

Hand Fracture CLIFF Peer Review

1. *Strength of evidence presented in CLIFF in modeling the characteristics and mission impact of this medical condition within the spaceflight environment?*

Score: 3

Grading Scale:

4 - *Confident*

3 - *Somewhat confident*

2 – *Neutral*

1 – *Somewhat unconfident*

0 – *Not confident*

2. How confident are you that these data accurately represent the spaceflight environment?	Tables 1, 2 Composite Incidence and Level of Confidence	Table 3, 4 BC/WC Loss of Crew and probability	Table 4 - Clinical Phase 1, 2 durations Table 5 – CP 2 Loss of Crew	Table 4 – RTDC % Table 6 – RTDC Loss of Crew	Table 4 – Loss of Crew Life % Table 7 – Loss of Crew Life, Loss of Crew	Table 8 – TI
Score	2	3	3	3	3	3

Comments and limitations:

1. **General comments.** Terrestrially, hand fractures are most often caused by falls, crush or twisting forces, or during contact sports. Although astronauts rely on their hands for translation, grasping, and stability in microgravity, the forces involved are unlikely to cause hand fractures by the same mechanisms that they do on earth. Some of the terrestrial references studied hand fractures in athletes who are involved in contact sports. Using these studies to estimate incidence would lead to an overestimation if applied to the entire mission. Therefore, it is assumed that the risk for hand fracture during nominal microgravity operations is 0% and the incidence is only applied when the crew is performing duties similar to an athlete, such as during EVA operations, or when astronauts are under the influence of a gravity field such as during lunar or Martian surface operations. There have been no reports of hand fractures during US spaceflights.

2. **Incidence.** As noted above, using terrestrial data would most likely lead to an overestimate of the incidence if this data is applied to the entire mission. Therefore, the risk during microgravity operations is assumed to be 0%, and the risk of hand fracture from terrestrial data is only applied to surface operations or during EVA's. The best case/worst case probability is cited as a range because

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of the paucity of data and uses a single terrestrial paper which reported the number of hand fractures requiring surgery (worst case). The clinical phase durations, RTDC and Loss of crew life probabilities are supported by terrestrial evidence, and I am in agreement with their calculation. The probability density curve that was derived appears to be a reasonable representation of the data presented.

3. Clinical phase data. I am in agreement with the clinical phase 1 duration entered in this CLIFF. This data was compiled by a team of expert clinicians, and I was involved in the discussions leading to the calculation of the clinical phase duration. CP2 was supported by terrestrial evidence.

4. Task impairment. The analysis was performed and reviewed by a separate team of expert clinicians. I am aware of the methods that were used but did not directly participate in the discussions.

5. Dependence on mission phase or duration of mission. This medical condition is dependent on the mission phase and its risk is assumed to be much higher during EVA's and surface operations.

6. Limitations

- There is a paucity of data for computing the best case/worst case probability. Therefore, the probability is quoted as a range.
- There is no spaceflight data for this CLIFF as there have been no reports of hand fractures during crewed missions. The risk during microgravity operations is assumed to be zero and the calculated incidence applies only to surface operations and EVA's.
- This CLIFF will need to be updated after IMPACT 1.0 once partial gravity operations are considered in the model.

Reviewed by:

David C. Hilmers