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# Comparison of smartphone application-based visual acuity with traditional visual acuity chart for use in tele-ophthalmology

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**Abstract:**

**PURPOSE:** The aim of this study was to compare the visual acuity (VA) by smartphone-based applications – EyeChart and the Peek Acuity to the standard Snellen chart to explore the possibility of using them as an alternative in tele-ophthalmology in the current COVID-19 pandemic.

**MATERIALS AND METHODS:** An analytical type of observational study was done on 360 eyes of 184 patients above 18 years of age. Patients with VA <6/60 and gross ocular pathology were excluded from the study. VA measured by these three methods was converted to logMAR scale for ease of statistical analysis. One-way analysis of variance with post Tukey HSD was used to compare the VA measured by these three methods.

**RESULTS:** There was no statistically significant difference between VA measured using the smartphone-based apps (EyeChart and Peek Acuity) and the Snellen chart ($F = 2.5411$, $P = 0.7925$) in 360 eyes assessed. VA measured by Peek Acuity ($P = 0.5225$) was more comparable to Snellen chart than EyeChart ($P = 0.4730$). Intraclass correlation coefficient (ICC) demonstrated a strong positive correlation for EyeChart (ICC: 0.982, $P < 0.001$) and Peek Acuity (ICC: 0.980, $P < 0.001$) with Snellen chart. A Bland–Altman difference plot showed good limits of agreement for both EyeChart and Peek Acuity with Snellen chart. In subgroup analysis, VA measured by Peek Acuity was not statistically different from Snellen in any subgroups, but in EyeChart, it was statistically different in emmetropes.

**CONCLUSION:** VA measured by smartphone apps (EyeChart and Peek Acuity) was comparable with traditional Snellen chart and can be used as an effective, reliable, and feasible alternative to assess VA in tele-ophthalmology.

**Keywords:**

EyeChart, Peek Acuity, smartphone, tele-ophthalmology, visual acuity

## Introduction

Visual acuity (VA) measurement is the most primary procedure in any ophthalmic practice. It evaluates the overall function of the visual system. VA has a very important role in the diagnostic and prognostic evaluation of any ocular pathology.[1] Various methods are used to measure VA, out of which Snellen chart and Early Treatment Diabetic Retinopathy Study (ETDRS) chart are well recognized. Snellen chart is commonly used in normal clinical practice as it is simple, familiar, less time-consuming, and cost-effective.[2]

Traditionally, VA is assessed by a trained technician or a health-care professional at standard conditions in a clinic or special setup. For this reason, physical attendance becomes a must to get the VA assessment done.[3,4] In these COVID pandemic times, social distancing, quarantine, travel restrictions, and other rules and regulations



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implemented by the government to limit the spread of COVID-19 infection had adversely affected the patient's accessibility to hospital care.[5-7] Along with it, the fear of contracting infection has reduced the number of patients seeking the hospital care for nonemergency purposes resulting in an interruption of ongoing medical treatment or patients presenting at the late stage of a disease which ultimately leads to progression of the disease and increases the treatment cost and ocular morbidity.[8]

Telemedicine was initially started as an alternative to give medical assistance either in rural areas or other unreachable populations, focusing on chronic disease management.[9,10] Over time, telemedicine has evolved and had proved to be useful in medical consultations in the time of epidemic and pandemics.[11] During the current COVID-19 pandemic, the number of tele-health visits increased several folds taking tele-ophthalmology to a new level.[12] Tele-ophthalmology helps in promoting clinical safety of both patients and consultants by treating patients in remote locations during epidemic and pandemics.[13] Despite these benefits, eye care clinicians face several obstacles in implementing tele-ophthalmology. The greatest difficulty has been finding a reliable way to measure the VA of patients remotely.[14] Many mobile applications (apps) are available to measure VA by a smartphone.[15] A few individual studies conducted found that VA measured by smartphone apps is comparable to standard chart. However, most of the studies are done in volunteers and their effectiveness in an actual patient is inconclusive.[16-22] The reliability and effectiveness of most of these acuity tools in standard clinical testing conditions are lacking.[23]

For VA assessment by smartphone-based apps to be successfully used in tele-ophthalmology, it should be free, reliable, and easily downloadable and have simple instructions to measure the VA. EyeChart in iOS platform and Peek Acuity in Android platform were found to satisfy the requirements. Hence, we compared them with standard Snellen chart used in clinical setting to explore the possibility of using them as alternative to assess VA in tele-ophthalmology in our setup.

## Materials and Methods

The current study was an analytical type of observational study done on 360 eyes of 184 patients above 18 years of age attending the outpatient department of ophthalmology in a tertiary care center in South India from August to October 2021. Institutional ethics committee approval was taken (approval date: 16-07-2021). The study protocol was strictly adherent to tenants of the Declaration of Helsinki. Assuming all three methods under the study are equal, using $P$ as 33.33% and q as 66.66% with error of 5%, sample size was calculated to be 356 using the formula $4pq/l^2$ which was approximated to be 360. Simple random sampling technique was used to select the required number of participants. People above the age of 18 years and who were willing to participate were included in the study. Patients with emmetropia, refractive error, cataract, and pseudophakia with VA better than 6/60 were included. Patients with gross ocular pathology and VA <6/60 were excluded from the study. Informed consent was taken from all participants after explaining in detail the aims, objectives, and procedures involved in the study.

Unaided VA of the selected participants was assessed on self-illuminated Snellen chart at a distance of 6 m and by applications (EyeChart and Peek Acuity) installed on the smartphone. Order of testing was random. Tumbling "E" optotype was used in all to give uniform results as Peek Acuity contains only tumbling E chart.

For testing VA, free version of Peek Acuity app (version 3.5.13) by peek vision was directly downloaded from Google Play Store, and was installed on Samsung Galaxy M30 (Android version 10). On opening the app for the first time, an optotype will be provided for manual calibration, which should be confirmed after physically measuring the width and height of "E" optotype using a ruler. The settings option provides provisions for selecting the distance (2 m and 3 m) and units (logMAR, Snellen metric, and Snellen imperial). All the instructions given by the app were followed. Brightness was set at maximum within the app. We measured VA at a distance of 3 m. It is an ETDRS-based chart. The patient points in the direction of the arms of the letter "E." The examiner records the result by swiping across the same direction as mentioned by the patient. The swiping helps to record the VA of patient without examiner seeing optotype, thus avoiding the patient taking clue from examiners facial expressiom.

The free version of EyeChart application by Dok LLC (version 2.3) for the purpose of the study was installed on an iPhone SE (iOS version 14.5.1). Instruction given by the application was followed. The device was held at eye level and brightness was set to maximum. Free version provides a randomizable form of Snellen chart, tumbling E chart, Sloan letter chart, and Landolt C chart. Pro version gives extra edge of randomizable near vision chart, line isolation, Amsler grid, and single optotype charts. In our current study, we used free tumbling E chart which measured the VA at a distance of 1.2 m. This is a Snellen-based chart.

Free version of both apps was used as they were sufficient to measure distant VA. All the three tests were done by a single examiner in the same room and lighting condition. VA was assessed monocularly with other eyes occluded and each test was repeated three times. Median value was selected and noted for further analysis.

VA measured on these charts was converted to logMAR units for ease of statistical analysis.[24] Statistical analysis was done using IBM SPSS statistics software version 27 (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, version 27.0. Armonk, NY, USA: IBM Corp).[25] One-way analysis of variance (ANOVA) test was done to compare the difference in VA between the three methods. Post Tukey HSD test was done for pairwise comparison. Intraclass correlation coefficient (ICC) values were done for analyzing the correlation. The Bland–Altman plots were used to evaluate the level of agreement between the abovementioned methods.

## Results

Three hundred and sixty eyes of 184 patients were assessed (one eye of 8 patients were excluded because of VA <6/60 or gross ocular pathology). The mean age was 39.59 (±15.66 SD) (range: 18–86), and of them, 50.5% were females. About 68.5% had education qualification beyond matriculation. In our study, majority of the patients were emmetropic accounting for 60% of study population. The clinical and visual profiles of the eyes in the study are given in Figure 1.

The median VA measured using Snellen chart was 0.00 logMAR (interquartile range [IQR]: 0.0, 0.3), whereas with EyeChart, it was 0.0 logMAR (IQR: 0.0, 0.3), and with Peek Acuity, it was 0.0 logMAR (IQR: 0.0, 0.3). The mean VA measured by Snellen chart was 0.18 (±0.28,) EyeChart was 0.21 (±0.3), and Peek Acuity was 0.16 (±0.26). In eyes with refractive error, the mean VA for Snellen chart was 0.36 (±0.25), EyeChart was 0.39 (±0.28), and Peek Acuity was 0.31 (±0.25). In eyes with cataract, the mean VA for Snellen chart was 0.71 (±0.18), EyeChart was 0.75 (±0.19), and Peek Acuity was 0.64 (±0.29). Assessment of normality of data was done by Shapiro–Wilk test, and equality of variance was done by Levene test.[26] Priori power of test was assessed for all data. Once criteria are met, one-way ANOVA test with post Tukey HSD/Tukey-Kramer test was done to compare the VA measured using three methods. The results of the same are given in Table 1

There was no statistically significant difference in VA measured using EyeChart, Snellen, and Peek Acuity ($F = 2.5411$, $P = 0.0793$). Post Tukey HSD test showed that VA by Peek Acuity ($P = 0.5225$) is slightly more comparable to Snellen chart than of EyeChart ($P = 0.4731$). Calculations made for right and left eyes separately gave similar results. In eyes with refractive error, the difference in VA measured by these methods was not statistically significant. Post Tukey test revealed that VA measured by EyeChart ($P = 0.6533$) is more comparable to Snellen chart than Peek Acuity ($P = 0.3408$) in eyes with refractive error. In cataract, the difference in VA measured by three methods was statistically significant ($F = 3.3273$, $P = 0.0397$). Post Tukey HSD test done for pairwise comparison showed that there is no statistically significant difference in VA measured by EyeChart ($P = 0.6327$) and Peek Acuity ($P = 0.2367$) in comparison with Snellen in cataract patients, whereas difference was observed between EyeChart and Peek Acuity ($P = 0.0397$). As emmetrope data do not satisfy

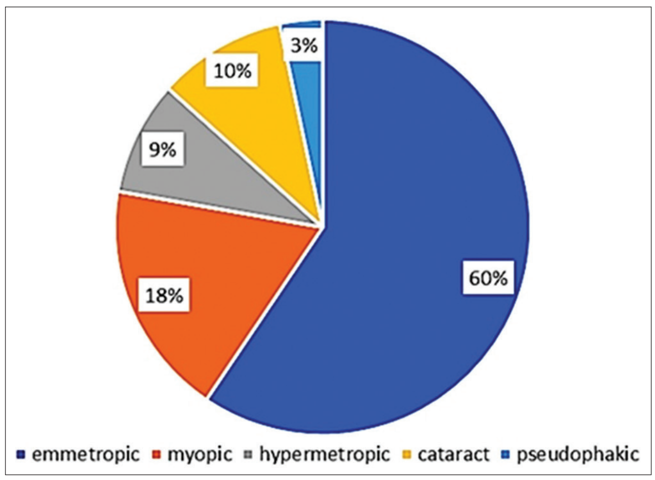


**Figure 1:** Clinical and visual profile of the eyes in the study

**Table 1: Summary of statistical analysis for comparing EyeChart, Peek Acuity, and Snellen chart**

| | DF (across group, with in group) | *F* statistic | *P* | Tukey HSD/Tukey-Kramer *P* | | |
|---|---|---|---|---|---|---|
| | | | | E-S | P-S | E-P |
| **One-way ANOVA with post Turkey HSD test** | | | | | | |
| Total (*n*=360) | 2,1077 | 2.5411 | 0.0793 | 0.4731 | 0.5225 | 0.0629 |
| Right eye (*n*=183) | 2,546 | 1.3372 | 0.2634 | 0.6866 | 0.6978 | 0.2315 |
| Left eye (*n*=177) | 2,528 | 1.2099 | 0.2990 | 0.6860 | 0.7477 | 0.2665 |
| Refractive error (*n*=98) | 2,201 | 2.6511 | 0.0723 | 0.6533 | 0.3408 | 0.0598 |
| Cataract (*n*=36) | 2,105 | 3.3272 | 0.0397 | 0.6327 | 0.2367 | 0.0397 |
| **Kruskal–Wallis test with post Tukey HSD test** | | | | | | |
| Emmetropes (*n*=214) | 2,693 | H=75.2832 | <0.0 | <0.05 (6.033e-11) | 0.1568 | <0.05 (1.281e-9) |

DF=Degree of freedom, E-S=EyeChart versus Snellen, P-S=Peek Acuity versus Snellen, E-P=EyeChart versus Peek Acuity, ANOVA=Analysis of variance, HSD=Honest significant difference the criteria for one-way ANOVA, nonparametric Kruskal–Wallis test was done to assess the statistical significance between the three methods. A statistically significant difference was found in VA measured by three methods (H = 40.9019, $P < 0.01$). Post Tukey test found that there is no significant difference in VA measured by Peek Acuity ($P = 0.1568$) and Snellen chart in emmetropes, but there is a statistically significant difference between EyeChart–Snellen chart ($P < 0.05$) and EyeChart–Peek Acuity ($P < 0.05$).

The summary of median difference and range is given in Table 2. The median difference in VA between EyeChart and Peek Acuity with Snellen chart was 0.0 logMAR. It was 0.0 logMAR for emmetropes and eyes with refractive error and cataract. Difference between EyeChart and Snellen chart when present was mostly positive, while difference between Peek Acuity and Snellen chart when present was negative. The percentage of patients showing difference in VA increases in eyes with refractive error and cataract. The details of the trend of difference in VA measured by EyeChart and Peek Acuity with Snellen chart are given in Figure 2.

ICC values for EyeChart–Snellen and Peek Acuity–Snellen are summarized in Table 3. It showed that a strong positive correlation exists between EyeChart and Snellen chart (ICC: 0.982, $P < 0.001$) and between Peek Acuity and Snellen chart (ICC: 0.980, $P < 0.001$). ICC done separately for right and left eyes gave similar results. ICC values between EyeChart and Snellen chart in eyes with refractive error and cataract also showed a strong correlation. Comparison between Peek Acuity and Snellen chart also showed a strong correlation in eyes with refractive error and cataract. Intraclass correlation for emmetropes was not calculated as one variable was constant (Snellen VA = 0 was considered emmetropes). The correlation plots are given in Figure 3.

The mean VA difference, standard deviation, and 95% limit of agreement (LoA) between EyeChart and Peek Acuity with Snellen chart are given in Table 4. The Bland–Altman plots showing the level of agreement between the EyeChart app and the Snellen chart and between the Peek Acuity app and the Snellen chart are shown in Figure 4. The trend of mean difference is given in Figure 5. LoA with 95% confidence interval (CI) (±1.96 standard deviation) between EyeChart (0.1940) and Peek Acuity (0.1905) with Snellen chart was in agreeable range. Comparison of limit of agreement of EyeChart and Peek Acuity in different subgroups with Snellen chart is given in [Figure 6].

**Table 2: Median difference with interquartile range and range**

| | Median difference in logMAR (IQR) | Range (minimum–maximum) |
|---|---|---|
| **EyeChart versus Snellen** | | |
| Total | 0.0 (0.0-0.1) | 0.4 (−0.2-0.2) |
| Emmetropes | 0.0 (0.0-0.0) | 0.1 (0.0-0.1) |
| Refractive error | 0.0 (0.0-0.1) | 0.4 (−0.2-0.2) |
| Cataract | 0.0 (0.0-0.1) | 0.3 (−0.1-0.2) |
| **Peek Acuity versus Snellen** | | |
| Total | 0.0 (0.0-0.1) | 0.3 (−0.2-0.1) |
| Emmetropes | 0.0 (0.0.0.0) | 0.1 (0.0-0.1) |
| Refractive error | 0.0 (−0.1-0.0) | 0.3 (−0.2-0.1) |
| Cataract | 0.0 (−0.1-0.0) | 0.4 (−0.2-0.2) |

IQR=Interquartile range

## Discussion

VA is a highly complex function. Assessment of VA is affected by a huge list of physical and physiological factors such as pupil size, accommodation, illumination, and chart characteristics. Several units and notational systems used in VA measurement make it more complicated. In addition to these factors, VA assessment using smartphones is influenced by factors such as

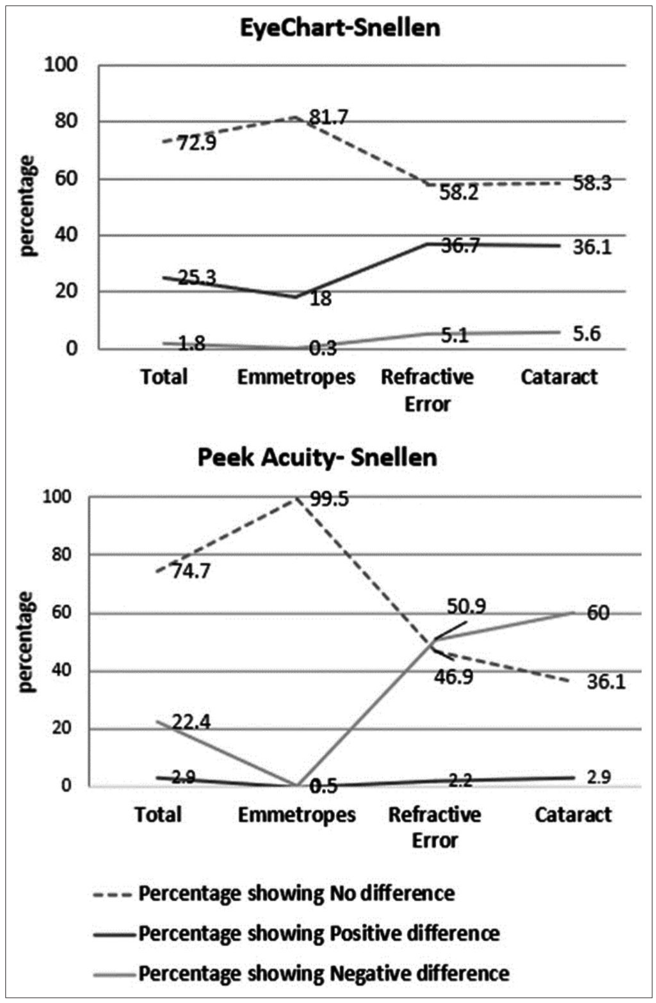


**Figure 2:** Trend of difference in visual acuity measured by EyeChart and Peek Acuity with Snellen chart

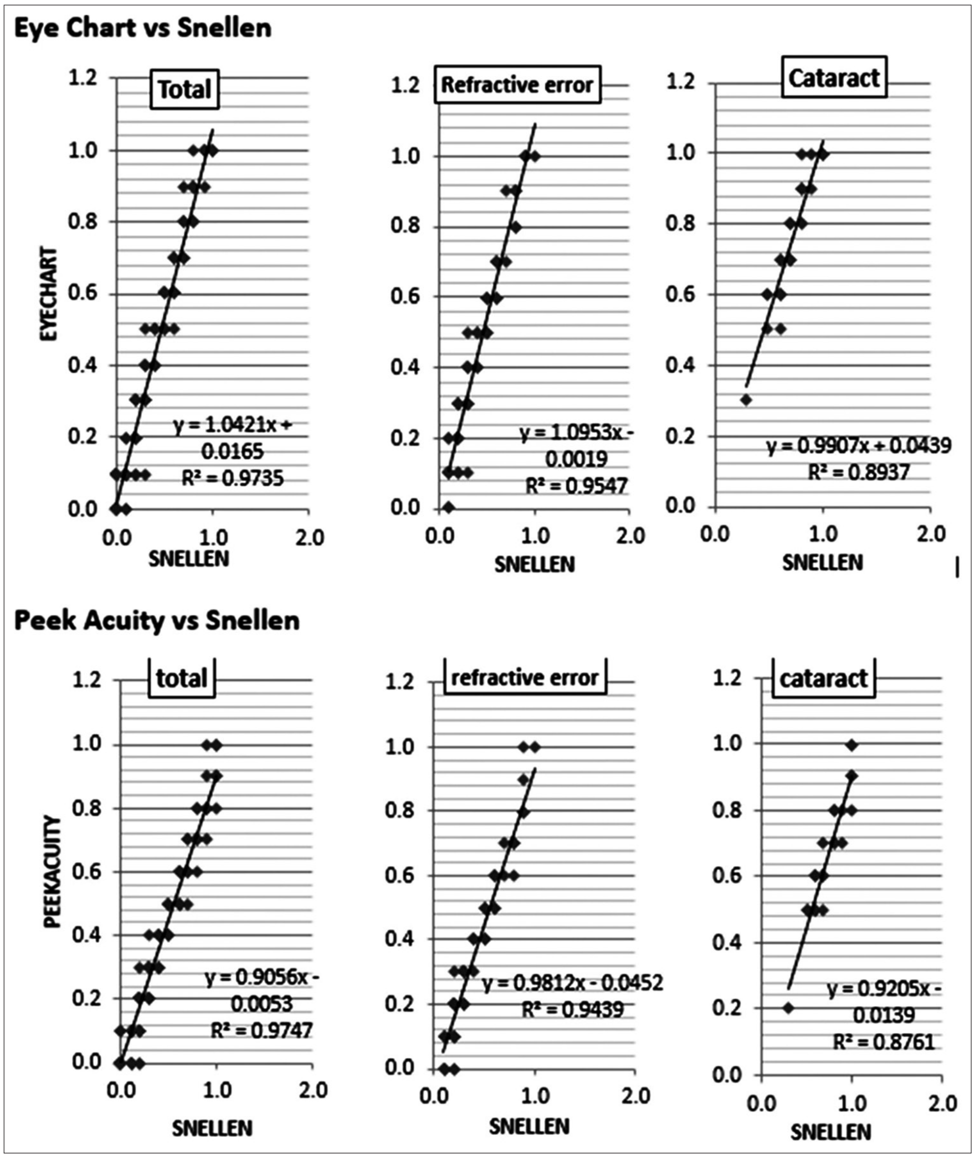


**Figure 3:** Correlation between logMAR visual acuity measured by EyeChart and Peek Acuity with Snellen. Correlation in subgroups – refractive error and cataract – is also given. The black solid line represents linear regression

**Table 3: Intraclass correlation coefficient with 95% confidence interval and significance**

| | Intraclass correlation coefficient | 95% CI | | Significant (*P*) |
|---|---|---|---|---|
| | | Lower bound | Upper bound | |
| **EyeChart versus Snellen** | | | | |
| Total | 0.982 | 0.966 | 0.989 | <0.001 |
| Right eye | 0.982 | 0.965 | 0.989 | <0.001 |
| Left eye | 0.981 | 0.964 | 0.989 | <0.001 |
| Refractive errors | 0.964 | 0.924 | 0.980 | <0.001 |
| Cataract | 0.926 | 0.791 | 0.968 | <0.001 |
| **Peek Acuity versus Snellen** | | | | |
| Total | 0.980 | 0.965 | 0.988 | <0.001 |
| Right eye | 0.981 | 0.962 | 0.989 | <0.001 |
| Left eye | 0.980 | 0.965 | 0.987 | <0.001 |
| Refractive errors | 0.951 | 0.764 | 0.981 | <0.001 |
| Cataract | 0.864 | 0.232 | 0.958 | <0.001 |

CI=Confidence interval

screen size, aspect ratio, pixel density, and screen brightness.[27-30]

On comparing the VA in all the participant eyes using these three methods (standard Snellen chart, smartphone applications – EyeChart in iOS platform and Peek Acuity in Android platform), there was no statistically significant difference observed. Literature on similar comparative studies, comparing these three methods, was found to be lacking. ICC values for VA measured by smartphone application – EyeChart and Peek Acuity – showed a strong correlation with Snellen chart. Subgroup analysis for eyes with refractive error and cataract also yielded a strong correlation. EyeChart and Peek Acuity apps show good LoA with Snellen chart as depicted by Bland–Altman plot (95% LoA). LoA (95% CI) is wider in eyes with refractive error and cataract

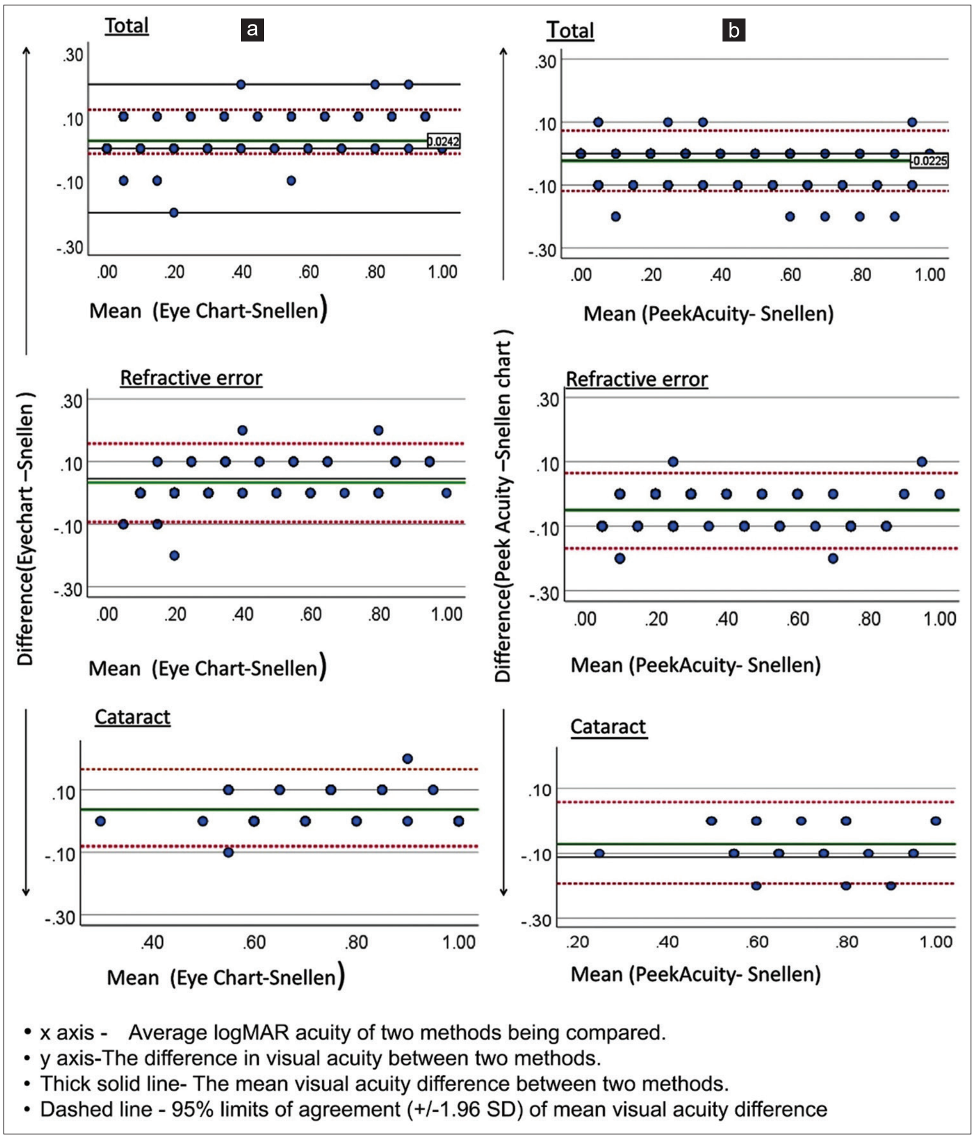


**Figure 4:** Bland–Altman plot for 95% limits of agreement between visual acuity in logMAR tested with EyeChart and Snellen chart (a) and Peek Acuity and Snellen (b)

**Table 4: Mean difference with standard deviation and 95% limit of agreement**

| | Mean difference in VA | SD | 95% LoA | |
|---|---|---|---|---|
| | | | Upper bound | Lower bound |
| **EyeChart–Snellen** | | | | |
| Total | 0.0242 | 0.0495 | 0.1212 | –0.0728 |
| Right eye | 0.0251 | 0.0516 | 0.1262 | –0.0760 |
| Left eye | 0.0232 | 0.0474 | 0.1164 | –0.0697 |
| Refractive errors | 0.0327 | 0.0639 | 0.1579 | –0.0925 |
| Cataract | 0.0371 | 0.0598 | 0.1543 | –0.0801 |
| **Peek Acuity–Snellen** | | | | |
| Total | –0.0225 | 0.0486 | 0.0728 | –0.1177 |
| Right eye | –0.0246 | 0.0502 | 0.0737 | –0.1230 |
| Left eye | –0.0203 | 0.0469 | 0.0716 | –0.1122 |
| Refractive errors | –0.0520 | 0.0596 | 0.0681 | –0.1688 |
| Cataract | –0.0714 | 0.0622 | 0.0505 | –0.2113 |

SD=Standard deviation, VA=Visual acuity, LoA=Limit of agreement

compared to normal emmetropes, implying a decrease in consistency in VA measurement in eyes with reduced vision. Pairwise comparison of VA of all participant eyes showed no statistically significant difference either between EyeChart and Snellen or between Peek Acuity and Snellen chart.

Pairwise comparison of VA between Peek Acuity and Snellen chart did not show any statistical significance even in emmetropes, eyes with refractive error, or in cataractous eyes. The mean difference of Peek Acuity measured at 3 m compared to standard Snellen chart at 6 m was – 0.02 (95% CI: 0.07, –0.11) in our study. Around 75% of the total sample showed a median difference of 0.0 logMAR which is promising. The percentage of patients showing no difference in VA measured by Peek Acuity and Snellen chart showed a steep decrease

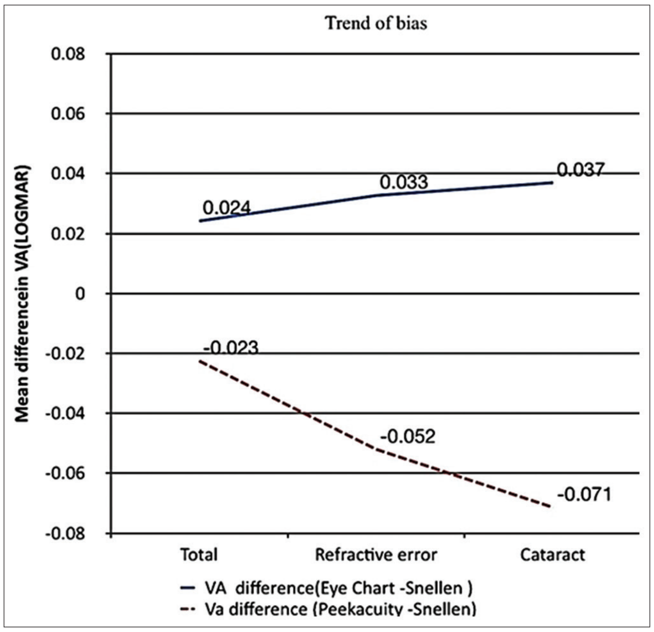


Figure 5: Trend of bias (mean difference)

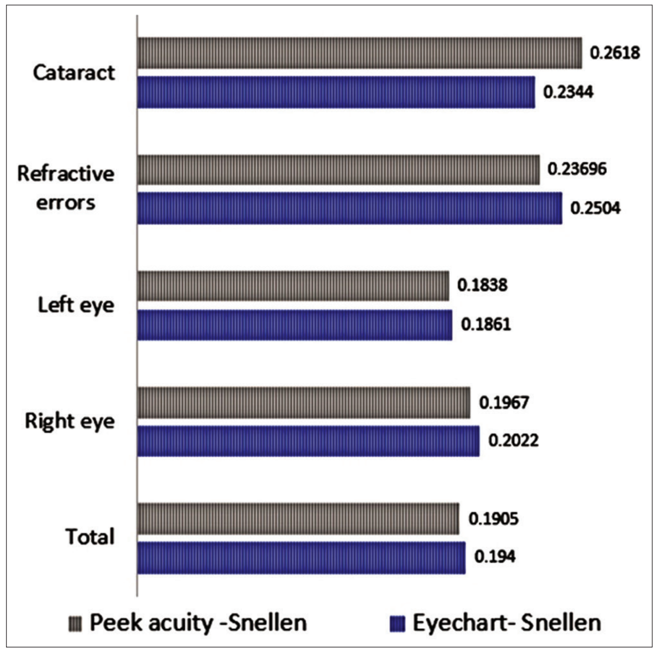


Figure 6: 95% limit of agreement in different groups

from 99% in emmetropic eyes to below 50% in eyes with reduced vision (refractive error – 46.9%, cataract – 37%). Mean difference in VA measured between Peek Acuity and Snellen chart shows an increasing trend with decrease in VA indicating increasing negative bias in patients with reduced vision. Even when the difference is present, it was mostly around 0.1 logMAR which is clinically acceptable. All these points indicate that VA observed by Peek Acuity is slightly overestimated in comparison to Snellen, especially in patients with reduced vision (around 50% giving better VA than Snellen). This is consistent with the finding of a study done by Basitarsus *et al*. in Kenyan population. The mean difference in Peek Acuity at 2 m and reduced Snellen chart at 3 m was 0.08 logMAR (95% CI: 0.06–0.10) in their study.[18]

Pairwise comparison showed that there is no statistically significant difference in VA measured between EyeChart and Snellen chart. In subgroup analysis, VA measured by EyeChart in emmetropes was statistically different from the Snellen chart, but in eyes with refractive error and cataract, the difference in VA was not statistically significant. The median difference was 0.0 logMAR for 72.9% of the participants. The percentage of patients showing no difference decreased with decrease in vision (emmetropes 81.7% to around 60% in both eyes with refractive error and cataract subgroup), but this is not as steep as in Peek Acuity. Mean difference between the EyeChart and Snellen chart is positive, and this positive bias increases with decrease in vision. All these points indicate that EyeChart slightly underestimates VA compared Snellen chart, and this tendency increases in patients with reduced vision. This difference mainly lies within 0.1 logMAR barring few outliers. These findings are consistent with a study done by Ansell k *et al*., who studied 24 normal participants and found that there is a statistically significant difference between EyeChart and Snellen chart. The mean difference in our study was 0.0242 (±0.04) which was less than their study 0.04 (±0.05). They also found that EyeChart gave slightly poorer VA compared to Snellen chart.[20]

In emmetropes, VA measured by Peek Acuity is more comparable to Snellen than EyeChart. In eyes with refractive error and cataract, VA measured by EyeChart is closer to Snellen values than Peek Acuity. Previous studies have found that ETDRS chart shows better VA than Snellen chart and VA difference between Snellen and ETDRS is more in patients with worst vision. In worst vision range, the number of letters in each line is less. Missing or identifying a letter makes a significant change in VA (Kaiser P *et al*.).[24] Peek Acuity gives a similar result when compared with Snellen in our study, indicating that VA measurement by Peek Acuity is more similar to ETDRS chart. Increased difference in VA between Peek Acuity and Snellen chart in poorer vision like cataract and refractive error may be attributed to this. Difference between Snellen-based EyeChart and traditional Snellen chart may be due to accommodation factor that may come to play as testing distance is short in EyeChart (1.2 m) compared to Snellen chart (6 m). This is more obvious in refractive error patients, especially a hyperopic patient who uses accommodation in short distance to focus, whereas myopic cannot result in blurred vision. This increases with severity of condition which correlates with worsening of vision. Cataract also results in myopic or hyperopic shift depending on type of cataract. This may be the reason for increased VA difference in worst vision between EyeChart and Snellen chart. Increased scattering of light in cataract may also contribute to it. Furthermore, EyeChart was more comparable to the ETDRS chart than Snellen chart in a previous study. In our study, we selected cataract patients whose VA was better than or equal to 6/60 irrespective of type and grade of cataract. Hence, definite correlation between refractive change in cataract to increased difference cannot be assessed. Peek Acuity calibrates the optotype and presents a single optotype at a time which increases the accuracy of Peek Acuity app. Crowding phenomenon and accommodation factor may adversely affect the VA measurement by EyeChart.[31,32]

Tiraset N *et al*. compared the Rosenbaum near vision card and a smartphone-based VA test (EyeChart) against ETDRS chart. It concluded that VA measurements with the Near Chart and smartphone-based EyeChart application corresponded well to the standard ETDRS chart.[21] Satgunan *P et al*. studied VA in four tools, namely COMPlog, reduced Snellen near vision, Peek Acuity (Distance VA), and Smart Optometry (Near VA), and found them to be comparable.[22]

With recent advances in technology, irrespective of the economic and educational status, most people are well versed with smartphones. Each home will have at least one person who is well versed in using smartphone, especially younger generation. With proper instructions, comparable results with clinical VA assessment can be achieved.

Major advantage of our study over other studies is that it was done on patients attending the outpatient department. It also compares the VA difference in eyes with refractive error and cataract. Limitations of our study are that we did not include eyes with gross ocular pathologies and sample sizes for subgroup analysis were small. Further studies comparing VA assessed at home with apps to that of Snellen chart at clinic setting can be done. A study involving larger sample size and including eyes with various ocular pathologies is suggested.

## Conclusions

Distant VA assessed by smartphone-based applications, EyeChart in iOS and Peek Acuity in android platform showed comparable VA with Snellen chart which is widely used in clinical eye care settings in India. EyeChart slightly underestimates VA compared to Snellen chart, and this tendency increases with decrease in VA observed among eyes with refractive error and cataract, whereas Peek Acuity app slightly overestimates VA in comparison to Snellen chart, especially in eyes with reduced vision like refractive error and cataract. Even then, these differences are still comparable and within the acceptable range. Our study suggests that smartphone-based mobile apps, EyeChart and Peek Acuity, can be used as an effective, reliable, and feasible alternative to assess VA in tele-ophthalmology, especially during pandemic times.


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Nil.

### Conflicts of interest
The authors declare that there are no conflicts of interests of this paper.


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