Analysis of Upper Limb Trajectories in Ampoule Opening

Masako Hirano¹, Atsue Ishii¹, Kohei Tomita¹, Noriko Hirata¹, Yoshitaka Nakanishi², Yasuaki Matsumoto³, Kazuma Nagamura³, and Yaemi Koshino³

Abstract—We analyzed the trajectory of the hand from the shoulder by decomposing six components into their constituent elements using motion capture. The movements of four individuals (one beginner and three experienced) were compared. The movement of the beginner was restricted mostly to the forearm, while the experienced individuals had different movements of the upper limb and moved multiple elements of the hand (shoulders, elbows, forearms, and wrists). We also found that the power of the hand as well as applying force times are two of the key factors to consider in ampoule opening.

I. INTRODUCTION

An “ampoule opening” is when a glass container containing a drug solution is broken by hand in order to administer the drug to patients. There are some problems with this process, including the scattering of glass pieces and potential injury to the finger [1]. Although there are various techniques laid out in procedure manuals, few studies have analyzed how to open an ampoule in detail. Basic safety information for beginners is also lacking. The purpose of this study is to determine upper limb trajectories during ampoule opening by decomposing six components into their constituent elements.

II. METHODS

A. Participants

Four healthy individuals participated in this experiment. Three of them had nursing qualifications/experience and experience with ampoule opening (2 females, 1 male), and one of them was a complete beginner (1 male). All participants were right-handed.

B. Experimental setup and data preprocessing

Each participant opened 15 ampoules (five each of 5 ml, 10 ml, and 20 ml). We asked the beginner to read the instructions provided by a pharmaceutical company in advance [2]. In the experiment, the performances were recorded using a MAC3D system (Motion Analysis Corp.) [3]. A total of 40 reflective markers were attached to each participant’s shoulder, elbow, forearm, and hand and were captured by a 14-unit infrared camera that simultaneously recorded the coordinates of the three-dimensional space. The movements of the upper limb were then decomposed into six elements—(a) shoulder abduction/adduction and forward flexion of shoulder/backward extension of shoulder, (β) external/internal rotation of shoulder, (δ) elbow flexion/extension, (γ) forearm pronation/supination, (θ) hand flexion/extension, and (φ) radial deviation/ulnar deviation—and the bend length, angle, and change position of each was calculated using these coordinates [4].

III. RESULT

The each hand trajectory of the participants while they opened the ampoule was divided into three orbits: 1) from starting the power to opening, 2) from opening to movement, and 3) from stopping the movement in a fixed position. Fig.1 shows the changes in each of the hand movements when two participants (beginner A and experienced B) cut down. And, the time when the ampoule was opened is set as 0 point.

![Figure 1. Time transition of the change in each of the hand movements](image)

IV. DISCUSSION AND CONCLUSION

Immediately around the ampoule opening, the movements of the beginner were very small, except for the forearm. In contrast, with the experienced participants, although there were differences in size of the movement of the shoulder, elbow, forearm, and hand, they were more tailored to each part. In addition, one of the experienced participants moved only his shoulder and elbow. This suggests that, in addition to the power of the hand, applying a safe force time it is also important. In the future, we will perform further analysis to clarify the relationship between how to fold and cut, and the cut surface of each ampoule. And we will establish the safety method to open an ampoule, including force data of each subject.

REFERENCES