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STANDARDISATION OF SMARTPHONE FUNDUS IMAGING IN DROMEDARY CAMELS (*Camelus dromedarius*)

Bharat Bandhu, S.K. Jhirwal, Mohan Lal Sharma, Sonu Meena and P. Bishnoi

Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Science, Rajasthan University of Veterinary and Animal Sciences, Bikaner- 334 001, Rajasthan, India

ABSTRACT

The present study was done to standardise the technique of cost-effective fundus imaging in camels using a smartphone fundus imaging assembly made from locally available materials such as PVC pipe, sand paper, glue, electrical insulation tape, smartphone with it's back cover and 20 D condensing lens. The camels were examined in sternal and lateral recumbency. The fundus images were recorded in continuous video mode and later on screenshot of desired images were taken from videos. The camels were more convenient in sternal recumbency as compared to lateral. The assembly was held perpendicular to the cornea. During examination, continuous eye globe movement and nictitating membrane covering cornea and sometimes damaged part of pupillary ruff were major constraints. The technique was cost effective, transportable and good quality fundus images were obtained.

Key words: Camel, funduscopy, fundus imaging, smartphone

Fundus photography is a key component of ophthalmology. High-quality fundus images need the use of appropriate optics and illumination. Smartphones are increasingly being used as clinical imaging devices in ophthalmology due to their growing availability and quick advancements in image capture and sharing technologies (Khanamiri *et al,* 2017 and Iqbal, 2021). A commercial fundus camera is expensive (Haddock *et al,* 2013). The images obtained by smartphone ophthalmoscopy are inferior in quality than those obtained by fundus cameras, yet they have great diagnostic significance (Sirin, 2020). The benefits of smartphone fundoscopy include wireless network access, low cost, long battery life, and easy transportability (Kanemaki *et al,* 2016; Haddock, 2018, and Yadav *et al,* 2023). The use of smartphones in diagnostic ophthalmology is growing these days because they make it easier to obtain feasible, high-quality retinal images at the field level. Artificial intelligence was used to detect automated diabetic retinopathy through smartphone-based fundus photography (Rajalakshmi *et al,* 2018). The present study was done to standardise the technique of cost-effective fundus imaging in camels using a Smartphone fundus imaging assembly made from locally available materials.

Materials and Methods

The present study was done in both the eyes (n=78) of 39 dromedary camels of different breeds. The smartphone fundus imaging assembly used was a modified version used previously by Raju *et al* (2016). The cost-effective fundus imaging assembly was made with locally available materials. The PVC pipe as an optical tube was aligned centrally at the camera hole of the smartphone adhered with glue. A piece of sandpaper was rolled and pasted inside the PVC pipe. At the other end of the optical tube, 20D condensing lens was fixed with electrical insulation tape (Fig 3). After smartphone positioned into the back cover, device was ready for fundus imaging. The fundus imaging was done in a semi dark room after dilation of pupil with 0.5% tropicamide, 20-30 min prior to examination.

Positioning and Fundus imaging

The camels were restrained either in sternal (Fig 1) or lateral recumbency (Fig 2). The smartphone side of the attachment was held with one hand while 20D lens rested on thumb of other hand and index or middle finger held the eyelid open, lens was held 3-5 cm away from cornea. The fundus images were taken in continuous video mode with the flashlight on, and then screenshots of the desired fundus images were

SEND REPRINT REQUEST TO BHARAT BANDHU email: bbandhu1997@gmail.com

retrieved from the video. The smartphone's flashlight illumination level was kept mild to maximum and the assembly was moved forward and backward to focus film distance for clear fundus images on the smartphone's display screen. Smartphone-based assembly was focused at various points on the cornea to obtain images of the central and peripheral retina. The optical tube attached with smart phone helped in alignment of phone and 20D condensing lens with respect to the eye, and the assembly was found satisfactory for fundus imaging. The sand paper inside the optical tube prevented scattering of light. The designed assembly was light weight and easy to operate

Results

Positioning of camels and examiner

Thirty two camels were secured in sternal recumbency and seven camels in lateral recumbency.

Fig 1. Fundus image capturing in sternal recumbency using smart phone fundus imaging assembly.

Fig 3. Components of smart phone fundus imaging assembly.

Continuous eye globe movement and covering of the eye globe by the third eyelid, partially or completely and sometimes a damaged floated part of the pupillary ruff produced hindrances in fundus imaging. In general, extending the neck slightly in lateral recumbency and tipping the nose ventrally in relation to the body often helped in the centering of the eyeball and retraction of the third eyelid thus facilitated the fundus visualisation. In younger camels, the fundus examination was difficult as they were quite active and did not follow the commands.

Fundus examination in lateral recumbency was found more satisfactory for aggressive and non cooperative camels. It was more convenient for the examiner in sitting position on suitable height stool when the camel was in sternal recumbency as compared to lateral recumbency. Images of the central

Fig 2. Fundus image capturing in lateral recumbency using smart phone fundus imaging assembly.

and peripheral retina were obtained satisfactorily by focusing the assembly at different corneal areas. Two small white dots were visible in the visual field of each fundus image. A few instances of corneal dryness were noted which might have been avoided by placing cotton over the eye and soaking it in a normal saline solution.

Normal appearance of camel fundus

The normal funduscopic appearance varied greatly between individual camels and among breeds. The created image was 3 to 4 times magnified and inverted. There was no clear differentiation between tapetum and non tapetum. Camel fundus showed high pigmentation area in the dorsal part, and a non pigmentation area in the ventral part. Position of optic

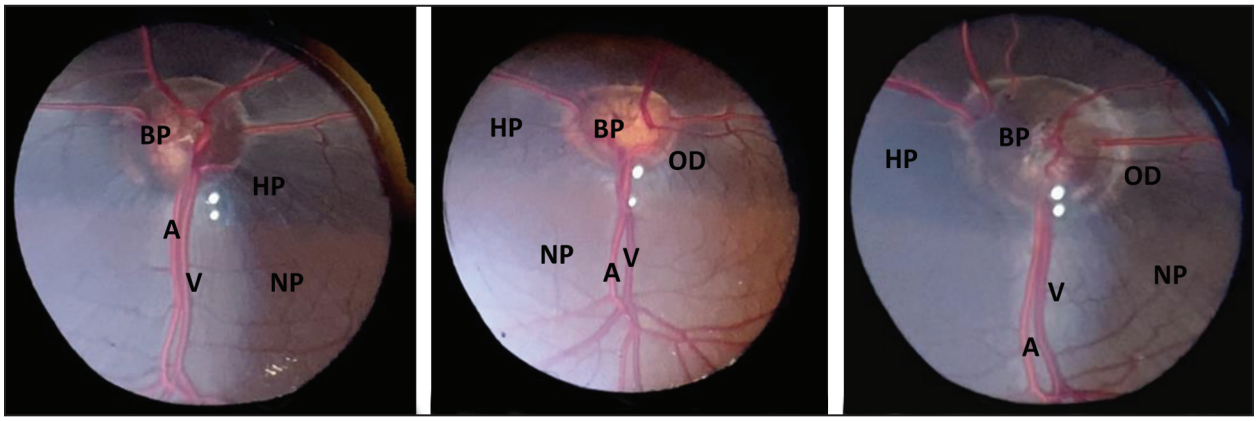

Fig 4. Fundus images showing high pigmentation, non pigmentation area, optic disc and retinal vessels. *HP-High pigmentation area, NP- Non pigmentation area, OD- Optic disc, BP- Bergmeister's papilla, A-Artery, V- Vein.

disc varied and retinal vessels emerged from optic disc towards retinal periphery (Fig 4).

Discussion

The design of smartphone fundus assembly in the present study was modified from Raju *et al* (2016) and Yadav *et al* (2023). In their study, the length of optical tube was 17 cm; however, in present study good quality fundus images were obtained with 26 cm optical tube length which may be attributed to the anatomical variations in the eye of human beings, dog and camel. The principle of smartphone fundoscopy in the present study and the inverted images obtained is based on the principle of indirect ophthalmoscopy in which the examiner's eye is replaced by smartphone's display screen, as stated earlier (Yadav *et al,* 2023).

Fundoscopy in a semi dark space resulted in reduced distracting highlights on the cornea (Yadav *et al,* 2023). When the light level was kept medium to maximum and the assembly was held perpendicular to the cornea, good quality fundus images were obtained. To obtain images of peripheral retina the assembly was focused at various positions of cornea as suggested by Shanmugan *et al* (2014) and Yadav *et al* (2023). In the present study, fundus imaging was done through smartphone camera application and the images were cropped with the smartphone integrated application suggested by Kanika *et al* (2023). However, Haddock *et al* (2013) employed the program Filmic Pro to have more control over camera settings while imaging, including exposure, focus, and lighting level. Filmic Pro or any other external camera application was not required for present study because the built-in camera application provided satisfactory control the focus and illumination level to obtain high quality fundus image.

In the present study, diagnostic quality fundus images were obtained using the smartphone fundus imaging assembly showing a high pigmented and non pigmented area in the fundus which was in agreement with Sini (2015) and Kelawala *et al* (2016). The smartphone fundus imaging was affordable, applicable in telemedicine, and transportable. It provided good quality fundus images, which might further be improved through latest generation of smartphone cameras with high resolution and greater image stabilisation.

Conflicts of Interest

The authors declare no conflict of interest.

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News

SYMPOSIUM, STAKEHOLDERS MEETING AND VISIT

Event 1: Participation in **North-East Woolen Expo** held in Guwahati, Assam, from 03 to 09 February 2024 for the promotion of camel fiber processing and marketing.

Event 2: Collaborated in ***Maru Manthan*- 2024,** held in Jaisalmer, Rajasthan on 9-10 February 2024. This event highlights the need to conserve critical desert ecosystems, the pastoral way of living and issues such as livelihood resilience, and sustainability, among the diverse communities and other actors present. This programme aimed to demonstrate Pastoral Production Systems, Show caseinnovations for desert communities, celebratethed the International Year of Camelids, and promoted the networking between individuals and organisations to combine action for a comprehensive desert bioregion agenda.

Event 3: An exposure visit of seven-member team from the North American Camel Ranch Owners Association of America at NRCC on 18-02-2024.

Event 4: AMUL-NRCC Symposium and stakeholders meeting took place along with visit to camel milk collection centre at Ghadsisha village, survey on Kacchiand Kharai camel breeding track, collection of plant and milk samples from the study area, visit Sarhad Dairy and its feed plant in Lakhond during 9 to 10 March 2024.

Event 5: Brainstorming Session on "Unravelling the Rumen Microbiome for Sustainable Ruminant Production: Past, Present and Future" on 12.03.2024. Dr. A. Sahoo (Director, NRCC), Dr N V Patil (Vice Chancellor, MAFSU, Nagpur), Dr. A. K. Puniya (Pr Scientist, NDRI) and Dr. C.G. Joshi (Director, GBRC) and many other prominent scientists attended the event.

Event 6: National Symposium cum Stakeholders Meet on "Importance, Innovation, Improvement in Processing of Non-Bovine Animal Produce for Successful Entrepreneurship" was organised at NRCC, Bikaner during 14 to 15 March 2024. The chief guest of the closing ceremony of the seminar was Prof. Manoj Dixit (Vice Chancellor, Maharaja Ganga Singh University; Bikaner).