

Innovative Treatments for Dental Emergencies During Lunar and Exploration Missions



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The risk of astronaut dental problems occurring on extended Exploration missions represents a significant health and safety concern that can impact mission success. Despite pre-flight examination and treatment of astronauts, not all dental problems can be prevented. The longer the space flights, the higher the probability that dental problems will occur. As none of the current treatments is amenable to astronauts who are on extended-duration space missions, we developed alternative methods to treat dental caries (tooth decay).

The current treatment of caries requires: (1) the administration of a local anesthetic; (2) drilling to remove the decayed part of a tooth; and (3) tooth reconstruction using composites that are also needed to manage tooth fracture or failed fillings. Presently available composite materials and standard techniques for reconstructing teeth are less than optimal for space exploration missions. Procedures necessitate a variety of bulky equipment and can be very complicated. For example, root canal treatment for spontaneously occurring tooth pain requires considerable skill and the transportation of bulky equipment. The treatment includes drilling to access the canal deep in the tooth, locating canal orifices in the presence of internal tooth bleeding, using fine instruments to remove all of the cell contents, and shaping and filling the canal. Not only is considerable skill essential to achieve this, but local anesthetic is also needed, which entails another set of complex skills.

We developed a lightweight, miniaturized microwave system to enable emergency dental treatments by a non-dental expert (e.g., an astronaut). This handheld microwave system consists of a sharply focused antenna, a signal source, and a power amplifier (figure 1). The system is customized to effectively (1) eliminate bacteria that are involved in the formation of caries; (2) cure (solidify) proprietary composites for repair and reconstruction of teeth in a patient's mouth in real time; and (3) treat diseased pulpal tissue (root canal) without drilling (patents).

Our results show that microwave energy focused through use of the newly developed antenna system can successfully cure the proprietary composites supplied by



Fig. 1. Microwave prototype device for dental treatments.

BioMat Sciences for tooth repair and reconstruction. This will enable rapid tooth reconstruction (following trauma) and caries treatment in real time in the patient's mouth. This system is under development to automatically determine how much time is required for curing the composite, thereby obviating the need for skilled dental training.

These studies required the development of a number of unique bacteria and mammalian cell-based model test systems. Results produced through use of these unique testbeds show that more than 99% of the caries that cause bacteria are killed within a 20- to 30-second exposure to microwave energy while minimally affecting the healthy gum tissue simulant. The proprietary composite materials for tooth reconstruction can be cured within 30 seconds. Preliminary results involving the efficacy of pulpal disease treatment indicate that effective ablation of diseased tissue may be achieved within 60 seconds.

This new technology development supports the (1) NASA Policy Directive to provide dental care during all mission phases; and (2) Human Research Program, Exploration Science Mission Directorate, and Space Operations Mission Directorate goals. It will also have widespread commercial applications on Earth, enabling dental care to be simplified, less invasive, less expensive, and longer lasting. This technology will be of particular value in military battlefield situations and to populations who, because they are living in isolated areas (figure 2), have limited access to dental care.

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continued

Patents

Noninvasive Treatment of Diseased Pulpal Tissue Using Focused Microwave Energy

Dental Composite Curing Using Focused Microwave Energy

Noninvasive Treatment of Dental Caries Using Focused Microwave Energy



Fig. 2. An example of an isolated area (lunar habitat).