MARS (Making Astronaut Resources Safe); Oral Health

Kadance McMahon; Mentored by Dr. Rita Pujari, NASA CoP at Great Basin College

Overview

Researched more sustainable dental care materials and procedures for space exploration.

Based on this research I designed an experimental design describing the way they could be tested in a laboratory setting.

This research's purpose is to improve the oral and overall health of astronauts on long term space missions or even when pursuing the possibility of colonizing Mars.

This research also aims to deepen our understanding of the effects of space on our oral health while providing new solutions.

Introduction

-The exploration and potential colonization of Mars signifies humanity's venture beyond Earth, posing unique challenges, notably in maintaining optimal oral hygiene due to environmental stressors like microgravity and heightened radiation exposure.

-The MARS oral health project aims to address these challenges by developing innovative and sustainable dental care solutions tailored for space, aligning with NASA's objective of fostering solutions for resource-scarce communities on Earth.

Hypothesis

-(#1): The utilization of modified oral hygiene materials designed for space conditions (experimental group 1) will exhibit noticeable improvement in oral health indicators compared to the control group.

-(#2): The implementation of sustainable dental care procedures specifically tailored to space conditions (experimental group 2) will demonstrate superior oral health outcomes compared to both the control group and experimental group 1.

Research

-There are many unique challenges of space including microgravity, decreased barometric pressure, and increased radiation exposure, affecting oral health during prolonged space missions.

- Microgravity impacts salivary composition and hormone levels; barometric pressure changes cause barodontalgia and dental barotrauma; radiation exposure leads to oral cancers, tooth decay, gum disease, and soft tissue damage.

- Astronaut oral health issues include tooth sensitivity, pain, gum swelling, dental barotrauma, and difficulties performing dental procedures due to limited space and equipment constraints; current oral health protocols for astronauts are still being refined.

- Procedures for astronaut dental care include yearly exams, dental treatments prior to launch, and wisdom teeth removal; challenges like brushing teeth in space without access to running water can lead to overlooked oral hygiene.

- Medical emergencies related to dental hygiene are rare in space, and limited medical equipment restricts procedures to basic dental care like tooth pulling, highlighting the need for further research into long-term effects of space environmental factors on oral health.

Experimental Design

Materials and Procedures to be tested in the experimental process:

-Materials:

- Dental Fillings (Radiation Resistant):

-Polymer Based Composite Fillings
-Ceramic-Based Fillings
-Nanostructured Fillings

- Enamel-Strengthening Agents:

-Compounds releasing fluoride ions
-Agents containing calcium and phosphate

- Biocompatible Dental Sealants:

-Resin-based sealants (modified to enhance radiation resistance)
-Nanostructured sealants
-Bioactive Sealants

- Dental Implants or Prosthetics:

-Titanium-based implants
-ZIrconia implants
-Nanostructured surfaces on implants

-Procedures:

- Oral Hygiene Kits:

-Antimicrobial Toothpastes
-Enhanced mouthwash with extreme antibacterial agents (could also aid in saliva generation).

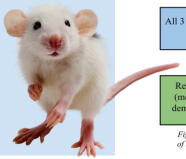
- Minimally Invasive Dental Techniques:

-Techniques using air abrasion
-Conservative approaches to cavity prevention
-Application of dental sealants

- Saliva Substitutes or Stimulants:

-Mouthwash or toothpaste containing Xylitol
-Products containing agents such as pilocarpine and cevimeline.

Dependent Variable: Oral health indicators (gum disease prevalence, tooth decay rates, etc.)
Independent Variable: Dental care practices tailored to Mars environment.
Controlled Variables: Age, gender, baseline oral health status, duration of exposure to space conditions



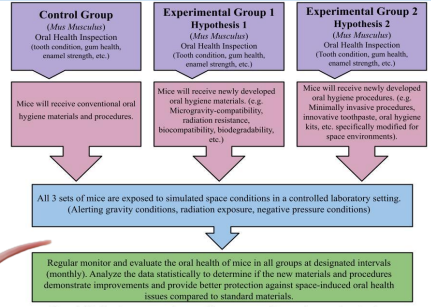


Figure 1: This flowchart represents the general flow or process of the experiments to determine the use of improved dental hygiene materials and procedures and the different data the researchers will obtain.

Possible Solutions

- Continue the research of space conditions on oral health, as well as new procedures or techniques and materials that are more sustainable for space exploration.
- More extensive testing and dental checkups should be performed on astronauts prior to travel, to ensure there are no imperfections in the teeth.
- Exercising the jaw/mouth muscles prior to launch will ensure bone density and mass of the mandible and maxilla are more equipped for space conditions, this could also help prolong the negative side effects of space.

Conclusion

-Experiment aims to test dental materials and procedures for space conditions, detailed in table 1, to potentially revolutionize oral health in space exploration.

-The experiment's duration is indefinite due to evolving space exploration techniques; it aims to uncover effective practices and materials, potentially improving oral health outcomes and validating adaptability to space conditions.

- Expected Outcomes: The expected results of investigating sustainable dental care practices for Mars colonization missions could potentially include:

- Improved Oral Health Outcomes
- Identification of Effective Practices and Materials
- Knowledge of the Effects of Space on the Bones (jaw)
- Validation of Adaptility
- Contribution to Astronaut Well-Being

References

-Asiri, A. M., Inamuddin, D., & Mohammad, A. (2018). *Applications of nanocomposite materials in dentistry*. Woodhead Publishing.

-Colombo, S., & Beretta, M. (2018). Dental Sealants Part 3: Which material? Efficiency and effectiveness. In *European Journal of Paediatric Dentistry* (Issue 19).

-Ericson, D., Kidd, E., McComb, D., Mjor, I., & Noack, M. J. (2003). Minimally Invasive Dentistry-Concepts and Techniques in Cariology. *Focus Article* . European Festival of Oral Science .

-Mäkinen, K. K., Isotupa, K. P., Kivilompolo, T., Mäkinen, P. L., Toivanen, J., & Söderling, E. (2001). Comparison of erythritol and xylitol saliva stimulants in the control of dental plaque and mutans streptococci. *Caries Research*, *35*(2), 129–135. https://doi.org/10.1159/000047444

This material is based upon work supported in part by the NVSGC under Grant No. ____