The ROYAL COLLEGE of OPHTHALMOLOGISTS

focus

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Remote vision testing

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Introduction

National restrictions in place during the COVID-19 pandemic prevented clinicians from seeing many patients face to face and remote care became necessary. Remote care depends on patients having suitable digital devices and connectivity. Visual acuity is an important marker of eye health, needed to aid triage decisions and to determine whether a patient requires an eye assessment. For common paediatric conditions, e.g. amblyopia, acuity is checked in a hospital environment every six weeks for a number of years. Digital visual acuity tests can be equivalent to traditional hospital-based charts. However, while remote, parent-led acuity is feasible and can be accurate, unexpected or spurious results are difficult to interpret if the test environment is not observed. Clinician-led testing provides greater confidence that the test has been conducted correctly, and that the best possible visual acuity has been recorded. We summarise the current state of play for remote acuity measurement, and other remote vision assessments.

Pre-pandemic

The development of digital technology for visual acuity assessment had begun before the onset of the pandemic. Applications presenting optotypes were shown to be effective and had been implemented in the developing world. For example, Peek Acuity presents an optotype on a mobile phone which a trained person can use to measure visual acuity. Kay iSight Test Pro is an application with both letter optotypes and Kay pictures for young children designed for healthcare professionals to use and which has been shown to replicate the accuracy of a standard hospital acuity test. Peekaboo Vision followed, with a grating card vision assessment for very young children. Whilst these applications have been shown to be equivalent to standard hospital tests in the hands of a trained professional, results are less predictable and therefore less reliable when used by an untrained parent or carer.[1]

Birmingham & Falkirk study

Aiming to improve on parent-led testing, we conducted a study aimed to determine whether clinician-led testing could be conducted via a video link. Orthoptists were located in the hospital, and patients and their parents were in their home. Orthoptists used a hospital computer to access the prototype web-based acuity testing application and connected to the family via a video call. No specific instructions were given about screen size or brightness, or the test environment e.g. room lighting or distractions. Parents calibrated their screen by dragging a calibration rectangle to match the size of a standard bank card held against the screen. Parents then used a tape measure to seat their child 1.5 metres away from the screen. There was no means to check if screen calibration was accurate or test distance was correct. The patient could see both the orthoptist and the acuity test on their screen and the orthoptist could see both the patient and the acuity test on their screen. Testing of BEO and uniocular acuities took approximately 5 minutes to complete, including setting up the test distance and calibrating the screen.

We found excellent agreement between standard acuity testing in clinic and the prototype. The mean test difference was only -0.004 logMAR (95% confidence interval (CI) -0.06–0.05) for BEO and did not change significantly with acuity. For monocular acuities, the mean test difference was only -0.008 (95% CI -0.04–0.03) and changed slightly with acuity, perhaps due to children with excellent acuity achieving better results at hospital testing than at home testing.

More relevant for patient monitoring, however, are the limits of agreement (LOA: mean +/- 1.96 standard deviations) which describe the maximum difference likely to be found between the two acuity measurements. For BEO acuities, the LOAs spanned -0.32 to 0.31 logMAR, and were slightly wider for uniocular acuities. This means that an observed change of acuity would have to exceed about 0.35 logMAR (3–4 lines) to be confident the change was real and not due to measurement error. In other words, when seeking a visual acuity change of <0.35 logMAR, the home system tested here may not be reliably interchangeable with hospital assessments of a patient. In amblyopia monitoring, clinicians typically judge the minimal important change to be about 0.1 logMAR. An observed change of, say, 0.2 logMAR may well be clinically important but could not be distinguished from measurement error.

Remote acuity testing

For home monitoring to be adopted with confidence, it must have good accuracy (little or no systematic difference between home and hospital test), low bias (results which agree similarly across all levels of acuity) and low variability (acceptably narrow LOAs). Whilst our study showed good accuracy and low bias, we found unacceptably wide variability.

Other studies have found LOAs ranging from ±0.08 to ±0.49 logMAR.[2–9] The key to narrow LOAs is altering the fewest factors between reference (e.g. hospital) and index (e.g. home) test sessions. Each changed aspect widens the LOAs (Table 1). The example above changed test (card to digital), setting (clinic to home), undertook tests several days apart and often changed tester. For these reasons, the ±0.3 logMAR LOAs are unsurprisingly towards the upper end of LOAs reported elsewhere. Testing younger children also means greater variability in acuity, and co-operation is likely to be poorer.

Some of these aspects cannot be controlled – for home testing to be widely adopted, the test setting must change from a hospital setting, for example. But variability can be improved by improving remote test design. Remote standardisation of screen brightness and orientation, accurate and reliable screen size calibration, remote monitoring of patient test distance, automated target scaling, optotype choices which match hospital optotypes, and reliable remote supervision of occlusion and cooperation are all technologically feasible. The study described here has partly informed the design of two commercial tests[10,11] as part of a government funded innovation competition.[12] As these and other new technologies are delivered, along with increased ease, the reliability of home vision testing will continue to improve, and with it, the confidence in the results. There are already several systems in use which have shown good accuracy, low bias, and acceptably low variability relative to standard clinical assessment.[2,5,6] Furthermore, accurate assessments are achievable even with smartphones, increasing the potential reach to families living in digital poverty.

Not just acuity monitoring

While monocular acuity stands apart as an arbiter for decision-making in amblyopia management, digital vision testing has growing traction, with acuity just one of many testable aspects of visual function. Notable examples, with variable levels of regulatory compliance and validation, are well summarised elsewhere[13] capturing visual field and colour vision. Other notable example capturing metamorphopsia[14] and stereopsis testing,[15] as well as more novel tools combining modalities.[16]

The future of vision assessments

Whilst the COVID-19 pandemic was an accelerator of digital healthcare, climate change and economic pressures are likely to become significant drivers for change in health provision. Patient journeys contribute substantially to healthcare carbon footprint and should be avoided whenever it is safe to do so. This has the added benefit of reducing school absences and parental loss of earnings. Bringing visual assessments to the patient has the potential to improve access for those who are unable to travel due to physical limitations, or fragility, and those for whom a traditional hospital environment can be distressing, e.g. those with neurodiversity or mental health concerns.

Clinicians' time is also at a premium and home vision testing could reduce travel time of those attending schools for screening assessments and could potentially enable faster and more efficient throughput of many routine but essential patient tests with resultant beneficial economic impact. As workforce issues continue to threaten viability of services, the ability to connect patients and clinicians without the requirement to share a room can only be beneficial.

Digital change and the introduction of remote technologies has the potential to improve care for both patient and clinician. Their adoption must not reduce the quality of care nor introduce uncertainty. Clinician-led home vision testing is on the brink of achieving a new model of care without compromising quality. Patient/webcam distance-sensing together with automatic screen adaptation to ambient lighting conditions brings potential for digital devices to match or even outperform conventional tests. Digital screens having intrinsic advantages to card-based tests, the traditional mainstay of test paradigms for children's vision.[17] While the technology has clear potential for a sea change in testing, the concept of the tele-orthoptist requires a large-scale, pragmatic clinical trial with open questions regarding how a blended model of face-to-face and remote testing best serves patients.

Table 1. Variables which may change between a reference and index test

Variable	Comments
Device	May affect brightness, screen orientation, grating density and quality, optotype size limits
Screen calibration	Affects optotype size and crowding
Time	Increased duration between tests increases chance of clinical change. Compliance with test may change
Location and environment	Home environment cannot be controlled: distraction, distance from screen, room lighting, reflections, noise levels
Supervision	Clinician or carer led, self-directed
Test type	Variation in crowding, optotype, thresholding technique, stopping criteria, scoring

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