

Analysis of Tear Chemistry Testing

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ABSTRACT:

Initially, the phenol red test was to be compared to the Schirmer Ia test. However, the phenol solution is not approved in the United States for use in the eye. Alternatively, the various forms of the Schirmer Tear Test were analyzed to determine whether or not anesthetic is needed for reliable results. Three conclusions were made. First, the Schirmer strips can be used with or without anesthetic. Second, the Schirmer recommended test time may be much longer than necessary. Third, the Schirmer test is not always a good indicator of dry eye candidates.

INTRODUCTION:

The cornea, a complex transparent tissue on the front of the globe, is protected, lubricated and cleansed by the lids and the tears. The measurement of these tears and tear chemistry in general are the focus of this paper.

The tears are composed of three layers. The layers are the 1) lipid (oily) layer, 2) aqueous (watery) layer and the 3) mucin (mucous) layer. (See diagram 1) The various components are secreted on the eye through many different glands (See diagram 2) and removed by evaporation and drainage through the puncta.<1>

The lipid layer is the most anterior layer of the tear film. It is produced by the meibomian gland and the sebaceous (glands of Zeis) and the sweat glands (glands of Moll) of the lid margin. The literature describes this layer to be approximately 0.1 microns thick. The purpose of this layer is to thicken and stabilize the tears while preventing evaporation. The quantity of the lipid layer is not critical unless the aqueous or mucin layers are decreased. In this situation, the literature reports the fatty acids in the lipid layer may begin to cause irritation.

The second layer is the aqueous layer. This layer makes up the physical majority of of the tears. Its thickness is about 7 microns.<2> It is produced by the main lacrimal glands and also by the accesory glands of Krause and Wolfring. Found within this layer are the immunity, nutrition and main lubrication of the cornea. Buffering of the tears is also found in this layer. It is an interesting note by the same author that most of the dry eye cases in North America are related to a reduction in the aqueous layer of the tears.

The most posterior layer, which has the most direct contact with the surface of the cornea, is the mucin layer. This layer, only .03 microns thick is secreted mainly by conjunctival goblet cells.<2> There is some evidence from the same source that it is

partially secreted by other glands including the lacrimal glands, the crypts of Henle and the glands of Manz. In combination with the sweeping action of the lids, the mucous and debris in the eye are swept into the inferior fornix and gathered in a thread like formation. This process is again reported by the same source to be found in the normal eye and often greatly exaggerated in the diseased eye.

When there is a problem with the tear flow mechanism, it is as previously mentioned, often found to be a problem with the aqueous portion of the tears. To determine the severity of the defect, several tests have been designed to help quantify the problem. One of these tests is the Schirmer test. This test involves the use of a piece of specifically designed filter paper placed inbetween the lower lid and the globe.<3> As tears are produced the wet area on the paper can be measured. The more tears that are absorbed, the greater the measured area will be. After studying many normal eyes, values for the expected amount of wet paper in a given amount of time have been determined. This test has classically been done in three ways.<4>

Schirmer I: The strip is placed in the eye and the wet length is recorded over time. This method is for basic and reflex secretion because

the strip itself causes reflex tearing and the basic secretion is always present.

Schirmer Ia: This method uses an anesthetic to stop reflex tearing. The effect of the basic tear rate is then tested.

Schirmer II: This version includes irritation of the nasal mucosa of the unanesthetized eye with a cotton swab. In this manner the reflex secretion is evaluated.

Most often, the above tests are done for five minutes as instructed by the directions on the Schirmer strip box. The length of the wet strip is then recorded.

An alternate tear testing method which is faster, does not require an anesthetic and is less invasive is the cotton thread tear test.<5> This test involves the use of a 70mm two-ply, raw cotton thread soaked in phenol red dye. A 3mm portion of the end the thread is bent over and placed inside the lower lid on the temporal side. (The general technique is similar to that used with the Schirmer strip.) The cotton thread is removed after the patient closes his eyes for fifteen seconds. The pH of the tears

causes the strip to turn from red to yellow. The length of the yellow portion of the thread is then measured. Less than 9mm is indicative of a possible dry eye. A mean of 16.7mm is expected for normal subjects as listed in the literature.

The cotton thread test mentioned above, (also called the phenol red test) has been used in several studies in Japan. The results are given above. However, the technique has not been approved in this country and I was therefore unable to use this method in my study. Consequently, this study will evaluate the use of anesthetic with the Schirmer Ia and also consider the time requirements and the diagnostic value of the Schirmer strips. It is proposed by this experimenter that the Schirmer tear strips are highly inefficient and the data they provide is often misleading. The details of this study are as follows.

METHOD:

The study group was composed of fifty randomly selected subjects. The subjects ages ranged from 18 to 75. They were students, faculty and clinical patients of the Ferris State University College of Optometry. Each subject was asked whether or not they felt they had any of the classical dry eye symptoms via a standard verbal questionnaire. These symptoms included a

high frequency of any of the following: foreign body sensation, burning, stinging, scratchiness, or general discomfort of the eyes without any known cause. Five of the subjects reported that they had previously been diagnosed as having dry eyes. Twenty five of the subjects reported that they felt they had one or more of the symptoms greater than fifty percent of the time but had not been diagnosed as having dry eyes.

Standard Schirmer's strips which had been prepared by the manufacturer were used. The strips were placed between the middle and outer third of the lower lid. Patients were told to blink as necessary. Standard exam room lighting was used at all times. Each patient was given two different tests on the same day. The first test was without anesthetic, (each eye) and the second was with anesthetic, (each eye). The first test involved placing the Schirmer strip into the eye and measuring the time required to reach the 10 mm mark on the strip thus assessing reflex and basic tears. The second test involved placing 0.5% proparacaine hydrochloride into the cul-de-sac and blotting out any excess. The strip was then left in place and again the time was recorded after the 10 mm mark was reached thus assessing basic tears. On the average the two tests were performed twenty minutes apart with a range from five minutes to thirty five minutes. The delay between tests allowed for maximum efficiency

in the clinic setting and also allowed the subjects to return to their normal comfort level before initiating the second test. All testing was completed by the author. (Jeffrey Sinclair)

RESULTS

The results from the two eyes gave similar statistical figures and were therefore combined to give the equivalent of one hundred pieces of data. Of all the subjects, including asymptomatic, symptomatic and those diagnosed as having dry eyes, only two subjects, (4%) provided data sufficient to indicate an eye which was expected to have a tear deficiency according to the Schirmer criterion for normal eyes. (According to the Schirmer criterion, less than 10 mm of wetting in five minutes with anesthetic indicates a dry eye.) Of all the eyes tested, 96% were normal according to the Schirmer criterion.

A significant difference was found in the time to reach 10 mm of wetting, between the testing done with and without anesthetic. The mean time to reach 10 mm of wetting for eyes without anesthetic was found to be 43.56 seconds while the mean time for the eyes with anesthetic was 122.75 seconds. Furthermore, 96% of the eyes tested reached 10 mm of wetting

without anesthetic in less than one minute and with anesthetic the same point was reached in less than two and one half minutes. Therefore, it was found that 10 mm of wetting in under one minute for the "aqueous" normal eye without anesthetic is a normal expected finding.

For further consideration, it is interesting to note that asymptomatic and symptomatic patients showed approximately a 1 second difference in means without anesthetic ($p \leq .82$) and approximately a 2 second difference with anesthetic. ($p \leq .77$) These results therefore show very little significant difference between the groups using Schirmer testing.

In contrast, when comparing the diagnosed dry eye patients and the non dry eye patients a significant difference was found between these groups using the Schirmer strips. Testing with or without anesthetic did not affect the significance. There was a difference of approximately 44 seconds between these groups without anesthetic ($p \leq .00$) and a difference of approximately 107 seconds with anesthetic ($p \leq .00$) These results are however not as conclusive as the symptomatic versus the asymptomatic results due to the fact that only five diagnosed dry eye patients were used in this study.

DISSCUSION

According to the Schirmer Ia instructions, a minimum of 10 mm should have been reached in five minutes to indicate a normal eye. From the data we can conclude that doing the Schirmer test for five minutes is not supplying any further information than the same test for one minute without anesthetic and two and one half minutes with anesthetic. Of course, this data is based on using the 10 mm criterion for stopping the test. If the 10 mm mark is not reached in the previously mentioned times, then this result implies that there is an aqueous deficiency. In this situatuion, further testing should be done. However, even this more simplistic approach to the Schirmer Test leaves much to be desired as I have found.

First, it is obvious from the subjective complaints during my study that the strip will irritate some eyes more than others. As a result the reflex tear stimulus is not consistent with all subjects. Second, the anesthetic does not appear to have the same effect on everybody. Some subjects could obviously have used another drop of anesthetic as they reported being able to feel the strip almost as much as without anesthetic. In addition, there is the problem of whether or not to blot the conjunctiva of a subject after instillation of the anesthetic.

The problem is that the portion of the drop left in the cul-de-sac is absorbed very rapidly by the strip and gives a false reading as if the tears were being absorbed.<6> However, to blot every subject was inconvenient and annoying to the patient. One other disappointment regarding this test is that the five minute time period can seem like an eternity to some patients.

CONCLUSION:

Since approximately one half of the subjects in this study experience some sort of "dry Eye" discomfort, it was expected that the Schirmer testing would suggest a significant number of dry eye cases based on its readings. However, only two of the subjects tested positive with the Schirmer strips. Testing with or without anesthetic was not a factor in this determination. In addition, the recommended five minute time period was much too long. Only one minute was required without anesthetic and two and one half minutes with anesthetic. If 10 mm was reached in these amounts of time or less, then no problem would be suspected using Schirmer testing. Nevertheless, since both forms of Schirmer testing proved to be poor indicators of dry eye symptoms, the test alone was not a good diagnostic tool and alternate sources need to be considered.

As mentioned previously, the phenol red test appears to be an excellent alternative to the Schirmer Tests. Since the phenol red test only requires a fraction of the time, and gives the same broad generalization about the aqueous layer without as much irritation, it is the logical choice for this type of testing. However, should there be an indication of a problem through the use of the phenol red test, more sophisticated testing will obviously be needed. One test would be the Break Up Time test, (BUT). This test can quantify the stability of the tear film.<7> Another set of tests discussed by the same study would be those tests using fluorescein or Rose Bengal. The Fluorescein would show epithelial breaks, erosions, and filaments while the Rose Bengal would display the degenerated tissue. In addition, as mentioned in the literature, it is often too easy to forget the use of the biomicroscope in assessing debris in the tears and the tear prism itself. Perhaps through the use of these other tests one could determine the need for even more in depth testing. One example would include some sort of analysis of the quantity and quality of the other two layers, (lipid and mucin) which the Schirmer test does not address. Many of the patients used in this study reported some form of discomfort in regard to a dry eye. For these patients, it is obvious that there is a need for one or more of the types of tear testing mentioned above since the Schirmer test reports them as being within normal

limits. It is therefore the conclusion of this paper that Schirmer tests I and Ia alone are not good indicators of dry eye cases which are anything less than grossly inadequate in aqueous production. To better evaluate borderline cases, alternates such as the phenol red test must be explored.

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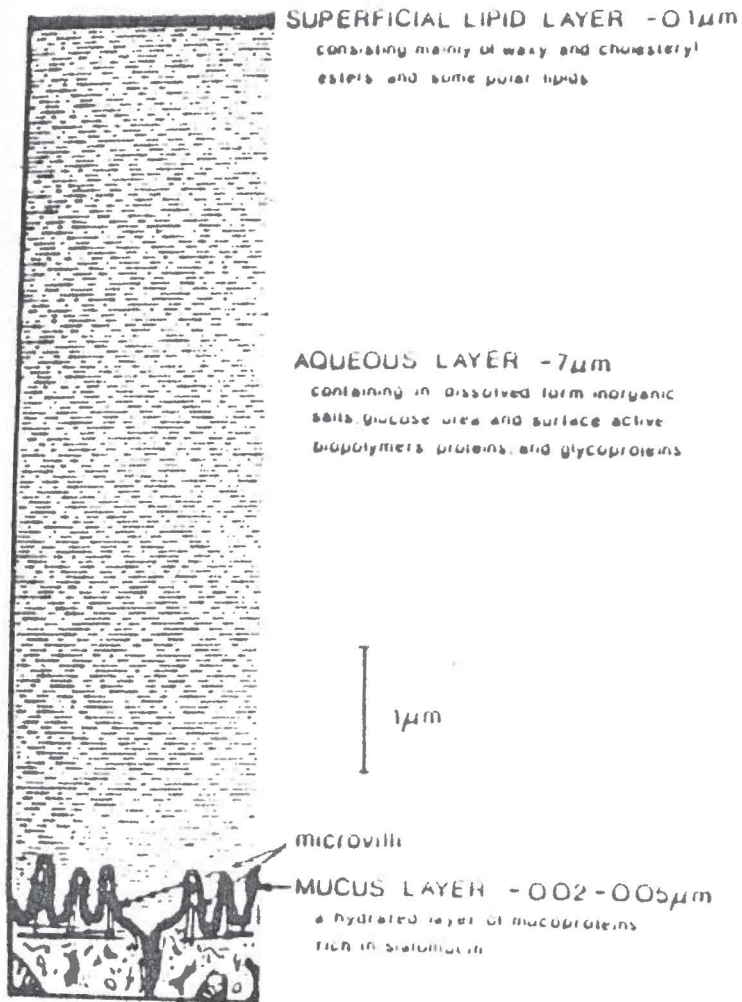


Diagram 1
 (Bartlett, 1984)

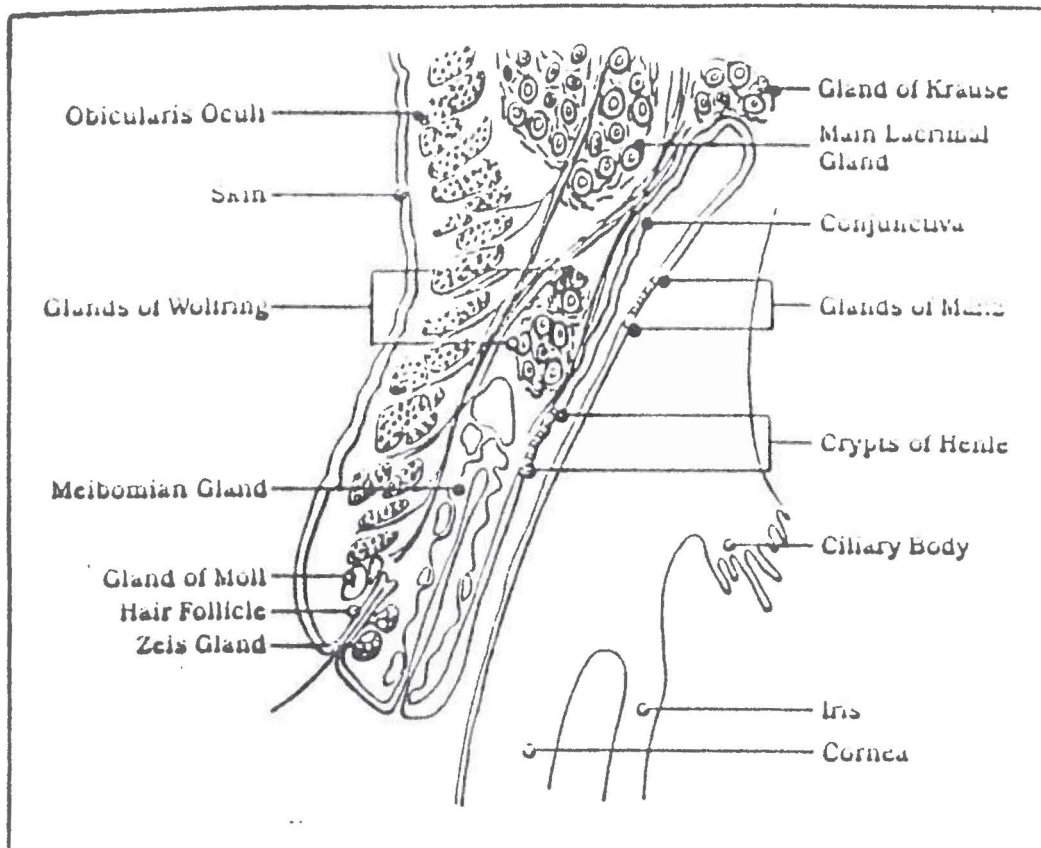


Diagram 2
 (Lyle, 1982)

Fig. 1: Cross-sectional view of the upper eyelid