by loss of bone mineral density, fluid imbalance, changes in immunity level, reduction in number of red blood cell count, cardiovascular & sensory motor de-conditioning, reduced cardiac muscle mass resulting in diminished cardiac function

II. Effect Of Weightlessness On Bones & Supporting Structures

All processes starting from bone formation, new bone deposition to bone mineralization decreases or stops during the phase of weightlessness. During microgravity phase, due to reduced stress on bones, they tend to lose minerals & become porous. Few studies have noted the effect of microgravity on osteoclastic activity which leads to bone resorption. Due to bone loss, bone mineral density decreases which result into weak bones & more prone to fractures. Skeletal muscle support is also not required for maintaining posture in absence of gravitational forces, thus resulting in weakening of these muscles.

III. Effect Of Microgravity On Head And Face

The change in atmospheric conditions effect the head and neck area of the astronauts in several ways. Due to barotrauma (Barotrauma is a condition which is experienced by tissues, which is caused by a difference in pressure between a gas space inside the body and the surrounding fluid.²) conditions like barotitis-media, barosinusitis, external otitic barotrauma, barotrauma-related headaches, dental barotrauma, barodontalgia, barotitis, barosinusitis and haemorrhages occur during descents made from high altitudes. A partial vacuum develops, due to decreased pressure which is manifested by a retracted tympanic membrane, precipitation of acute inflammation of the middle ear cavity and sinus, which is known collectively as barotrauma.

Vacuum created due to the difference in air pressure leads to inflammatory condition of the paranasal air sinuses, known as Barosinusitis. This vacuum is stressful for the mucosal linings of sinuses, which results in submucosal haematoma, mucosal oedema, etc. which can lead to headache, dizziness, and anoxia. Imbalance in

fluid distribution of body result into 'moon face' appearance of face. Ensuing pain and numbness can occur due to pressure exerted on branches of trigeminal nerve.

IV. Effect On Oral Cavity

Due to changes in the external environment barometric pressure changes, which can cause dental pain, this condition is known as barodontalgia. Common oral defects like dental caries, pulp necrosis, defective tooth restorations, pulpitis, impacted teeth and mucous retention cysts, apical periodontitis, periodontal pockets can cause barodontalgia.²

It can be caused by two ways-

- Due to creation of pressure changes in the tooth, caused by carious activities or because of defects in it.²
- As the pressure reduces during ascents, leading to dissolution of gases in the blood vessels, due to which bubbles enter the pulp.²

V. Effect On Tooth

The effect of microgravity on tooth results in dental caries, pulpitis, defective tooth restorations, apical periodontitis), pulp necrosis, vertical root fracture and impacted teeth.²

VI. Pulpitis And Barotrauma

Pulp diseases are the major causative pathology of barodontalgia. They can develop in conjunction with teeth with new and recurrent caries, teeth which experience pulpitis after restorative treatment, in intratreatment endodontic symptoms, in periodontal abscesses, in dental and periodontal cysts. Holowatyj RE concluded that the causative reason for barodontalgia could be pulpal hyperaemia. The placement of a zinc oxide eugenol (ZOE) base was found to prevent barodontalgia when reversible pulpitis was the underlying cause. It was also suggested that when people who were subjected to large pressure changes were treated, it would be best to avoid procedures such as capping of exposed pulp. Rather, an endodontic treatment could be indicated.²

Odontocrexis

Calder and Ramsey studied tooth fractures caused by a high altitude environment and they coined the term, "odontocrexis", to describe physical disruption of teeth with leaking restorations due to barometric pressure changes.² The tooth damage was experienced when there were inferior quality restorations and unrestored teeth with and without caries. The damage was caused accidentally due to expansion of gas which was trapped beneath the restorations. Some of the causes were fractures in porcelain fused metal restorations, pressure changes in microtubules of dental cements, which could lead to dislodgement of crowns.² A study done by DK Patel et al. on fractures of posterior teeth showed that mesiocclusodistal restorations were more prone to tooth fractures.²

Effect On Peridontium

In flyers who fly at high altitudes, decrease in oxygen levels can have a deleterious effect on teeth, fillings, gums and the mouth. A common complaint is xerostomia, due to decrease in saliva content, which increases the risk of periodontal diseases. Predisposing factors of flying personnel include poor oral hygiene, nervousness, flying fatigue.

Effect On Jaw Bones

Pathological conditions like apical periodontitis (jawbone cysts and granulomas), periodontal pockets, impacted teeth, mucous retention cysts are common in astronauts during flying. Due to bone loss and decrease in bone mineral density the jaw bones become more prone to fractures.⁴ Level of osteocalcin increases in saliva, serum and GCF during microgravity, which leads to bone resorption.⁵

Effect On Oral Flora

Increases in total anaerobes, *Baeteroides*, *Fusobacteria*, *Veillonella*, total aerobes, *Neisseria*, *Lactobacilli*, *Staphylococci*, *Candida*, and *enteric bacilli* activity could be due to the isolated environment and might further contribute to higher prevalences of periodontitis and caries.⁶

VII. Effect On Saliva, Salivary Proteins

Salivary gland gene expression is modulated by numerous factors, including functional activity, neurohormonal stimulation and pharmacologic agents. Results of a study conducted by Maija Mednieks, Aditi Khatri showed that the expression of secretory proteins associated with beta-adrenergic hormone regulated responses and mediated *via* the cyclic AMP pathway was significantly altered, whereas that of a number of unrelated proteins was not.³ Due to altered fluid distribution and fluid imbalance, the flow of saliva reduces during microgravity and leads to xerostomia. Increased bone resorptions contribute significantly to raise the salivary state of saturation with respect to the calcium salts, namely, calcium oxalate and calcium phosphate. In addition, other environmental and dietary factors may adversely affect salivary composition and increase stone formation risk during space flight.⁴

VIII. Effect On Prosthesis

Decrease in barometric pressure can impair the retentions of complete dentures (both maxillary and mandibular dentures; among which maxillary dentures totally depend on this).² Change in pressure in microtubules of the cement layer, results in a reduced retention of the crown. Mostly, the cement layers beneath the crowns become weak due to microleakage.² To favor the retention of prosthesis, an implant supported prosthesis can be chosen.

IX. Problem Facing During Surgery

When an upper posterior tooth is extracted, the dentist should not rule out the existence of an oroantral communication. Involvement of oroantral communication can lead to sinusitis and it can be adverse if it is exposed to a pressure changing environment.

X. Flight Restriction

Grounding of a patient is required when there is interference with the flight capabilities of the aircrew members.² This can be caused by intake of medications, which causes side effects like headache, nausea and dizziness.² Due to the intra oral pressure, the blood clot which is formed after the surgical procedure in patient's mouth can come out and it can lead to intra oral bleeding. So, here, flight restriction is needed until the symptoms subside.² Restorations which are being done recently have a greater probability for fractures than the old ones. It is the duty of dentists to notify their patients (aircrew members) about the post-operative flight consequences and restrictions.²

XI. Effect Of Microgravity On Temporomandibular Joint

In case of microgravity there is reduction in overall muscle mass thus causing insufficient increase in muscle tonicity during stressful period.⁷ The effect of stress directly affects the temporomandibular architecture along with overall reduction in bone mineral density of complete body. Abnormal facial expression, loss of sensation of pain and temperature, decreased tongue, and mandibular movements in simulation microgravity environment were observed due to fluid shift mechanism.⁴ In longer duration space visits, circulating parathormone concentration also reduces which in turn reduces vitamin D metabolism & thus resulting into overall vitamin D deficiency. The effect on disorientation of complete body homeostasis affects combinedly towards disarrangement of temporomandibular joint function.⁷ Lactate dehydrogenase isoenzyme levels increased during HDT(head down tilt), this implied the development of muscular atrophy.⁴

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