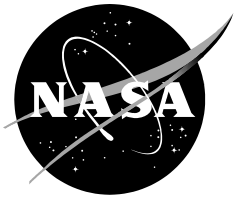
NASA/TM–2012-217368



Review of Spaceflight Dental Emergencies

Anil Menon, MD, MS, MPH
The University of Texas Medical Branch
NASA/Johnson Space Center Bioastronautics Contract

September 2012

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers, but having less stringent limitations on manuscript length and extent of graphic presentations.

- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.

- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.

- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at ***http://www.sti.nasa.gov***

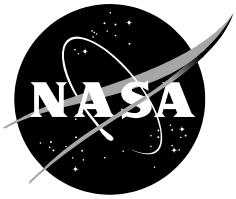
- E-mail your question via the Internet to help@sti.nasa.gov

- Fax your question to the NASA STI Help Desk at (301) 621-0134

- Telephone the NASA STI Help Desk at (301) 621-0390

- Write to:
  NASA STI Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076-1320

NASA/TM–2012-217368



Review of Spaceflight Dental Emergencies

Anil Menon, MD, MS, MPH
The University of Texas Medical Branch
NASA/Johnson Space Center Bioastronautics Contract

September 2012

Available from:

NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320
301-621-0390

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
703-605-6000

This report is also available in electronic form at http://techreports.larc.nasa.gov/cgi-bin/NTRS

Introduction

All exploration class missions—extending beyond Earth's orbit—differ from existing orbital missions by being of longer duration and often not having a means of evacuation. If an exploration mission extends beyond a year, then there will be a greater lapse since the crewmembers' last terrestrial dental exams, which routinely occur each year. This increased time since professional dental care could increase the chance of a dental emergency such as intractable pain, dental decay requiring a temporary filling, crown replacement, exposed pulp, abscess, tooth avulsion, or toothache. Additionally, any dental emergency will have to be treated in-flight with available resources and personnel who may not have extensive training in dental care. Thus, dental emergencies are an important risk to assess in preparation for exploration missions.

Literature Review

A review of in-flight dental events was performed by an analysis of PubMed seeking related search terms such as "dental," "space," "astronaut," "cosmonaut," "tooth," "decay," and "caries." The Lifetime Surveillance of Astronaut Health (LSAH) was queried for dental treatment preflight and in-flight. LSAH retained written dental exam records that were individually evaluated for relevant diagnoses. Additionally, flight surgeons and dentists were asked about their recollections of dental events that might not be recorded in LSAH exam notes. Data from the Integrated Medical Model (IMM) helped predict incidence rates for possible missions.

Predicted Incidence

In a paper published in 1977, Brown et al synthesized results from previous research on dental complaints in isolated terrestrial environments as well as a 3-year study of the astronaut population to estimate the risk of a dental problem occurring during the spaceflight missions to Skylab in the 1970s. For a 3-man, 28-day mission, such as the Skylab 2 mission, a 0.92 percent risk was calculated for an in-flight dental event capable of significantly impairing a crewmember's productivity.[1] Current data from the IMM estimate the following incidences (in events per person-year): dental carries 0.39 (SD 0.0234), dental abscess of 0.0230 (SD 0.00590), exposed pulp of 0.0201, dental avulsion 0.00292, dental crown replacement of 0.00518, and dental filling replacement of 0.00511.[2] An analysis of all medical conditions within IMM found that the medical condition most likely to end in evacuation from the International Space Station would be a dental abscess. Comparable terrestrial environments such as Antarctica, submarines, foreign combat deployments, or wilderness environments, reflect these high incidence rates of dental complaints. For instance, dental complaints among explorers taking part in the 1960s Antarctic expeditions ranked second to traumatic injuries, despite pre-screening for dental disease.[3] Data collected from sailors aboard submarines during the 1990s show a rate of 0.018 events per person-year with 7% to 9% of evacuations resulting from dental emergencies.[4] In deployed United States and British troops after 2000, incidence rates ranged between 0.12 and 0.18 events per person-year.[5-8]

In-Flight Events

There is no written documentation of an in-flight dental emergency in US astronauts. However, a NASA dentist described a crown displacement in-flight that was temporarily repaired by the crewmember with onboard supplies and without any complications (John Hatcher, DDS, December 2011). On short-duration missions, crown displacement can be treated with temporary sealant and permanently replaced after return to Earth. The risk of pain from incorrect crown placement, the risk of aspiration of a loose crown, and an immediately sensitive tooth during the repair procedure must be balanced against permanently replacing the crown in-flight. This could preserve the tooth spacing and can reduce sensitivity if repaired appropriately.

Cosmonauts have also reported lost fillings and crowns in-flight that were thought to be dislodged by the vibrations associated with launch.[9] There are anecdotal reports of cosmonauts experiencing dental pain in-flight. [10] A Russian cosmonaut was reported to have suffered incapacitating dental pain during the last 2 weeks of his 96-day flight aboard Salut 6 in 1978.[11] According to the report, there did not appear to be a contingency plan in place. Space Station MIR also had a dental event reported between March 1995 and June 1998, comprising 1% of the medical events reported during that period. Dental caries were identified and treated with a temporary filling from a dental kit.[12] In addition, between February 7, 1987, and February 9, 1996, the MIR program had 304 medical events documented and one was related to a case of dental caries, resulting in an incidence rate of 0.01% per 100 days.

Near Flight Events

Pulpitis is documented as occurring once preflight, within 90 days of launch, and once postflight during the Apollo program.[13] Both cases required emergent attention and if the timing of the condition shifted to coincide with the mission, the crewmember might not have been able to accomplish critical tasks because of the resulting pain. Three other dental events occurred preflight but were less severe—a displaced crown and tooth fractures requiring treatment. During the shuttle era, a NASA flight surgeon recalled similar preflight events were identified and treated as recently as 2 weeks before flight (Richard Jennings, MD, December 2011). Both of these diagnoses were periapical abscesses caused by deteriorating dental amalgams and required immediate attention. Both cases resulted in root canal and would have had significant pain if they occurred during a mission, raising the potential for impeding the crewmembers' operational objectives. Dental repair with fillings potentiates barodontalgia—a finding tested during Apollo missions with altitude chambers and observed aboard T-38 flights.

The following parameters for preflight and in-flight diagnoses were used in an LSAH query:

Primary Caries: Indicates cases in which it can be explicitly determined that this is the first diagnosis of caries for the indicated tooth.

Secondary Caries: Indicates cases in which it can be explicitly determined that there was a prior diagnosis of caries for the indicated tooth. The number of prior diagnoses per tooth is insignificant.

Order Unknown: Indicates cases in which there is a diagnosis of caries, but it cannot be explicitly determined whether this is a diagnosis of primary caries or secondary caries.

Primary Crown, Unspecified Cause: Indicates cases in which there is no mention of any diagnosis; however, there is mention that this is the first crown placed for the indicated tooth.

Secondary Crown, Unspecified Cause: Indicates cases in which there is no mention of any diagnosis; however, there is mention that this is a secondary crown placed for the indicated tooth. The number of prior crowns placed per tooth is insignificant.

Root Canal, Unspecified Cause: Indicates cases in which there is no mention of any diagnosis; however, there is mention that there was a root canal performed on the indicated tooth.

Tooth Extraction, Unspecified Cause: Indicates cases in which there is no mention of any diagnosis; however, there is mention that the indicated tooth was extracted.

Filling applied, Unspecified Cause: Indicates cases in which there is no mention of any diagnosis; however, there is mention that a filling was applied.

Abscess Diagnosis: Indicates cases in which there is abscess in the diagnosis.

Periodontal Disease Diagnosis: Indicates cases in which there is periodontal disease in diagnosis.

This data was likely an under-representation of actual disease since not all data were recorded and captured by this query. In fact, personal communication from local flight surgeons (handwritten dental reports, debrief notes, electronic medical records, and private medical conference notes) confirmed that LSAH data only captured a small subset of dental complaints. There were no in-flight events recorded. Preflight events began at the time that astronauts entered the corps and ended at first flight, death, or date of this query (July 23, 2010). In the male population, preflight, there were 173,450 person-days with a total of 5 carries (0.00006%), 4 abscesses (0.00005%), and 11 periodontal disease cases (0.00013%). In the female population, there were 43,855 person-days with a total of 0 caries, 0 abscesses, and 1 periodontal disease (0.0001%). The reduced number of documented cases and definite diagnoses might account for the lower observed numbers as compared to IMM predicted incidence rates, which are 0.3% for dental carries, 0.02% for pulpitis, 0.003% for avulsion, and 0.005% for crown replacement.

Conclusion

In-flight dental emergencies have been a rare event given current data and records. Long-duration missions raise the probability of a significant in-flight dental emergency similar to those incidents observed preflight. Preflight events requiring root canals had the potential for significant mission impact and occurred within close proximity to launch. Given the increasing probability of an event and the potential for mission impact, exploration missions will need to focus on preflight and in-flight prevention as well as preparing crewmembers by training them how to treat dental emergencies such as caries, pulpitis, abscesses, fractures, and crown displacement.

References

[1] Brown LR, Frome WJ, Handler S, Wheatcroft MG, Rider LJ. Skylab Oral Health Studies. In: Johnston RS, Dietlein LF, eds. *Biomedical Results from Skylab (NASA SP-377)*. Washington DC:National Aeronautics and Space Administration; 1977:35-44.

[2] Integrated Medical Model. Dental Conditions. Johnson Space Center. Accessed 2011 Oct.

[3] Lisney SJ. Dental problems in Antarctica. *Br Dent J*. August 1976;141(3):91-92.

[4] Deutsch WM. Dental events during periods of isolation in the U.S. submarine force. *Mil Med*. January 2008;173(1 Suppl):29-37.

[5] Chaffin J, King JE, Fretwell LD. U.S. Army dental emergency rates in Bosnia. *Mil Med*. December 2001;166(12):1074-1078.

[6] Chaffin J, Moss D. Review of current U.S. Army dental emergency rates. *Mil Med*. January 2008;173(1 Suppl):23-26.

[7] Moss DL. Dental emergencies during SFOR 8 in Bosnia. *Mil Med*. November 2002;167(11):904-906.

[8] Richardson PS. Dental morbidity in United Kingdom Armed Forces, Iraq, 2003. *Mil Med*. June 2005;170(6):536-541.

[9] Marshburn TH. Acute Care. In: Barratt M, Pool S, eds. *Principles of Clinical Medicine for Space Flight*. New York: Springer; 2008:101-122.

[10] Savage DK. A brief history of aerospace dentistry. *J Hist Dent*. July 2002;50(2):71-75.

[1 1]Ball JR, Evans CH. *Safe Passage: Astronaut Care for Exploration Missions*. Washington DC:National Academy Press;2001.

[12] Gontcharov IB, Kovachevich IV, Pool SL. In-Flight medical incidents in the NASA-MIR program. *Aviat Space and Env Med*. July 2005;76(7):692-696.

[13] Hawkins WR, Zieglschmid JF. Clinical Aspects of Crew Health. In: Johnston RS, Dietlein LF, Berry CA, eds. *Biomedical Results of Apollo (NASA SP-368)*. Washington DC:National Aeronautics and Space Administration; 1975:46-84.

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 2012	NASA Technical Memorandum

4. TITLE AND SUBTITLE
Review of Spaceflight Dental Emergencies

5. FUNDING NUMBERS

6. AUTHOR(S)
Anil Menon

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Lyndon B. Johnson Space Center
Houston, Texas 77058

8. PERFORMING ORGANIZATION REPORT NUMBERS
S-1130

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
TM-2012-217368

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Available from the NASA Center for AeroSpace Information (CASI)
7121 Standard
Hanover, MD 21076-1320 Category: 52

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
All exploration class missions—extending beyond Earth's orbit—differ from existing orbital missions by being of longer duration and often not having a means of evacuation. If an exploration mission extends beyond a year, there will be a greater lapse since the crewmembers' last terrestrial dental exams. This increased time could increase the chance of a dental emergency such as intractable pain, dental decay requiring a temporary filling, crown replacement, exposed pulp, abscess, tooth avulsion, or toothache. Any dental emergency will have to be treated in-flight with available resources and personnel who may not have extensive training in dental care. Thus, dental emergencies are an important risk to assess.In-flight dental emergencies have been a rare event given current data and records. Long-duration missions raise the probability of a significant in-flight dental emergency similar to those incidents observed preflight. Preflight events requiring root canals had the potential for significant mission impact and occurred within proximity to launch. Given the increasing probability of an event and the potential for mission impact, exploration missions will need to focus on preflight and in-flight prevention and preparing crewmembers by training them how to treat dental emergencies such as caries, pulpitis, abscesses, fractures, and crown displacement.

14. SUBJECT TERMS	15. NUMBER OF PAGES	16. PRICE CODE
dentistry; aerospace medicine; health; long duration space flight	12	

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

Standard Form 298 (Rev Feb 89) (MS Word Mar 97) NSN 7540-01-280-5500
Prescribed by ANSI Std. 239-18
298-102