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Kertas Asli/*Original Articles*

Tear Stability, Corneal Staining and Dry Eye Symptoms in Contact Lens Wearers

(Kestabilan Air Mata, Pewarnaan Kornea dan Simptom Mata Kering dalam Kalangan Pemakai Kanta Sentuh)

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ABSTRACT

The aim of this study was to examine tear stability of contact lens wearers (CLW) in young Malay adults aged 18 and above and to compare the results with non-contact lens wearers (NCLW). Corneal staining and McMonnies Dry Eye Questionnaires (MDEQ) scores between habitual soft CLW and NCLW were also compared. It also aimed to find correlation between tear stability and MDEQ scores. Quasi-experimental and case control study was conducted among 53 participants (53 right eyes) at UiTM Vision Care, UiTM Puncak Alam Campus. Twenty six participants were habitual soft CLW and twenty seven were NCLW. Tear stability was measured using non-invasive tear break-up time (NIBUT) and invasive tear break-up time (TBUT). Corneal staining was measured using Efron Grading Scale and dry eye symptoms evaluated using MDEQ. Mean scores of NIBUT and TBUT for CLW were 5.23 ± 7.3 sec and 2.19 ± 2.41 sec respectively; for NCLW were 8.71 ± 4.33 sec and 3.00 ± 1.69 sec respectively. There were significant differences in NIBUT (Mann-Whitney U, p = 0.0001) and TBUT (Mann-Whitney U, p = 0.001) between the CLW and NCLW. There was also significant difference in percentage of corneal staining found between the CLW (22.6%) and NCLW (7.5%), (Chi-square, p = 0.013). However no significant difference was found in MDEQ scores between the CLW (7.54 ± 3.62) and the NCLW (8.15 ± 3.38) group, (Mann-Whitney U, p = 0.42). There were also no correlations found between tear stability and MDEQ scores in the two groups. The results of this study showed NIBUT and TBUT values were significantly higher in NCLW than in CLW and corneal staining was more extensive in CLW. Contact lens practitioners need to be aware of changes in tear stability as results of contact lens wear and take the necessary action to improve on the management of their patients during aftercare consultation.

Keywords: Tear stability; contact lens; NIBUT; TBUT; corneal staining; dry eye

ABSTRAK

Tujuan kajian ini ialah untuk mengkaji kestabilan air mata (NIBUT dan TBUT) pemakai kanta sentuh dalam kalangan belia Melayu berumur 18 tahun hingga ke atas berbanding dengan bukan pemakai kanta sentuh. Pewarnaan kornea dan skor McMonnies Dry Eye Questionnaires (MDEQ) dalam kalangan pemakai kanta sentuh dengan bukan pemakai kanta sentuh juga dibandingkan. Kajian kawalan kes dan kuasi eksperimen dilakukan kepada 53 peserta (53 mata kanan) di UiTM Vision Care, Kampus UiTM Puncak Alam. Dua puluh enam (26) peserta adalah pemakai kanta sentuh dan 27 adalah bukan pemakai kanta sentuh. Kestabilan air mata diukur menggunakan kaedah bukan invasif (NIBUT) dan invasif (TBUT). Pewarnaan kornea dinilai dengan menggunakan Skala Penggredan Efron dan penilaian simptom mata kering dilakukan menggunakan soal selidik MDEQ. Min NIBUT dan TBUT untuk pemakai kanta sentuh ialah 5.23 ± 7.3 s dan 2.19 ± 2.41 s, untuk bukan pemakai kanta sentuh adalah 8.71 ± 4.33 s dan 3.00 ± 1.69 s. Terdapat perbezaan signifikan dalam nilai NIBUT (Mann-Whitney U, p = 0.0001) dan TBUT (Mann-Whitney U, p = 0.001) antara kedua kumpulan ini. Terdapat perbezaan signifikan berkaitan peratus pewarnaan kornea antara kumpulan pemakai (22.6%) dan bukan pemakai kanta sentuh (7.5%), (Chi-square, p = 0.013). Namun demikian tiada perbezaan signifikan dalam skor MDEQ antara pemakai (7.54 ± 3.62) dan bukan kanta sentuh (8.15 ± 3.38), (Mann-Whitney U, p = 0.42). Skor MDEQ didapati tidak berkolerasi dengan kestabilan air mata pemakai. Hasil kajian ini menunjukkan nilai NIBUT dan TBUT adalah lebih tinggi dalam kalangan bukan pemakai kanta sentuh berbanding dengan pemakai kanta sentuh manakala pewarnaan kornea adalah lebih tinggi dalam kalangan pemakai kanta sentuh. Pengamal kanta sentuh perlu peka terhadap perubahan kestabilan air mata disebabkan oleh pemakaian kanta sentuh supaya dapat meningkatkan pengurusan pesakit semasa lawatan pemeriksaan lanjutan.

Kata kunci: Kestabilan air mata; kanta sentuh; NIBUT; TBUT; pewarnaan kornea; mata kering

INTRODUCTION

Tear stability is usually disrupted when a foreign body like a contact lens is placed on the eye. Contact lens seems to disrupt the tear film into prelens and postlens tear layer that make it susceptible to disturbances and evaporation (Nichols & King-Smith 2003). In some cases the disruption leads to dry eye and this condition is often reported by contact lens wearers (CLW) (Guillon & Maissa 2005 and Nichols & Sinnot 2006). A study by Nichols & Sinnott (2011) showed there were many clinical consequences as results of placing a contact lens on the eye such as contact lens–related dry eye symptoms, tear thinning, reduced tear stability and corneal staining. Among the many symptoms mentioned above, corneal staining was the most common symptom found to be associated with contact lens wear although it was often observed in otherwise normal individuals as well.

The role of tear film stability in contact lens wear is therefore very important since this indirectly will determine comfort and ability to wear contact lenses successfully (Nichols et al. 2013). Tear film stability can be assessed using invasive and non-invasive techniques. In an invasive procedure, fluorescein dye is instilled onto the cornea and a tear break-up-time (TBUT) can be measured using a slit lamp biomicroscope. This procedure is convenient but TBUT has been known to cause a change in the condition of the tear film and may cause its instability (Mengher et al. 1985a), therefore a non-invasive tear break up time (NIBUT) is a more preferred method for evaluating tear stability.

Previous studies on tear stability among CLW have shown conflicting results with some showing a decrease (Shrestha et al. 2012, Muselier-Mathieu et al. 2014) whilst others found no changes in tear film stability between CLW and non-contact lens wearers (NCLW) (Chopra et al. 1985, Guillon et al. 1997). Tear film instability if left unchecked usually leads to dry eye syndrome (Nichols et al. 2013). Dry eye will then damage the exposed surface epithelium which in turn causes chronic irritation of the ocular surface (Gumus et al. 2011).

Damage to the epithelial surface can be detected by corneal staining. A study by Nichols & Sinnott (2011) showed the frequency of corneal staining in a total of 413 contact lens wearers differed depending on sectional locations of the cornea. In their study corneal staining was seen mostly in the inferior section (39.7%) followed by temporal (24.9%), nasal (16.9%) and superior sections (14.5%). Similarly the highest average grade for corneal staining was also found in the inferior section followed by temporal, nasal and superior sections. Jalbert et al. (1999) however found that corneal staining was recorded more often in the inferior and superior sections relative to other areas of the cornea.

Symptoms of dry eye exhibited by CLW may be checked using dry eye questionnaire. McMonnies & Ho (1987) developed the McMonnies Dry Eye Questionnaire (MDEQ) consisting of 12 questions that focused on clinical risk factors for dry eye. Respondents were asked to answer all questions and the scores which have weighted scoring scale were noted. The score range from 0 to 45 and a score of 14.5 and above is indicative of a dry eye. The McMonnies score has been shown to be a useful screening instrument (McMonnies & Ho 1987, Tang et al. 2016) and have good discriminant ability when comparing mild and severe dry eye (Nichols et al. 2004).

Anecdotal observations in our clinic have shown many contact lens wearers have poor tear stability but have no complaints of dry eye. At present there are not many data on tear stability of CLW in young Malaysian adults. Thus, this study aims to investigate tear stability (NIBUT and TBUT) of CLW in young Malay adults and to compare the results with NCLW. The study also aims to find associations between tear stability and symptoms of dry eye in habitual CLW using MDEQ.

EXPERIMENTAL METHODS

PARTICIPANTS

Participants were recruited from amongst students at the Optometry Clinic, Puncak Alam Campus by placing advertisement around the Optometry clinic and as well as by words of mouth. The inclusion criteria included participants aged 18 and above, habitual CLW and agreed to participate in the study. The exclusion criteria included participants who had any systemic or ocular disease affecting eye health. All participants must not be on any systemic or topical medications that could affect their ocular or tear physiology. The same criteria were applied in recruiting a control group of NCLW.

RESEARCH INSTRUMENTS

A modified aspheric bowl with a radial pattern painted on the concave side was used in this study. It was identical to the one used by Mohidin, Bay & Yap (2002). This instrument has a one-centimetre hole poked in the middle of the bowl to allow a near telescope (4x magnification) to be installed at the back and used as the observation eyepiece. The bowl was internally illuminated with a mean luminance of 50cd/m². Detail explanation of this instrument and its functions has been described elsewhere (Mengher et al. 1985b).

A slit lamp biomicroscope and fluorescein strip (Fluo 900, Entod Research Cell UK Ltd, London) were used to evaluate TBUT and corneal staining. Besides that, MDEQ was also used in this study to find whether there were any differences in the MDEQ score between the CLW and NCLW.

PROCEDURE

The participants were first informed about the objectives and procedure of the study. They were also asked to fill in

and sign a consent form before the procedure was carried out. Preliminary examination was first carried out to ensure the inclusion and exclusion criteria were met. CLW were asked to remove their contact lens on the right eye only while NCLW were asked to remove their spectacles before any measurements were taken.

NIBUT was measured on the right eye by using a modified bowl perimeter with radial grid pattern painted on it together with 4x near telescope attached in the middle for viewing. The time taken for the mire images on the cornea to become distorted or out of focus after a complete blink while the eye remained open was timed using a stopwatch. Five consecutive readings were taken and the mean of the best three readings was considered for evaluation (Cho 1993).

TBUT was measured using fluorescein strip and a slit lamp biomicroscope. Fluoresecein strip was wetted with saline (Opticare, Excel Visions Medicals Sdn Bhd) and the excess saline shaken off. It was then instilled onto the eye by touching the tip of the strip onto the lower bulbar conjunctiva while the participant was looking up, making sure that the tip did not touch any part of the cornea to prevent reflex tearing. The participant was asked to blink a few times to spread the fluorescein. A break in the tear film was observed using a slit lamp biomicroscope (6 x magnifications) and a cobalt blue filter. The time taken for the first black patch to appear on the cornea after a complete blink while the eye remained open was timed using a stopwatch. Three consecutive readings were taken and the mean was considered for the evaluation of TBUT.

Extent and severity of corneal staining were also assessed using a slit lamp biomicroscope (12 x magnifications) with the instillation of fluorescein dye and viewed under cobalt blue filter. For recording, the cornea was arbitrarily divided into four sections (Figure 1): S1-superior cornea, S2-nasal cornea, S3-inferior cornea and S4-temporal cornea. Efron Grading Scale (Table 1) was used to note the extent and severity of corneal staining with grade 0 to 4.

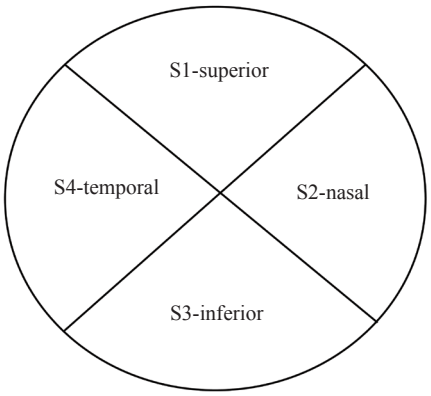

FIGURE 1. Sections one (S1) to four (S4) to assess extent and severity of corneal staining using Efron grading scale

TABLE 1. Efron grading scale for evaluation of corneal staining

Grade	Extent of corneal staining
0	None: clear cornea, no staining
1	Trace: light punctuate staining
2	Mild: more light punctuate staining
3	Moderate: pan-corneal punctuate staining
4	Severe: heavy pan-corneal punctuate staining

Participants were then asked to fill up MDEQ, consisting of 12 questions in total. A score of 14.5 was indicative of a dry eye. All the measurements were done by one examiner (NZ) between 9.00 am and 12.00 noon to counter effects of diurnal variation. The intra observer reliability was not done but to ensure reliability of data NZ also underwent an intensive training for NIBUT measurements prior to the start of the study. Five NIBUT measurements were taken and best three readings closest to each other were noted, as recommended by Cho (1993). This study was approved by the Research Ethics Committee of Universiti Teknologi MARA and followed the tenets of Declaration of Helsinki.

Data was analysed using SPSS version 18. Shapiro-Wilkes test was initially run to test the normality of the data collected. The test showed data for NIBUT and TBUT were not normally distributed, hence a non-parametric test, Mann Whitney-U test was carried out to find the differences in tear stability (NIBUT and TBUT) between the CLW and NCLW. Corneal staining observed in the different sections of the cornea of CLW and NCLW were noted. Chi square test was used to compare corneal staining found in CLW and NCLW. Mann Whitney-U test was used to compare means MDEQ score in the CLW and NCLW. Spearman's correlation test was done to find any association between tear stability and MDEQ score. p value was considered significant if it was less than 0.05.

RESULTS

There were a total of 53 participants who took part in this study. Of the 53 participants, 26 (49.1%) of them were habitual CLW and the other 27 (50.9%) were NCLW. Among the 26 CLW, one participant (3.8%) wore daily disposable soft contact lens, 20 participants (76.9%) wore monthly disposable soft contact lens and five participants (19.2%) wore three-month disposable soft contact lens. Participants consisted of 100% females.

The mean age among CLW was 22.71 ± 0.96 years and the mean age among NCLW was 22.63 ± 1.21 years. All the 53 participants were students at UiTM Selangor Puncak Alam Campus. Most of them wore monthly disposable soft contact lenses for about 8 hours per day and at least for 5 days per week. Participants have been wearing lenses for 3-36 months.

Tear evaluation of CLW and NCLW were shown in Table 2. Since the mean of NIBUT and TBUT values were not normally distributed, Mann Whitney-U test was used for comparison and the results showed that mean values for NIBUT and TBUT were significantly lower in CLW as compared to NCLW.

Observed corneal staining across the four sections of the cornea was shown in Figure 2. The grades and severity of staining was also shown in Figure 3. For analysis, corneal staining found in all sections of the cornea was combined (Figure 4) and Chi-square test was done. The results showed significant difference in percentage of corneal staining found in CLW and NCLW (Pearson Chi-Square, $X^2 = 13.85$, p = 0.0002).

TABLE 2. Tear evaluation in CLW and NCLW

	NIBUT (sec)				TBUT (sec)			
	Mean ± SD	Median	Min	Max	Mean ± SD	Median	Min	Max
CLW (n = 26 eyes)	5.23 ± 7.26	3.05	1.00	36.51	2.19 ± 2.41	1.46	0.61	12.02
NCLW (n = 27 eyes)	8.71 ± 7.69	7.69	4.00	25.13	3.00 ± 2.61	2.61	1.22	8.22
Mann-Whitney U test	p = 0.0001*				p = 0.001**			

* Non-Invasive tear break up time (NIBUT): Mean values was significantly lower in CLW compared to NCLW, U = 111.0, z = 4.270, p = 0.0001
** Invasive tear break up time (TBUT): Mean values was significantly lower in CLW compared to NCLW, U = 170.0, z = 3.221, p = 0.001

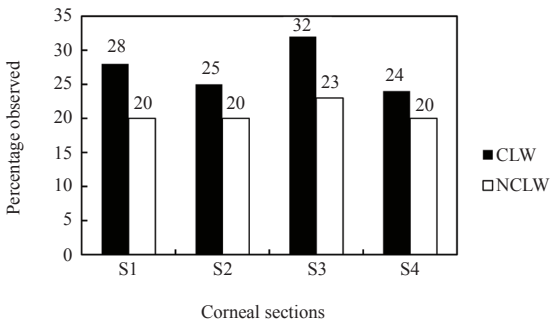

FIGURE 2. Corneal staining observed at different sections of the cornea between CLW and NCLW

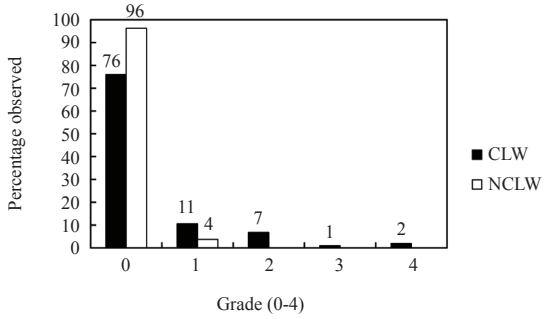

FIGURE 3. Grades and severity of corneal staining in CLW and NCLW

There was no significant differences in MDEQ mean scores between the CLW (7.54 ± 3.62) and NCLW (8.15 ± 3.38), (Mann-Whitney U = 306.0, z = -0.905, p = 0.421). Based on MDEQ classification of dry eye there was only one out of the fifty-three participants (2%) diagnosed as having dry eye (Table 3).

A Spearman's rank order correlation was also run to assess the relationship between tear stability measured using NIBUT, TBUT and MDEQ score. The results showed

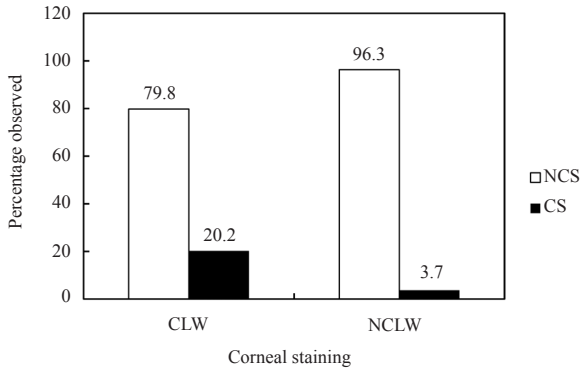

FIGURE 4. Corneal staining observed in the CLW and NCLW; CS-corneal staining, NCS-no corneal staining

weak negative correlation between NIBUT and MDEQ score ($r_s = -0.088$, p = 0.53) and weak positive correlation between TBUT and MDEQ score ($r_s = 0.104$, p = 0.46) but both results were not significant.

DISCUSSION

The participants in this study were all university students at the UiTM Puncak Alam Campus with mean age of 22.71 ± 0.96 years for the CLW and 22.63 ± 1.21 years for NCLW. They were all females. The demography resembled many previous studies that showed female preference in wearing contact lenses (Mohidin & Fung 2009, Jones et al. 2016). The majority wore monthly disposable contact lenses. The mean scores of NIBUT and TBUT measured in this study were significantly lower in habitual CLW than in NCLW. Previous study by Shrestha et al. (2012) also showed the mean NIBUT and TBUT were also significantly lower in CLW as compared to NCLW. Muselier-Mathieu et al. (2014) also showed that tolerant and intolerant CLW

TABLE 3. McMonnies score and dry eye classification in CLW and NCLW

	MDEQ mean score	Dry eye classification	
		Non-dry eye ≤ 14.5	Dry eye > 14.5
CLW (N = 26 eyes)	7.54 ± 3.62	N = 25 (96.2%)	N = 1 (3.8%)
NCLW (N = 27 eyes)	8.15 ± 3.38	N = 27 (100%)	N = 0 (0%)
Mann-Whitney U = 306, z = -0.805	p = 0.421*		

* Not significant

had a shorter TBUT than the control group. Kopf et al. (2008) found that during soft contact lens wear, the quality of the tear film was poorer in the inter-blink interval among CLW. Factors that might have contributed to changes in the tear film structure that led to dry eye included hyperosmolarity, inflammation and tear film instability. Hyperosmolarity is considered to be the core mechanism in dry eye. The tear film is altered with contact lens wear that leads to an increase in evaporation thus disturbing tear stability (Workshop 2007). Lens parameter and wearing schedules could also change the tear film structure during contact lens wear (Nichols & Sinnott 2006).

Most of the corneal staining in our study was seen in the inferior section followed by the superior section in both groups of CLW and NCLW. Nicholl and Sinnot (2011) found that most of the staining was found in the inferior section followed by temporal section. Jalbert, Sweeney & Holden (1999) showed corneal staining was more prevalent in the superior section followed by the inferior section of the cornea of their soft CLW. Presence of corneal staining and the order of which most staining occurred in the different sections of the cornea seemed to be different between studies but many (Begley et al. 1996, Schwallie et al. 1997, Nichols & Sinnot 2011) have shown that corneal staining occurred more often in the inferior and superior sections of the cornea than the nasal and temporal sections.

Factors related to characteristics and demographics of corneal staining in CLW are still not well understood. Corneal staining has been attributed to dessication or hypoxia (Meng & Polse 2007). It can also be due to fluorescein remaining longer at the tear meniscus especially in the inferior section of the lower eyelid (Josephson & Caffery 1988). Other factors such as water content, wearing time, rubbing due to irritation and lens wear modality can also contribute to the selective damage seen at the inferior section of the cornea (Begley et al. 1996). Aside from dry eye, deposits on the contact lens can also cause corneal staining (Goldberg et al. 1997, Nicholl & Sinnot 2011). Although we did not examine contact lens deposits of our participants in our study, all of our participants wore disposable lenses and lens wearing duration was less than three years. It is unlikely that contact lens deposits would cause the staining. Physiological changes to the cornea has been shown to occur as results of long term extended lens wear that may include microcysts, epithelial thinning, reduced epithelial adhesion and enlarge epithelial cells. Our subjects exhibited none of these physiological changes of the cornea.

Our study also showed significant differences between percentage of corneal staining found between the CLW and NCLW. Majority of CLW (76%) however had no staining on their cornea. Of the 24% CLW who had corneal staining, only 3% had severe and moderate staining whilst 21% had traces and mild staining. The low staining found on CLW could be attributed to the modality of lens wear since all the CLW in this study wore disposable lenses. It was also possible that the CLW whom were all educated university students were taking good care of their lenses. The duration of contact lens wear was also relatively short (3-36) months and this could also contribute to the low grade staining.

There was no significant difference in MDEQ score between the CLW and NCLW. There was also no significant correlation found between NIBUT and MDEQ score and between TBUT and MDEQ score. Our results are similar to a study by Tan & Morgan (2016) who showed no correlation between MDEQ score and NIBUT and between MDEQ score and TBUT. Tan & Morgan (2016) study also showed that MDEQ did not correlate with any of the conventional tests used clinically for the measurement of tear stability. However Shrestha et al. (2012) found positive correlation between NIBUT and MDEQ score and also between TBUT and MDEQ score, although the correlation was very weak. The differences could be due to the small number of CLW in our study (N = 53) compared to Shrestha's (N = 131). Based on MDEQ classification only 3.8% of CLW in our study have dry eye and none among the NCLW, whereas Shrestha's study showed 23% of their CLW and 17% of their NCLW had symptoms of dry eye. The mean age of their participants and the standard deviations were also higher than ours and this could explain the weak positive correlations since dry eye seems more prevalent as we grow older (Schaumberg et al. 2009). Gothwal et al. (2015) re-analysed MDEQ using Rasch analysis and surmised that MDEQ was not effective as a measure since did not have the ability to distinguish more than two strata (present or absent) of participants' symptoms. They speculate that in a different population and greater number of participants with greater spread of disease severity, MDEQ can function quite well as a measure and this was shown in a study reported by Guo et al. (2016) involving thousands of participants in a multicentre centre analysis across China. Their results showed positive correlation between MDEQ and TBUT.

CONCLUSION

In conclusion the results of this study showed NIBUT and TBUT values were higher in NCLW than habitual CLW. Corneal staining was also found more extensive in CLW than NCLW. There was no correlation between tear stability (NIBUT & TBUT) and MDEQ scores. The findings from this study will provide invaluable input to management of patients among practising optometrists and researchers on tear stability and ocular surface changes as results of contact lens wear.

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