# Tissue Soldering—A Novel Countermeasure for Wound Closure

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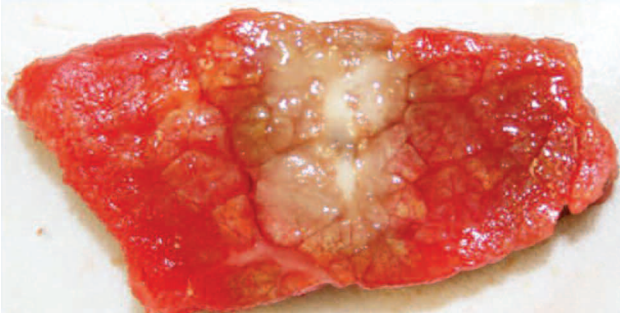
An injury rate of 0.06 per person, per year, is expected for human exploration missions based on data obtained from U.S. and Russian spaceflights, military (flight and submarine), and Antarctic base experiences. For a six-member crew on a 2.5-year Mars mission, the estimated incidence rate for a serious illness requiring emergency care is approximately one person per mission. A serious illness requiring intensive care is expected once every three Mars missions.

Since communications will be significantly delayed (7-40 minutes) on exploration-class missions to Mars, the crew will have to provide its own health care. Medical emergencies will need to be addressed by crew members trained in emergency medical procedures and without real-time support from the flight surgeon in the Mission Control Center. In addition to emergency medical conditions, crew members must also be able to accurately diagnose and treat common illnesses as well as any space-related ailments. To successfully achieve this, medical equipment and treatment protocols must be adapted to a more autonomous, user-friendly, and "smart" format. Equipment design must also accommodate the need for reduced launch-mass.

These studies address the area of emergency closure of traumatic wounds incurred while living and working in space, on the Moon, and on Mars, and represent a joint effort between the Electromagnetic Systems Branch in the Engineering Directorate and the Biomedical Research and Countermeasures Projects Branch in the Space Life Sciences Directorate. This research advances the goals of the Human Research Program by developing technologies and tools to enable safe, reliable, and productive human space exploration. This is a high-priority area with a ranking for the International Space Station, and for the Moon and Mars missions.

The objective of this research is to develop a handheld instrument capable of effectively closing and sterilizing wounds using microwave frequencies. This tissue-soldering method involves the sealing of wounds, without the use of sutures, using bio-absorbable proteins as the sealant or solder. The rapid closure of wounds helps prevent infection to restore function. This is critical, especially if the human immune system is altered or weakened during spaceflight.

The experimental approach involves producing a "test wound" of designated size (length and depth) on a piece of lean beef. Once the incision or cut is made, different candidate protein solders and varying microwave parameters/frequencies are tested for wound closure efficacy. To date, more than 100 tests have been performed to optimize the various parameters. Once a cut is sealed, the effectiveness of wound closure is measured using a tensile strength meter. Welds stronger than the uncut (uninjured) beef are consistently and precisely achieved.



*A cut piece of beef sealed using microwave energy and protein solder.*

## Additional Applications

In addition to enabling the treatment of wounds for space applications, this technology could be widely applied on Earth including: 1) treatment of traumatic wounds caused by accidents or violence; 2) improvement of current surgical procedures for repair of large solid human visceral organs (liver, spleen, and kidney), including the creation of hemostasis; and 3) military battlefield applications.

## Conclusions

A disclosure of invention was filed titled "Microwave Tissue Welding for Wound Closure." The results of the research establish the feasibility of using specific microwave frequencies for the immediate sealing of traumatic wounds using bio-compatible proteins as a sealant. With additional testing and further development, this technology could be widely applied both on Earth and on exploration-class missions for emergency medical wound closures and surgical procedures. This novel countermeasure can facilitate wound repair, minimize infection, enhance recovery, and restore function.