

Virtual Reality Phacoemulsification: a Comparison Between Skilled Surgeons and Students Naive To Cataract Surgery

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ABSTRACT

We have developed a simulator for virtual phacoemulsification surgery. In the current study, the performance of one experienced cataract surgeon was compared to the performance of four subjects naive to cataract surgery. They all operated on the same virtual patient and a number of different response variables were measured. It was found that the experienced subject performed better than the naive subjects on almost all response variables. This indicates that the simulator developed by us is authentic for phaco emulsification surgery. The lack of negative effects in case of complications during virtual phacoemulsification surgery makes the phaco simulator that we developed a very attractive tool for learning phacoemulsification surgery.

Keywords: cataract surgery, phacoemulsification, simulator, autenticity

1. INTRODUCTION

The present work is a primary clinical evaluation of the authenticity of the simulator for phacoemulsification cataract surgery (phaco) that we have developed [1-4].

Phacoemulsification cataract surgery (phaco) is today the most common surgical procedure in modern societies approaching 1/100 inhabitant/yr. With increasing population age the prevalence of cataract surgery is expected to increase further.

Phaco consists of an approximately 3 mm incision into the eye in the periphery of the cornea, opening of the crystalline lens by tearing an operculum in the anterior lens capsule, capsulorhexis, liquid dissection of the crystalline lens into cortical and nuclear components, ultrasound emulsification and simultaneous aspiration of the nucleus, aspiration of the cortical material and implantation of an artificial intraocular lens into the empty capsule. The success of the operation is related to the maintenance of an intact capsular bag.

For the practical learning of phaco, the student usually primarily observes an experienced colleague during 3-6 months. Under this period, the student also usually practice the procedure in wet lab surgery on enucleated animal eyes. Thereafter, the student practices the procedure in incrementing steps until he has done the complete procedure. This usually takes another 1-3 months. Finally, the experienced teacher sits on the side as a backup for complications, normally during another 1-3 months. Despite this extensive teacher intensive training, surgeons in training have reported an incidence of 5-20 % of capsular ruptures during their first 200 cases [5-8]. These figures are similar for experienced surgeons [9, 10]. Studies of experienced surgeons have shown that the number of complications decreased exponentially reaching the asymptote after 400 [11] and 1000 cases respectively [12].

Recent development of personal computers have made it possible to simulate virtual reality with relatively inexpensive computers. It has been demonstrated that virtual reality training leads to faster adaptation to the psychomotor restrictions encountered by laparoscopic surgeons [13].

Our phaco simulator [1-4] consists a personal computer, simulation software and a surgeon interface (Figure 1).

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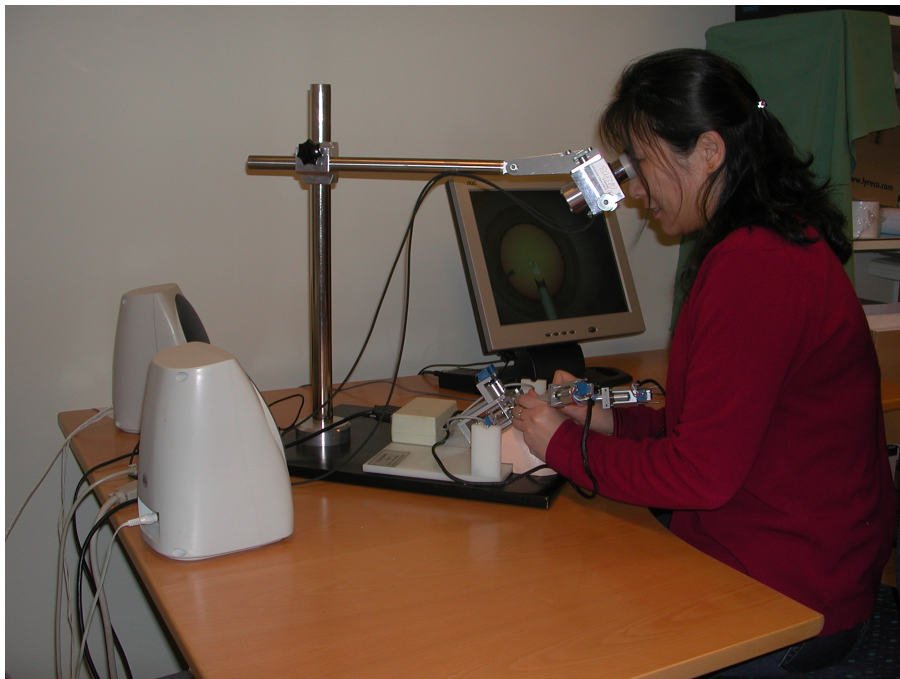


Figure 1 Cataract surgery simulator

The simulation software is based on a generalized simulation software (M-base®, Melerit AB, Sweden) working on top of Cosmo 3D/Optimizer (Silicon Graphics Inc., USA). M-base has been used to write the phacoemulsification procedure. The surgeon interface consists of a phacoemulsification hand piece and a nuclear manipulator hand piece, both mounted with four degrees of freedom (three space dimensions and rotation), a microscope foot pedal controlling x and y-direction and focusing in the field and zoom, and a one dimensional phacoemulsification pedal that controls irrigation, aspiration and phaco-power depending on the pedal position.

The aim of the current work was to make a primary evaluation of the authenticity of the phaco simulator

1 METHODS

Altogether, five subjects were included in the current study. Of these, one was a surgeon that just started to operate on his own, here called experienced, and four students with theoretical knowledge but completely without experience of phaco surgery, here called naïve. The experienced subject took a tutorial consisting of; a video demonstration of a simulator phaco session, three tutorial simulator sessions of phaco with instructor, and one measurement session. The naïve subject took a tutorial consisting of; a video of a normal phaco operation, a video demonstration of a simulator phaco session, three tutorial sessions and one measurement session.

During the measurement session the patient case was adjusted to; nucleus hardness 0.5 rel., nuclear rotational stability, 1 rel., distance tip-irrigation port, 2.0 mm, bubble group incidence, 1 group/min, number of bubbles per group, 4, x-y drift frequency, 1 /min, x-y drift speed, 2 mm/s, x-y max drift amplitude, 4 mm, zonula max length, 1.5 mm, zonula strength, 1 rel., pupil size, 7 mm, nuclear fragment dislocation elevation, 1 mm, phaco initiation angle, 10.0 deg (counter-clockwise from forehead), manipulator initiation angle, 290 deg (counter-clockwise from forehead deg).

During the measurement session the following response variables were measured; time consumption during the phaco procedure, phaco energy used, relative time in focus of the phacoemulsification tip during different parts of the procedure, relative time centered on the operation field, phacoemulsification tip path length, phaco emulsification tip behind the capsule, procedure time without irrigation, ocular damage variables, manipulator tip path length, improper manipulator tip handling, time of operation field occluded with bubbles and zonular distension.

2 RESULTS

The naive subject used more procedure time for the total procedure as well as for the sculpting and evacuation (Figure 2).

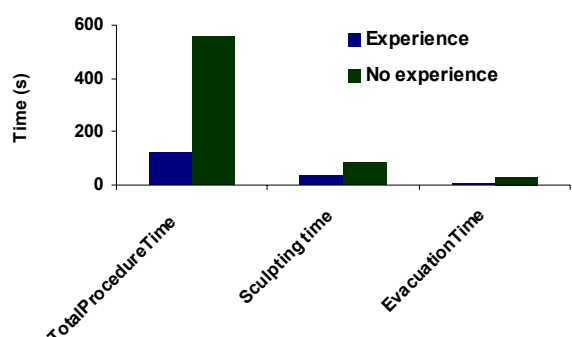


Figure 2 Phaco procedure time consumption

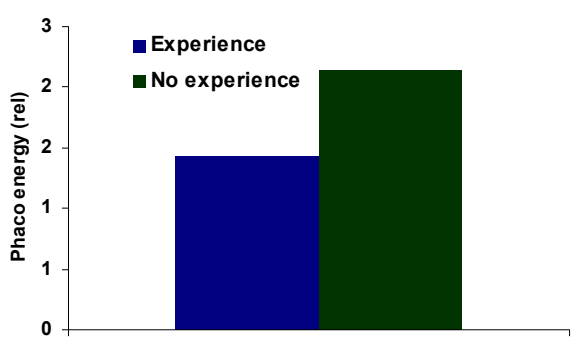


Figure 3 Phaco energy used

The naive subject consumed more phaco energy than the experienced (Figure 3).
The naive subjects were defocused more relative time than the experienced (Figure 4).

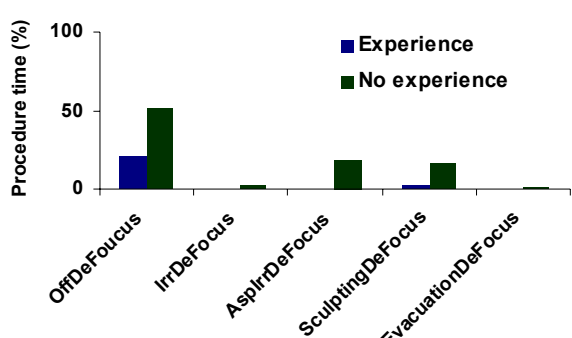


Figure 4 Foot pedal focusing

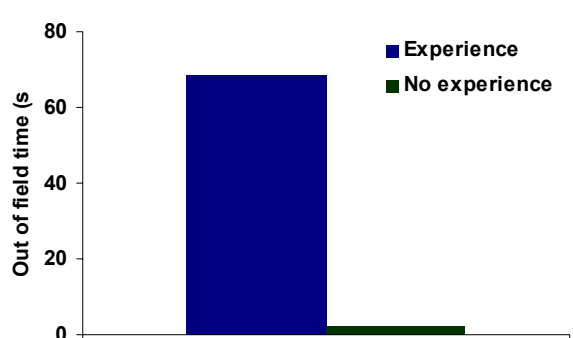


Figure 5 Foot pedal x-y adjustment

The experienced subjects were out of field during more time than the naive subjects (Figure 5).
The naive subjects moved the phacoemulsification tip around more than the experienced (Figure 6).

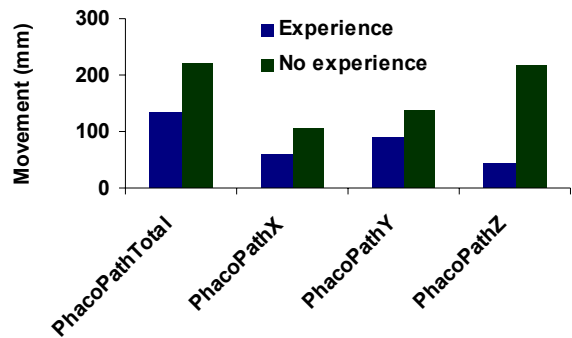


Figure 6 Phacoemulsification tip path

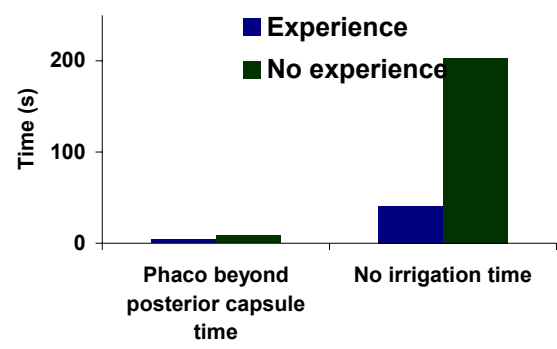


Figure 7 Improper phaco

The naive subjects kept the phaco tip behind the posterior capsule more time than the experienced and forgot to put the irrigation on for much more time than the experienced subjects (Figure 7).

The experienced subject hit the cornea from behind more accumulated time than the naive subjects but the naive subjects spent more time with the phacoemulsification tip on the iris and on the rhexis (Figure 8).

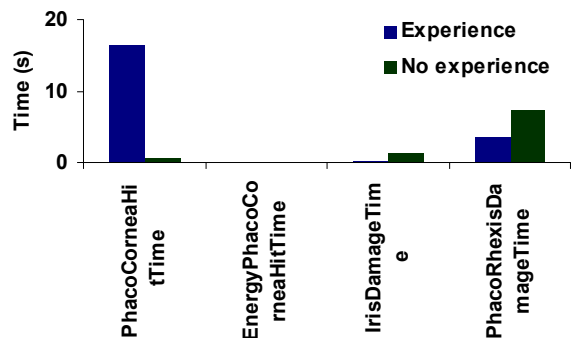


Figure 8 Ocular damage

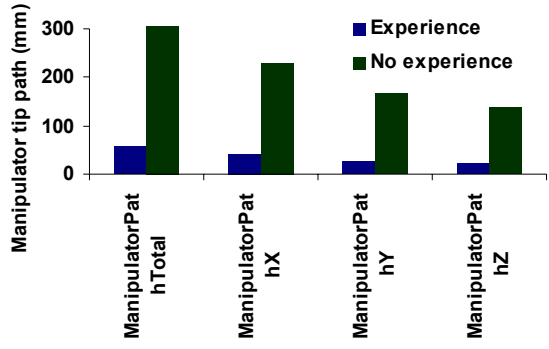


Figure 9 Manipulator path.

The naive subjects moved the manipulator tip around much more than the experienced subject (Figure 9).

The naive subjects kept the manipulator behind the iris and the posterior capsule much more time than the experienced subject (Figure 10).

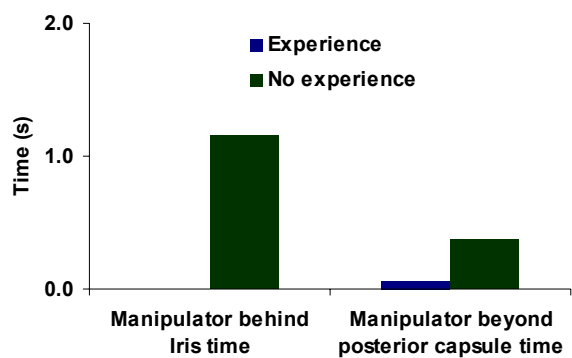


Figure 10 Improper manipulator handling.

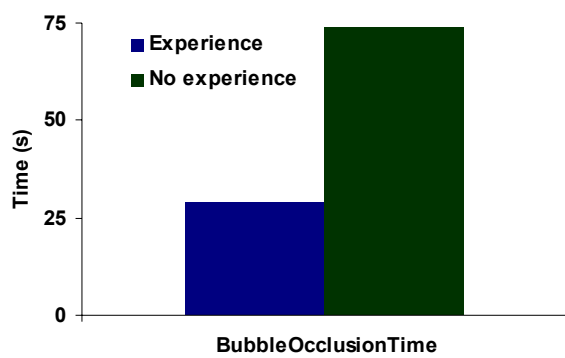


Figure 11 Bubble occlusion time

The naive subject allowed bubble occlusion of the operating field much more time than the experienced subject (Figure 11).

The naive subjects stretched the zonules much more than the experienced subject (Figure 12).

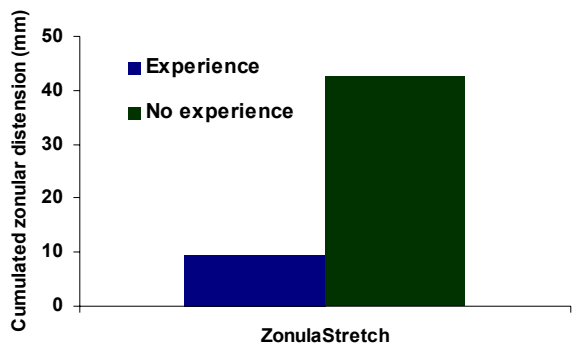


Figure 12 Zonular distension

3 DISCUSSION

The purpose of the current study was to compare naive subjects with an experienced subject during phaco surgery, with regard to a number of different response variables in order to elucidate the authenticity of the phaco simulator that we developed [1-4].

The fact that the experienced subject performed superior to the naive subjects in almost all response variables studied (Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10, Figure 11, Figure 12) indicates that the phaco simulator is authentic for phaco emulsification surgery. Now this need to be confirmed in a large controlled study.

The current finding indicates that the phaco simulator that we developed probably has a good potential as a tool to learn phaco surgery in virtual reality before starting on human patients. The complete lack of negative effects in case of complications during virtual phaco surgery makes the phaco simulator that we developed very attractive.

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