

EVA Related Fingernail Delamination 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	3	3	2	4	4	3

Comments and limitations:

1. **General comments.** This CLIFF addresses EVA related suit fingernail delamination injuries. The EMU gloves, while pressurized, cause constant contact and friction with the tips of the fingers, particularly as astronauts perform tasks in which they need to extend their reach. Fingernail injury and even onycholysis have been common complaints among crew members while on spaceflight EVA's in microgravity and during neutral buoyancy (NBL) training underwater in unit gravity. Suit design has been implicated in hand and fingernail injuries because of the competing requirements for pressurization and dexterity. Important advances have been made throughout the space program to improve the comfort and safety of the suit. It is unclear how well historical data that documents the rate of fingernail injuries in older EMU's with older gloves will inform the incidence in newer designs. However, most spaceflight data comes from experience in microgravity EVA's. During exploration missions, most of the EVA's will be in partial G. Therefore, data from training runs underwater may be more informative for future missions. Since some fingernail injuries during an EVA are of minor consequence, they may go unreported. The best case is considered to be mild to moderate nail bed trauma with partial onycholysis that responds to treatment. The worst case is severe nail bed trauma causing onycholysis and/or nail loss despite treatment.

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2. Incidence. A study by Charvat, 2015, was used to calculate the incidence data. This study included both the spaceflight EVA experience and data from NBL runs on fingernail injuries and delamination. The number of data points from NBL runs is much larger than the spaceflight EVA's and therefore drives the calculated incidence. Normally, we would base our incidence calculation on spaceflight data rather than terrestrial studies. However, since exploration EVA's will most likely be performed in partial gravity fields, the use of NBL data in unit gravity is felt to be appropriate for this CLIFF. The incidence calculation was determined on a person-EVA basis. Since the exploration space suits will presumably incorporate improvements in design, it is possible that the incidence of fingernail injuries will be lower than historical experience. It is likely that very minor delamination injuries have not been reported in the past which could lead to a small underestimate of the true incidence value. The best case/worst case probabilities used information from the Charvat study, consisting of questionnaires from crewmembers after EVA training runs. Of the fingernail injuries reported post-training run, 10% involved complete onycholysis which was taken as the worst-case probability. Clinical phase duration, RTDC and Loss of crew life probabilities are supported by terrestrial evidence, and I am in agreement with their calculation. Both RTDC and Loss of crew life probabilities were considered to be zero given the medical condition definition. The probability density curve that was derived appears to be a reasonable representation of the data presented.

3. Clinical phase data. I agree 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 mission phase as it is only applicable to EVA operations.

6. Limitations

- Under-reporting for this condition could have occurred during past space missions and NBL training runs due to subtle fingernail injuries that were not of clinical consequence. This may result in underestimation of the incidence.
- Glove design has changed over time, and there appears to be a correlation with the current model having a higher incidence of fingernail injury
- The incidence was based on historical data from past spaceflights which used EVA suits that will not be utilized in future missions. Since the exploration space suits will presumably incorporate improvements in glove design, it is possible that the incidence of fingernail injuries will be lower than historical experience.
- There is a paucity of data regarding the length of symptoms from EVA fingernail injuries; thus, expert opinion and terrestrial data were used.

Reviewed by:

David C. Hilmers