Finger Dislocation Cliff

Branch Baseline

Dislocation of a joint occurs when traumatic forces cause complete loss of continuity between the joint's 2 articulating surfaces. Subluxation occurs when the loss of continuity between the joints is only partial. A dislocation may or may not involve a fracture. Dislocations of the finger joints involve either the interphalangeal (IP) joint or the metacarpo phalangeal (MCP) joint.

Causes for dislocation may include hyper extension, hyper flexion, ulnar or radial stress, axial load, or injury caused by direct pressure or crushing. (Polansky, 2011)

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:	In-flight
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Gamma
Occurrence:	Poisson

Data Characteristics	
Events:	1
Person Years:	45.49
Space Flight Incidence Rate (Events / Person Years):	1 / 45.49 = 0.021982853374368

Incidence Comments

A study to analyze the incidence of musculoskeletal injuries and Minor Trauma in Space includes one dislocation without site/mission information. (Scheuring, 2009)

We have an anecdotal report of this event occurring in Skylab (Collins, 1988). The event is not included in the Skylab list of events. (HORDINSKY, 1977)

According to the information reported retrospectively by the crew member to a flight surgeon, (Scheuring, 2009)) the dislocation was successfully reduced by the affected crew member and there was no mission impact.

Based on the Real World System data, 18.17 was added to persons years (Saile, 2017)

Updated the Person-Years based on the revised real world system integrated incidence data. The integrated person years changed from 18.17 to 18.13 so the conditions person years changed from 45.53 to 45.49 (Saile L., 2017)

Information Regarding Prevention

Selection criteria

Disqualifying conditions in the musculoskeletal category include:

Traumatic, inflammatory, degenerative, congenital and metabolic disorders, or disease of any bone, joint, muscle or supporting structure that interferes with the performance of duties; chronic arthritis with functional disability that interferes with the performance of duties; benign tumors or cysts, single or multiple, sufficiently large to interfere with performance of duties, or to create a fracture potential. Osteochondromatosis or multiple cartilaginous exostoses that interfere with performance of duties; Joint instability e.g. recurrent subluxations or dislocations of an articulation;. Intra-articular loose bodies, osteocartilaginous or metallic foreign objects, in any joint that interfere with performance of duties; Non-union of fractures; mal-union of fractures that interferes with performance of duties. Less than functional range of motion and stability of all joints. A total range of motion of the wrist of 70 degrees dorsal extension plus 80 degrees palmar flexion: ulnar deviation 45 degrees plus 15 degrees radial deviation. Pronation of the hand to 90 degrees and supination to 80 degrees. Chronic or recurrent bursitis, tendinitis, and synovitis sufficient to interfere with the performance of duties.

Conditions requiring special consideration by the MSMB include: history of osteochondromatosis or multiple cartilaginous exostoses that have been successfully surgically excised; history of joint instability that has been medically or surgically corrected; history of intra-articular loose bodies in any joint surgically removed with no residual; any fracture in which hardware, e.g. rod, plate, pin or screw, was used for fixation, if the fixation devices remain in place, will require orthopedic consultation; Minor deviations from the range of motion of the wrist; Osteopenia will require endocrine evaluation and possibly other specialized scanning techniques. (International Space Station Program, 2009)

Other

NASA requirements and documents support safety first. However, injuries result from an accident and there are no real medical preventive measures available.

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
Collins, 1988	2	Incidence
Saile, 2017	1	Incidence

Alternative Incidence Data

Analog Populations

A study among US Navy Submarines determined that the incidence of injuries was 0.056 (5.6/100) for officers and 0.201 (20.1/100) for enlisted men per person-years. Information was not stratified by type of injury. The most common cause of limited or no duty days among enlisted men was injury (1824 d), followed by digestive (403 d), and musculoskeletal (350 d). Among officers, the highest morbidity rate was for respiratory illnesses, followed by **injury**, and musculoskeletal disorders. The population was composed of 240 submarine patrols, between 1 January 1997 and 30 September 2000; total of 1389 officers and 11,952 enlisted crew members served aboard participating submarines for 215,086 and 1,955,521 person-days at sea. In summary, potentially mission-impacting medical events reported among officers aboard submarine patrols were rare (36.3 per 100 person-years underway. The officers are most analogous to current space program participants. 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) Finger dislocation ICD-9 code is 834. Thomas' study includes codes 800-999 as a group

A longitudinal cohort study of 4,122 US Army deployed to Iraq for 15 months was performed. A casualty in customary military usage means active duty service member lost to the theater of operations for medical reasons. This study covers only disease and non battle injuries (DNBI). Musculoskeletal injuries were classified in three major categories: upper extremity, lower extremity and axial spine. There were 667 total musculoskeletal injuries; 270 to the upper extremity and a total of 27 instability injuries, with 16.1% MEDEVACs (5/31). Total hand injuries were 17.5%. (Belmont, 2010) We cannot determine an incidence for finger dislocation.

Non Analog Populations

Terrestrial data for finger dislocation is scarce.

In the United States dislocations accounted for 5% of injury treatment episodes and 2% of self-reported injury episodes. Incidence of self reported injuries is higher for the 18-44 age group and remains similar for injury treatment episodes for all age groups. Males aged 65 and older were treated for dislocations, open wounds, and other musculoskeletal injuries at higher rates than females. A substantial majority of the 3.4 million dislocation injury episodes (74%) treated in 2006 were treated in physician offices.

Injury Treatment Episodes and Rate by Type of Musculoskeletal Injury by Sex and Age, treated in Emergency Rooms United States 2006 to 2007. B y age groups 18-44 and 45-64 proportion rates are 5% and 6% treatment episodes. Self reported proportion rates are 4 and 2% respectively.

Rates per 100 population for dislocation overall, 18-44 and 45-64 are 1.1, 0.9, and 1.4 respectively. By gender and the same distributions, male rates are 1.3, 1.1 and 1.7; female rates are 1.0; 0.6 and 1.1. (Table 6-4) Burden of Musculoskeletal diseases. (Visits by site of dislocation injuries, for all other sites, which include hands and fingers is15.7%, but we cannot segregate the fingers data. (Jacobs, 2008)

We estimated 15.7% of the total dislocation rate to obtain a more approximate incidence which may be overvalued: (1.1 /100 population *15.7%) 0.001727 (0.9/100 * 15.7%) 0.001413 and 0.002198 (1.4/100 * 15.7%). Of note the15.7 percentage of all injuries other than shoulder and knee is similar to the Army's hand injuries 17.5%

A retrospective review of all documented injuries to the hand, first ray, and fingers sustained by American football players in the National Football League over a 10-year period (1996-2005) was performed using the League's injury surveillance database. A total of 1385 injuries occurred to the hand, first ray, and fingers over the 10 seasons studied.

48% involved the fingers. Finger injuries were most commonly dislocations at the level of the proximal interphalangeal joint, typically involving the ulnar 2 digits. (Mall, 2008)

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 %: 99 - 100)	100	1	1 - 18	336 - 504 - 672	0	0	0
ISS-based Treatment (worst case scenario %: 0 - 1)	100	1	10 - 33	336 - 504 - 672	0 - 33	0 - 1	0
Untreated Best Case	0	0	10 - 33	336 - 504 - 672	0 - 18	0	0
Untreated Worst Case	0	0	19 - 64	336 - 504 - 672	19 - 64	0 - 100	0

[1]Clinical 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".

[2]Clinical 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.

[3]Clinical 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

Best case scenario is defined as a simple dislocation, without interposed soft tissue

Worst case scenario is defined as a complex dislocation with interposed soft tissue which may require surgical reduction.

Percentage of best case versus worst case scenario

Because many injuries to the phalanges go unreported, defining a true incidence is difficult, as well as establishing a percentage of simple versus complex dislocation. The literature has focused on specific types and most often in the form of case reports. (Freiberg, 2006)Volar dislocations are irreducible and are described as very rare, rare, and uncommon. (Deshmukh, 2005); (Freiberg, 2006); (Polanski, 2011) Lacking a specific percentage we determined 0-1% to be used as the worst case percentage (Kerstman, 2011). Thus the best case percentage is 99-100%

Best Case Comments

Finger Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Digit regional grid fracture ratings are based on Table 15-2, pp.391-394 (American Medical Association, 2008). The Digit regional grid ratings are converted to percentage of Whole Person Impairment (WPI), using the Index or middle finger to whole person values. which are based on Table 15-12, pp 421-423. 394 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total FI ratings are calculated combining the WPIs using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. physical exam, vital signs, and splint for the best case scenario, is estimated in one hour. During Clinical Phase II, FI is estimated in 1 to 18%. Duration is estimated in 336-672 hours, or 2 to 4 weeks. In Clinical Phase III, full recovery is expected and FI is 0%. By definition EVAC and LOCL are not expected for the best case scenario.

Worst Case Comments

Finger Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Digit regional grid fracture ratings are based on Table 15-2, pp.391-394 (American Medical Association, 2008). The Digit regional grid ratings are converted to percentage of Whole Person Impairment (WPI), using the Index or middle finger to whole person values. which are based on Table 15-12, pp 421-423. 394 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total FI ratings are calculated combining the WPIs using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. physical exam, vital signs, splint, is estimated in 1 hour. During Clinical Phase II, FI is estimated in 10 to 33%. Duration is estimated in 336-672, 2 to 4 weeks. In Clinical Phase III, full recovery may or may not occur and FI is estimated at 0-33%. Phalangeal Fractures are a class IIa event, manageable with the HMS and not likely to require evacuation or affect mission duration. (Johnston, 2008) Phalangeal dislocations may be considered in the same class. None of the astronaut corps' hospitalizations has been for finger dislocation. EVAC is estimated at 0 to 1% based on National Electronic Injury Surveillance database for finger dislocations from 2010 to 2015 admitted to hospital was 1.48% of historical count of 42,280 seen for treatment (US Consumer Product Safety Commission, 2015). LOCL is not expected for finger dislocation.

Untreated Best Case Comments

Finger Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Digit regional grid fracture ratings are based on Table 15-2, pp.391-394 (American Medical Association, 2008). The Digit regional grid ratings are converted to percentage of Whole Person Impairment (WPI), using the Index or middle finger to whole person values, which are based on Table 15-12, pp 421-423. 394 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total FI ratings are calculated combining the WPIs using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

During Clinical Phase II, FI is estimated in 10 to 33%. Duration is 336 to 772 hours, similar to the treated best case scenario. In Clinical Phase III, recovery may or may not occur. Since in the untreated scenario there would be no analgesics to treat pain, FI is estimated at 10-33%. EVAC is estimated in 0 to 0% for the untreated best case based on the definitions for best case scenario. By definition LOCL is not expected for this scenario.

Untreated Worst Case Comments

Finger Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Digit regional grid fracture ratings are based on Table 15-2, pp.391-394 (American Medical Association, 2008). The Digit regional grid ratings are converted to percentage of Whole Person Impairment (WPI), using the Index or middle finger to whole person values, which are based on Table 15-12, pp 421-423. 394 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total FI ratings are calculated combining the WPIs using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

During Clinical Phase II, FI is estimated in 19 to 64%. Duration is 336 to 672 hours, or 2 to 4 weeks, similar to the treated worst case scenario. In Clinical Phase III, recovery is unlikely and FI remains 19-64%. Since, in the untreated scenario, there is no treatment available to control pain or adequately immobilize the dislocated joint, EVAC is expected to be required (100%). LOCL is not expected.

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 Medical Association, 2008	3	FI
American Medical Association, 2008	3	FI
Johnston, 2008	2	EVAC
Kerstman, 2011	5	BCWC
US Consumer Product Safety Commission, 2015	2	EVAC

Additional Comments

We conducted PubMed searches for phalangeal OR finger AND dislocation epidemiology with poor results. Phalangeal and metacarpal-phalangeal dislocations incidence results are combined with fractures and sprains/strains.

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Blood Pressure Cuff (regular, large)	0	1	2	No	Yes	Measure blood pressure
Blood Pressure Monitor	0	1	1	No	Yes	Measure blood pressure
BZK wipes	0	4	60	Yes	No	Cleanse skin.
Finger splint	1	1	1	No	Yes	to immobilize joint
Lidocaine (Xylocaine) plain 1%, 10mL multi dose vial	0	1.5	3	Yes	Yes	For digital nerve block
Medical tape	0.03	0.03	5	Yes	No	single-coated tapepressure adhesive tape
Needle [25g]	0	2	4	Yes	Yes	For lidocaine administration
Nitrile gloves (large, medium, and small) (pair)	0	1	30	Yes	No	Personal Protective equipment for CMO
Sharps container	0	1	40	No	No	To dispose of medical waste such as used medical needles, scalpels, IV catheters, razors, vials
Syringe (3cc)	0	2	20	Yes	Yes	Administer Lidocaine
Tylenol (Acetaminophen) 325 mg	12	40	150	Yes	Yes	pain relief
Ultrasound gel (2 packets)	1	1	17	Yes	Yes	Use with Ultrasound machine
Ultrasound machine	1	1	1	No	Yes	For diagnostic purposes
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	6	30	Yes	Yes	Pain relief

Resource Comments

The table was revised on 8/5/2011. ISS address dislocations in the same way as fractures. All resources included in the table are available on board (Mission Operations Directorate (MOD), 2011).

Urban standards of care (Divelbiss, 2011)refer to splint immobilization and referral to rehab and surgery for complex dislocations while ISS Checklist main focus is emergency immobilization of the joint and pain relief.

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
Incidence	1.5
Functional Impairment	3
Best Case / Worst Case	5
EVAC / LOCL	2
Resources	2
QUALITY OF EVIDENCE	**2.7**

Description	Range
Excellent	1-2
Good	2.1-3
Fair	3.1-4
Poor	4.1-5

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