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Canon CP-TX1 camera – As a screening tool for amblyogenic risk factors

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Purpose: To evaluate the Canon CP-TX1 camera as a screening tool for ARFs in a pediatric population and estimate the prevalence of ARFs. **Methods:** In a pediatric outpatient space, largely in the immunization clinic, after obtaining parental consent, we encouraged children to be photographed from a distance of 5 feet in a dim room by using a CP-TX1 camera with the red-eye reduction feature off. Based on the captured red reflex, children were labeled as normal (symmetrical red reflexes in the two eyes, with no visible crescents); all others were considered as abnormal or positive for ARFs. All photographed children were assessed by an optometrist/refractionist for VA by age-appropriate methods. Data were entered into a 2 × 2 contingency table on statpages.org, and diagnostic indices were calculated with 95%CI. **Results:** With a sample of 262 children, we obtained a sensitivity of 0.82, a specificity of 0.98, a positive predictive value of 0.92, a negative predictive value of 0.94, a positive likelihood ratio of 41.06, a negative likelihood ratio of 0.17, and a prevalence of 0.24 for ARFs. **Conclusion:** CP-TX1 performed well as a screening tool to identify ARFs in children. Placing such a camera in an immunization clinic offers a chance to identify children with ARFs at a time when amblyopia is eminently reversible.

Key words: Amblyogenic risk factors, Brückners reflex, Immunization clinic

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Amblyopia, meaning "dull vision" in Greek, is defined as "decrease of visual acuity in one eye when caused by abnormal binocular interaction or occurring in one or both eyes as a result of pattern vision deprivation during visual immaturity, for which no cause can be detected during physical examination of the eye(s) and which in appropriate cases is reversible by therapeutic measures."[1] Von Graefe aptly sums it as a condition in which the observer sees nothing and the patient very little. It is considered to be the most common cause of monocular visual impairment in children and young adults affecting 2%–5%.[2,3] Being a childhood malady, its morbidity in terms of years of impairment is far greater. Both screening and treatment of amblyopia are cost-effective.[4-6] It costs about $1800/Quality-adjusted life years (QALY) in treating amblyopia compared to $4500/QALY for cataract surgery, $345,000 for central retinal artery occlusion (paracentesis), $174,000 for photodynamic AMD therapy, and $44,000 for annual retinopathy screening in a 45-year-old diabetic patient.[6] The worldwide prevalence of amblyopia is 1%–5%,[7,8] whereas in southern India, the figure is 1.1%.[9]

The common amblyogenic risk factors (ARFs) remain strabismus and anisometropia, both alone and in combination. Uncommon causes are deprivation occurring when the visual axis is obscured, as in severe ptosis, corneal opacities, or cataract. Most of these latter conditions are easily noticed by the parents and timely attention is likely to be sought. Small strabismus and anisometropia can often be missed. Children with amblyopia in one eye are at greater risk of accidentally becoming blind due to injury in the good eye.[10] The lifetime risk of bilateral visual impairment (BVI) in amblyopes is reportedly 18%, and they live on average 7.2 years with BVI, while these figures are 10% and 6.7 years, respectively, in non-amblyopes.[11]

Amblyopia is easily treatable if diagnosed early.[12] The age at which children are most sensitive to amblyopia is during the first 2–3 years of life, and this sensitivity gradually decreases until the child reaches 6 or 7 years of age, when visual maturation is complete and the retinocortical pathways and visual centers become resistant to abnormal visual input.[1] Older children with anisometropic refractive error have higher prevalence and depth of amblyopia than younger children.[13]

Treatment methods include spectacles for ametropia and anisometropia, often combined with patching or atropine-penalization, augmented by appropriate active vision therapy.[14,15]

Globally, efforts have been made to screen otherwise healthy children for amblyopia and ARFs,[16-21] but often the equipment and strategies used are costly, resource-intensive, and not easily portable.

As these screening studies employ different equipment with varying definitions of amblyopia and on different age groups, they are not easily comparable; this has translated into varying sensitivities and specificities. What is needed is handy, affordable, portable equipment that can work despite a lack of an active electrical connection and can be handled by non-medical personnel with a brief period of training.

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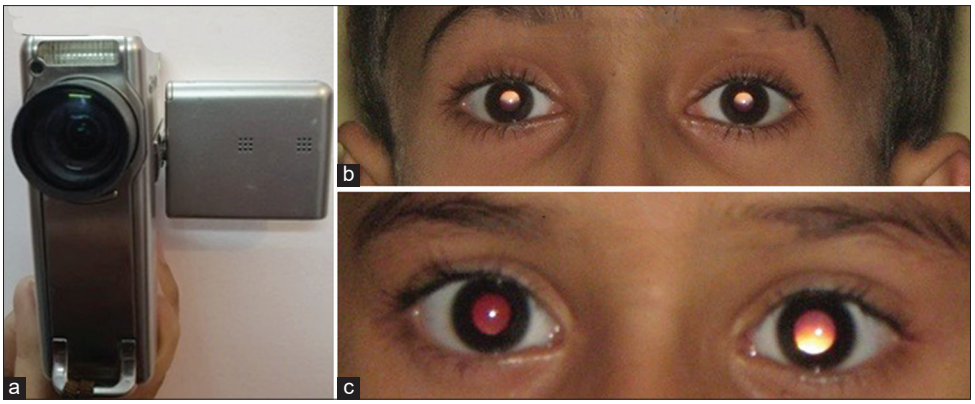

Figure 1: Showing the Camera CP-TX1 (a) and the Brückners reflexes, with upper crescents indicating myopia (b), and inferior, hypermetropia (c). (PS: the crescents appear reversed when compared to the direct ophthalmoscope, because of the reversed positioning of the light source vis-à-vis the sight hole/lens)

Previously, we have demonstrated the usefulness of the Canon CPTX1, a consumer digital camera, as an effective way to screen for ARFs in a strabismology clinic-based sample.[18] Clinic-based patients in India are often of an age where anti-amblyopia treatment is less likely to be effective. We felt that the CPTX1 should demonstrate its usefulness in a pediatric population as amblyopia is most amenable to therapeutic interventions at this age.[18,22] We reflected and felt that the pediatric and immunization clinic of a tertiary care public hospital would provide a great opportunity where children would be available and accessible, especially because India has had a rather extensive immunization program in place since 1978.[23] Immunization programs may reach about 90% of targeted children. Currently, the EPI (age group covered is from birth to 10 years) has a coverage of 63%[24,25] and provides immunization against diphtheria, pertussis, tetanus, childhood tuberculosis, hepatitis, measles, and tetanus[26] and is likely to yield a varied sample. Although amblyopia prevalence is reportedly 2%–5%,[8,7] it stands to logic that the prevalence of ARFs would be higher as many children with ARFs may not have a visual deficit. Indeed, one study suggests that the prevalence of ARFs is much higher at 21% ± 2%.[27]

We thus designed this study to determine the prevalence ARFs (refractive errors, strabismus, etc.) through screening of children coming to the immunization clinic, pediatric OPD, well-baby clinic, and general eye OPD by capturing and assessing the red reflexes with the Canon CPTX1.

Methods

All cooperative children (12 months–10 years) coming to the immunization clinic, well-baby clinic, and general out-patient department of pediatrics, xxxxxxxx Medical College, who were cooperative enough, were recruited after obtaining informed consent from their parents.

Method

We clicked the photographs from a distance of 5 feet in a dim room by using the CP-TX1 camera with the red-eye reduction feature off. We re-snapped the child till the red reflexes (Brückner reflexes) were adequately visible on the camera screen [Fig. 1]. Based on the captured red reflex, the children were labeled as normal (symmetrical red reflexes in the two eyes, with no visible crescents); all others were considered as abnormal or positive for ARF.

Subsequently, all photographed children were assessed by an experienced orthoptician for strabismus and by a refractionist for VA by using age-appropriate methods (Snellen, logMAR, Lea Symbols or Cardiff Acuity) and cycloplegic refraction. We identified strabismus by using Hirschberg reflexes and cover test and quantified it by prism bar cover test (PBCT) or the modified Krimsky test. We assessed the refractive status for iso-ametropia and anisometropia based on spherical equivalents. We essentially looked for strabismus and ametropia, these being by far the commonest ARFs.

We excluded children whose parents declined consent, appeared sick, those who lacked a red glow on distant direct ophthalmoscopy in any eye, including one-eyed children, children less than 1 year, and more than 10 years.

Results

Our study included 262 children. Of these, 147 (56.1%) were males and 115 (43.9%) females. The baseline characteristics are shown in Table 1.

Among 262, 199 were normal and 63 had ARFs, providing a prevalence of 24%. The diagnostic indices (95%CI) are summarized in Table 2. The positive and negative predictive values were 0.92 (0.84–0.97) and 0.94 (0.92–0.95), respectively. The accuracy was calculated as 0.94.

The summary of diagnostic indices (95%CI) in different subsets is depicted in Table 3.

Discussion

By using the Canon CPTX1 digital camera, we screened for ARFs in a pediatric sample of 262 children, where the prevalence of ARFs was 24%. We obtained a reasonably high sensitivity of 0.82 and a high specificity of 0.98. Even subset analyses for strabismus, anisometropia, isoametropia, and anisometropia with strabismus returned sensitivities and specificities largely above 80%.

From the perspective of gestational age, eight of 19 children with prematurity had asymmetrical Brückner reflexes suggestive of ARFs (42.1%) compared to 55 of 243 children of term gestation (22.6%), giving an OR of 2.49 (95%CI: 0.95–6.48), $P = 0.063$. Despite the lack of statistical significance, the size of the OR suggests that prematurity impacts the greater occurrence of ARFs. More studies would help further clarify this.

Arnold *et al*.[28] performed a study on 108 children 1–12 years of age in 2014 to assess the efficacy of four photoscreeners: sensitivity and specificity for Plusoptix were reported as 0.83 and 0.86, respectively; for SPOT screener as 0.80 and 0.85; for the iScreen as 0.92 and 0.88; and for

Table 1: The baseline characteristics of the children included

Subsets	Age in year $\bar{x}$ (±SD) Range	BCVA logMAR $\bar{x}$ (±SD) Range		SE $\bar{x}$ (±SD) Range Hypermetropes		SE $\bar{x}$ (±SD) Range Myopes	
		RE	LE	RE	LE	RE	LE
Normal	6.14 (2.73)	0	0	0.40 (0.57)	0.40 (0.56)	-	-
n=199	1-10			0-2.50	0-2.50	-	-
Strabismus	6.04 (2.19)	0.19 (0.24)	0.18 (0.32)	0.61 (0.49)	0.48 (0.51)	−1.08 (1.23)	−0.92 (0.95)
Alone *n*=14	2.5-10	0.0-0.6.	0.0-1.0	0.0-1.5	0.0-1.5	−0.25 to−2.5	−0.25 to−2.0
Anisometropia	6.31 (2.34)	0.16 (0.31)	0.17 (0.27)	2.74 (2.30)	2.27 (2.34)	−2.93 (3.26)	−3.08 (2.79)
Alone *n*=16	1.5-9.0	0.0-1.0	0.0-0.70	0.5-7.5	0.0-6.5	−0.5 to−9.0	−1.0 to−6.25
Isoametropia	7.31 (2.52)	0.18 (0.17)	0.19 (0.17)	3.0 (2.13)	3.0 (2.13)	−3.08 (1.51)	−2.93 (1.65)
alone *n*=16	3-10	0.0-0.48	0.0-0.48	0.25-6	0.25-6	−0.75 to−5	−0.75 to−5
Anisometropia	6.62 (2.43)	0.30 (0.48)	0.51 (0.46)	3.70 (3.87)	2.67 (3.08)	−1.0	−4.0
With strabismus *n*=13	2-10	0-1.50	0-1.40	0-10	0-9.0	-	-
Isoametropia	5.3 (3.4)	0.1 (0.1)	0.1 (0.1)	1.4 (1.2)	1.4 (1.2)	−1.9 (2.0)	−2.2 (2.4)
with strabismus *n*=4	2-10	0.0-0.2	0.0-0.2	0.5-2.3	0.5-2.3	−0.5 to−3.9	−0.5 to−3.9
Overall	6.22 (2.66)	0.04 (0.17)	0.6 (0.19)	1.41 (1.71)	1.34 (1.50)	−2.29 (2.19)	−2.55 (1.82)
n=262	1-10	0-1.5	0-1.4	0.25-10	0.25-9.0	−0.25 to−9.0	−0.25 to−6.25

Table 2: Statistics of indices of the overall sample: value (95%CI)

Sensitivity	Specificity	Positive Likelihood Ratio	Negative Likelihood Ratio	Prevalence
0.82 (0.74-0.86)	0.98 (0.95-0.99)	41.06 (16.8-124)	0.17 (0.13-0.26)	0.24 (0.19-0.29)

Table 3: Statistics of indices in different subsets: value (95%CI)

Subsets	Sensitivity	Specificity	Likelihood Ratio Positive	Likelihood Ratio Negative
Strabismus alone (*n*=14) (without anisometropia) vs. normals (*n*=199)	0.92 (0.69-0.99)	0.98 (0.96-0.98)	46.19 (18.69-64.9)	0.07 (0.004-0.32)
Anisometropia alone (*n*=16) vs. normal (*n*=199)	0.68 (0.45-0.83)	0.98 (0.96-0.99)	34.2 (11.9-103.0)	0.32 (0.16-0.56)
Isoametropia alone (*n*=16) vs. normal (*n*=199)	0.81 (0.58-0.94)	0.98 (0.96-0.99)	40.42 (15.3-95.38)	0.19 (0.06-0.43)
Anisometropia with Strabismus (*n*=13) vs. normals (*n*=199)	1 (0.76-1)	0.98 (0.96-0.98)	49.75 (21.36-49.8)	0 (0.0-0.24)
Isoametropia with strabismus (*n*=4) vs. normal (*n*=199)	0.5 (.096-0.89)	0.98 (0.97-0.98)	24.87 (3.38-74.5)	0.51 (0.10-0.93)

GoCheckkids application for iPhone 4S, it was 0.81 and 0.91, respectively. On average, all four performed well, with the mean sensitivity being 80% and specificity 88%. Sensitivities obtained on CPTX1 are largely comparable, except being exceeded by the iScreen, while the specificity surpasses them. We believe that this suggests that the CP-TX1 camera is unlikely to miss most ARFs.

Bani *et al*.[18] used the same camera (CPTX1) in 2013, although on an older population, to pick up ARFs much like us: their mean age was 22.05 ± 8.62 years as compared to 6.22 ± 2.66 years for ours. They published a sensitivity of 0.86 (95%CI: 0.84–0.89) and a specificity of 0.85 (95%CI: 0.77–0.93). They successfully demonstrated the feasibility of using a consumer digital camera as a screening tool for ARFs. We took this further to show that it works well in an appropriate pediatric setting too. Compared to Bani *et al*.,[18] our study showed a greater specificity and comparable sensitivity.

In a study done by Matta *et al*.[29] titled "Screening for amblyogenic risk factors using the PlusoptiX S04 photoscreener on the indigent population of Honduras," the authors report specificity (0.98) and positive predictive value (0.88) comparable to ours while sensitivity (0.94) is better. They conducted the study on 105 children (1–17 years) who came for an eye examination to the clinic.

Another study[30] quite similar to ours titled "Photoscreening for amblyogenic factors by public health personnel: the Eyecor Camera System" done on 127 subjects with a mean age of 6 years (range: 7 months–20 years) reported a sensitivity of 0.81, quite like us, with a poorer specificity of 0.83.

Silbert *et al*.[16] evaluated the plusoptiX photoscreener and SureSight autorefractor for pediatric vision screening on 90 children with age between >1 and 17 years. In their study, the plusoptiX demonstrated a sensitivity of 98%, a specificity

of 88%, both positive and negative predictive values of 96%, whereas the SureSight autorefractor showed a sensitivity of 95%, a specificity of 65%, a PPV of 87%, and a NPV of 85%.

Our study suggests that the CPTX1 camera is quite effective in identifying ARFs and is portable and affordable and can be used effectively on a pediatric population as young as 1 year.

Conclusion

This work demonstrates a simple way of identifying ARFs, often asymptomatic, among children, with an easily affordable equipment that can be handled with limited training by paramedical personnel. The idea of using it in the immunization clinic is both novel and likely to be yielding high dividends. Identifying the ARFs in an age when the children are easily amenable to remedial measures will be of great benefit. The digital format allows for easy sharing with experts. We hope that such simple options are adopted widely in our country and in those that face similar challenges.

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Conflicts of interest

There are no conflicts of interest.

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