Evaluation of Ergonomics in foot pedals used during ocular surgery in the aims of presenting improvements

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Abstract: This study aims to perform an evaluation of the ergonomics of a commercially available foot pedal used in surgical procedures, such as cataract surgery and implement improvements rendering the operation of foot pedals more efficient. For this purpose, a human centered design framework consisting out of four steps is put in place. In a first step, the relevant literature is reviewed. A second step is devoted to the analysis of video footage which has been recorded during real surgery and when the pedal was used by various surgeons. A heuristic evaluation of the pedal is done in a third step. In a fourth step, shortcomings in a commercial foot pedal are formulated and improved design solutions are proposed. Design solutions are prototyped for user testing. In our poster, we intend to present and discuss the prototyped solutions.

Keywords: surgery, pedal, Interface

1. Introduction

More and more, ergonomics is proving to be very important to the career longevity of surgeons and from previous research it has been proven that there is much improvement to be made around ergonomics in the operating room (OR) (Betsch et al. 2020; Wauben et al. 2006). In 2006 Wauben et al. sent out a total of 1,292 questionnaires to surgeons and from the returned answers almost 80% reported discomfort in the neck, shoulders and back.
In many surgical procedures, the surgeon uses both of their hands to operate instruments, therefore foot pedals are often employed to control and activate certain functions without having to desterilize hands. During cataract surgery for example, foot pedals are used to control the phaco handpiece that the surgeon holds in his hands. Shimizu(Shimizu et al. 2011) found that most commercially available foot pedals force the surgeons to assume a sub-optimal posture ergonomically, which could be easily improved by slanting the pedal with a 25° inclination. In the present study, we aim to perform an evaluation of the ergonomics of a commercially available foot pedal used in various ocular surgeries, to then propose improvements.

2. Material and Method

The pedal is part of the OS4 (Oertli Instruments AG, Berneck, Switzerland) surgical platform used to perform cataract surgeries amongst other surgical interventions. Figure 1 shows various views of the pedal.

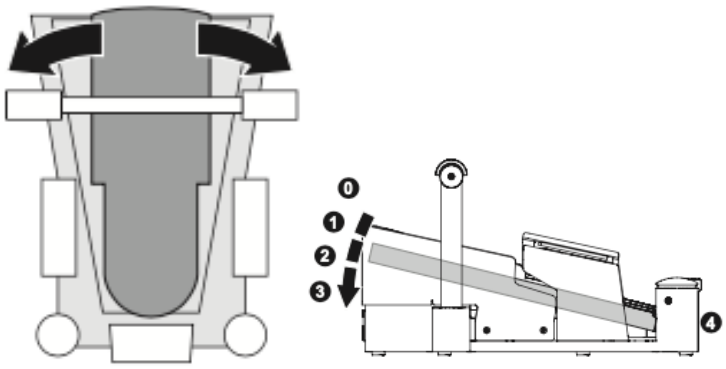

***Figure 1**: Foot Pedal for surgery investigated in the present study. The numbers refer to the different positions of the pedal's center piece.*

The first step of the pedal evaluation was doing a literature review concerning pedals used in surgery, ergonomic guidelines and international standards on the topic. In order to decompose and analyze the use of the pedal in surgery, an abstraction hierarchy of the cataract surgery was performed. Then a sequential task analysis was done to study the use of the actuators in terms of relative position, frequency and duration of use. For this purpose, we relied on videos taken while the pedal was used during cataract surgery.
Finally, a posture analysis of the foot is being done to determine the phases of comfort and discomfort during the surgery. For this purpose, the angular movement range of the foot ranging from maximum dorsiflexion to maximum plantar flexion was divided into six equidistant angles (Fig. 2).

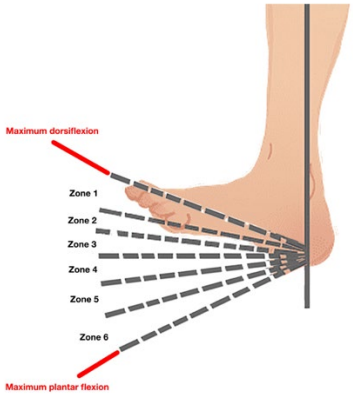

***Figure 2**: Division of the angular movement of the foot in six equidistant zones used in evaluation of comfort of the foot posture.*

The videos consisted of footage filmed inside the OR. Four operations by 3 different surgeons were filmed. Each operation was filmed from four angles, two depicting the upper body of the surgeon, one depicting the foot and the pedal and a view on the eye of the patient (Figure3). The combined length of the 3 videos is around 75 minutes.

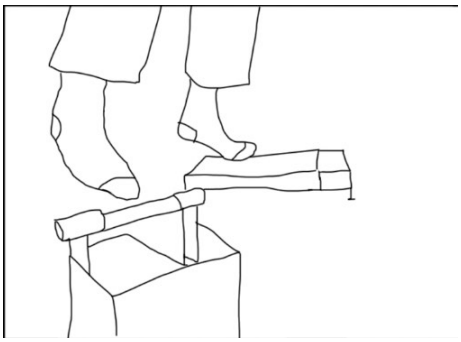

***Figure 3**: Illustration of the format of video footage provided for the study. The two pedals used by surgeons are showing, the microscope pedal in the background and the studied pedal showing in the foreground of the illustration.*

3. Results

The results of the sequential task analysis for the use of the pedal is shown in Fig. 4. The analysis include 4 surgeries and the total video footage time was 75 minutes. The most frequent movement successions were from the floor to the center piece and from the heel button to the center piece.

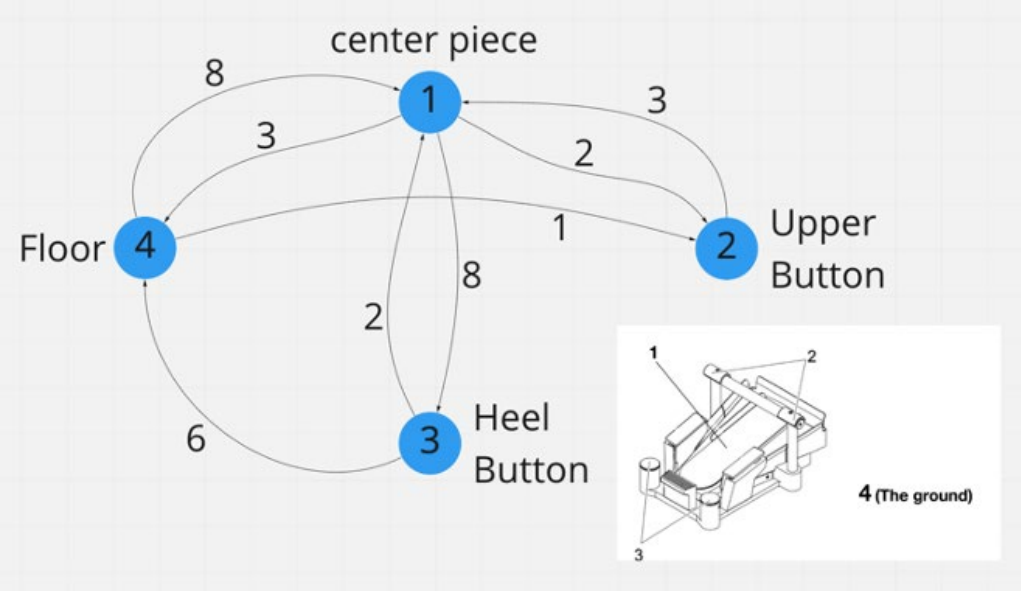

***Figure 4**: Results of the sequential task analysis reporting transition frequencies between the different actuators in the pedal. Total analyzed video footage 75 minutes. 4 surgeries.*

Then a temporal analysis followed, determining the length and frequency of the pedal presses. It differed between surgeons, some do long presses while others prefer short bursts of presses. Some of our comparison results are presented in fig. 5.

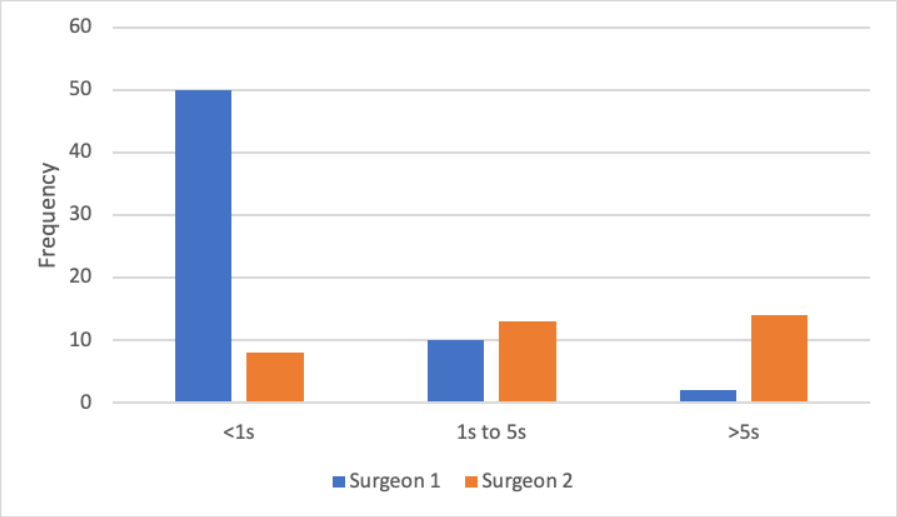

***Figure 5**: Comparison of the length of presses on the pedal between two of the three different surgeons investigated up to the time of publication of this work.*

Finally, as a preparation for the posture analysis, a literature review to determine the maximum dorsiflexion and plantarflexion angles was done.
(Baumbach et al. 2014) determined the maximum dorsiflexion angle at various degrees of knee flexion, for weightbearing and non-weightbearing cases. 20 asymptomatic volunteers aged 18-40 years (50% female) was assessed prospectively at six different degrees of knee flexion (0°, 20°, 30°, 45°, 60°, 75°, Lunge). For pedal use in surgery, it is in between both cases, as the ankle bears the weight of the foot but not the whole body.

4. Discussion and Conclusion

A framework for studying the ergonomics of foot pedals was developed and the first pilot measures were conducted successfully, however some improvements in the video recording technique could be done to facilitate the extraction of the leg and foot angular positions to then determine the comfort and discomfort in the surgeon's lower limbs. A heuristic evaluation was also performed through the temporal analysis and sequential task analysis. The steps three and four of our study are still in progress and will be completed at a later date.

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Gesellschaft für
Arbeitswissenschaft e.V.

Technologie und Bildung in hybriden Arbeitswelten

68. Kongress der
Gesellschaft für Arbeitswissenschaft

Otto-von-Guericke-Universität Magdeburg

Fraunhofer-Institut für Fabrikbetrieb und
Fabrikautomatisierung IFF, Magdeburg

02. – 04. März 2022

GfA-Press

Bericht zum 68. Arbeitswissenschaftlichen Kongress vom 02. – 04. März 2022

Otto-von Guericke-Universität Magdeburg;
Fraunhofer-Institut für Fabrikbetrieb und -automatisierung IFF, Magdeburg

Herausgegeben von der Gesellschaft für Arbeitswissenschaft e.V.
Sankt Augustin: GfA-Press, 2022
ISBN 978-3-936804-31-7

NE: Gesellschaft für Arbeitswissenschaft: Jahresdokumentation

Als Manuskript zusammengestellt. Diese Jahresdokumentation ist nur in der Geschäftsstelle (s. u.) erhältlich.

Schriftleitung: Prof. Dr. Rolf Ellegast
im Auftrag der Gesellschaft für Arbeitswissenschaft e.V.

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