

Dental Crown Loss Cliff

Branch Baseline

Over 60% of all restorative dentistry involves the replacement of restorations. The most common reasons for crown replacement were crown fracture and tooth fracture, followed by esthetics and secondary caries. The UK Adult Dental Health Survey in 1998 identified people aged 45-54 as having the most crowns with nearly half of that age group having at least one crown. (Wilson, 2003)

Crown is the part of the tooth located above the gum line (Dye, 2007). The term crown is also used for “cusps” or intra-coronal restorations.

Despite the fact that astronauts undergo extensive dental evaluation prior to space flight, the possibility of loosening of a previously placed crown exists, and therefore dental crown replacement can be done on orbit. Marshburn, 2008 2666 /id}</

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

Crowns Data Characteristics

Fixed Rate:	0.00518
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Incidence Comments

A dental emergency has not occurred among US astronauts in flight.

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

Lost/loose/ fractured crowns accounted for 1.8% (n 26) and lost/loose/fractured post crowns accounted for 1.7% (n 24) of total dental emergencies. The sum of both events is 3.5%. Richardson estimated morbidity rate 148 cases per 1000 person-year Royal Navy and marines (1.48 per person-year); 160 cases per 1000 person-year in the army, which is 0.148 and 0.16 per person-year respectively. We estimated the morbidity for lost/loose/ fractured crown and crown posts (3.5% of 0. 148) at **0.00518 per person-year** and (3.5% of 0.16) 0.0056. We chose to use the Royal Navy and Marines for our incidence rate in the model.

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:

When a crown becomes dislodged during space flight and the tooth is asymptomatic the preferred treatment is to stow the crown and await return to earth. The risk of discomfort due to incorrect replacement of the crown or the risk of dislodging and aspiration is too great. If the tooth is sensitive, the correct procedure is to temporarily re-cement the crown.

All cement needs to be removed from the internal aspect of the crown and from around the tooth with a dental carver or excavator. Next the fit of the crown should be checked by placing the crown on the tooth and asking the subject to bite down while keeping a finger on the side of the crown. These steps need to be repeated until the bite feels no different when the crown is in or out. The crown and tooth should be dried off and the tooth isolated with gauze or cotton rolls. The luting cement is mixed on a tongue depressor and placed inside the crown. Once the crown is in place, the patient should be told to bite down gently for 3 to 5 minutes. Floss the cement from between the teeth and remove excess cement from the tooth. [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]

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
Richardson, 2005	2	Incidence

Alternative Incidence Data

There is anecdotal report of crowns dislodging in cosmonauts caused by vibration and acceleration during launch (Marshburn, 2008)

Analog populations

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-year, 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 3.3% prosthodontic failures dental emergencies (n=7), we estimated an incidence of 0.005148. 71% required treatment (5/7). 18.5 % of all dental emergencies required palliative care. There is no information on the type of emergencies requiring pain medication.

An analysis of 10 years of data collected on Polaris submarines over the ten year period 1963-1973 reported 0 incident of crown replacement from a total of 50 dental events (0.00) (Tansey, 1979)

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 %: 79 - 89)	100	0.25	0 - 5	0.25 - 0.25 - 0.25	0	0	0
ISS-based Treatment (worst case scenario %: 11 - 21)	100	0.75 - 1	5 - 10	0.5 - 12.25 - 24	0 - 5	0	0
Untreated Best Case	0	0	5 - 10	0.25 - 0.25 - 0.25	0 - 5	0	0
Untreated Worst Case	0	0	10 - 20	0.5 - 12.25 - 24	5 - 20	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 the loss of a crown without any pain and can wait until return to earth.

The **worst case scenario** is loss of a crown which requires re-cementing of the crown.

Loss of a crown in a tooth without prior root canal treatment may cause an exposed pulp or pulpitis. These are addressed in the Dental: Exposed Pulp or Dental: Abscess Clinical Finding Forms.

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. Eleven percent (2/ 26) with lost/loose/fractured crowns and 21 % (5/ 24) lost/loose/fractured post crowns are included in this category. These percentages serve as our worst case estimates. Thus the best case percentage is 79-89%.

Best Case Comments

Dental Crown Replacement is a temporary condition 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) with some modifications. 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. Dislodging of a crown is considered a minor event and the assigned classes were modified accordingly. For best case scenario, during Clinical Phase I grade 0 and the lower end of the scale for grade 1 were used. There was no change for Clinical Phase III, e.g. Class 0. For worst case and untreated best case scenarios, impairments were assigned using the lower and mid level of the scale for Class 1. For Clinical Phase III, grade 0 and the lower level of Class 1 were used. For the untreated worst case scenario, during Clinical Phase II the mid level of Class 1 and lower level of Class 2 were used. During Clinical Phase III, the lower level of Class 1 and the lower level of Class 2 were used. 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 15 minutes, to follow the procedure indicated in the ISS Medical Checklist, i.e. dental exam and cleaning and stowing the crown. **Clinical Phase II**, FI is estimated in 0 to 5%. Duration is estimated in 15 minutes based in observation period. During **Clinical Phase III**, by definition FI is 0%. By definition, EVAC and LOCL are not expected in the best case scenario.

Worst Case Comments

Dental Crown Replacement is a temporary condition 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) with some modifications. 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. Dislodging of a crown is considered a minor event and the assigned classes were modified accordingly. For best case scenario, during Clinical Phase I grade 0 and the lower end of the scale for grade 1 were used. There was no change for Clinical Phase III, e.g. Class 0. For worst case and untreated best case scenarios, impairments were assigned using the lower and mid level of the scale for Class 1. For Clinical Phase III, grade 0 and the lower level of Class 1 were used. For the untreated worst case scenario, during Clinical Phase II the mid level of Class 1 and lower level of Class 2 were used. During Clinical Phase III, the lower level of Class 1 and the lower level of Class 2 were used. 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 follow the procedures indicated in the ISS Medical Checklist for replacing the crown (Hatcher, 2007). Because of limited dentistry training for the CMO, we added 15 minutes to the upper limit. During **Clinical Phase II** FI is estimated at 5 to 10%. Duration is estimated in 30 minutes to 24 hours. During **Clinical Phase III**, the pain may not resolve completely thus FI is 0-5%. By definition, EVAC and LOCL are not expected.

Untreated Best Case Comments

Dental Crown Replacement is a temporary condition 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 2898 /id }with some modifications. 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. Dislodging of a crown is considered a minor event and the assigned classes were modified accordingly. For best case scenario, during Clinical Phase I grade 0 and the lower end of the scale for grade 1 were used. There was no change for Clinical Phase III, e.g. Class 0. For worst case and untreated best case scenarios, impairments were assigned using the lower and mid level of the scale for Class 1. For Clinical Phase III, grade 0 and the lower level of Class 1 were used. For the untreated worst case scenario, during Clinical Phase II the mid level of Class 1 and lower level of Class 2 were used. During Clinical Phase III, the lower level of Class 1 and the lower level of Class 2 were used. For further description of gradings refer to the ClIFF Appendix.

During Clinical Phase II, FI is estimated at 5 to 10%. 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 5%. By definition, EVAC and LOCL are not expected for this scenario

Untreated Worst Case Comments

Dental Crown Replacement is a temporary condition 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) with some modifications. 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.

Dislodging of a crown is considered a minor event and the assigned classes were modified accordingly. For best case scenario, during Clinical Phase I grade 0 and the lower end of the scale for grade 1 were used. There was no change for Clinical Phase III, e.g. Class 0. For worst case and untreated best case scenarios, impairments were assigned using the lower and mid level of the scale for Class 1. For Clinical Phase III, grade 0 and the lower level of Class 1 were used. For the untreated worst case scenario, during Clinical Phase II the mid level of Class 1 and lower level of Class 2 were used. During Clinical Phase III, the lower level of Class 1 and the lower level of Class 2 were used. For further description of gradings refer to the ClIFF Appendix.

During **Clinical Phase II**, FI is estimated at 10 to 20%. Duration is estimated from 30 minutes to 24 hours, similar to the treated worst scenario. During **Clinical Phase III**, the pain may improve or may not resolve and FI is estimated at 5 to 20%. No EVAC has been documented in analog populations for a minor condition like crown replacement. 25% of cases were regarded as having a moderate or serious operational impact (Richardson, 2005). 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). By definition, 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
American Association of Oral and Maxillofacial Surgeons, 2008	3	FI
American Medical Association, 2008	3	FI
Richardson, 2005	2	BCWC
Deutsch, 2008	2	EVAC

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
CMRS	0	1	1	No	No	Restrain crew member to ensure safety
Cotton pellet	0	1	6	Yes	No	To apply topical anesthetic
Cotton swabs	0	2	6	Yes	No	To dry affected tooth
Dental Adhesive (76 grams)	0	0.1	1	Yes	Yes	Adhesive to replace crown
Dental Adhesive Tip	0	1	1	Yes	Yes	Applicator for dental adhesive
Dental carver file (G)	0	1	1	No	Yes	To remove cement from dislodged crown
Dental explorer/probe (E)	0	1	1	No	Yes	To remove cement from dislodged crown
Dental mirror (H)	1	1	1	No	Yes	For dental exam and procedure.
Gauze pads (4x4)	2	4	50	Yes	No	To absorb blood or fluids from skin; to squeeze excess anesthetic from cotton pellet
Scissors - Trauma	0	1	1	No	Yes	To cut gauze, tape
Tongue depressor	0	1	20	Yes	No	To mix temp bond base and accelerator

Resource Comments

ISS Medical Checklist includes dental crown replacement. All resources included are addressed in the ISS medical checklist (Mission Operations Directorate (MOD), 2011).

We added chew on opposite side, ziplock bag and dental anesthesia to the resource table.

Our search for crown replacement clinical guidelines yielded no results. 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)

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

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		
QUALITY OF EVIDENCE	2.2		

Reference List

Reference

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