The history and importance of aeronautic dentistry

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Abstract: Current projected missions to Mars will require 18 to 24 months of exposure to microgravity conditions, which might have serious effects on human physiology, including that of the oral cavity. Very few studies have been published on the effect of microgravity on the oral cavity, although it has been reported that microgravity increases the prevalence of periodontitis, dental caries, bone loss and fracture in the jaw bone, pain and numbness in teeth and oral cavity tissue, salivary duct stones, and oral cancer. Aeronautic dentistry is a new field, so further study of the effects of microgravity are required. In this article, we review the role of aeronautic dentistry in space missions and offer our recommendations for the future growth of this field. (J Oral Sci 53, 143-146, 2011)

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Introduction

Human physiological adaptation to the conditions of space is a challenge faced in the development of human spaceflight (1). With current technology, a round trip to Mars is estimated to require at least 18 months just for transit (2). Investigating the effects on the human body of such prolonged exposures in space is vital in the preparation for such journeys. Advances in aerospace technology in the 20th century provided human beings with an opportunity to encounter a microgravitational (almost 0-g) environment, and this experience will increase in the present century. Astronauts experience weightlessness during space flight. Because the human body is designed to live in a 1-g environment, as on Earth, exposure to microgravity causes significant changes in body functions. Exposure to microgravity and the space environment during short- and long-duration space missions has important medical and health implications in astronauts. These include neuro-vestibular problems involving space motion sickness and disorientation during flight, as well as impaired balance and neuromuscular coordination after landing; cardiovascular and fluid-related problems of orthostatic hypotension immediately after spaceflight; altered cardiac susceptibility to ventricular arrhythmias; reduced cardiac muscle mass and diminished cardiac function; muscle-related problems of atrophy involving loss of muscle mass, strength, and endurance; decreased bone mineral density; circadian rhythm-related problems involving sleep and performance; and immune-related problems involving infections and immunodeficiency. Numerous countermeasures have been developed and tested for moderating these physiological changes. These procedures include careful screening and selection of new astronaut candidates and drug and exercise regimens during or after flight, which ensure the prompt return of crew members to flight status (2-15). Very few studies have been published on the effects of microgravity on the oral cavity (16-18). However, it has been reported that periodontitis, dental caries, bone loss and fractures in the jaw bone, pain and numbness of

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teeth and oral cavity tissue, salivary duct stones, and oral cancer are more prevalent after exposure to simulated microgravity, as compared with normal, 1-g, earth environments (16-21). We propose that a new field, aeronautic dentistry, be introduced to facilitate dental research and practice in aeronautical environments (17).

**History of aeronautic dentistry**
During World War II – As aircraft begin to fly at altitudes higher than 25,000 feet, the number of dental emergency visits by flight crewmen increases.
1945 – A position for dental research is established at the Army Air Force School of Aviation Medicine at Randolph Field, Texas, in the United States.
1950 – Space pilots are provided dental care (Air Force Dental Service), although little has changed since the early days of dentistry, ie, prevention remains the best cure.
1957 – The original guidelines for dentistry in space medicine are developed by the General Office (Air Force Manual 160-13).
1960 – Beginning of astronautical dental training program.
1966 – Air force assigns dental officer Major William Frome to full-time duty at National Aeronautics and Space Administration (NASA) in Houston to maintain the oral health of astronauts.
1970 – The term barodontalgia is introduced to refer to the phenomenon previously referred to as aerodontalgia.
1970 – Colonel Frome continues to serve with NASA during the Skylab program.
1980 – Colonel Johan Young at University of Texas at San Antonio is appointed as NASA medical operations consultant for developing dental instruments and guidelines for preventive and emergency procedures in zero-gravity environments.
2000 – The National Academy of Science Institute of Medicine Committee on Space Medicine discusses how to maintain the oral health of astronauts on long missions.
2007 – The term aeronautic dentistry is introduced by Dr. Balwant Rai.
2009 – Dr. Balwant Rai is the first dentist to be appointed Health and Safety Officer for the Mars Desert Research Station.
2009 – Dr. Balwant Rai and Jasdeep Kaur conduct the first study on the effect of simulated microgravity on the oral cavity.
2010 – Dr. Balwant Rai offers the first ever course in aeronautic dentistry, at Kepler Space University.

**Dental emergencies in microgravity are true medical emergencies**
Dental emergencies have been infrequent during space flight, due to comprehensive preflight examinations and preventive measures while the crew is in training. However, as the duration of space flights increases in planned exploration-class missions to the Moon, Mars, and beyond, the possibility of a dental emergency during space flight will increase. Although space crews live and work in a weightless environment, forces produced from the mass and velocity of moving object can cause tooth fracture and other significant injuries to the face and jaw. In addition, cracked teeth, inflammation or infection of the tooth pulp, temporomandibular disorders, periodontal abscesses, and dental caries may develop during a long-duration flight (15-21).

**The need for dentists and new dental technologies for Mars missions**
A dentist will be required for any extended-duration space flight to Mars. Radiographs, root canals, and comprehensive dental care are luxuries that are not available in space. Moreover, since in-flight equipment and supplies carried into space are strictly constrained by restrictions on weight and storage space – in addition to the requirement that they function well in microgravity – the dental equipment that is suitable for such a mission is currently limited. However, these limitations can be successfully addressed by the development of new technologies and the expansion of current technologies. It will be necessary to discover new methods of maintaining oral hygiene in microgravity environments. With the construction of long-term space habitats, such as the International Space Station, NASA’s plans for exploration-class missions are maturing, and the provision of comprehensive dental treatment to crews during space flights will become not only possible, but practicable, in the near future (1,2). However, the most important goal of clinical aeronautic dentistry will be to quickly return an astronaut or cosmonaut with a dental emergency to optimal health.

NASA has established strict standards for the selection, retention, and preflight dental examination of astronauts chosen for a specific space flight, and a strict clinical schedule is followed. At 6 months before launch, crew members undergo an examination. If dental treatment is deemed necessary, all such treatment is completed by 3 months before launch, so as to minimize the potential for problems during flight. The crew medical officers attend a preflight briefing that prepares them to address dental emergencies that might occur during flight. Finally, and most importantly from our perspective, all astronauts – whether assigned to a crew or not – are expected to maintain optimal physical and oral health and to follow good oral hygiene practices. Universities and space agencies take this
recommendation seriously, as it is very important for long missions, such as a Mars mission.

The duties of aeronautic dentists

Designing and conducting experiments in aeronautic dentistry

Ground-based research encompasses all activities that can be performed on Earth, including ongoing research in preparation for real microgravity and post-flight control studies. To date, the present author (BR) has conducted 3 studies on the effects of simulated microgravity on the oral cavity (16,22,23), and these studies appear to be the only work in this field. We maintain that there are a number of reasons to perform ground-based studies in the field of acceleration research. These include:

1) determining the effects of acceleration (weight) on the system under investigation;
2) preparing for real microweight experiments on orbiting spacecraft, sounding rockets, and parabolic flight aircraft;
3) identifying the parameters that might be changed under real microweight conditions, so as to better define the performance of flight-experiment test hardware under conditions of simulated gravity or hypergravity (eg, launch);
4) examining the interaction of a system under study in relation to the hardware being used in a real microweight experiment;
5) investigating the effect of launch accelerations and vibrations on the system under study or in combination with the utilized hardware.

Finally, because ground-based research facilities are readily available as compared with other facilities, studies can be performed on a day-to-day basis, thus producing a greater volume of valuable scientific data for publication.

Curriculum and training

A proposed curriculum for aeronautic dentistry has been published (16). The present author (BR) has proposed 2 types of training (16): an FAD (Fellowship of Aeronautic Dentistry) to be awarded to students completing an introductory course requiring 18 weeks of full-time study and a PGDAD (Postgraduate Diploma in Aeronautic Dentistry) to be awarded to students completing an advanced course requiring 36 weeks of full-time study. The curriculum is expected to be finalized after discussion with experts in dentistry and space medicine.

Funding

Research funding should be started by NASA, the Indian Space Research Organization, and the International Space Station, because they have already established guidelines for dental safety on long missions, such as the Mars mission. To begin this process, close collaboration between space agencies and dental schools will be required.

Recommendations

A course in aeronautic dentistry should be included in the dental curriculum. In addition, an aeronautic dental institute should be opened to collaborate with space agencies in advancing development and research, MSc and/or PhD degrees in Aeronautic Dentistry should be added to dental curricula, and journals and other media in the field of dentistry should highlight the need for greater knowledge of and research in aeronautic dentistry. Finally, a CDE (continuing dental education) program or workshop/training course in aeronautic dentistry should be developed and implemented.

References