Comparative Evaluation of the ETDRS Visual Acuity Chart and Arclight Cloth Chart (ARCchart) for Primary Eye Care in Resource-Limited Settings

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Abstract

This study compared the Arclight Cloth Chart (ARCchart) to the gold standard ETDRS chart for visual acuity (VA) measurement in 63 participants. The ARCchart showed a limit of agreement between −0.23 logMAR and 0.26 logMAR with ETDRS values. It demonstrated 93% sensitivity, 95% CI [86, 100] and 90% specificity, 95% CI [84, 97] when used to screen for VA worse than 0.20 logMAR. Despite its potential limitations as a tool to measure subtle changes in VA over time, the low-cost, portable cloth VA chart is a valuable alternative for measuring VA in resource poor settings.

Keywords: Visual acuity chart, low cost, logMAR

Introduction

Visual acuity (VA) measurement is typically performed using a cardboard or plastic letter chart mounted on a wall. It is crucial for identifying those with reduced vision, for detecting and monitoring change in VA after optical intervention and for monitoring eye conditions. Chart design advancements have allowed more accurate VA quantification with the current gold standard for research purposes being the Early Treatment of Diabetic Retinopathy Study (ETDRS) chart (Ferris et al., 1982; Rosser et al., 2004). This utilises a logMAR progression and controls for factors that affect accuracy such as letter crowding, contrast and legibility (Bailey & Lovie, 1976; Ferris et al., 1982).

ETDRS or other logMAR equivalent charts are now widely used in high resource settings. However, accessing these charts can be challenging in low- and middle-income countries (LMICs) where the burden of disease, and consequently the need, is greatest. Electronic versions are limited by the need for electricity and hardware such as a mobile phone or a screen attached to a computer, while printed ETDRS charts are bulky, expensive, and easily damaged.

The Arclight Cloth Chart (ARCchart) has been developed as a low cost, portable alternative to traditional VA tools in alignment with several strategic healthcare initiatives promoting integrated people-centred eye care (IPEC) in LMICs (see Figure 1). This innovative chart employs a modified logMAR format with a reduced number of letters per line and fewer lines of letters compared to traditional charts. Despite these adaptations, the ARCchart maintains a similar range of letter sizes as the ETDRS chart, testing from 1.0 to −0.2 logMAR with a 0.2 logMAR step between lines at 3 metres testing distance. Each line comprises three letters, except for the 1.0 line, which has two letters. Furthermore, the chart incorporates four different "Sloan" letters (H, O, V, Z) on one side and "Illiterate Es" on the other, enhancing its versatility. A notable feature of the ARCchart is that it is printed on high-quality 17×22 cm white cloth. This design allows the chart to be folded and stored within the Arclight direct ophthalmoscope case, serving as an important part of an affordable eye diagnostic set.

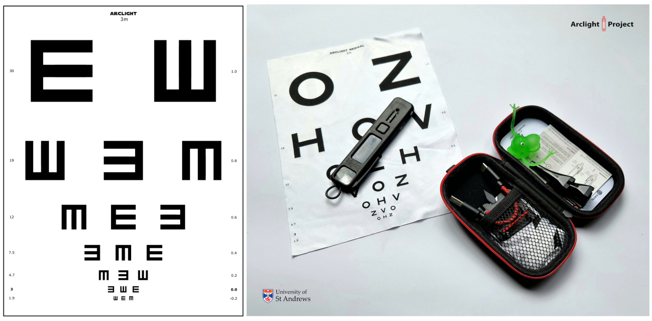

Figure 1: *ARCchart with "Illiterate Es" on one side and "Sloan" letters on the other as part of the Arclight Diagnostic Set. The chart is a 17×22 cm double-sided silk screen printed 80% polyester/20% polyamide microfibre cloth.*

While the ARCchart's novel design offers significant practical and cost advantages, the impact on accuracy of VA measurement remains uncertain. Therefore, this study aims to compare the ARCchart with the gold standard ETDRS chart to assess its suitability as a tool for routine VA testing and vision screening, as described in the World Health Organisation (WHO) Primary Eye Care Manual (World Health Organisation, 2018). By evaluating accuracy, we can determine its potential to test VA in remote and resource-limited settings. This can support the aspirations of the WHO and the International Association for the Prevention of Blindness (IAPB) to establish Integrated People-centred Eye Care (IPEC) in LMICs as part of the drive towards universal health coverage in LMICs (The International Agency for the Prevention of Blindness, 2022; World Health Organisation, 2013; 2022).

Methods

Participants

A total of 63 patients from an optometry practice in Fife, Scotland, participated in the study. The age of the participants ranged from 18 to 80 years old (mean 56.5 ± 17.9 years). They had refractive errors between +4.50 D and −5.25 D mean spherical equivalent with astigmatism between 0 DC and 3.50 DC (see Table 1). A single, UK-qualified optometrist randomly measured vision using both the ETDRS and ARCchart. Participants' VA was measured in both eyes (right eye first) using standardised instructions, asking them to read out letters from the top of the chart to the smallest letter they could see. They were prompted once if they hesitated or stopped. One measure was taken using each method. All measurements were conducted monocularly without refractive correction. The study conformed to the tenets of the Declaration of Helsinki and was approved by Glasgow Caledonian University ethics committee.

Table 1: *Participant characteristics*

Characteristic	*M* (*SD*)
Age (years)	56.5 (17.8)
Refractive error (D)	+0.20 (2.02)
VA (ETDRS)	0.41 (0.43)
VA (ARCchart)	0.40 (0.44)

Note: *n* = 63 (39 female). VA measured in logMAR.

ETDRS Chart Measurement

Participants were positioned 4 metres away from a back-illuminated ETDRS chart (luminance: 230 cd/m2, letter contrast: 86%). Responses were scored on a letter-by-letter basis, with ETDRS VA measures derived using the standard clinical method of scoring by letter (Ferris et al., 1982) rather than by line (0.02 change per letter).

ARCchart Measurement

The ARCchart measurement followed a similar protocol as the ETDRS measurement, but at a 3-metre distance. Due to the chart having fewer letters and lines, each letter had a score of 0.067 for the 3-letter rows and a 0.1 incremental change for the 2-letter row (1.0 line). Room illuminance during the ARCchart measures was 160 lux, and letter contrast was 78%.

Data Analysis

Data from both eyes (n = 126) were analysed using statistical package Jamovi (Version 1.1.9.0). The tests were two tailed with type I error set at $\alpha = 0.05$. Paired t-test was used to compare paired means. The agreement between ARCchart and ETDRS VA was examined using Bland-Altman plot (Bland & Altman, 1986), with limits of agreement calculated as ±1.96 standard deviation of the differences of the mean. To assess the sensitivity and specificity of ARCchart, the ETDRS value of 0.2 logMAR was used as the cut-off for passing or failing a screening test, corresponding to the pass/fail standard set by the WHO Primary Eye Care Manual (World Health Organisation, 2018).

Results

Paired t-test found no statistically significant difference between the mean ARCchart VA vs. ETDRS VA (0.39 logMAR vs. 0.41 logMAR respectively, p-value = 0.225). Bland-Altman plot (see Figure 2) shows that the mean difference (± standard deviation) between the ETDRS and the ARCchart was 0.01 ± 0.12 logMAR, with a limit of agreement between −0.23 logMAR and 0.26 logMAR. There was no relationship between the size of differences at different levels of logMAR VA.

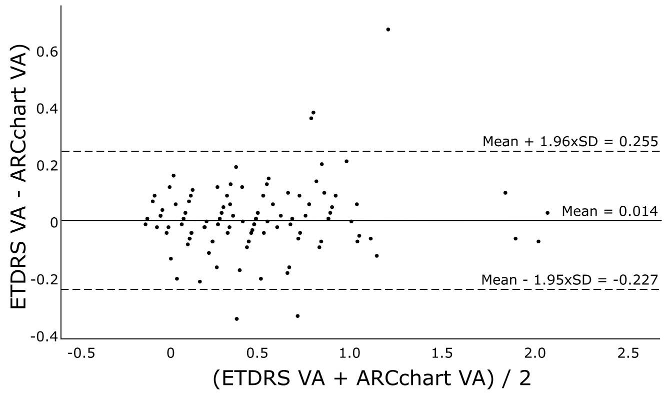

Figure 2: *Bland-Altman plot for ETDRS and ARCchart agreement. Difference in VA between the charts (ETDRS VA – ARCchart VA) plotted against average ([ETDRS VA + ARCchart VA]/2) VA values. The mean is represented by solid line and the upper and lower limits of agreements are represented by dashed lines.*

The ARCchart demonstrated 93% sensitivity, 90% specificity, 84% positive predictive value, and 96% negative predictive value in identifying ETDRS VA better than 0.2 logMAR, 95% CIs [86, 100] [84, 97] [74, 94], and [92, 100], respectively.

Discussion

The aim of the study was to validate the new ARCchart by comparing its performance to the gold standard ETDRS test chart. No significant difference was found between the ARCchart and ETDRS mean values. From a visual screening perspective, sensitivity and specificity calculations using the 0.2 logMAR cut-off used in many screening protocols suggest the ARCchart can perform well in a screening environment and will be a useful low-cost VA test for middle- to low-income countries.

The growing global need for eye care is a significant challenge for health systems. At least 2.2 billion people have vision impairment or blindness, with at least 1 billion experiencing preventable vision impairment (World Health Organisation, 2019). The WHO report "Eye Care in Health Systems: Guide for Action" advocates for IPEC as a key component of universal health coverage. IPEC aims to provide equitable access to eye care services for everyone, regardless of their socioeconomic background (World Health Organisation, 2022). In this context, the ARCchart offers a valuable, low-cost, quick, and portable solution to improving access to eye care services in low- and middle-income countries.

However, there are limitations to both the study and the ARCchart itself. Bland-Altman plot found that the limit of agreement between the two vision tests was greater (±0.24 logMAR) than reported confidence interval values (<±0.10 logMAR) found when comparing two high contrast ETDRS measures (Sánchez-González et al., 2021). This increase is likely due to the reduced sampling in terms of the number of lines and letters used in the ARCchart, which limits its use as a tool to monitor change in VA after interventions and subtle progressive vision changes due to chronic eye disease. The level of agreement between the two vision tests did not change over the range of VA measured, suggesting that the ARCchart can be used to examine individuals with reduced VA in a screening context.

The study also had some limitations, as it was performed in an optometry practice during the COVID-19 lockdown, which limited experimental control to some extent. However, consistent lighting was maintained, and the same instructions and examiner were used for all participants. To reduce recall bias, participants were asked to read the near card between monocular tests. The two charts were performed at different distances, but the small dioptric difference (≅0.08 D) is unlikely to have a significant bearing on results.

By integrating eye care into health systems and fostering collaboration across various sectors, IPEC aims to provide equitable access to eye care services for everyone, regardless of their socioeconomic background. In this context, the ARCchart offers several advantages, including low cost, independence from mobile phones, portability, and being part of a comprehensive well-established diagnostic package. These benefits make it a potentially valuable VA testing tool for low- and middle-income countries.

In conclusion, our results suggest that although the ARCchart cannot replace the ETDRS chart in controlled, well-equipped research and clinical environments it is an appropriate frugal tool for identifying patients with low vision in LMICs. This could ultimately, as part of the Arclight Package, contribute to improving healthcare delivery and accessibility in these regions, supporting the goals of IPEC and universal health coverage.

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References

Bailey, I. L., & Lovie, J. E. (1976). New design principles for visual acuity letter charts. *American Journal of Optometry and Physiological Optics*, *53*(11), 740–5. https://doi.org/10.1097/00006324-197611000-00006

Bland, J. M., & Altman, D. G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*, *1*(8476), 307–10.

Ferris, I., Frederick L., Kassoff, A., Bresnick, G. H., & Bailey, I. (1982). New visual acuity charts for clinical research. *American Journal of Ophthalmology*, *94*(1), 91–96. https://doi.org/10.1016/0002-9394(82)90197-0

Rosser, D. A., Murdoch, I. E., & Cousens, S. N. (2004). The effect of optical defocus on the test–retest variability of visual acuity measurements. *Investigative Ophthalmology & Visual Science*, *45*(4), 1076–1079. https://doi.org/10.1167/iovs.03-1320

Sánchez-González, M. C., García-Oliver, R., Sánchez-González, J.-M., Bautista-Llamas, M.-J., Jiménez-Rejano, J.-J., & De-Hita-Cantalejo, C. (2021). Minimum detectable change of visual acuity measurements using ETDRS charts (Early Treatment Diabetic Retinopathy Study). *International Journal of Environmental Research and Public Health*, *18*(15). https://doi.org/10.3390/ijerph18157876

The International Agency for the Prevention of Blindness. (2022). Integrated People-centred Eye Care Advocacy to Action Toolkit. https://www.iapb.org/wp-content/uploads/2022/11/IPEC-Advocacy-to-Action-Toolkit-27JUN2022-1.pdf

World Health Organisation. (2013). Universal eye health: A global action plan 2014–-2019. https://www.who.int/publications/i/item/universal-eye-health-a-global-action-plan-2014-2019

World Health Organisation. (2018). Primary eye care training manual. https://www.afro.who.int/sites/default/files/2018-06/WEB-2835-OMS-Afro-PrimaryEyeCaretrainingmanual-20180406.pdf

World Health Organisation. (2019). World report on vision. https://www.who.int/publications/i/item/9789241516570

World Health Organisation. (2022). Eye care in health systems: Guide for action. https://www.who.int/publications/i/item/9789240050068

Sammenlikning av ETDRS visustavle og Arclight tekstiltavle (ARCchart) for bruk til synstesting i ressurssvake settinger i primærhelsetjenesten

Sammendrag

Denne studien sammenliknet Arclight tekstiltavle (ARCchart) med en standard ETDRS tavle for måling av visus hos 63 deltakere. ARCchart oppnådde grenseverdi for samsvar med ETDRS målingene på mellom −0,23 logMAR og 0,26 logMAR med 93% sensitivitet, 95% CI [86, 100] og 90% spesifisitet, 95% CI [84, 97] når visus var dårligere enn 0,20 logMAR. Til tross for potensielle begrensninger ved måling av små visusforskjeller over tid, er den bærbare ARCchart tekstiltavlen et verdifullt lavkost alternativ for måling av visus i ressurssvake settinger.

Nøkkelord: Visustavle, lavkost, logMAR

Valutazione comparativa delgli ottotipi ETDRS e Arclight Cloth (ARCchart) per la misurazione dell'acuita' visiva in setting clinici con risorse limitate

Riassunto

Questo studio ha confrontato l'ottotipo Arclight Cloth (ARCchart) con l'ottotipo gold-standard ETDRS per la misurazione dell'acuità visiva (VA) in 63 partecipanti. L'ARCchart ha mostrato un limite di accordo tra −0,23 logMAR e 0,26 logMAR rispetto ai valori ETDRS. Ha dimostrato una sensibilità del 93%, IC al 95% [86, 100] e una specificità del 90%, IC al 95% [84, 97] quando utilizzato per la selezione di VA peggiore di 0,20 logMAR. Nonostante possibili limitazioni come strumento per misurare piccole variazioni nell'acuità visiva nel tempo, l'ottotipo per la misurazione dell'acuità visiva economica e portatile è un'utile alternativa in contesti con risorse limitate.

Parole chiave: Ottotipo per la misurazione dell'acuità visiva, basso costo, logMAR