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Refractive Intervention

Peripheral Refraction Using Ancillary Retinoscope Component (P-ARC)

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Received: August 22, 2023
Accepted: February 19, 2024
Published: April 3, 2024

Keywords: myopia; peripheral retinoscope; peripheral refraction; open-field autorefractor

Citation: Thakur S, Maldoddi R, Vangipuram M, Kalivemula M, Ch SNSH, Karthikesh A, Verkicharla PK. Peripheral refraction using ancillary retinoscope component (P-ARC). Transl Vis Sci Technol. 2024;13(4):7, https://doi.org/10.1167/tvst.13.4.7

Purpose: To assess the agreement of retinoscope-based peripheral refraction techniques with the criterion standard open-field autorefractor.

Methods: Fifty young adults (mean age, 24 ± 3 years) participated in this study. Two masked, experienced senior examiners carried out central refraction and peripheral refraction at the temporal 22° (T22°) and nasal 22° (N22°) eccentricities. Peripheral refraction techniques were (a) peripheral refraction using ancillary retinoscope component (P-ARC), (b) retinoscopy with eye rotation, and (c) open-field autorefractor. Peripheral refraction with retinoscopy values was compared with an open-field autorefractor (Shinn Nippon NVision-K) to assess the agreement. All measurements were taken from the right eye under noncycloplegic conditions.

Results: The mean difference ±95% limits of agreement of peripheral refraction values obtained using P-ARC from T22° (+0.11 diopters [D] ± 1.20 D; $P = 0.20$) or N22° (+0.13 D ± 1.16 D; $P = 0.13$) were comparable with open-field autorefractor. The eye rotation technique compared to autorefractor showed a significant difference for T22° (+0.30 D ± 1.26 D; $P = 0.002$); however, there was an agreement for N22° (+0.14 D ± 1.16 D; $P = 0.10$). With respect to the identification of peripheral refraction patterns, examiners were able to identify relative peripheral hyperopia in most of the participants (77%).

Conclusions: Peripheral refraction with P-ARC was comparable with open-field autorefractor at T22° and N22° eccentricities. Peripheral retinoscopy techniques can be another approache for estimating and identifying peripheral refraction and its patterns in a regular clinical setting.

Translational Relevance: Retinoscope with P-ARC has high potential to guide and enable eye care practitioners to perform peripheral refraction and identify peripheral refraction patterns for effective myopia management.

Introduction

The association between myopia and the refractive error patterns of the peripheral retina has generated significant interest among clinicians and researchers in the last decade.[1–4] It has been hypothesized that individuals with myopia have steeper retinal shapes, smaller relative peripheral eye lengths, and relative peripheral hyperopia (RPH).[5,6] Various optical treatment modalities, such as orthokeratology,[7,8] center distance multifocal soft contact lenses,[9,10] and peripheral defocus spectacles lenses,[11–13] are intended to counteract RPH by imposing relative peripheral myopia (RPM) to slow down the axial growth and control myopia progression.

Numerous techniques have been used to estimate peripheral refraction, such as peripheral retinoscopy,[14–26] double-pass setup,[27,28] open-field autorefractor,[22] photorefraction,[29] and an aberrometer-based technique.[30] Among these techniques, the open-field autorefractor has been used widely for determining peripheral refractive error.[31] However, it is expensive and requires a larger clinical space (3 × 3 m^2) to place the fixation targets in the visual field, limiting its usage in routine clinical practice. Considering the potential role of peripheral refractive errors in myopia, it is important to understand and estimate the pattern of peripheral refraction in a more simplistic and universally approachable manner.

Given the ubiquitous use of retinoscopes in comprehensive eye care facilities, the importance of using them to perform peripheral refraction cannot be undermined, particularly with the growing interest in understanding the patterns of peripheral refractive error in myopia practice.[32,33] Although the technique of determining peripheral refraction using a retinoscope was first introduced by Rempt et al. in 1971,[14] several studies investigated peripheral refraction using retinoscopy and the influence of off-axis retinoscopy on central refraction.[14–18,21,24–26]

We aimed to compare the peripheral refractive error values obtained using peripheral refraction with an ancillary retinoscope component (P-ARC) and peripheral retinoscopy with eye rotation against the criterion standard of the open-field autorefractor. P-ARC (details in the Methods section) is a trial frame-mounted LED-based attachment that enables/guides eye care practitioners to perform peripheral refraction in desired visual field angles using retinoscope along the horizontal meridian without participant requiring eye rotation for fixating peripherally placed targets or needing extra clinical space for placement of targets, and peripheral refraction with eye rotation—a procedure in which the participant fixates the eccentric targets placed on the wall in the visual field by eye rotation and the peripheral refraction is determined by the examiner while being in a central position.

Methods

The study was conducted at L V Prasad Eye Institute (LVPEI), Hyderabad, India, and was approved by the Ethics Committee of LVPEI (Ethics No. LEC–BHR-P-07-22-906). The protocol followed in this study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants after providing them with information related to the nature and consequence of the study.

We used G*Power software[34] to calculate the required sample size, with the parameters assuming 80% power to detect a difference of 0.50 ± 1.00 diopter (D) (paired t test) between peripheral retinoscopy techniques and open-field autorefractor. The calculated sample size was 34. Lundström et al.[20] compared the Hartman-Shack technique with peripheral retinoscopy and reported a mean difference of 0.77 ± 0.72 based on a sample of 50 participants. Further, a review work by Han et al.[35] on a descriptive study of sample sizes in agreement studies indicated a median sample size of 50 for continuous endpoint.

Fifty young adults (30 females) aged 18 to 32 years (mean age, 24 ± 3 years) were included in this study. Based on the noncycloplegic, open-field autorefractor values, myopia was defined as a spherical equivalent refractive error (SER) obtained with a refractive error of ≤ -0.50 D ($n = 29$)[36] and nonmyopes as > -0.50 D ($n = 21$). The participants were primarily optometry students and staff from LVPEI. Individuals with any history of ocular pathology or surgery, strabismus, or any systemic illness that could affect the refractive error status, and those who have undergone vision therapy for any accommodative or vergence anomalies, using any myopia control treatment and with a miotic pupil (pupil size of <2.3 mm) were excluded from the study.

Construction and Working of P-ARC

The prototype of the P-ARC was developed at LVPEI through a collaboration between the Myopia Research Lab and the Center for Technology Innovation. The P-ARC comprises a light-dependent resistor, a light sensor, a LED, and a controller fixed onto a three-dimensionally printed mount. This mount can be placed in the innermost trial lens shelves (one closer to the eye) of the trial frame, which is used for performing refraction using a retinoscope (Fig. 1A). *The* P-ARC is connected to an external power adapter through a power cable.

Two light-dependent resistors are positioned inside the tube-like structures that extend outward in a V shape. These tube-like structures have a small, center circular opening, allowing the retinoscopic light to project onto the light sensor through holes placed on each side of the central axis at the specific angle of 22°. The light sensors detect the light coming from the retinoscope, and the controller triggers an LED to indicate that the light has entered through the desired peripheral angle. This feature enables the examiner to align themselves at an angle of 22° (temporal and nasal) to perform peripheral refraction. The design of the P-ARC is interchangeable and can be mounted to facilitate peripheral refraction for both eyes. Figures 1B

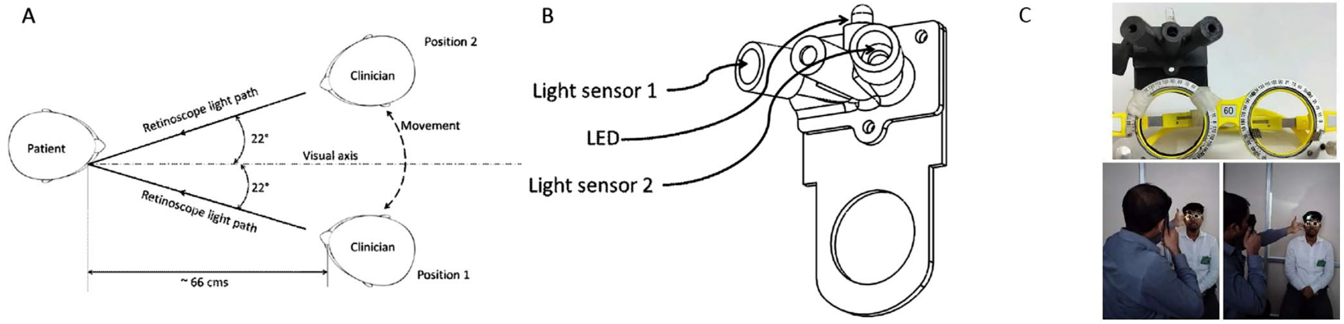

Figure 1. Illustrates details of the peripheral ancillary retinoscope component (P-ARC). (A) Schematic diagram showing the peripheral refractive error measurement technique at the temporal 22° and nasal 22° eccentricities. (B) Design of P-ARC with two light sensors placed inside the tube-like structures. (C) Trial frame with P-ARC, and the examiner performing peripheral refraction on a participant with the guidance from light sensors using a retinoscope. See Supplementary Video for technique. *Informed consent was obtained for the photograph.

Table 1. Technical Specifications of the P-ARC

S. No	Parameters	Values
1	Dimension	40 mm length × 40 mm breadth × 70 mm height
2	Weight	11.0 g
3	LED indicator	White color LED
4	Adjusted threshold lux levels for light sensor	$\geq$11 lux
5	Area of the sensor aperture	19.6 mm^2
6	Charging method	Nonchargeable, USB power supply 5 volt

and 1C depict a schematic illustration of the procedure, followed by the examiners performing peripheral retinoscopy using the P-ARC. The technical specifications of the P-ARC are provided in Table 1.

During the construction of the ancillary retinoscope component, measurement angles of >22° were not chosen purposefully for the peripheral refraction. First, with the increase in retinal eccentricity to perform peripheral refraction, the pupil becomes more elliptical, and the retinoscopic reflex breaks from the center to the peripheral margin of the pupil—the phenomenon was termed the double sliding-door effect by Rempt et al.[14] Atchison[37] indicated that, as the measurement angle increases, the pupil appears elliptical, and tangential diameter increases, resulting in a narrower pupil and increased off-axis aberrations and makes retinoscopy more challenging. Additional reasons for not selecting measurement angle beyond 22° were to avoid the obstruction of the retinoscopy reflex by the rim of the trial frame and the nasal bridge if the degree of measurement was increased. Moreover, selecting a measurement degree lower than 22° might lead to the retinoscopy reflex coinciding with the location of the optic disc (15.5 ± 1.1°).[38]

Procedure

The study procedure is illustrated as shown in the flowchart in Figure 2. A total of three peripheral refraction techniques were performed: (i) P-ARC, where the examiner performed peripheral retinoscopy after aligning themselves at ±22° (temporal and nasal) based on the visual feedback received from the LED; (ii) peripheral retinoscopy with eye rotation, in which participants were instructed to rotate their eyes to view a distance target placed on a wall at ±22° (temporal and nasal), and the examiner performed retinoscopy being in the central position; and (iii) peripheral refraction with an open-field autorefractor at ±22° (temporal and nasal) (Shin Nippon NVision-K 5001, Tokyo, Japan). The refractive error values using retinoscopy were performed under dim light conditions (7–10 lux), without the use of cycloplegia. Performing peripheral refraction without cycloplegia allows for direct comparison with refraction results measured under natural pupil conditions.[31] The time taken to complete each peripheral refraction technique was $\leq$3 to 5 minutes. A Maltese cross (luminance of 0.02–0.03 cd/m^2, 85% Michelson contrast, size, 6 × 6 cm^2

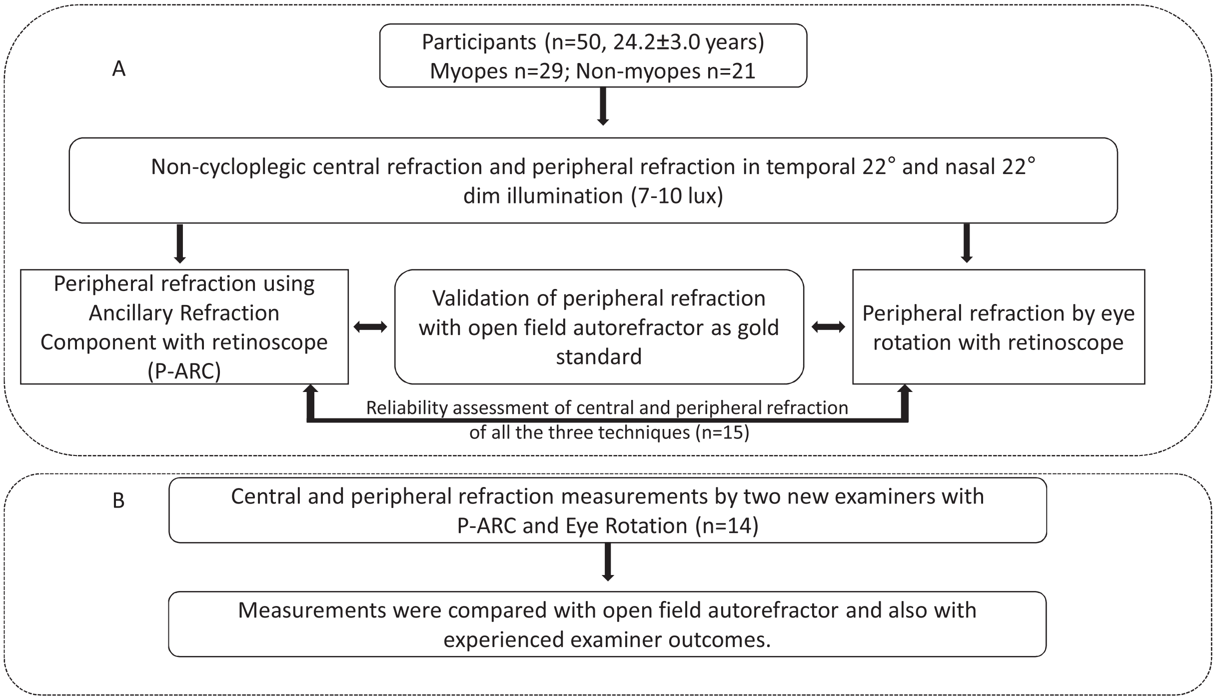

Figure 2. Flowchart of the study methodology illustrating peripheral refraction performed by (A) experienced and (B) junior examiners.

crosses) was used as the distance target in all refraction techniques.[39]

Two examiners (ST as examiner 1 and RM as examiner 2) performed central and peripheral refraction in 50 participants using all three techniques. Both examiners are experienced optometrists with ≥4 to 5 years of clinical practice, which is similar to the critical experience level needed to have a peak performance while performing retinoscopy (≥4 years of experience: accuracy of retinoscopy 0.06 ± 0.11 D; precision, 0.13 ± 0.08 D).[40] Further, both examiners were trained at the same institute and, therefore, are expected to have similar level of skills to perform refraction using a retinoscope. The retinoscopy values obtained by each examiner were documented on a separate sheet to maintain masking in data collection. Subsequently, one of the two examiners performed the central and peripheral refractive error values using an open-field autorefractor. In this procedure, the participants were instructed to fixate on a Maltese cross positioned 2.5 m away in the central 0°, temporal 22°, and nasal 22° visual fields. Five consecutive values were obtained for each location. These refractive error values were performed after the completion of the other two peripheral retinoscopy techniques to minimize examiner bias. The open-field autorefractor (Shinn Nippon NVision-K) used in this study allows measurements with a pupil size of ≥2.3 mm.[41] The power step for the autorefractor was set at 0.25-D steps for comparison with retinoscopy values. The values for temporal and nasal eccentricities were not randomized to avoid confusion while entering the data into the datasheet. Participants were given a resting period of approximately 5 minutes between sessions to mitigate the effects of fatigue and eye strain, which might influence the oculomotor tonus.[42] The repeatability of all three techniques was assessed by repeating the central and peripheral refraction in a subset of the participants ($n = 15/50$) during two visits with a time gap of 25 to 30 days.

In addition, we decided to include two junior optometrists who had recently graduated and had <1 year of clinical practice. Both junior optometrists, who had no prior experience in performing peripheral refraction using a retinoscope, required minimal training by a brief demonstration for both retinoscopy techniques by one of the senior optometrists. The peripheral retinoscopy techniques performed by the junior examiners involved a subset of 14 participants. This step aimed to evaluate whether there would be any variation in the outcomes of the peripheral refraction values with retinoscopes performed by an inexperienced examiner. To maintain masking, both junior examiners were unaware of each other's refractive error values.

Statistical Analysis and Randomization

The statistical analysis was performed using IBM SPSS Statistics version 21.0.0 (SPSS, Inc., Chicago, IL). The Shapiro–Wilk normality test indicated that the differences between retinoscopy techniques and open-field autorefractor were normally distributed ($P > 0.05$). The Pearson correlation test was used to assess the correlation strength of the peripheral retinoscopy values between the two experienced examiners. Bland–Altman plots were used to evaluate the mean difference and 95% limits of agreement (LoA) of refractive error values obtained using all three techniques and for assessing their repeatability. The refractive error values obtained using the open-field autorefractor were considered the criterion standard. The paired *t* test was used for all pairwise comparisons, and the intraclass correlation coefficient (ICC) was used to determine the repeatability of all three techniques. An ICC value of <0.50 was considered poor, 0.5 to 0.75 as moderate, 0.75 to 0.9 as good, and >0.9 as excellent reliability.[43] The refractive measures included in the analysis were sphere, cylinder, SER, J_0, and J_{45}. The formulas used to calculate the vector components were as follows: $J_0 = -C/2 \times \cos 2\alpha$ and $J_{45} = -C/2 \times \sin 2\alpha$, where C represents the cylindrical power and α is the cylindrical axis. J_0 includes the cylindrical power at 90° and 180° meridians, which represents with-the-rule astigmatism (WTR) and against-the-rule astigmatism (ATR), and J_{45} includes the cylinder power at 45° and 135° meridians, representing oblique astigmatism. The relative peripheral refraction was calculated by subtracting the SER values of the peripheral refractive errors from the central refractive error values. A difference of ≥+0.25 D between the central and peripheral values was considered as RPH and others as RPM.[44] The rationale behind defining peripheral refraction, measured using either an open-field or retinoscope, with a 0.25 D cutoff is to identify even subtle difference between central and peripheral refraction (either RPH or RPM). Considering that this difference tends to increase with an increase in eccentricity, a 0.25-D difference is expected to represent the minimum acceptable discrepancy, particularly at less eccentric locations. A P value of <0.05 was considered statistically significant.

Overall, a strong correlation was found between examiners 1 ($n = 50$) and 2 ($n = 50$) for both central and peripheral refraction values obtained using a retinoscope. The mean ± SD central refractive error values for examiners 1 and 2 were similar (−1.56 D ± 1.73 D; −1.63 D ± 1.60 D, independent *t* test; $P = 0.63$). However, for cylinder, the correlation values indicated a weak to moderate correlation between the two examiners. The correlation values, sphere, cylinder, and SE, obtained by both examiners for each eccentricity are shown in Supplementary Table S1. Simple randomization was performed on the individual data of the two examiners to avoid intra-examiner memory bias towards peripheral refraction values, such that only one data point from either of the examiners was considered for the final analysis ($n = 50$; examiner 1, $n = 23$; examiner 2, $n = 27$).

Results

Agreement of Central and Peripheral Refractive Error Components

The agreement for central and peripheral refractive error components between the three techniques is shown in Figure 3. The mean ± SD of central refraction SER values obtained using the open-field autorefractor were −2.34 D ± 1.46 D for myopes and +0.08 D ± 0.28 D for nonmyopes. A comparison of the mean difference ±95% LoA in central SER, sphere, and cylinder components between retinoscopy and open-field autorefractor was +0.29 D ± 0.83 D (paired *t* test; $P < 0.001$), +0.34 D ± 0.73 D ($P < 0.001$), and −0.11 D ± 0.83 D ($P = 0.09$), respectively. Similarly, for the power vector components, the differences between the two techniques were not significant for J_0 (−0.05 D ± 0.42 D; $P = 0.11$) and J_{45} (+0.02 D ± 0.37 D; $P = 0.44$).

In the temporal 22°, there was no significant difference in the mean difference ±95% LoA for the SER values between peripheral refraction with P-ARC and open-field autorefractor (+0.11 D ± 1.20 D; $P = 0.20$). However, a statistically significant difference was found between SER values of the peripheral refraction, with eye rotation technique and open-field autorefractor (+0.30 D ± 1.26 D; $P = 0.002$). For the nasal 22°, the mean difference ±95% LoA for the SER values for peripheral refraction obtained using P-ARC (+0.13 D ± 1.16 D; $P = 0.13$) or eye rotation (+0.14 D ± 1.16 D; $P = 0.10$) were comparable with the open-field autorefractor. The difference in the cylindrical components of the temporal and nasal 22° obtained using P-ARC (−0.14 D ± 1.4 6 D; $P = 0.07$) and eye rotation technique (+0.16 D ± 1.68 D; $P = 0.07$) was similar to the open-field autorefractor.

Comparison of Power Vector Components (J_0 and J_{45}) in the Temporal and Nasal 22°

In temporal 22°, the mean difference ±95% LoA of J_0 values was not significant between the P-ARC

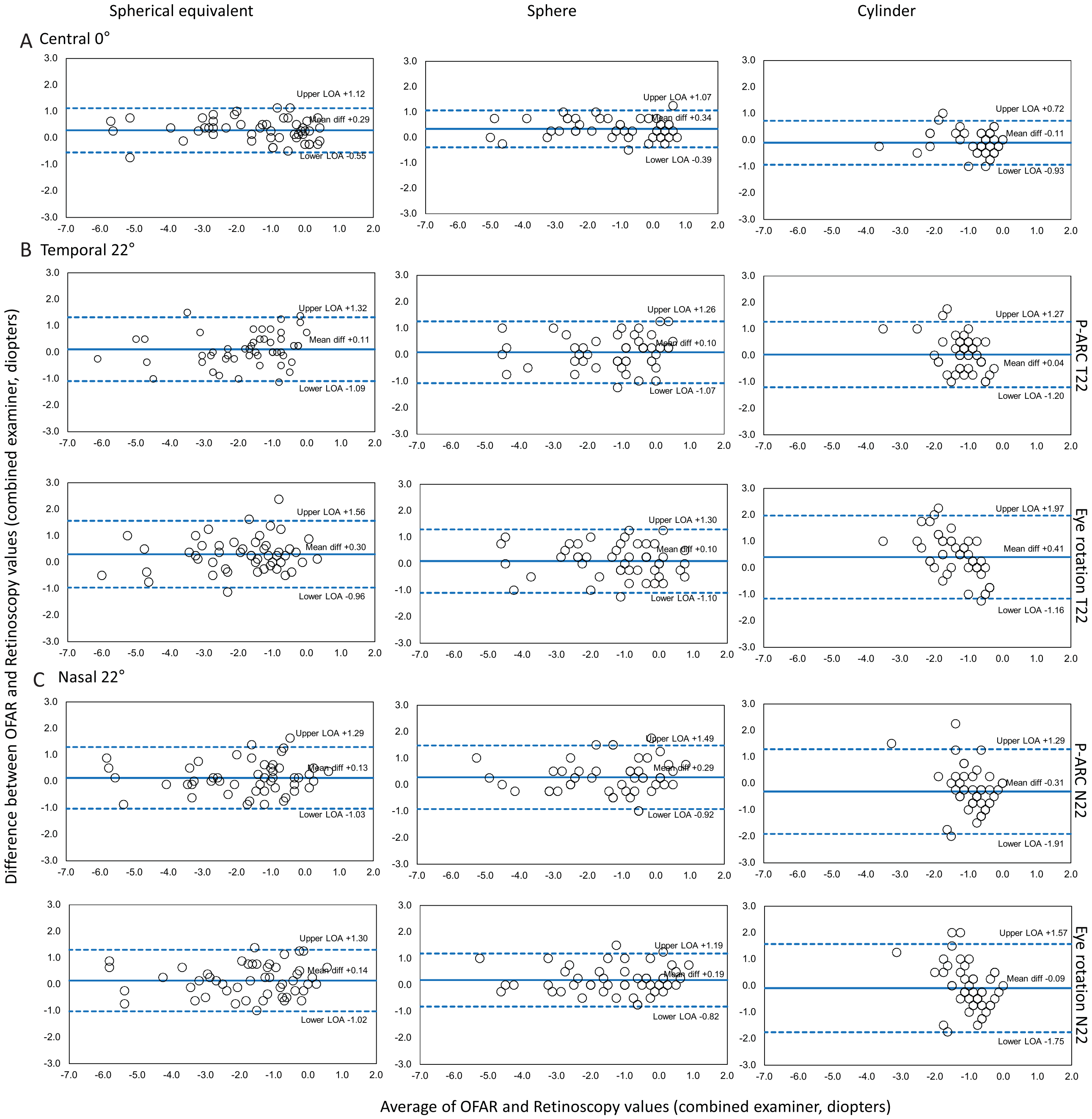

Figure 3. (A) Bland–Altman plots for the agreement between central 0° and (B) peripheral refraction values for temporal 22° and (C) nasal 22° between the open-field autorefractor and combined examiner values using various techniques. The solid and two dashed blue lines (A, B, and C) represent the mean difference and upper and lower LoA between the open-field autorefractor and combined examiner retinoscope values for peripheral refraction, respectively.

and open-field autorefractor (+0.05 D ± 0.79 D; $P = 0.34$); however, a significant difference was noted between the open-field autorefractor and the eye rotation technique (+0.17 D ± 0.95 D; $P = 0.02$). In nasal 22°, the mean difference ±95% LoA of J_0 values was significant between the P-ARC and open-field autorefractor (−0.24 D ± 0.86 D; $P < 0.001$); however, not with the eye rotation technique (−0.09 D ± 0.89 D; $P = 0.18$). The mean difference ±95% LoA of J_{45} values with the temporal and nasal 22° eccentricities exhibited significant differences ($P < 0.001$) between the open-field autorefractor and P-ARC (0.23 D ± 0.48 D and −0.17 D ± 0.51 D) and between the open-field autorefractor and eye rotation technique (0.16 D ± 0.53 D and −0.20 D ± 0.57 D).

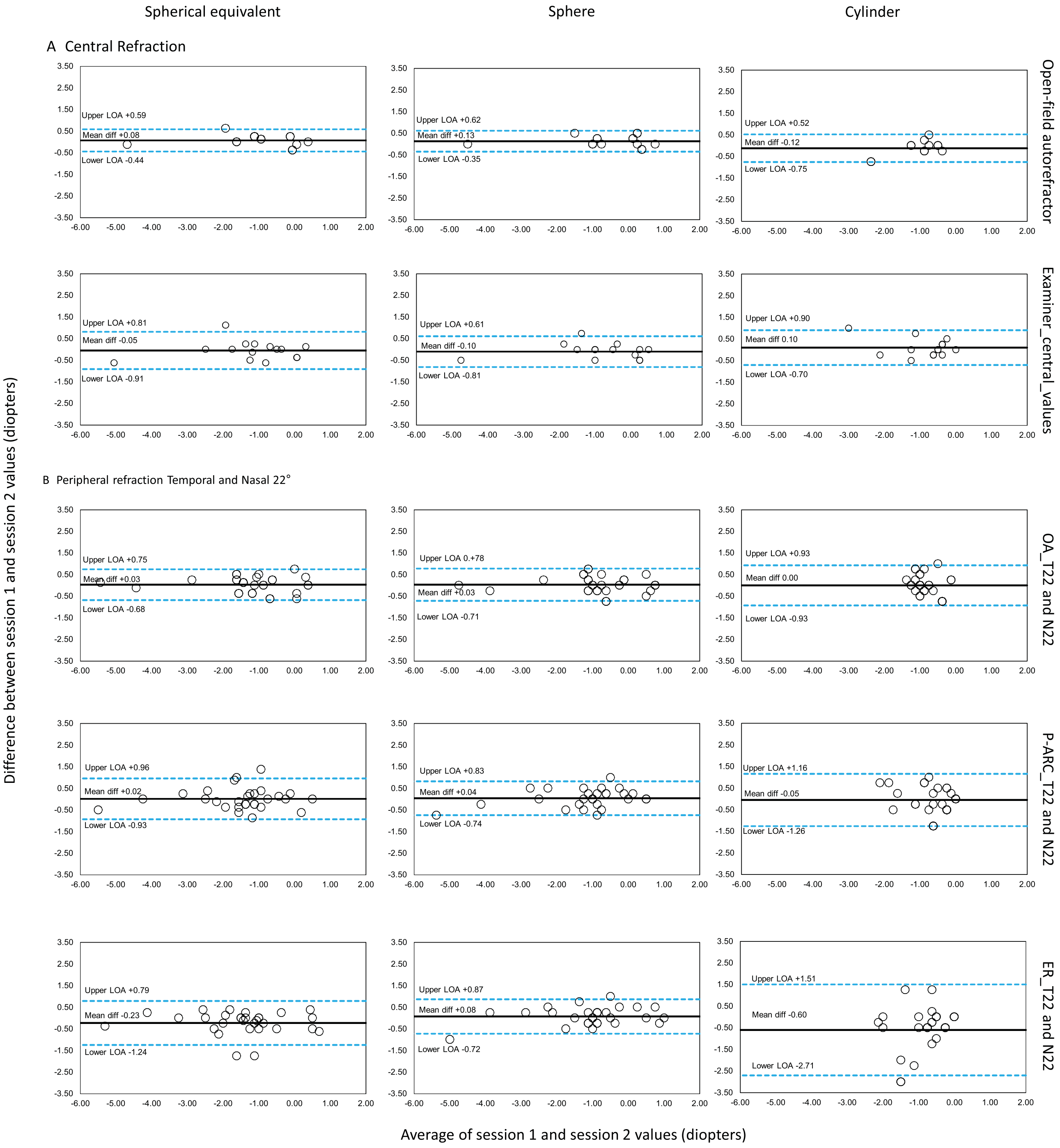

Figure 4. The Bland–Altman plots depict the repeatability of spherical equivalent, sphere, and cylinder refractive error values. (A) Central refraction values of both open-field autorefractor and examiner; (B) Peripheral refraction (temporal and nasal 22° eccentricities) of the three peripheral refraction techniques. The solid and two dashed blue lines represent the mean difference and upper and lower LoA between the open-field autorefractor and combined examiner retinoscope values for peripheral refraction, respectively.

Repeatability of the Three Refraction Techniques

The repeatability of the refractive error values at central 0°, temporal 22°, and nasal 22° was assessed in a subset of 15 participants (Fig. 4). The mean difference between two visits (95% confidence interval [CI]) of central SER values obtained by open-field autorefractor and retinoscope was 0.21 D (95% CI, 0.10–0.31) and 0.30 D (95% CI, 0.15–0.45), respectively

Table 2. Comparison of Mean Difference (95% LoA) of Central 0° and Peripheral Refractive Error Values Between Two Peripheral Retinoscopy Techniques Open-field Autorefractor, Performed by Junior Examiners 1 and 2

		Mean Difference (95% LoA)					
		Spherical Equivalent (D)		Sphere (D)		Cylinder (D)	
Eccentricity	Condition	Junior Examiner 1	Junior Examiner 2	Junior Examiner 1	Junior Examiner 2	Junior Examiner 1	Junior Examiner 2
Central 0°	OFAR vs. CR	0.09 (−0.49 to +0.67)	−0.10 (−1.02 to +0.82)	0.18* (−0.41 to +0.77)	0.05 (−0.83 to +0.94)	−0.18 (−0.86 to +0.50)	−0.30* (−1.00 to +0.39)
Temporal 22°	OFAR vs. P−ARC	−0.10 (−1.46 to +1.26)	−0.50 ± 0.21* (−2.01 to 1.22)	0.00 (−1.39 to +1.39)	−0.29 (−1.62 to +1.04)	−0.20 (−1.16 to +0.77)	−0.43* (−2.08 to +1.22)
	OFAR vs. ER	−0.08 (−1.24 to +1.08)	−0.33 (−1.53 to +0.86)	−0.18 (−1.53 to +1.17)	−0.41* (−1.64 to +0.81)	0.20 (−1.19 to +1.58)	0.16 (−1.59 to +1.91)
	P−ARC vs. ER	0.02 (−1.22 to +1.26)	0.17 (−0.58 to +0.92)	−0.18 (−1.71 to +1.35)	0.13 (−0.76 to +0.51)	0.39 (0.96 to +1.75)	0.59* (−0.64 to +1.81)
Nasal 22°	OFAR vs. P−ARC	−0.18 (−1.55 to +1.19)	−0.38 (−1.92 to +1.16)	−0.09 (−1.60 to +1.42)	−0.16 (−1.66 to +1.34)	−0.18 (−1.78 to +1.42)	−0.45 (−2.21 to +1.45)
	OFAR vs. ER	0.10 (−0.81 to +1.01)	−0.30 ± 0.19 (−1.68 to +1.07)	0.23 (−0.85 to +1.31)	−0.14 (−1.46 to +1.17)	−0.27 (−1.74 to +1.20)	−0.32 (−2.01 to +1.37)
	P−ARC vs. ER	−0.28 (−0.88 to +1.43)	0.08 (−0.78 to +0.94)	0.32 (−0.89 to +1.53)	0.02 (−0.57 to +0.61)	+0.09 (−1.00 to +0.82)	0.13 (−0.81 to +1.06)

CR, central retinoscopy; ER, eye rotation; OFAR, open-field autorefractor.

*Indicates a significant difference between the two techniques. *P* value of <0.05 was considered as statistically significance.

(Supplementary Table S2). Mean difference for peripheral SER (T22°and N22°) between two visits obtained with open-field autorefractor was 0.16 D (95% CI, 0.08–0.24) (paired *t* test; $P = 0.63$) and P-ARC 0.41 (95% CI, 0.20, 0.61) ($P = 0.85$). However, the eye rotation technique exhibited a significant variability between two visits, with a mean difference 95% CI of 0.36 D (95% CI, 0.18–0.54; $P = 0.02$). The central SER and sphere values exhibited excellent repeatability for both the open-field autorefractor (ICC, 0.98 [95% CI, 0.94–0.99]; ICC, 0.98 [95% CI, 0.95–0.99]) and the retinoscopy (ICC, 0.95 [95% CI, 0.85–0.98]; ICC, 0.96 [95% CI, 0.90–0.99]). A similar trend was observed for peripheral refraction across all the techniques in both eccentricities.

Agreement With Two Junior Examiners ($n = 14$)

The mean difference ±95% LoA for central SE values obtained using central retinoscopy were comparable with the open-field autorefractor values from junior examiners 1 (+0.09 D ± 0.58 D; $P = 0.28$) and 2 (−0.10 D ± 0.92 D; $P = 0.44$). As shown in Table 2, there were no significant differences ($P \geq 0.06$) in peripheral SER values obtained by the junior examiners using P-ARC or eye rotation technique compared with the open-field autorefractor. However, T22° values obtained by junior examiner 2 using P-ARC were the exception ($P = 0.03$).

Identification of Relative Peripheral Refractive Error Patterns

In comparison with the open-field autorefractor, both experienced and junior examiners were able to efficiently identify the pattern of RPH in most participants (77%) along the temporal and nasal 22°. One-way analysis of variance revealed no significant variation in the relative peripheral SER values of the open-field autorefractor, P-ARC, and eye rotation techniques for temporal 22°, $F_{(2,149)} = 0.95$; $P = 0.39$, and nasal 22° eccentricities, $F_{(2,149)} = 1.36$; $P = 0.26$. A similar nonsignificant trend was observed for myopes in all three techniques for temporal 22°, $F_{(2,86)} = 1.07$; $P = 0.35$, and nasal 22°, $F_{(2,86)} = 1.98$; $P = 0.15$.

Discussion

This study compared two peripheral refraction techniques using a retinoscope (P-ARC and eye rotation) against an objective measure of peripheral refraction (open-field autorefractor). The findings indicated that the differences between the two retinoscopy techniques and the open-field autorefractor at both eccentricities were comparable.

On comparing the central refractive error values between retinoscopy and open-field autorefractor, a mean difference ±95% LoA of 0.29 D ± 0.83 D akin to the previous report in the younger age group (mean difference ± standard deviation, 0.29 ± 0.39 D, 6–17 years).[45] The differences in the working principles and wavelengths used[46] probably reflect the variation between the two techniques.[47–49] A slightly larger mean difference ±95% LoA was observed for peripheral refractive error values in T22° (P-ARC: 0.11 D ± 1.20 D; eye rotation: +0.30 D ± 1.26 D) and N22° (P-ARC: 0.13 D ± 1.1 6D; eye rotation: +0.14 D ± 1.16 D). The peripheral SER values obtained with the retinoscope using P-ARC were similar to the open-field autorefractor at both temporal 22° and nasal 22°. However, a significant difference was observed with the eye rotation technique in the temporal 22°.

The mean difference in SER between the open-field autorefractor and the two peripheral retinoscopy techniques ranged from +0.14 D to +0.30 D (temporal 22° and nasal 22°). A similar difference was reported by Lundström et al. at temporal 20° eccentricity.[20] In their study, the mean difference (SER) between peripheral retinoscopy and aberrometer was −0.77 D, and the difference between the peripheral retinoscopy and photorefraction was −0.25 D. They also observed that peripheral refractive errors become more pronounced at higher eccentricities, potentially due to increased astigmatism.[20] This notion was further supported by Lotmar,[50] who reported a good agreement between measured and theoretical model values of ≤30° eccentricities. However, no study has directly compared noncycloplegic peripheral refraction values obtained using a retinoscope and an open-field autorefractor, making it difficult to compare our findings.

The repeatability of the spherical component was similar across all techniques, which could be because of the noncycloplegic/nonmydriatic nature of the measurements or the inclusion of young adults with stable accommodation. The peripheral SER (T22°and N22°) values obtained with open-field and retinoscopy with P-ARC in both visits were comparable, with open-field exhibiting greater repeatability. The cylindrical components obtained using P-ARC at both eccentricities were similar to the open-field autorefractor. The poor repeatability of the cylindrical values from peripheral retinoscopy using eye rotation might be because of variable fixation while performing the retinoscopy between two visits caused by the rotation of the eye to view the eccentric target.

A recent study conducted by Leighton et al.[33] reported that a relative peripheral hyperopic refractive error in the nasal retina led to an increased risk of axial elongation. Zhang et al.[32] investigated the influence of baseline relative peripheral refraction profile on the efficacy of defocus incorporated multiple segments (DIMS) spectacle in controlling myopia progression in Chinese myopic children. The study reported that children with RPH benefit more from DIMS spectacles than those with RPM in terms of controlling refractive error progression and axial elongation.[32] Moreover, the myopia control effects of DIMS were within 20° eccentricities on the nasal retina.[32] This finding aligns with earlier reports in rhesus monkeys where defocus beyond approximately 20° from the fovea did not consistently alter the central 0° refractive development.[51] There has been an increased interest in the use of peripheral refraction in clinical practice, especially in myopia management, where clinicians need to mitigate the potential risk factors that can influence the efficacy of myopia control treatment. Taking this evidence into consideration, estimating that peripheral refraction of approximately 20° is useful for clinicians to personalize their plan of treatment by prescribing peripheral defocus myopia control lenses (spectacle or contact lens) to individuals with RPH. As previously noted, the retinoscope is a commonly used instrument in primary eye care services.[52] Therefore, using it to perform peripheral refraction is a viable and cost-effective option for eye care practitioners to estimate an individual's relative peripheral refractive error profile. Retinoscope with P-ARC was able to identify the pattern of RPH either in nasal 22° or temporal 22° in most of the participants (77%). The success-to-failure ratio of 3.3:1.0 can be explained by two possible reasons, and it might not accurately represent the effectiveness of peripheral refraction using P-ARC in identifying RPH. First, this may be due to the low degree of myopia (mean ± SD, −2.34 D ±1.46 D for myopes) observed in the majority of participants. Recent studies have indicated that RPH is evident in individuals with myopia of >−2.50 D (moderate to high myopia) compared with those with low myopia.[5,53] Second, these differences could be linked to ethnicity, as RPH is shown to be prominent in East Asian eyes compared with non–East Asian eyes.[54]

This study had a few strengths. First, two masked examiners performed peripheral refraction using two retinoscopy techniques on the same individual simultaneously, within a gap of approximately 2 to 5 minutes. The examiners might remember refractive error values obtained from the previous techniques, which might lead to intraexaminer bias. To minimize this bias, we randomly selected the values obtained by each masked examiner for the retinoscopy techniques of a participant and later combined them. Second, all the peripheral refraction techniques were performed on the same day to avoid any unknown factors that might influence the outcomes of the study.[55] The limitation of this study was that it recruited young adults who generally have good fixation stability and can accurately follow the examiner's instructions. Further research is required to compare the agreement between noncycloplegic peripheral retinoscopy and open-field autorefractor in children who are expected to have more variable fixation[56] and are less cooperative.[57] Second, we evaluated the repeatability of the three techniques in a subset of participants. Given the study's requirements, participants were required to attend multiple visits. However, the majority of our participants were interns and students who were unable to return for additional visits either because they had completed their internships or had left the institute. Last, the peripheral refraction was performed at two eccentric points (T22°and N22°), which may not provide a comprehensive representation of the peripheral refractive profile across the entire retina and can be relevant in a context of research. However, in any clinical setting (both private and hospital-based settings), the ability to perform off-axis retinoscopy in at least two points with a cost-effective and easy-to-use fixation device holds a significant value. This capability would assist clinicians in at least identifying whether the individual exhibits peripheral hyperopia or not, thereby allowing a tailored approach when prescribing peripheral defocus spectacles.

Retinoscope with P-ARC can be used effectively for peripheral refraction. It requires less space compared with eye rotation (to fixate on the distant target) and does not require participants to fixate on the eccentric targets. It can act as a guide and enable eye care practitioners to ensure an accurate fixation angle with a stationary eye and head position. The outcomes of this study are important in the present scenario because most of the optical myopia control treatment is based upon the peripheral refractive error profile in individuals with myopia.

Acknowledgments

The authors thank Megha Antony and Lakshmi Kousalya Akkina for collecting data as junior examiners, for their support in conducting the study.

Supported by the Hyderabad Eye Research Foundation, LV Prasad Eye Institute, India.

Indian patent application has been filed for the design of the ancillary retinoscope component - E-137/2880/2023/CHE.

Disclosure: **S. Thakur**, (P); **R. Maldoddi**, None; **M. Vangipuram**, (P); **M. Kalivemula**, (P); **S.N.S.H. Ch**, (P); **A. Karthikesh**, None; **P.K. Verkicharla**, (P)

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