

Dental Avulsion (Tooth Loss) Cliff

Branch Baseline

Avulsion is the complete displacement of a tooth from the socket and constitutes a true dental emergency. A likely mechanism on orbit would be due to damage to pre-existing restorations or dental trauma. Treatment is available on orbit with topical and systemic analgesics, instruments in a toothache kit and antibiotics. (International Space Station Integrated Medical Group, 2008)

After a traumatic injury, the first priority is to locate the tooth. The possibility of aspiration must always be considered in microgravity where an avulsed tooth could float freely in the oropharynx or elsewhere. (Hodapp, 2008)

Incidence Data Included in the Model

The model imports the following incidence information from the IMM database: incidence data category, space adaption status, incidence data, incidence and occurrence distribution data and incidence data characteristics. Data category defines the type of data available for incidence calculations (i.e. raw data vs. fixed data). Space adaptation identifies medical events that onset occurs in the first 5 days of flight and does not reoccur. Incidence values vary by data category and define the number of medical events per person-year or medical events per person-at-risk for each medical condition. Incidence values can be modified by crew characteristics such as gender. Modifying characteristics are noted below and incidence values are listed individually for each characteristic. Distributions are assigned to medical events incidence values and occurrences in the model. For each crew member in a given trial, the incidence and number of occurrences of each medical condition are randomly selected from these probability distributions. Detailed descriptions of the distributions are included in the IMM Technical Description Document.

Incidence

Data Category:	Fixed
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data

Incidence:	Fixed
Occurrence:	Poisson

Data Characteristics

Fixed Rate:	0.00292
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Incidence Comments

A dental emergency has not occurred among US astronauts in flight. (International Space Station Integrated Medical Group, 2008)

Deutsch (Deutsch, 2008) determined that of 5187 total medical consultation in the US Submarine Force 3% were due to dental reasons. Incidence density rates were determined using the number of initial visits as the numerator, and the total number of person-days underway was the denominator. When excluding revisits 109, 3% of 3562, initial visits were for dental conditions. Trauma accounted for 8.3% of initial visits

Rates by ICD-9 codes 873.6 and 873.7, *Injury to mouth*, was 0.8 per 100,000 person days at sea (n 18), or **0.00292 person-years**. This percentage is similar to Richardson's in the UK Navy (Richardson, 2005) and Chaffin's in the US Army (Chaffin, 2001). Codes 873.6 and 873.7 include other conditions and no further information on sub-codes is provided, so the estimated incidence may be overvalued

Deutsch reported based on broad ICD-9 diagnoses codes 873.6 and 873.7:

873.60 Mouth, unspecified site; 873.61 Buccal mucosa; 873.62 Gum (alveolar process); 873.63 Tooth (broken) (fractured) (due to trauma) Excludes: cracked tooth (521.81); 873.64 Tongue and floor of mouth; 873.65 Palate; and 873.69 Other and multiple sites.

873.7 Internal structures of mouth, complicated: 873.70 Mouth, unspecified site; 873.71 Buccal mucosa; 873.72 Gum (alveolar process); 873.73 Tooth (broken) (fractured) (due to trauma) Excludes: cracked tooth (521.81); 873.74 Tongue and floor of mouth; 873.75 Palate; and 873.79 Other and multiple sites. 873.6 Internal structures of mouth, without mention of complication: (Centers for Disease Control and Prevention (CDC), 2008)

Evacuations (EVACs) were reported at 7-9%. The nature of dental EVACs was not reported. Not all evacuations are due to emergencies. (Deutsch, 2008)

Information Regarding Prevention

Disqualifying dental conditions include:

Any dental defects that interfere with clear speech or cause changes in the contours of the face which interfere with the performance of duties; complete edentulism or insufficient number of natural healthy teeth to masticate a normal diet or enunciate clearly; dental prostheses (any removable dental prosthesis, which if lost or broken, would not leave enough natural healthy teeth to masticate a normal diet or enunciate clearly; any unilateral removable dental prosthesis that could be swallowed); diseases and abnormalities of the jaws or associated structures, including periodontal disease, that are not easily remedied or may interfere with the performance of duties; severe malocclusion that interferes with the mastication of a normal diet or clear enunciation; any dental defects such as dental caries, dental dysplasia, enamel dysplasia, symptomatic cracked teeth, defective restorations, defective prosthesis, and defective implants until resolved; partially erupted or impacted third molar teeth with the potential to cause erosion of adjacent teeth, pericoronitis, or periodontal defect until resolved; infections of endodontic or periodontic origin until resolved. Active orthodontic treatment requires dental consultation. Active orthodontic treatment is disqualifying for space flight duties (International Space Station Program, 2009)

Treatment(s):

The first priority is to locate the tooth. Once the avulsed tooth is found it should be stored for examination upon return. If the tooth is fractured, palpate the patient's lips and tongue for fragments that may have lodged there. Removal of fragments is done to prevent infection. (Hodapp, 2008)

Prevention:

At 6 months before launch crewmembers undergo examination, if treatment is deemed necessary, all such treatment is completed 3 months before launch. All astronauts are expected to maintain optimal physical and oral health and to follow oral hygiene practices (Hodapp, 2008)

Other:

Lower light levels, limited dental training for CMOs, limited supplies, and the need to retrain tools remain the most significant challenges for assessing and treating dental problems on orbit (Marshburn, 2008)

Incidence Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
Deutsch, 2008	2	Incidence

Alternative Incidence Data

Analog populations

Richardson (Richardson, 2005) reviewed the dental morbidity experienced by U.K. Armed Forces serving in Iraq from deployment on Operation Telic in January 2003 until the end of phase 1 on May 1, 2003. U.K. Armed Forces dental teams treated 1800 emergency patients, including 135 prisoners of war. A total of 1523 of these were regular troops and 101 were reservists or Royal Fleet Auxiliary troops. This gave morbidity rates of 148 cases per 1,000 personnel per year for the Royal Navy/Royal Marines and 160 cases per 1,000 per year for the Army. Lost restorations and fractured teeth were by far the most common problems experienced, followed by pericoronitis, pulpitis, and periapical pathological conditions. Both the rates of morbidity and the types of problems experienced were very similar to those reported by other nations in previous conflicts.

Trauma to teeth/oral mucosa accounted for 1.7% (n 24) of total dental emergencies. Richardson estimated morbidity rate 148 cases per 1000 person-year Royal Navy and marines (0.148 per person-year); and 160 cases per 1000 person-year in the Army, which is 0.148 and 0.16 per person-year respectively. We estimated the trauma to teeth/oral mucosa rates (1.7% of 0.148) at 0.002516 per person-year and (1.7% of 0.16) 0.00272. Of a total of 426 conditions causing moderate or serious operational impact, eleven (2.6%) were trauma to teeth and oral mucosa. We estimated the proportion rate to be 46% (11/24).

Chaffin (Chaffin, 2001) studied retrospectively dental emergencies experienced by 2449 US soldiers in Bosnia, in 2000, deployed 201.95 days. The overall emergency rate was 156 per 1000 soldier-years, 0.156. ICD-9 codes were not included; an emergency is any condition that prompts a soldier to leave their duty station. The true emergencies like extreme pain due to infection, irreversible pulpitis or trauma represented 25% of patients seen. These conditions would have required evacuation without on site dental care. Based on the 1.9% trauma dental emergencies (n=4), we estimated an incidence of 0.002964. 18.5 % of all dental emergencies required palliative care. There is no information on the type of emergencies requiring pain medication. We cannot infer from the types of treatment rendered, e.g. oral surgery, no treatment indicated, or other treatment, which ones were used to treat avulsion.

Tansey did an analysis of 10 years of data collected on Polaris Nuclear Submarines, 1963-1973. (Tansey, 1979) There were no incidents of dental avulsion from a total of 50 dental events reported.

Thomas reported on the health events occurring among highly screened, healthy US submariners. ICD9-codes 800-899 had a rate of 3.1 for officers and 8.5 for enlisted men per 100 person-years, 0.031 and 0.085 per person-year respectively. Codes for dental avulsion fall under this category but data were not broken down by type of injury. The majority of the medical events reported among officers and enlisted men could be considered minor and non-life threatening, with little or no impact on unit mission. (Thomas, 2003)

Treatment and Outcomes

Based on the best evidence available best and worst case percentage ranges are assigned. The medical condition is divided into three clinical phases in all three clinical phases a functional impairment is assigned. The clinical phase I and II's functional impairments remain for the duration for that respective clinical phase. The function impairment in clinical phase III represents final impairment for this medical condition and remains for the rest of the mission. Other mission end states include evacuation and loss of crew life.

The IMM checks medical resource availability once the number of medical events and scenarios has been established. If there is not sufficient essential resources called out in the ClIFF, then the medical condition will go down an untreated best or worst case scenario pathway.

The table below summarizes the treated and untreated best and worst case scenarios.

	Clinical Phase I Diagnosis & Initial Treatment ¹		Clinical Phase II On-going Treatment / Convalescence ²		Clinical Phase III Recovered / Mission End State ³		
	FI* (%)	Duration (hrs)	FI* (%)	Duration (hrs) (Min - ML - Max)	FI* (%)	EVAC** (%)	LOCL** (%)
ISS-based Treatment (best case scenario %: 54 - 100)	100	0.33	0 - 17	0.5 - 36.25 - 72	0	0	0
ISS-based Treatment (worst case scenario %: 0 - 46)	100	0.75 - 1	6 - 34	24 - 48 - 72	0 - 17	0	0
Untreated Best Case	0	0	6 - 34	0.5 - 36.25 - 72	0 - 17	0	0
Untreated Worst Case	0	0	22 - 55	24 - 48 - 72	0 - 17	0	0

¹Clinical Phase I: Clinical phase I covers only the initial assessment of the affected crew member to define his or her medical condition, and completion of appropriate initial treatment to stabilize the crew member. While the affected crew member is being assessed, he or she is not able to perform any assigned tasks, thus Functional Impairment during this phase is considered 100%. In the untreated case, there is no diagnosis performed or treatment given, therefore Functional Impairment and Duration will always be "not applicable".

²Clinical Phase II: On-going Treatment and Convalescence- During clinical phase II, the affected crew member is receiving any appropriate follow-on treatment for his or her medical condition to allow the crew member to recover as much as he or she is able to recover in the ISS environment. Clinical phase II also encompasses relapses or reoccurrences of the same original medical condition in clinical phase I necessitating additional treatment or recovery time due to unsuccessful primary treatment response. The duration in Clinical Phase II is expressed in minimum, most likely (ML) and maximum hours. This was updated for future capabilities in IMM but is currently not being used by the model.

³Clinical Phase III: Recovered/Mission End State- Clinical phase III is reached once the affected crew member has recovered from the medical condition as much as he or she is able to recover in the ISS environment. This may or may not be recovery from the given medical condition to the full extent possible. If this "recovered" state results in an evacuation or loss of the crew member, this will be noted in the mission end state results.

*Functional Impairment (FI) is a measure of the affected crew member's health and performance ability.

**Two mission end state results are addressed in the ClIFF: 1) Evacuation (EVAC) - crew and patient are evacuated from the spacecraft due to the medical condition, and 2) Loss of crew (LOCL) - death of affected crew member due to medical condition. EVAC is considered as an end state result if any of the following criteria are met: 1) potential LOCL, 2) potential significant permanent impairment, or 3) potential intractable pain. Probability distributions are assigned for each range of values within the Table of Treatments and Outcomes.

Refer to the Integrated Medical Model Technical Document for more information on how risk is reported by the IMM, Crew Health Index (CHI) and Quality Adjusted Mission Time calculations.

Definition and Probability of Best and Worst Case Scenario: (includes definitions of best and worst case scenarios and identifies the probability of those scenarios.)

Scenario Comments

The **best case scenario** is defined as avulsion due to trauma with mild pain and bleeding that is easily controlled.

The **worst case scenario** is defined as avulsion due to trauma, with moderate to severe pain that may require narcotic analgesics, and/or bleeding is prolonged beyond 20 minutes.

Avulsed tooth or teeth related or combined with maxillofacial bone fractures are addressed in the Head Injury Clinical Finding Forms (Cliff). Subluxation or fractured tooth is addressed in the Exposed Pulp Cliff. Complications of avulsion are addressed in the Dental abscess Cliffs

Percentages of how often best versus worst case scenarios occur are based on Richardson's study (Richardson, 2005). He estimated types of morbidity causing moderate or serious operational impact among regular troops. 46% (11/24) with trauma to teeth/oral mucosa are included in this category. To allow for uncertainty, we are estimating 0-46% for our worst case scenario. Thus the best case percentage is 54-100%.

Best Case Comments

Dental Avulsion may cause temporary impairment and it is not listed in the AMA Guides for Permanent Impairment. Our functional impairments calculation follows the IMM mild non-space adaptation template and Guidelines to the Evaluation of Impairment of the Oral and Maxillofacial Region (American Association of Oral and Maxillofacial Surgeons, 2008). Loss of dentition may impair mastication. Mastication disorders ratings are based on Table 11-7, p.269 (American Medical Association, 2008). Of note, mastication impairments are indicated in percentages, with no class. A mouth injury may cause oral pain. Based on anatomical location we are using Glossopharyngeal Neuralgia to grade the pain. Glossopharyngeal Neuralgia (WPI) is based on Table 13-19, p.343 (American Medical Association, 2008). Combined FI ratings are calculated combining both the Mastication and Glossopharyngeal Neuralgia (WPI) Impairment using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of gradings refer to the Cliff Appendix.

By definition, functional impairment (FI) is 100% during **Clinical Phase I**. Duration is estimated to be 20 minutes, to follow the procedure indicated in the ISS Medical Checklist, i.e. dental and oral exam, and taking oral medication (Hatcher, 2007). **Clinical Phase II**, FI is estimated in 0 to 17%. Duration is estimated in 30 minutes to 3 days based in the ISS medical checklist. During **Clinical Phase III**, total recovery is expected; by definition FI is 0%. By definition, EVAC and LOCL are not expected in the best case scenario.

Worst Case Comments

Dental Avulsion may cause temporary impairment and it is not listed in the AMA Guides for Permanent Impairment. Our functional impairments calculation follows the IMM mild non-space adaptation template, except for the untreated worst case scenario. Uncomplicated avulsion causes pain but its duration is limited. We are also following Guidelines to the Evaluation of Impairment of the Oral and Maxillofacial Region (American Association of Oral and Maxillofacial Surgeons, 2008). Loss of dentition may impair mastication. Mastication disorders ratings are based on Table 11-7, p.269 (American Medical Association, 2008). Of note, mastication impairments are indicated in percentages, with no class. A mouth injury may cause oral pain. Based on anatomical location we are using Glossopharyngeal Neuralgia to grade the pain. Glossopharyngeal Neuralgia (WPI) is based on Table 13-19, p.343 (American Medical Association, 2008). Combined FI ratings are calculated combining both the Mastication and Glossopharyngeal Neuralgia (WPI) Impairment using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of gradings refer to the Cliff Appendix.

By definition, functional impairment (FI) is 100% during **Clinical Phase I**. Duration is estimated to be 45 minutes to one hour, to follow the procedures indicated in the ISS Medical checklist for Dental Avulsion (Hatcher, 2007) During **Clinical Phase II** FI is estimated at 6 to 34%. Duration is estimated in 24 to 72 hours, one to 3 days. During **Clinical Phase III**, the pain may not resolve completely thus FI is 0-17%. By definition, EVAC and LOCL are not expected.

Untreated Best Case Comments

Dental Avulsion may cause temporary impairment and it is not listed in the AMA Guides for Permanent Impairment. Our functional impairments calculation follows the IMM mild non-space adaptation template, except for the untreated worst case scenario. Uncomplicated avulsion causes pain but its duration is limited. We are also following Guidelines to the Evaluation of Impairment of the Oral and Maxillofacial Region (American Association of Oral and Maxillofacial Surgeons, 2008). Loss of dentition may impair mastication. Mastication disorders ratings are based on Table 11-7, p.269 (American Medical Association, 2008). Of note, mastication impairments are indicated in percentages, with no class. A mouth injury may cause oral pain. Based on anatomical location we are using Glossopharyngeal Neuralgia to grade the pain. Glossopharyngeal Neuralgia (WPI) is based on Table 13-19, p.343 (American Medical Association, 2008). Combined FI ratings are calculated combining both the Mastication and Glossopharyngeal Neuralgia (WPI) Impairment using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of gradings refer to the Cliff Appendix.

During Clinical Phase II, FI is estimated at 6 to 34%. Duration is estimated at 30 to 60 minutes similar to the treated best case. During **Clinical Phase III**, the pain may not resolve completely and FI is estimated at 0 to 17%. By definition, EVAC and LOCL are not expected for this scenario.

Untreated Worst Case Comments

Dental Avulsion may cause temporary impairment and it is not listed in the AMA Guides for Permanent Impairment. Our functional impairments calculation follows the IMM mild non-space adaptation template, except for the untreated worst case scenario. Uncomplicated avulsion causes pain but its duration is limited. We are also following Guidelines to the Evaluation of Impairment of the Oral and Maxillofacial Region (American Association of Oral and Maxillofacial Surgeons, 2008). Loss of dentition may impair mastication. Mastication disorders ratings are based on Table 11-7, p.269 (American Medical Association, 2008). Of note, mastication impairments are indicated in percentages, with no class. A mouth injury may cause oral pain. Based on anatomical location we are using Glossopharyngeal Neuralgia to grade the pain Glossopharyngeal Neuralgia (WPI) is based on Table 13-19, p.343 (American Medical Association, 2008). Combined FI ratings are calculated combining both the Mastication and Glossopharyngeal Neuralgia (WPI) Impairment using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of gradings refer to the ClIFF Appendix.

During **Clinical Phase II**, FI is estimated at 22 to 55%. Duration is estimated from 24 to 72 hours, similar to the treated worst scenario. During **Clinical Phase III**, the pain may improve or may not completely resolve. FI is estimated at 0 to 17% similar to the treated worst case scenario. Not all evacuations are of equal urgency. If another evacuation was occurring a less urgent dental patient could be evacuated at the same time for convenience. (Deutsch, 2008) The majority of the medical events reported among officers and enlisted men could be considered minor and non-life threatening, with little or no impact on unit mission. (Thomas, 2003). EVAC and LOCL are not expected for this scenario.

Treatment and Options Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
Richardson, 2005	2	BCWC
American Association of Oral and Maxillofacial Surgeons, 2008	3	FI
American Medical Association, 2008	3	FI
American Medical Association, 2008	3	FI
American Medical Association, 2008	3	FI
Thomas, 2003	2	EVAC

Additional Comments

We searched PubMed using the terms Dental Avulsion and incidence, epidemiology, microgravity, astronauts, evacuations, and MEDEVACs

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Cleocin (Clindamycin) 300mg	0	15	60	Yes	Yes	Oral antibiotic to prevent infection.
Dental mirror (H)	1	1	1	No	Yes	For dental exam
Gauze pads (4x4)	2	6	50	Yes	No	To absorb blood or fluids from skin and mouth
Motrin (Ibuprofen) 400mg	4	12	500	Yes	Yes	Anti-inflammatory and pain relief
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	4	30	Yes	Yes	Pain relief
Water	1	1	1	No	No	Mouth rinse

Resource Comments

ISS medical checklist includes dental Dental Avulsion as a medical condition. All resources included are addressed in the ISS medical checklist (Mission Operations Directorate (MOD), 2011).

Our search for Dental Avulsion clinical guidelines yielded two results, both for pediatric dentistry. Terrestrially many common clinical dental procedures do not have high-quality clinical guidelines available. The results of a literature search demonstrated a lack in both the number and quality of clinical dental guidelines that support common dental procedures. (Faggion, 2008)

Comparison of the Med Checklist and current treatment process.

Based on the Pediatric guidelines replant of the avulsed tooth is recommended for permanent teeth as soon as possible to stabilize the replanted tooth, to optimize healing of the periodontal ligament and neurovascular supply while maintaining esthetic and functional integrity. Replanting is contraindicated when there is a compromising medical condition; or compromised integrity of the avulsed tooth or supporting tissues. Antibiotic coverage should be considered. (American Academy of Pediatric Dentistry (AAPD) , 2010) During a mission the integrity of the avulsed tooth and supporting tissue will be difficult to assess because of limited dental expertise and resources.

The main discrepancy is that the ISS med checklist instructs the Crew Medical Officer to dispose of the tooth, while terrestrial guidelines recommend saving the tooth for the possibility of replant with definitive care. Definitive dental care is not available on orbit and the possibility of aspiration must always be considered in microgravity where an avulsed tooth could float freely in the oropharynx or elsewhere.

An Algorithm of first-aid management of dental trauma for medics and corpsmen (Zadik, 2008), used for training of Israel Defense Forces School of Military Medicine, recommends to replant the tooth or stow it away and refer immediately to a dentist or emergency department.

Required Resources Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
NASA Mission Operations Directorate (MOD), 2011	2	Resources
American Academy of Pediatric Dentistry (AAPD) , 2010	3	Resources

Level Of Evidence

Input Data	LOE Average	Description	Range
Incidence	2	Excellent	1-2
Functional Impairment	3	Good	2.1-3
Best Case / Worst Case	2	Fair	3.1-4
EVAC / LOCL	2	Poor	4.1-5
Resources	2.5		
QUALITY OF EVIDENCE	2.3		

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