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# Comparison of Amplitude and Implicit Time Between Jet Electrode, Dencott Electrode and Dawson-Trick-Litzkow Electrode in Multifocal Electroretinography Examination in Adult

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## Abstract

***Introduction:*** *Multifocal electroretinography (ERG) is an examination which measures retinal electrical activity as a response to lighting stimulus and allows simultaneous recording in many topographic locations. Various electrodes have been developed to balance examination accuracy and also patients' comfort. The objective of this study is to establish normal values of multifocal ERG and to compare the values and the comfort level using Jet, Dencott and DTL electrode in Indonesian Adult.*

***Methods****: Through convenient sampling 49 normal Indonesian subjects between 19 and 49 years old were selected. Multifocal ERG amplitudes and implicit time values were measured according to recommendation by the ISCEV. Evaluation consisted of N1 and P1 wave in ring 1 to 5. after the examination, all subjects filled in a questionnaire about comfort level, adopted from the visual analog scale.*

***Result****: We observed a statistically significant difference in multifocal ERG normal values between electrode with higher wave amplitudes and longer implicit time in Jet and Dencott electrodes compared to DTL electrodes. Jet and DTL electrodes are more comfortable than Dencott electrodes for Indonesian adults in multifocal ERG.*

***Conclusion****: DTL electrodes give the lowest wave amplitude and the shortest implicit time and are the most comfortable electrode compared to Jet and Dencott electrodes, in multifocal ERG in Indonesian adults.*

**Keywords:** multifocal electroretinography, Jet electrode, Dencott, Dawson-Trick-Litzkow, comfort level, normal Indonesian adult

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## INTRODUCTION

Electroretinography (ERG) is an examination which measures retinal electrical activity as a response to lighting stimulus.[1] ERG depicts objective photoreceptor and inner retinal layer functional integrity, which does not depend on patient's voluntary response.

Therefore, ERG is useful in non-cooperative patients and infants.[2] Multifocal ERG allows simultaneous recording of retinal responses in many topographic locations, particularly in 40-50° central retina.[3,4]

Multifocal ERG recording is performed using various commercially available system.[5] Parameter settings in each system will affect the recording and result interpretation.[6] Standards for multifocal ERG recording has been published by International Society for Clinical Electrophysiology of Vision (ISCEV), however ISCEV requires normal values be determined according to race, device, and patients' characteristics in each institution.[8,9] Study to attain normal multifocal ERG values is not yet available in Indonesia. Furthermore, electrode selection also affects recording results, which necessitates comparison and conversion between each electrode.

A study in India found the mean normal N1 amplitude in ring 1 of -56.40 nV/deg2 and N1 latency of 21.81 ms.[10] Study in Japan found the mean normal N1 amplitude in ring 1 of 16.37±2.11 nV and N1 latency of 20.84±0.35 msec.[11] Another study in Malaysia found the normal mean amplitude in 1 subject of 48.72 nV/deg$^2$.[12]

Various electrodes have been developed to balance examination accuracy and also patients' comfort. Contact lens electrode is more superior to other types of electrodes, in terms of less recording noise and good reproducibility. Several corneal contact lens electrodes are used in multifocal ERG recording, including Jet and Dencott electrodes. Dencott electrode is larger in size due to its scleral coverage and protrusions to open the eyelids.[13] Conversely, Jet electrode is smaller and covers only the cornea. Although more accurate, corneal contact electrodes are not very comfortable for the patients. DTL (Dawson, Trick, dan Litzkow) electrode, which consists of silver thread electrode and placed on the inferior conjunctival fornix, has been shown to be more comfortable for patients.[14-17] However some controversies are present regarding each electrode's accuracy and reproducibility. Several studies showed that DTL electrode resulted in lower accuracy compared to standard contact lens electrode.[15,16]

Another study showed that DTL and contact lens electrodes had comparable results.[18,19] Furthermore, individual responses recorded with DTL electrode are as stable and reproducible as contact lens electrode.[18,20]

In Cipto Mangunkusumo Hospital Kirana, Jet electrode is the electrode that is routinely used for multifocal ERG examination. Another electrode that is used is Dencott electrode which is produced by Metrovision. These electrodes contact the cornea, which poses risk of corneal erosion and patient discomfort.[21] Conversely, DTL electrode can be considered less invasive and more comfortable, albeit its accuracy is still controversial. Because each electrode has its own advantages, its choice is operator dependent. Normal value data for each available electrode is then required to allow a broader selection of electrodes.

## METHODS

This study is an analytical study that aims to compare the use of three different types of ERG electrode. The Health Research Ethics Committee of the Faculty of Medicine, Universitas Indonesia had approved this study. This study was performed in Cipto Mangunkusumo Hospital Ophthalmology Clinic during April to July 2018. The study target population is adult Indonesians (19-49 years old) with normal eyes. Subjects were recruited using convenient sampling, from employees, nurses, refractionists, medical students, and doctors in FMUI-Cipto Mangunkusumo Hospital Kirana.

Patients who come only to undergo checkup examination, spectacles change, or patients' family were also recruited until minimum sample size was attained. Inclusion criteria is Indonesian subject in Cipto Mangunkusumo Hospital Kirana, with normal eye or mild refractive error, within the age range of 19-49 years old, who consent to participate in this study and signed the informed consent. Exclusion criteria is subjects with high myopia (≥ 6 Diopter), had a history of intraocular surgery, ocular laser procedure, ocular trauma, long-term drug use, or having hard to dilate pupils. Drop-out criteria is subjects who declined to participate further in the study or could not complete the examination, or experience side effects from the examination. Informed consent was obtained from all subjects after explaining the study procedures and the effects that may result.

Subjects who met the eligibility criteria were examined using 3 types of ERG electrodes that are being compared in this study; Jet Electrode, Dencott Electrode and DTL Electrode. Examinations were performed by the same operator on the same day. Random allocation using simple randomization method was used to determine sequence of used electrodes. The choice of electrodes is placed in an envelope, and its sequence is taken out of the envelope by the ERG operator in the same day of the examination. Masking was not needed since the subjects did not know the shape and appearances of each electrode. The multifocal ERG was performed following the ISCEV guideline and standard value using Vision Monitor Monpack One Metrovision ERG system. After multifocal ERG was performed, subjects were asked to complete a questionnaire regarding the comfort level of each electrode.

Data analysis were performed using SPSS version 20.0. Study subjects were counted in person unit, therefore in one subject two eyes can be examined as different data. Amplitude and latency results from each electrode were analyzed using Intraclass Correlation Coefficient test and then continued with linear regression, paired T-test or Wilcoxon test, and Bland-Altman test. The comfort level of each electrode was analyzed using Wilcoxon test.

## RESULTS

From the 49 subjects recruited, 25 were female and 24 were male. Intraclass correlation coefficient showed variable correlation between the three electrodes in all parameters measured, as given in Table 1. Normal values of multifocal electroretinography in Indonesian adults, using Jet electrodes, Dencott electrodes and DTL electrodes, are shown in Table 2. The p-values were obtained from the paired t-test analysis.

Table 1. **Intraclass correlation coefficient comparison of electrodes used in multifocal ERG examination. (n=98 eyes)**

| Variable | Intraclass Correlation Coefficient | |
|---|---|---|
| | Jet vs Dencott | Jet vs DTL |
| Ring 1 N1 latency | 0.044* | 0.294* |
| Ring 1 N1 amplitude | 0.403* | 0.452* |
| Ring 2 N1 latency | 0.264* | 0.446* |
| Ring 2 N1 amplitude | 0.609** | 0.595** |
| Ring 3 N1 latency | 0.323* | 0.088* |
| Ring 3 N1 amplitude | 0.558** | 0.567** |
| Ring 4 N1 latency | 0.725** | 0.627** |
| Ring 4 N1 amplitude | 0.342* | 0.409* |
| Ring 5 N1 latency | 0.828*** | 0.742** |
| Ring 5 N1 amplitude | 0.742** | 0.497* |
| Ring 1 P1 latency | 0.264* | 0.190* |
| Ring 1 P1 amplitude | 0.624** | 0.463* |
| Ring 2 P1 latency | 0.673** | 0.580** |
| Ring 2 P1 amplitude | 0.806*** | 0.501** |
| Ring 3 P1 latency | 0.809*** | 0.757*** |
| Ring 3 P1 amplitude | 0.826*** | 0.580** |
| Ring 4 P1 latency | 0.804*** | 0.782*** |
| Ring 4 P1 amplitude | 0.797*** | 0.534** |
| Ring 5 P1 latency | 0.862*** | 0.788*** |
| Ring 5 P1 amplitude | 0.858*** | 0.528** |

*) Poor ICC **) Average ICC ***) Good ICC

Table 2. **Comparison of mean or median values of multifocal ERG examination results using various electrodes. (n=98 eyes)**

| Variable | Jet | Dencott | DTL |
|---|---|---|---|
| Ring 1 N1 latency | 27.76 ± 2.28 | 26.5 ± 3.39* | 27.08 ± 3.48* |
| Ring 1 N1 amplitude | -831 (-1807; -22.5) | -553 (-1760: -1.3)* | -593 (-1404; -121)* |
| Ring 2 N1 latency | 27.4 ± 1.3 | 26.4 ± 1.8* | 27.4 ± 1.5* |
| Ring 2 N1 amplitude | -590 (-1080; -213) | -442 (-933; -65)* | -385 (-799; -66.5)* |
| Ring 3 N1 latency | 26.9 ± 2 | 26.4 ± 1.1* | 26.9 ± 1.2* |
| Ring 3 N1 amplitude | -513 (-1054; -274) | -450.5 (-957; -92.4)* | -328.5 (-680; -16.1)* |
| Ring 4 N1 latency | 26.9 ± 2 | 26.6 ± 1* | 26.8 ± 1.1* |
| Ring 4 N1 amplitude | -495 (-752; -189) | -504 (-958; -31) | -323.5 (-546; -74.7)* |
| Ring 5 N1 latency | 27.1 ± 0.9 | 26.6 ± 1* | 27 ± 1* |
| Ring 5 N1 amplitude | -560 (-764; -258) | -527 (-880; -281) | -312.5 (-535; -87.2)* |
| Ring 1 P1 latency | 49.79 ± 2.41 | 47.88 ± 3.93* | 51.9 ± 3.3* |
| Ring 1 P1 amplitude | 1594 (407-3493) | 1039 (195-2723)* | 1091 (256-2433)* |
| Ring 2 P1 latency | 46.6 ± 1.2 | 45.8 ± 1.5* | 47.3 ± 1.5* |
| Ring 2 P1 amplitude | 1141 (551-1952) | 864 (367-1602)* | 687 (243-1221)* |
| Ring 3 P1 latency | 45 ± 1.1 | 44.7 ± 1.3* | 45.5 ± 1.2* |
| Ring 3 P1 amplitude | 1054 (597-1746) | 906 (495-1451)* | 611 (310-1024)* |
| Ring 4 P1 latency | 44.6 ± 1 | 44.4 ± 1.1* | 44.9 ± 1.1* |
| Ring 4 P1 amplitude | 1086 (590-1617) | 996 (649-1437)* | 605 (218-940)* |
| Ring 5 P1 latency | 44.7 ± 1.1 | 44.3 ± 1.0* | 44.9 ± 1* |
| Ring 5 P1 amplitude | 1212 (602-1651) | 1172 (744-1571) | 642 (211-1098)* |

*) Significant, with p value <0.05 (paired T test or Wilcoxon test)

Table 3. **Mean comfort level score of electrode. (n=98 eyes)**

| Electrodes | Mean comfort level score |
|---|---|
| Jet | 2 (0-9) |
| Dencott | 5 (0-10) |
| DTL | 2 (0-7) |

The mean comfort level score using each electrode and Wilcoxon test comparison between them are shown in Table 3 and 4.

Table 4. **Comparison of comfort level between electrodes. (n=98 eyes)**

| Electrode comparison | p value |
|---|---|
| Jet - Dencott | <0.001* |
| Jet - DTL | 0.306 |
| Dencott - DTL | <0.001* |

*) Significant with p value <0,05 (Wilcoxon test)

## DISCUSSION

This study describes normal values of multifocal ERG recording results in normal Indonesian population. This study also compares normal standard value between electrodes and their respective comfort level scores. Electrode which is used as the comparator is Jet electrode, because this electrode is recommended by ISCEV for multifocal ERG recording.[22,23] Furthermore Jet electrode is the only corneal contact lens electrode which is used for multifocal ERG recording in Indonesia and is the most commonly used electrode in the world.[10,23]

Dencott electrode is used in this study due to its corneal contact property, and is the default electrode which is supplied by the Metrovision device system (which is used in Cipto Mangunkusumo Hospital Kirana). The use of DTL electrode in this study is in accordance to ISCEV standard, which states that electrode which contacts in proximity to the cornea or bulbar conjunctiva may also be used for multifocal ERG recording.[23,24] Other corneal contact lens electrodes which are commonly used globally include Burrian-Allen, Dorian Gold Lens, and Henkes electrodes.[9,11] However these electrodes are not available in Indonesia.

Sample size in this study is sufficient, because this study recruited 98 eyes from 49 subjects. Female to male proportion among study subjects is balanced. The number of subjects within the age range of 19-29 years old is similar to those in the age range of 30-39 years old, with those above 40 years old are less.

This study used randomization for electrode usage sequence, to minimize bias due to fatigue during ERG recording, which dominantly affect the last electrode that is used. To minimize the fatigue, subject is allowed to take breaks between each electrode usage.

In this study, intraclass correlation coefficient (ICC) analysis is used to explain that higher ICC shows higher correlation from Dencott and DTL electrode recording to Jet electrode recording for each recorded parameter. ICC is the ideal parameter to determine correlation power and agreement among recordings.[25,26] Good ICC value comparison between Jet and Dencott electrode is shown in 8 out of 20 variables, while moderate and poor ICC are shown in 6 out of 20 variables each. In comparison between Jet and DTL electrode, good ICC value is obtained in 3 out of 20 variables. Moderate ICC value is obtained in 9 out of 20 variables, while poor ICC value is obtained in 8 out of 20 variables. ICC value results in this study showed a trend of higher ICC value for more peripheral waveform locations. This finding is in accordance to the study by Garcia et al[23], where poor ICC value is obtained in 2 out of 5 variables, namely in ring 1 and ring 2, and moderate ICC value is obtained in 3 out of 5 variables, namely in ring 3 to ring 5. Study by Garcia et al[23] assessed ICC values in 5 variables from multifocal ERG examination between Jet and DTL electrodes, which is ring 1 to ring 5 P1 amplitude. There was no adverse effect due to electrodes usage in this study, including corneal erosion or ocular infection.

This study had several strengths, which are sufficiently large number of subjects (98 eyes), a balanced distribution in male to female proportion among subjects, and the evaluated variables are quite vast. Evaluated variables included latency and amplitude of N1 and P1 waveform in 5 rings. Finally, the number of electrodes used in this study is greater than other studies.

The limitation of this study is that normal values are only sought in normal adults within the age range of 21-46 years old. This age range excluded those from pediatric or geriatric age range, who may have different normal multifocal ERG parameter values, due to the difference in their physiologic retinal electrical development and senescence. Furthermore, comfort level score in this study only assessed what the subjects experienced subjectively. However objective comfort criteria, including the frequency of displaced or expulsed electrode from the ocular surface during the multifocal ERG recording session was not evaluated. This factor may also affect patients' comfort and recording duration.[23] Another limitation is that this study did not follow the most updated ISCEV guideline.[27] Since the data collection were performed before the latest guideline was published in 2021, the examinations were performed using the available guideline at that time.

## CONCLUSION

There is a statistically significant difference in the wave amplitudes between Jet, Dencott and DTL electrodes. DTL and Jet electrodes are the most comfortable electrodes in multifocal ERG for normal adult.

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