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Space Dentistry

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Abstract

The oral cavity functions in taste, mastication, solubilization and digestion of nutrients, as well as in respiration and speech, and participates in innate and adaptive immunity. Saliva creates and regulates the environment of the oral cavity, and changes in its composition and rate of secretion have significant effects on oral tissues as well as on systemic health.

Since the beginning of the era of space travel, there have been mentions of related health effects. Various studies have described the effect of space travel and microgravity on health. Some of these studies involved short and extended follow-ups of the effect of microgravity on the head and neck of astronauts.

Short and extended follow-ups of the effect of microgravity on the head and neck of astronauts. Humans have long dreamed of flying and in recent years, the dream has evolved to exploring space and creating new habitats on other planets such as Mars.

This led to an increase in the need for dental treatment of the flight crew members, which led to the creation of aviation dentistry for the screening and treatment of the oral cavity of the flight crew.

We are moving towards a more conservative approach than before, such as removing pulp less teeth in aircrew patients or extracting roots that had a fracture or incomplete extraction. With all the advancements in aerospace knowledge, the aviation dentistry has rarely or briefly been discussed in dental textbooks.

Dentists must screen each flight crew member thoroughly and impose flight restrictions and ground them if necessary; Therefore, we aimed to analyse the oral and maxillofacial health effects associated with this sophisticated mission. It is essential to identify relevant problems and address microgravity complications.

Keywords: Salivary Glands, Mandible, Teeth, Morphology, Protein Expression

Introduction

The oral cavity is the body's portal for the intake and initial processing of food and liquids, functioning in taste, mastication, solubilization and digestion of nutrients. Additionally, the oral cavity plays a role in respiration and speech as well as in innate and adaptive immunity.

The components of the oral cavity include the teeth, consisting of three types of mineralized tissue, and their supporting structures, the bones of the maxilla and mandible and alveolar processes, and the periodontal ligament.

The oral mucosa, which covers the alveolar processes, tongue, palate, cheeks, inside of the lips and floor of the mouth, consists of keratinized and non-keratinized epithelium overlying the connective tissues of the lamina propria and submucosa. Located extra orally are the major salivary glands: the parotid, the submandibular and the sublingual, which convey their product, saliva, to the oral cavity via long ducts. Saliva, consisting of water, electrolytes and a large number of proteins, glycoproteins and small organic substances, creates and regulates the environment of the oral cavity.

Changes in composition and rate of secretion of saliva have significant effects on oral tissues as well as on general health. In addition to the major glands, numerous small minor salivary glands are present in the subepithelial connective tissue throughout much of the oral cavity.

Among the organic constituents of saliva are digestive enzymes, calcium binding proteins, a variety of growth factors and regulatory molecules, antimicrobial components and immunoglobulins, and mucins that lubricate and moisten the oral tissues[1].

Other protective components of saliva include those involved in buffering and neutralizing acids produced by oral microorganisms and ingested with food and drink. Most are produced and secreted by the cells of the salivary glands, nevertheless a number of other proteins derived from other cells, tissues and organs also find their way into saliva.

The presence of these substances and the ease of, and the noninvasive means of, collecting saliva have led to a great deal of interest for its use as a diagnostic fluid. Consequently, significant progress has been made in using saliva to detect oral and other cancers, several oral and systemic diseases, and to assess physiological and environmental stressors[2].

Human physiological adaptation to space is challenging in human space flight. Astronauts will encounter physiological and psychological alterations during the journey when they return to the earth. Exposure to microgravity and the space environment, even over a short or long period, affects human health

These effects include neurovestibular problems, involving space motion sickness, disorientation, impaired balance, neuromuscular coordination, fluid retention, orthostatic hypotension, ventricular arrhythmias, reduced cardiac muscle mass, atrophy of muscles, sleep disorders, immune-related problems such as infection and immunodeficiency, psychological effects, temporomandibular joint dysfunction (TMD) and dysfunction of masticatory muscles associated with pain including in the oral cavity.

Very few studies have been published on the effect of microgravity on the oral cavity. However, it has been reported that microgravity increases the prevalence of periodontitis, dental caries, periodontal bone loss, fracture of the jawbone, pain, dysesthesia in the teeth and oral cavity tissue, salivary duct stones and oral cancer.

The aim of the study was to analyse all the literature regarding microgravity and management of complications of the head and neck among astronauts.

Microgravity and its effect on bone formation

Bone loss is considered to be one of the most serious and potentially intractable biomedical consequences of human space flight. However, microgravity-induced changes in bone are not uniform along the skeletal axis. For instance, while bone mineral density (BMD) decreases in the lower extremities, it increases in the skull.

A similar pattern of region-specific changes in bone properties has been reported to occur with head-down bed rest[3-6]

In space, mechanical stress is reduced, leading to a decreased rate of osteogenesis and an increased adipogenesis rate. Osteoblasts are derived from MSCs, but in μg the differentiation process does not occur properly and the resulting bone loss has been attributed to osteoblasts due to their

- Reduced proliferation and activity,
- Reduced differentiation and
- Decreased response to bone-related factors in the microenvironment.

Observations have also been made regarding the cytoskeleton of osteoblasts; there is growing evidence that the cytoskeleton is closely connected to nuclear morphology and that the enlarged nuclei observed in flight osteoblasts could be a result of cytoskeletal disruption[7-9].

Head and neck barotrauma

Based on the Boyles Law, the surrounding pressure of gas volume varies inversely at a constant temperature and the gas volume in the body's rigid cavities is associated with atmospheric pressure, in which changes in pressure may lead to several adverse effects known as barotrauma [10].

Barotrauma may occur during hyperbaric oxygen therapy, diving or flying; head and face barotrauma include bar otitis-media, barosinusitis, barotrauma related headache, bar odontalgia and dental barotrauma.

The variation in the volume of the gas inside the body's rigid cavities, which is linked with the variation in atmospheric pressure, causes several harmful effects. This variation may lead to various conditions, such as bar otitis media, barosinusitis, barotrauma-related headaches, dental barotrauma and bar odontalgia [11]

During the descent from high altitudes, a partial vacuum develops, which is manifested by a retracted tympanic membrane leading to bar otitis and barosinusitis [12].

Barosinusitis is an inflammation of the paranasal air sinuses, whereas acute inflammation of the middle ear cavities and inflammation of the sinuses cause barotrauma. The vacuum created due to air pressure difference causes mucosal oedema, dizziness, headache and anoxia[13].

Masticatory muscles

Under microgravity conditions, the muscle mass decreases, which results in a small increase in muscle tonicity in difficult situations. Muscles will, in general, become feeble as they are used less often against the power of gravity [14].

Therefore, muscle loading is an important factor in maintaining muscle mass; atrophy is unavoidable when the load is removed. Nevertheless, masticatory muscles do not lose mass in clinical conditions such as myopathy requiring critical care.

The properties of masticatory muscles can, therefore, be harnessed to conserve mass[15]. Mandible elevator muscles that act against gravitational forces, such as the masseter, temporalis and medial pterygoid, are more vulnerable than their counterparts[16].

Temporomandibular joint

The temporomandibular joint (TMJ) is the most perplexing joint in the human body and enables the hinging motion of the mandible in one plane and simultaneously enables sliding movement; consequently, the TMJ is referred to as the ginglymoarthroidal joint [17].

The TMJ comprises the temporal bone, the mandibular condyle and an articular plate and is classified as a compound joint. It is encompassed by facial musculature, tendons and ligaments, which permit its function[18].

The circadian rhythm of the body is affected by microgravity conditions and is associated with physiological changes; psychological stress also increases, resulting in sleep disturbances[19].

This stress legitimately influences the temporomandibular construction as well as the general decrease in bone mineral mass of the complete body[14].

Temporomandibular disorders (TMDs) have multifactorial a etiologies and can involve sleep disorders and stress due to microgravity. Higher levels of psychological distress among the TMJ and skeletomuscular muscle groups are prone to being influenced by psychological domains, with lower levels of TMJ pain than muscle pain.

Bar odontalgia

Bar odontalgia is a kind of oral pain caused by a change in barometric pressure in an otherwise asymptomatic organ. The occurrence of pain as a result of changing pressure depends on the related pathology[20].

Bar odontalgia is a symptom and not a pathologic condition itself. Normally, bar odontalgia is an exacerbation of preexisting subclinical oral disease. It occurs due to the entrapment of gases in the closed chamber because it is unable to adjust to the internal pressure[21,22].

Pain occurring on descent is related to facial barotrauma or pulp necrosis and pain occurring on the ascent is related to the vital pulp tissue. Pain occurring on both ascent and descent are related to periapical disease[21].

Reduction in atmospheric pressure, in the context of direct bar odontalgia, causes an effect on the affected tooth and, in the context of indirect bar odontalgia, stimulation of the superior alveolar nerves at the time of maxillary barosinusitis can cause pain. Pain in teeth can occur due to the stimulation of nociceptors in the maxillary sinus[21].

Bar odontalgia can occur as a result of defective tooth restorations, pulp necrosis, dental caries, periodontal pockets, mucous retention cysts, impacted cysts and dental caries[23]. Pulp/periapical conditions and symptoms can classify bar odontalgia into 2 types: pulp/periapical-related direct bar odontalgia and bar otitis/barosinusitis-induced 'indirect' barodontalgia[24].

Odontocrexis

This condition is also known as a barometric tooth explosion. Preexisting leaked restorations or recurrent caries underneath restorations can cause tooth explosion in a high-altitude environment. A common cause of damage is the expansion of gas trapped beneath restorations[25].

Calder and Ramsey reported that poor-quality restorations and unrestored teeth result in tooth damage[26].

The crowns were poorly positioned because of fractures of PFM restorations and changing pressure in the microtubules of dental cement[27].

Salivary gland

Specific morphological changes were seen in the PG after a 13- to 15-day flight on the STS-135 and STS-131 shuttle missions, and 30 days on the Bion-M1 biosatellite. In the acinar cells autophagic vacuoles were common, and apoptotic ells were seen more frequently.

The autophagic vacuoles often contained degenerating secretory granules as well as other organelles. Some cells in the intercalated and striated ducts had large endocytic vacuoles containing dense content in the apical cytoplasm. Immunogold labeling showed the presence of acinar secretory proteins in these vacuoles[15,16].

The underlying basis for these changes is believed at least in part to be the loss of neural stimulation due to reduced masticatory activity. This is indicated by experiments where withholding food for 24–48 h, or feeding rats a liquid diet, results in numerous autophagic vacuoles containing degenerating secretory granules and an increase in the number of apoptotic cells in the PG[21]

Aviation dentistry & periodontal health

Rai et al., tested periodontal criteria such as probing depth, bleeding on probing and attachment loss in some healthy individuals on a Mars mission. The measure of all the criteria was fundamentally superior at the end of the mission than at the beginning. During microgravity studies, elevated bone resorption by osteoclasts was observed[5,6].

Mainly, levels of macrophage inflammatory proteins, as a potential indicator of bone loss, were found to be inversely associated with other patterns towards the end of the analysis. On the other hand, in space travel, the reduced oxygen can harm teeth, restorations and gums.

Due to a decrease in oxygen level, a common complaint is xerostomia and due to a decrease in saliva content, there is an increase in the risk of periodontal disease[23]. Another reason can be the breathing of dry compressed gases in the aircraft[28]. Other factors influencing crew member periodontal health include poor oral health, anxiety and flying exhaustion[4]

Aviation dentisty & oral surgery

The main focus of oral surgery in the context of aviation dentistry is the extraction of posterior maxillary teeth, which can lead to oroantral communication and later lead to sinusitis, as flight crews experience a pressure-changing environment; therefore, the dentist must screen for the presence of oroantral communication and when he or she finds it, the patient must be referred to an oral surgeon for the closure of oroantral communication [29-31].

Aviation dentistry & endodontics

From 1940 to now, the chief reason for bar odontalgia has been pulpitis. Proper diagnosis of pain should be made to treat bar odontalgia at an earlier stage. Bar odontalgia often goes unnoticed due to negligence[24].

Rossi recommended endodontic treatment in cases of deep dental carries and suspicion of invasion of bacteria into the pulp chamber instead of direct pulp capping.

Open, unfilled root canals can cause leakage of the intracanal infected content into the periradicular tissues as well as facial subcutaneous emphysema[32]

Aviation dentistry & restorative dentistry

Arrested lesions are associated with minimal risk in our daily life since they are not active, but Sognnaes suggested that such lesions may become active in a pressure-changing environment and should be removed to prevent any problems during the flight[21]. We must be careful with amalgam restorations since there is a higher chance of corrosion due to increased exposure to oxygen from pure oxygen inhalation.

Hawkeye reported that cold temperature is unlikely to be the dominant mechanism underlying dental fracture. This is because of differential thermal contraction of amalgam materials compared with tooth hard tissue in cases of the low temperature in a high-altitude environment[33].

Additionally, excessive occlusal forces were a factor in dental restoration dislodgement, as seen in aircrew members; Sognnaes suggested that clenching or grinding of teeth was a causative factor for restorative failure[21].

Aviation dentistry & prosthodontics

Retentions of dentures are based on atmospheric pressure, adhesion and gravity. Reduced barometric pressure can impair the retention of complete dentures, which indicates that implant supported prostheses favour prosthesis removal. Lyons stated that the type of cementation is important, and he says that crowns cemented with resin cement did not have reduced retention, whereas those cemented with glass–ionomer cement or zinc phosphate cement had reduced retention under environmental pressure changes.

This result is mostly due to micro porosities expanding and contracting upon the pressure changes leading to weakened cement and microleakage may also be one of the factors related to low strength detected in zinc phosphate and glass–ionomer cement[34,35].

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