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REPEATABILITY OF NONINVASIVE KERATOGRAPH 5M MEASUREMENTS ASSOCIATED WITH CONTACT LENS WEAR.

Running short title:

REPEATABILITY OF KERATOGRAPH 5M WITH CONTACT LENSES

Authors

García-Montero María[1], PhD; Rico-del-Viejo Laura[1], MSc; Lorente-Velázquez Amalia[1], PhD; Martínez-Alberquilla Irene[1], MSc; Hernández-Verdejo Jose Luis[1], PhD; Madrid-Costa David[1], PhD.

[1] Department of Optometry and Vision, Faculty of Optics and Optometry, Complutense University of Madrid, Madrid, Spain

Corresponding Author

María García-Montero, PhD

Department of Optometry and Vision, Faculty of Optics and Optometry.

Complutense University of Madrid.

Avda Arcos de Jalón, 118, 28037

Madrid (SPAIN)

e-mail: mgarc01@ucm.es

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ABSTRACT

Objective: to assess the intra-rater repeatability of the measurements of tear meniscus height (TMH), noninvasive Keratograph tear breakup time (NIKBUTs) and ocular redness measurements obtained with the Keratograph 5M (K5M) in a sample of soft silicone hydrogel CL wearers over 15 days.

Methods: prospective study over two consecutive weeks. Three measurements of TMH, NIKBUTs (NIKBUT-first and NIKBUT-average) and ocular redness were obtained in different sessions; the first day (baseline, at 8 hours of wear, and after lens removal) and the last day of wear -15th day (at 8 hours of wear and after lens removal). The repeatability of measurements were assessed by two intraclass correlation coefficient (ICC) forms; single measurement [ICC (2,1)] and multiple measurements (k=3) [ICC (2, k)].

Results: The repeatability of baseline TMH [ICC (2,1) >0.90 ; CR=0.06 mm] and after and during CL wear [ICC (2,k) >0.90 ; CR≤0.07 mm] were excellent. The repeatability of baseline NIKBUT-average [ICC (2,k) =0.89 (0.82 to 0.93) ; CR=6.07 sc] was maintained after CL removal, but was poorer during CL wear. The repeatability of baseline NIKBUT-first [ICC (2,k) =0.80 (0.69 to 0.87) ; CR=8.74 sc] was maintained after CL removal and during CL wear at moderate-good level.

Conclusions: Intra-rater repeatability of TMH, NIKBUTs and ocular redness performed by K5M after CL wear remain stable when three measurements are performed. However, intra-rater repeatability during CL wear decreased only for NIKBUT average and was not affected by time of use (15 days).

Keywords: Keratograph 5M ; repeatability; contact lens ; tear film

TEXT

Several biophysical tear film and ocular surface changes have been associated with contact lens (CL) wear.[1] Prior to fitting with CL there are a number of tests available to the practitioner to assess the tear film and ocular surface in order to study the suitability of adaptation. The Oculus Keratograph 5M (K5M) (Oculus, Wetzlar, Germany) is a corneal topographer with multiple non-invasive features that analyzes the ocular surface, including tear meniscus height (TMH), non-invasive keratograph break-up time (NIKBUT) and bulbar and limbal hyperemia assessment.

It has been suggested that NIKBUT can be used as a tool to assess pre-corneal and pre-lens tear film quality for prescribing CL in order to study the tear film stability.[2] Likewise, it is important not to forget bulbar and limbal redness in contact lens wearers when redness is related to the extent of oxygen transmissibility of contact lens materials and may indicate corneal hypoxia. [3, 4]

Therefore, clinical measures need to be repeatable in order to work in clinical-diagnostic quality environments. Reliability refers to the repeatability or precision of measurement, while repeatability is defined as the degree of proximity of scores obtained under similar conditions.[5]

The intra-rater repeatability of K5M (Oculus, Wetzlar, Germany) evaluation has been validated in previous studies in healthy eyes [6-9] and in dry eyes.[8, 10] The repeatability of the parameters evaluated by the K5M is an essential requirement for use of the latter as a diagnostic tool or in the follow-up of interventions or ocular surface alterations (refractive surgery, dry eye).

However, we have found no studies that validate intra-rater repeatability in the management of contact lens patients. In addition, establishing the number of measures to

be performed in a single assessment to ensure an acceptable level of repeatability of scores is another issue considered.[11]

Accordingly, the aim of current study was to assess the intra-rater repeatability of measurements for TMH, NIKBUTs and ocular redness in healthy subjects with soft silicone hydrogel (Si-Hy) CL wear.

MATERIAL AND METHODS

A prospective study was carried out at the Faculty of Optics and Optometry of the Complutense University of Madrid. It was reviewed and approved by the Institutional Review Board of the Optometry Clinic, and all the procedures complied with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from all patients once the purpose and possible consequences of the study had been explained to them. Inclusion criteria were to be current contact lens wearers, in the age range from 18 to 40 years. Exclusion criteria included an active ocular allergy, refractive surgery, dry eye or systemic medication known to affect tear film production.

The study was carried out using a commercial monthly-soft Si-Hy contact lens. All the participants underwent imaging with the Keratograph 5M® (K5M; Oculus ,Wetzlar, Germany), an advanced corneal topographer with a built-in real keratometer and a color camera optimized for external imaging equipped with a modified tear film scanning function. Three measurements of the TMH, the first break of non-invasive Keratograph tear breakup time (NIKBUT first), average break of non-invasive Keratograph tear breakup time (NIKBUT average) and ocular redness were automatically obtained using Oculus K5M software according to the manufacturer's instructions. Ocular redness scores were analyzed

by R-scan software and the automated redness scores evaluated were: nasal limbal redness (NLR), temporal limbal redness (TLR), nasal bulbar redness (NBR) and temporal bulbar redness (TBR).

The study was conducted over two consecutive weeks. Previously one week of washout without any contact lens was required to participants. Measurements were taken in different sessions on the first and last day of wear (15 days). On the first day of wear, measurements were taken before contact lens insertion (baseline), at 8 hours of wear, and after the lens was removed. On the last day of wear (after 15 days of use), measurements were taken at 8 hours of wear and after the lens was removed. Measurements without contact lenses were registered 20 minutes after lens removal. The repeatability results were divided into three groups; baseline conditions, without the contact lens after 1 day and 15 days of use and during contact lens wear, at 8 hours of use on the 1st and 15th days. Only data from the right eye was used for statistical analysis.

Clinical examination was performed in the following order to minimize the effect of the assessment [12] : TMH , ocular redness and NIKBUTs (NIKBUT first, NIKBUT average).

The TMH score was obtained by the examiner from the registered image. NIKBUTs scores were obtained directly from the device. Ocular redness was obtained with the R-Scan software of the Keratograph 5M. The R-Scan is a module that automatically and objectively classifies the bulbar and limbal degree of redness. The R-Scan detects the blood vessels in the conjunctiva and evaluates the degree of redness according the JENVIS grading scale.[13]

All the measurements were taken by the same examiner in a room with controlled temperature (24±1°C) and humidity (39%±2%). All subjects used the same contact lens solutions (Optifree Express Mds, Alcon Laboratories, Inc., Fort Worth, TX, USA).

Under repeatability conditions, independent test results were obtained using the same method, the same subject, the same examiner, and the same equipment with the shortest time possible between successive TMH and ocular redness readings. NIKBUT first and NIKBUT average readings were taken with an interval of at least 120 seconds. Repeatability was assessed by performing 3 examinations of 64 eyes in the various sessions.

The statistical analysis was performed using SPSS statistical package version 23 (SPSS Inc, Chicago, IL, USA). The intra-rater repeatability for each parameter evaluated was assessed by means of repeated measures analysis of variance (ANOVA) and statistical parameters including the following statistical variables: within-subject standard deviation (Sw), coefficient of repeatability (CR), within-subject coefficient of variation (CoV), intrasubject precision, intraclass correlation coefficient (ICC) and their 95% confident intervals.

Two ICC were calculated based on two ICC forms; two-way random effects, absolute agreement and single measurement [ICC (2,1)] and two-way random effects, absolute agreement and multiple measurements (k=3) [ICC (2, k)]. The ICC type (single measurement or average of measurements) provide results based on the number of measurements to be performed.

The ICC (ranging from 0 to 1) assesses the consistency for data sets of repeated measurements within sessions.[14, 15] The closer the ICC is to 1, the better the measurement consistency indicating that total variation in measurements is due solely to variability in the parameter being measured. The 95% confident interval of the ICC estimate (not the ICC estimate itself) should be used as the basis to evaluate the level of reliability. There are different scales to identify the value that indicates acceptable clinical reliability.[5, 16] ICC values below 0.5 can be indicative of poor reliability, values between 0.5 and 0.75 indicate

moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values above 0.90 indicate excellent reliability. [15, 17]

The within-subject standard deviation (Sw) is a simple way of estimating the standard deviation of repeated measurements. The CoV was calculated as the ratio of the Sw to the overall mean and estimates the amount of variation seen between repeated measures taken from the same individual at different time points. A smaller CoV means that the repeatability is higher. The intrasubject precision was defined as 1.96×Sw, which indicated the size of the range of error of the repeated measurements for 95% of observations. The coefficient of repeatability (CR) was calculated using the within-session standard deviation (S_w) of $1.96\times\sqrt{(2xS_w^2)}$ or $2.77xS_w$ [15], which indicated the interval within which 95% of the differences between measurements are expected to lie.

RESULTS

Descriptive Statistics

Sixty-four subjects (48 men and 16 women; mean age 26.3 ± 2.5 years; age range 21 to 32 years) were enrolled and all the protocols in each session were followed. The baseline descriptive statistics for TMH, NIKBUT first, NIKBUT average, NLR , TLR, NBR and TBR were 0.28 ± 0.01 mm , 10.56 ± 7.02 sec, 12.74 ± 6.54 sec, 0.73 ± 0.42, 0.46 ± 0.27, 1.12 ± 0.44 and 0.68 ± 0.28 respectively. The descriptive statistics obtained in different sessions are summarized in tables 2 and 3.

Intra-rater repeatability under baseline conditions

The level of reliability considering ICC type single measurement can be regarded as excellent for TMH measurements [ICC 0.95 (95% CI = 0.92 to 0.96); CR=0.06], as good to excellent for NBR [ICC 0.89 (95% CI = 0.84 to 0.93);CR=0.41] and NLR [ICC 0.87 (95% CI = 0.81 to 0.91);

CR=0.42], as moderate to good for TBR [ICC 0.78 (95% CI = 0.69 to 0.85); CR=0.37] , TLR [ICC 0.75 (95% CI = 0.65 to 0.83); CR=0.38] and NIKBUT average [ICC 0.73 (95% CI = 0.61 to 0.82); CR=9.51], and finally as poor to moderate for NIKBUT first [ICC 0.57 (95% CI = 0.43 to 0.69); CR=12.77].

The level of reliability considering ICC type average measurement for NIKBUT first can be regarded as moderate to good [ICC 0.80 (95% CI = 0.69 to 0.87); CR=8.74].

Table 1 shows the results of repeatability analysis under baseline conditions.

Intra-rater repeatability after CL removal

Table 2 shows the results of the reliability index measured with the K5M without the contact lens after 1 day and 15 days of use.

The TMH repeatability was slightly poorer for ICC single values classified as good to excellent for both sessions: first and fifteenth day. However, the coefficient of repeatability was 0.12 mm and 0.06 mm on day 1 and on day 15 respectively.

Ocular redness repeatability on day 15 considering ICC type average measurement can be regarded as excellent for NLR [ICC 0.97 (95% CI = 0.95 to 0.98); CR=0.25], TLR [ICC 0.97 (95% CI = 0.96 to 0.98); CR=0.15], NBR [ICC 0.96 (95% CI = 0.94 to 0.98); CR=0.23] and TBR [ICC 0.97 (95% CI = 0.95 to 0.98); CR=0.16].

The level of reliability considering ICC type single measurement for NIKBUT first on day 1 and on day 15 were [ICC 0.46 (95% CI = 0.29 to 0.62); CR=12.25] and [ICC 0.48 (95% CI = 0.32 to 0.63); CR=12.75] respectively. Both of them can be regarded as poor to moderate.

Intra-rater repeatability during contact lens wear

Table 3 shows the results of reliability scores measured during contact lens wear, at 8 hours of use on the 1st and 15th days.

The level of reliability considering ICC type average measurement can be regarded as excellent for TMH measurements on day 1 and day 15 [ICC 0.97 (95% CI = 0.95 to 0.98); CR=0.05] and [ICC 0.96 (95% CI = 0.95 to 0.98); CR=0.04] respectively.

The level of reliability considering ICC type average measurement can be regarded as moderate to good for NIKBUT first, on day 1 [ICC 0.67 (95% CI = 0.50 to 0.79); CR=10.74] and on day 15 [ICC 0.73 (95% CI = 0.58 to 0.83); CR=9.31], and also for NIKBUT average, on day 15 [ICC 0.70 (95% CI = 0.54 to 0.82); CR=7.40]. Regarding NIKBUT average, on day 1 the reliability index was [ICC 0.63 (95% CI = 0.43 to 0.77); CR=8.56] classified as poor to moderate.

DISCUSSION

Several studies have revealed the impact on ocular surface and tear film stability of Si-Hy CL wear and have also reported changes in TMH [18, 19], NIKBUTs [19-21] and bulbar redness [19]. Non - or minimally invasive and objective tests have a major advantage over more invasive and subjective techniques to assess ocular surface parameters. Therefore, it is crucial to establish the degree of repeatability of the measures.

In the current study, the TMH, NIKBUTs and ocular redness were measured using K5M in monthly Si-Hy contact lens-wearing patients. To the best of our knowledge, this is the first study to assess the repeatability of TMH, NIKBUTs and ocular redness measured by K5M in monthly Sy-Hy contact lens-wearing patients over two weeks.

Previous studies have reported the repeatability index of K5M parameters (TMH, NIKBUTs and redness) in healthy eyes without contact lens. Tian et al. 2016 [8] studied the repeatability of TMH and NIKBUTs scores in healthy population (n=42) .They reported ICC values of 0.84 (95% CI = 0.75 to 0.90) and values of CR=0.14 mm for TMH scores. This ICC score can be

classified as moderate to excellent. In reference to NIKBUTs scores, the limit of repeatability for NIKBUT first and NIKBUT average were 5.24 sc and 5.60 sc respectively. Other authors found poorer repeatability limits for NIKBUTs scores; Markoulli et al. 2018 [7] concluded that the coefficient of repeatability of NIKBUT first and NIKBUT average were 13.96 sc and 11.37 sc respectively, and Fernandez et al 2018 [6] found limits of agreement for NIKBUT first and NIKBUT average of 13.46 sc and 10.34 sc respectively.

Regarding ocular redness, Wu et al. 2015 [9] studied repeatability of bulbar redness in 30 eyes and observed values of ICC= 0.947.

Our results under baseline conditions are in agreement with those previously reported, although with some considerations. Firstly, the TMH repeatability levels are better. TMH measurement revealed an excellent level of repeatability and would enable a single TMH measurement in clinical protocols maintaining those levels. In this case, changes below 0.06 mm (CR = 0.06) should not be considered clinical changes.

Secondly, in order to maintain values of excellence (ICC> 0.90) in terms of redness scores, three measurements need to be taken, with the NLR and NBR variables able to achieve those levels.

And finally, the level of repeatability of NIKBUT average was classified as moderate to excellent with CR = 6.07 sc based on three measurements. In case of only one measurement, the CR increased to values of 9.51 sc. Therefore, we recommend taking into consideration the ICC obtained, but giving special attention to the precision values and repeatability coefficients. Hence, if taking only one measure of NIKBUT average, it should be noted that changes of less than 9.51 sc cannot be justified as significant clinical changes.

255 The NIKBUT first is the parameter with the poorest repeatability. We recommend
256 performing at least 3 measurements, which ensures a moderate to good level with a CR of
257 13.78 sc and a coefficient of variation of 29.87%.
258 Despite the good reliability results in healthy eyes, some authors have studied reliability in
259 dry eyes. Tian et al 2016 reported that in dry eyes the NIKBUTs were more reliable, but TMH
260 was less reliable in patients with DED. [8] On the other hand, Baek et al. 2015 concluded that
261 K5M was a useful non-invasive tool in the evaluation of the TMH in patients with dry eye
262 syndrome, publishing CR values of 0.04 mm. [10]
263 These results show that changes in the ocular surface can cause changes in the repeatability
264 of the measurements. In addition, wearing contact lenses implies an interaction between
265 the lens and the ocular surface. Therefore, to validate intra-rater repeatability of K5M in the
266 management of contact lens patients is relevant.
267 The current study addresses two aspects; firstly if contact lens wear can induce changes in
268 the ocular surface that affect the levels of repeatability, and secondly, if contact lenses and
269 the time of use affect the repeatability index.
270 After contact lens removal (table 2) the ICC average measure [ICC (2, k)] remained with the
271 same rating (excellent, moderate, good and poor) as under baseline conditions.
272 In the case of TMH, three measurements should ideally be taken when this parameter is
273 being evaluated after contact lens removal. This ensures that the levels of TMH repeatability
274 will be the same as those obtained with a single measurement [ICC (2,1)] under baseline
275 conditions.
276 These results suggest that contact lens wear and time of wear does not induce changes in
277 the analyzed variables that affect the K5M repeatability.

In terms of reliability index during contact lens wear (table 3), our results suggest the advisability of performing 3 measurements while the TMH, NIKBUT first and ocular redness kept the same [ICC (2, k)] rating. However the repeatability of NIKBUT average decreased. The ICC average measure [ICC (2, k)] levels decreased in two grades, going from good-excellent under baseline conditions to poor-good during CL wear. Despite the loss of repeatability of the NIKBUT average, it has been observed that [ICC (2, k)] on the 15^{th} day is better than on the first day. This indicates that CL can be an artifact for the NIKBUT average measurement during CL wear, while time of CL use is not an influencing factor (15 days). These results are particularly interesting, because the NIKBUT average measurement is a major variable in the management of CL wear.

In a recent study, the authors aimed to ascertain whether the additional information on tear film stability assessed using NIKBUT could contribute towards an improved assessment of the prescribed CL. The authors suggest that this may certainly help to choose the most suitable CL in cases where comfort and fitting are equally good. [2]

Use of the repeatability coefficients is recommended to establish the limits of the instrument itself, which differ under the conditions studied (baseline, after CL removal and during CL wear).

However, in our study design with 3 repeated measures (n'=3) and a sample of 64 (n=64), there is at least 12.25% uncertainty in the repeatability results. From a practical viewpoint, a small sample might restrict the range of values over which precision is tested and bias the result in terms of the variation in the population as some individuals might have more variation than others. Therefore, a large sample is advocated in instrument precision studies to ensure that instrument precision is adequately assessed over a greater range of measurement. [22] Thus, in order to increase the percentage of certainty in the repeatability

results it is necessary to increase the efforts in the validity and reliability studies on the management of CL wear.

With lens wear, the tear film undergoes extensive biophysical and biochemical changes, which have the potential to influence tear function and/or contact lens tolerance.[23] Therefore, the measurement, recording and monitoring of ocular surface parameters are important in the management of contact lens wear.

According to our study, intra-rater repeatability of K5M for TMH, NIKBUTs and ocular redness after CL wear remained stable when three measurements were performed. However, intra-rater repeatability during CL wear decreased only for NIKBUT average and was not affected by time of use (15 days).

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Tables 1,2 and 3

Table 1. Intra-rater repeatability of K5M parameters under baseline conditions considering two intraclass correlation coefficient types: single measurement and average of measurements.

	Baseline													
			ICC single measure						ICC average measures					
	Mean	SD	ICC	95% CI for ICC	Sw	CoV(Sw)%	Precision	CR	ICC	95% CI for ICC	Sw	CoV(Sw)%	Precision	CR	Dif CoV(%)
TMH(mm)	0.28	0.01	0.95	0.92 to 0.96	0.02	8.03	0.04	0.06	0.98	0.97 to 0.99	0.01	4.74	0.03	0.04	3.29
NIKBUT first (sc)	10.56	7.02	0.57	0.43 to 0.69	4.61	43.66	9.03	12.77	0.80	0.69 to 0.87	3.15	29.87	6.18	8.74	13.78
NIKBUT average (sc)	12.74	6.54	0.73	0.61 to 0.82	3.43	26.94	6.73	9.51	0.89	0.82 to 0.93	2.19	17.20	4.29	6.07	9.74
NLR	0.73	0.42	0.87	0.81 to 0.91	0.15	20.47	0.29	0.42	0.95	0.93 to 0.97	0.09	12.39	0.18	0.25	8.08
TLR	0.46	0.27	0.75	0.65 to 0.83	0.14	30.17	0.27	0.38	0.90	0.85 to 0.94	0.09	19.07	0.17	0.24	11.10
NBR	1.12	0.44	0.89	0.84 to 0.93	0.15	13.01	0.29	0.41	0.96	0.94 to 0.97	0.09	7.82	0.17	0.24	5.19
TBR	0.68	0.28	0.78	0.69 to 0.85	0.13	19.66	0.26	0.37	0.91	0.87 to 0.94	0.08	12.30	0.16	0.23	7.36

TMH: tear meniscus height; mm: millimeters; NIKBUT first: first break of non-invasive Keratograph tear breakup time; NIKBUT average: average break of non-invasive Keratograph tear breakup time; sc: seconds; NLR: nasal limbal redness; TLR: temporal limbal redness; NBR: nasal bulbar redness; TBR: temporal bulbar redness ; SD: standard deviation; ICC: intraclass correlation coefficient; 95% CI = 95% confidence; Sw: within-subject standard deviation; CoV: coefficient of variation of Sw; CR: coefficient of repeatability; Dif CoV(%): differences between single measure CoV and average measure CoV.

Table 2. Intra-rater repeatability of K5M parameters measured without the contact lens after 1 day and 15 days of use considering two intraclass correlation coefficient type: single measurement and average of measurements. The impact on reliability index of contact lens wear.

	Day 1 - after remove CL													
			ICC single measure						ICC average measures					
	Mean	SD	ICC	95% CI for ICC	Sw	CoV(Sw)%	Precision	CR	ICC	95% CI for ICC	Sw	CoV(Sw)%	Precision	CR	Dif CoV(%)
TMH(mm)	0.32	0.02	0.92	0.87 to 0.95	0.04	12.92	0.08	0.12	0.97	0.95 to 0.98	0.02	7.66	0.05	0.07	5.27
NIKBUT first (sc)	9.73	6.03	0.46	0.29 to 0.62	4.42	45.46	8.67	12.25	0.72	0.55 to 0.83	3.19	32.76	6.24	8.83	12.70
NIKBUT average (sc)	12.39	6.12	0.67	0.54 to 0.79	3.50	28.26	6.86	9.70	0.86	0.78 to 0.92	2.29	18.46	4.48	6.34	9.80
NLR	0.88	0.52	0.93	0.90 to 0.96	0.13	15.23	0.26	0.37	0.98	0.96 to 0.99	0.08	9.01	0.16	0.22	6.23
TLR	0.59	0.30	0.92	0.88 to 0.95	0.08	14.32	0.17	0.23	0.97	0.96 to 0.98	0.05	8.51	0.10	0.14	5.80
NBR	1.20	0.50	0.92	0.88 to 0.95	0.14	11.65	0.27	0.39	0.97	0.96 to 0.98	0.08	6.90	0.16	0.23	4.75
TBR	0.83	0.27	0.80	0.70 to 0.87	0.12	14.67	0.24	0.34	0.92	0.88 to 0.95	0.08	9.10	0.15	0.21	5.56
	Day 15 - after remove CL													
TMH(mm)	0.26	0.01	0.92	0.88 to 0.95	0.02	8.36	0.04	0.06	0.97	0.96 to 0.98	0.01	4.97	0.03	0.04	3.39
NIKBUT first (sc)	9.33	6.40	0.48	0.32 to 0.63	4.60	49.33	9.02	12.75	0.74	0.59 to 0.84	3.28	35.16	6.43	9.09	14.17
NIKBUT average (sc)	12.12	5.98	0.66	0.53 to 0.77	3.47	28.64	6.80	9.62	0.86	0.77 to 0.91	2.27	18.77	4.46	6.31	9.88
NLR	0.80	0.50	0.91	0.86 to 0.94	0.15	18.81	0.30	0.42	0.97	0.95 to 0.98	0.09	11.19	0.18	0.25	7.63
TLR	0.53	0.32	0.92	0.88 to 0.95	0.09	16.90	0.18	0.25	0.97	0.96 to 0.98	0.05	10.03	0.10	0.15	6.87
NBR	1.12	0.42	0.90	0.84 to 0.93	0.14	12.28	0.27	0.38	0.96	0.94 to 0.98	0.08	7.34	0.16	0.23	4.94
TBR	0.77	0.32	0.91	0.86 to 0.94	0.10	12.84	0.19	0.27	0.97	0.95 to 0.98	0.06	7.66	0.12	0.16	5.18

TMH: tear meniscus height; mm: millimeters; NIKBUT first: first break of non-invasive Keratograph tear breakup time; NIKBUT average: average break of non-invasive Keratograph tear breakup time; sc: seconds; NLR: nasal limbal redness; TLR: temporal limbal redness; NBR: nasal bulbar redness; TBR: temporal bulbar redness ; SD: standard deviation; ICC: intraclass correlation coefficient; 95% CI = 95% confidence; Sw: within-subject standard deviation; CoV: coefficient of variation of Sw; CR: coefficient of repeatability; Dif CoV(%): differences between single measure CoV and average measure CoV.

Table 3. Intra-rater repeatability of K5M parameters measured during contact lens wear, at 8 hours of use on the 1st and 15th days, considering two intraclass correlation coefficient type: single measurement and average of measurements. The impact on reliability index during contact lens wear.

	Day 1 - 8 h wearing CL													
			ICC single measure						ICC average measures					
	Mean	SD	ICC	95% CI for ICC	Sw	CoV(Sw)%	Precision	CR	ICC	95% CI for ICC	Sw	CoV(Sw)%	Precision	CR	Dif CoV(%)
TMH(mm)	0.25	0.01	0.91	0.87 to 0.94	0.03	11.32	0.06	0.08	0.97	0.95 to 0.98	0.02	6.73	0.03	0.05	4.59
NIKBUT first (sc)	10.31	6.75	0.40	0.25 to 0.56	5.21	50.53	10.21	14.44	0.67	0.50 to 0.79	3.87	37.57	7.59	10.74	12.96
NIKBUT average (sc)	15.31	5.08	0.36	0.20 to 0.52	4.06	26.50	7.95	11.25	0.63	0.43 to 0.77	3.09	20.17	6.05	8.56	6.33
NLR	0.75	0.53	0.92	0.88 to 0.95	0.15	19.81	0.29	0.41	0.97	0.96 to 0.98	0.09	11.76	0.17	0.25	8.05
TLR	0.44	0.30	0.85	0.79 to 0.90	0.11	26.06	0.22	0.32	0.95	0.92 to 0.97	0.07	15.82	0.14	0.19	10.24
NBR	1.15	0.47	0.91	0.86 to 0.94	0.14	12.47	0.28	0.40	0.97	0.95 to 0.98	0.09	7.43	0.17	0.24	5.03
TBR	0.74	0.30	0.80	0.71 to 0.86	0.14	18.60	0.27	0.38	0.92	0.88 to 0.95	0.09	11.54	0.17	0.24	7.07
	Day 15 - 8 h wearing CL													
TMH(mm)	0.24	0.00	0.90	0.85 to 0.94	0.02	9.22	0.04	0.06	0.96	0.95 to 0.98	0.01	5.51	0.03	0.04	3.71
NIKBUT first (sc)	9.67	6.44	0.47	0.31 to 0.62	4.68	48.41	9.18	12.98	0.73	0.58 to 0.83	3.36	34.73	6.59	9.31	13.67
NIKBUT average (sc)	15.48	4.90	0.44	0.28 to 0.60	3.66	23.65	7.18	10.15	0.70	0.54 to 0.82	2.67	17.23	5.23	7.40	6.42
NLR	0.59	0.49	0.76	0.66 to 0.84	0.24	40.25	0.46	0.66	0.91	0.85 to 0.94	0.15	25.32	0.29	0.41	14.93
TLR	0.38	0.22	0.84	0.76 to 0.89	0.09	23.07	0.17	0.25	0.94	0.91 to 0.96	0.05	14.11	0.11	0.15	8.97
NBR	0.92	0.39	0.93	0.89 to 0.96	0.10	11.19	0.20	0.29	0.98	0.96 to 0.98	0.06	6.64	0.12	0.17	4.55
TBR	0.68	0.26	0.83	0.76 to 0.89	0.10	15.38	0.20	0.29	0.94	0.90 to 0.96	0.06	9.42	0.13	0.18	5.96

TMH: tear meniscus height; mm: millimeters; NIKBUT first: first break of non-invasive Keratograph tear breakup time; NIKBUT average: average break of non-invasive Keratograph tear breakup time; sc: seconds; NLR: nasal limbal redness; TLR: temporal limbal redness; NBR: nasal bulbar redness; TBR: temporal bulbar redness ; SD: standard deviation; ICC: intraclass correlation coefficient; 95% CI = 95% confidence; Sw: within-subject standard deviation; CoV: coefficient of variation of Sw; CR: coefficient of repeatability; Dif CoV(%): differences between single measure CoV and average measure CoV.