HOW DOES GOLDMANN APPLANATION TONOMETRY FOR MEASUREMENT OF INTRAOCULAR PRESSURE COMPARE WHEN THE PROCEDURE IS PERFORMED WITH FLURESS VERSUS PROPARACAINE?

By

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This paper is submitted in partial fulfillment of the requirements for the degrees of

Doctor of Optometry

Ferris State University
Michigan College of Optometry

May, 2006

ABSTRACT

BACKGROUND: Many practitioners have currently been using proparacaine instead of Fluress when performing Goldmann applanation tonometry, due to the staining of contact lenses when Fluress is used. The purpose of this study was to calculate the difference in intraocular pressure measurements when taken with Fluress versus proparacaine, and to investigate whether that difference is statistically significant. METHODS: A total of 42 eyes had Goldmann applanation tonometry performed twice, once with Fluress and once with proparacaine. The individual pressure values and the difference between measurements with Fluress and measurements with proparacaine were then plotted on three separate graphs. The deviations between measurement results were analyzed to determine whether the difference was statistically significant. RESULTS: Goldmann applanation tonometry performed with proparacaine under-estimated the intraocular pressure by a statistically significant amount of 1.62 mmHg ($p = 0.012$; t-test = 2.68), with a range from –6 mmHg to +1 mmHg when comparing it to Fluress measurements. CONCLUSIONS: Our study found a significant difference in intraocular pressure measurements taken with proparacaine compared to Fluress. Even though using proparacaine for IOP measurement may be convenient for contact lens wearers and more cost effective, this study supports the use of Fluress instead of proparacaine when obtaining the most accurate measurement of intraocular pressure.

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INTRODUCTION

Intraocular pressure measurement is one of the basic diagnostic methods in ocular health assessment. Accurate intraocular pressure (IOP) readings are important in the detection and follow-up of primary and secondary glaucoma as well as in the differential diagnosis of primary open-angle glaucoma, normal-tension glaucoma, and ocular hypertension. Tonometry has been performed since the latter part of the nineteenth century. There are a variety of impression and applantation devices used in IOP measurement. The contemporary standard for applanation tonometry is the Goldmann applanating device. Compared with other techniques, the effects of intraocular volume change, surface tension, and corneal rigidity are negligible so that the applanation pressure corresponds well to the true IOP.[1] The theoretical basis of Goldmann applanation tonometry (GAT) lies in the Imbert-Fick law, which states that a perfect sphere has its pressure equally distributed and that measurement of a known area by an applied force represents that pressure.[2] Hence, the eye is presumed to be a perfect sphere, and IOP is calculated from the required force to applanate a fixed area of the corneal surface (3.06 mm^2) with a fixed doubling prism.

Traditionally, Fluress (sodium fluorescein and the topical anesthetic benoxinate) has been topically applied to the eye in preparation for GAT. Anesthetic allows the flat tip of the Goldmann tonometer probe to come into contact with the patient's cornea while

the patient looks in primary gaze. Fluorescein then spreads into the tear fluid of the eye, forming a meniscus surrounding the area of contact between the circular probe tip and the corneal surface. The clinician adjusts the pressure applied to the probe until the fixed prism has doubled the inner limit of the fluorescent meniscus. The width of the fluorescein semicircles should be approximately one-tenth of the diameter of the flattened area.[1] If fluorescein semicircles are too wide, IOP measurement will be artificially high, and conversely if fluorescein semicircles are too narrow, IOP measurement will be artificially low. The fluorescence is visualized by using the cobalt filter of the slit lamp as the flat end of the Goldmann probe rests against the corneal surface. Examples that may contaminate applanation reading are: variations in fluorescence of the tear film, accommodation, anxiety, Valsalva manueuvers, eye movements, and other environmental influences. In addition, abnormal corneas from refractive surgeries and such may cause a significant underestimation of IOP.[1,3] Corneal thickness, astigmatism, and direction of gaze are also clinically important sources of error in GAT.[4]

Most practitioners accept 21 mm Hg or less as normal and a difference of 3-4 mmHg between eyes of the same person to be normal values. However, the practitioner must not rely solely on IOP measurement to rule out a diagnosis of glaucoma. Optic nerve head assessment, nerve fiber layer and retina evaluations, visual field analysis, and a thorough anterior segment evaluation including gonioscopy are needed to determine whether the IOP is normal for that individual.

Goldmann applanation tonometry is typically performed with Fluress (sodium benoxinate) or topical ophthalmic anesthetic and fluorescein sodium dye observed with the cobalt filter. However, GAT can also be performed using proparacaine solution only and white light. Advantages of using proparacaine include cost effectiveness and IOP measurement of contact lens wearers (no staining of contact lenses with proparacaine). Although there has not been much research comparing the accuracy of IOP measurement with Fluress vs. measurement with proparacaine, Jose et al. speculated that the values obtained do not differ depending upon the choice of anesthetic.[5] Others have found statistically different measurements between the two. For example, both Roper[6] and Bright et al.[7] found that proparacaine under-estimates the intraocular pressure measurement by 5.62 mmHg and 7.01 mmHg respectfully. There have also been studies researching the minimum concentration needed for proparacaine and benoxinate to be effective on their own. Results indicated that 0.25% proparacaine is an effective anesthetic dose on all patients, and that 0.2% benoxinate and 0.125% proparacaine would be effective on patients over age 40.[8] This study concluded that significantly lower doses of anesthetic can be used which will result in less stinging, reduced hypermemia, and shorter duration of action.[8]

Due to the lack of research in this area, the purpose of this study is to further research and compare IOP measurements with Fluress versus proparacaine, and determine if values obtained are statistically different depending on which anesthetic is

used. The information gained from this study will aid eye care professionals in determining "true" IOP readings and thus, management of glaucoma and ocular hypertension patients. It may also educate the same professionals in cost effectiveness and convenience of the best anesthetic to use in IOP measurement in clinical practice.

METHODS

Twenty-one patients including optometry students and staff (42 eyes) were used in this study, with fourteen of the subjects being female. The students and staff volunteered to be part of the experiment, which took place over one afternoon. After the patients had given informed consent, one examiner performed GAT on all patients. GAT was performed twice on each patient, once with Fluress and once with proparacaine, with ten minutes between measurements. The order to which anesthetic was used first was randomized in the beginning of the experiment by placing a red "x" on half of the recording sheets, (which signified proparacaine first) and then shuffling the sheets.

For GAT, a Topcon slit lamp with a calibrated Goldmann tonometer was used. Tonometer tips were sanitized between patients. The cobalt blue filter was used with measurements performed with Fluress, and white light was used with measurements performed with proparacaine.

After the collection of the data, statistical analysis was performed. Each eye was treated separately and analyzed by comparing the values obtained with Fluress versus

proparacaine. Each value for Fluress and proparacaine obtained was plotted as a line graph in Figure 1 (Appendix A), and also on a radar chart depicted in Figure 2 (Appendix B) to show how similar the data collected agreed between all eyes of the study. The difference between proparacaine compared to Fluress was then determined for each eye and plotted in Figure 3 (Appendix C). Standard deviation and variance values were obtained from all measurements taken with Fluress and also from all measurements taken with proparacaine.

RESULTS

The difference between intraocular pressures taken with Fluress and those taken with proparacaine was significantly different ($p = 0.012$; t-test = 2.68) and positively correlated ($r= 0.735$) as depicted in Figures 1 & 2 (Appendices A & B). The average difference between measurements was 1.62 mmHg lower with proparacaine with a range from –6 mmHg to +1 mmHg, when compared to Fluress measurements. This is shown in Figure 3 (Appendix C). The mean intraocular pressure measurement with Fluress was 15 mmHg +/- 2.77 mmHg, while the mean for proparacaine was 13.5 mmHg +/- 2.67 mmHg. The sample variance values for Fluress and proparacaine measurements were 7.68 and 7.62, respectfully.

DISCUSSION

Many may argue that the accuracy of intraocular pressure measurements is not crucial, considering that pressure findings are not always diagnostic of glaucoma. Most critically, one must always take into account the evaluation of the patient's optic nerve head and nerve fiber layer above visual fields and tonometry when considering a diagnosis of glaucoma. With the increasing number of contact lens wearers, who would experience absorption of the dye in contact lenses if Fluress was used, and the cost effectiveness of not purchasing Fluress, some have found it easier to measure intraocular pressures without a fluorescein component.

Consistent with a study performed by Roper,[6] and another by Bright et al.,[7] this study found that there is a significant statistical difference in intraocular pressure measurements taken with proparacaine compared to Fluress. Proparacaine was found to under-estimate the pressure measurement by 1.62 mmHg, on average. In the publication by Roper, the result was an under-estimation of approximately 5.62 mmHg.[6] Roper states that the tears must be stained with fluorescein in order to view the apex of the tear meniscus, which defines the applanated area.[6] Bright et al. showed an even greater under-estimation with proparacaine (7.01 mmHg).[7] However, it should also be noted that Bright et al. had a sample size of 100 patients, with an increased difference with increasing pressure readings.[7]

In summary, our study found a significant difference in intraocular pressure measurements taken with proparacaine compared to Fluress. Specifically, our study

found an average under-estimation of 1.67 mmHg when using proparacaine compared to Fluress. Although this seems like a small amount of error, the differences ranged between –6 mmHg to +1 mmHg. Even though using proparacaine for IOP measurement may be convenient for contact lens wearers and more cost effective, this study supports the instillation of Fluress instead of proparacaine when obtaining the most accurate measurement of intraocular pressure with Goldmann applanation tonometry.

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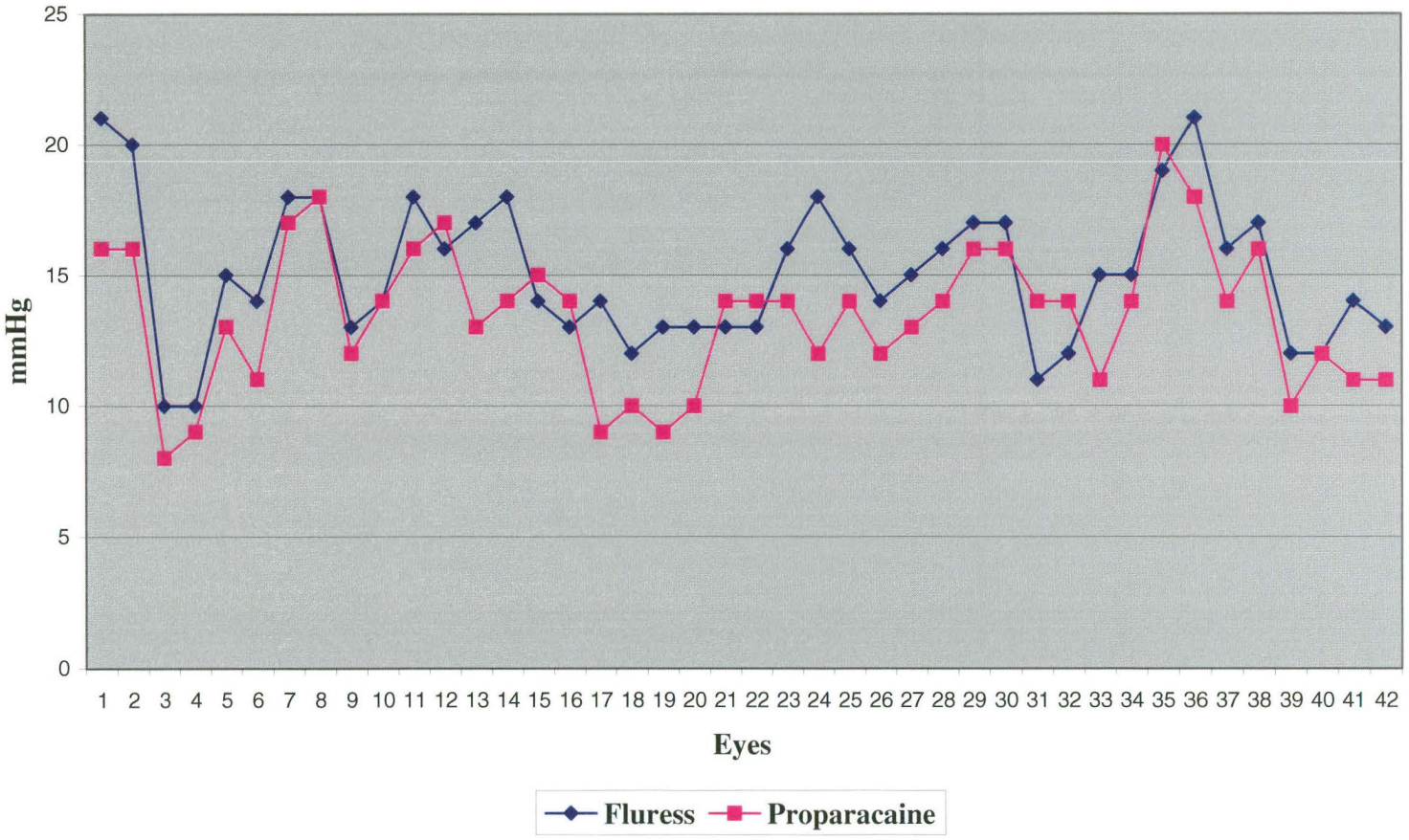
APPENDIX A

FIGURE 1. INTRAOCULAR PRESSURE MEASUREMENT TAKEN WITH PROPARACAINE COMPARED TO FLURESS

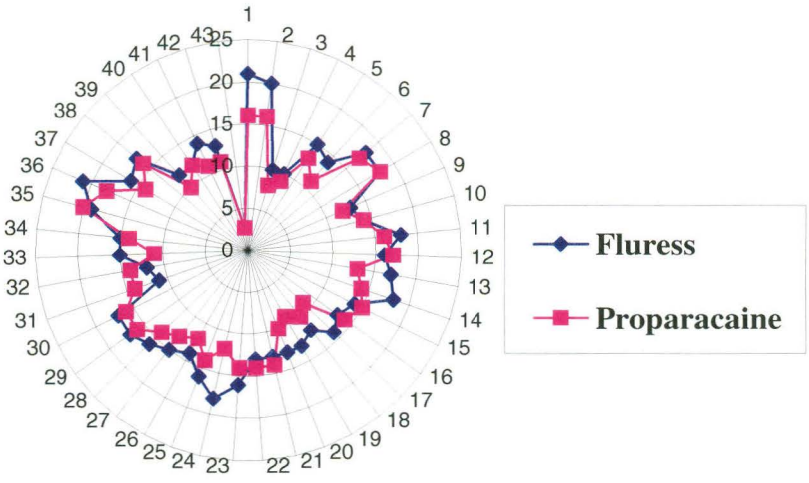
Figure 1. Intraocular Pressure Measurement Taken with Proparacaine Compared to Fluress



APPENDIX B

FIGURE 2. PROPARACAINE COMPARED TO FLURESS

FIGURE 2. Proparacaine Compared to Fluress



APPENDIX C

FIGURE 3. INTRAOCULAR PRESSURE DIFFERENCE, PROPARACAINE COMPARED TO FLURESS

FIGURE 3. Intraocular Pressure Difference, Proparacaine Compared to Fluress