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Defining the clinical role of adapted digital light field photography in the treatment of HIV-induced Kaposi's sarcoma lesions

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Background

Kaposi's sarcoma (KS): a vascular tumor associated with HHV8 and HIV infection

KS burden at Maputo Central Hospital (MCH):

- Referral center for all of southern Mozambique, 1500 beds, >65% HIV+ patients on medical services
- Dermatology ward: 50 beds, >30% of admitted patients suffer from Kaposi's sarcoma and its complications
- 10-15 cases/month admitted with advanced KS; additional 15-20 cases/month treated outpatient
- KS is the most common form of malignancy seen at MCH among men, second most frequent among women

Current KS standard of care:

- First line treatment: chemo- and concomitant antiretroviral-therapy
- Pre-treatment photographs rarely taken to establish a baseline for therapeutic monitoring
- Post-therapy improvement is based on gross examination and clinical judgment
- Tracking correlation between therapy dosing and shrinkage of lesion size is difficult due to variation and number of lesions

Figure 1. Lytro camera; from https://www.lytro.com/camera

Aim of the study: determine the utility of adapted digital light field photography in a resource-limited setting and establish best clinical practice for future KS monitoring via photography

Digital Light Field Photography

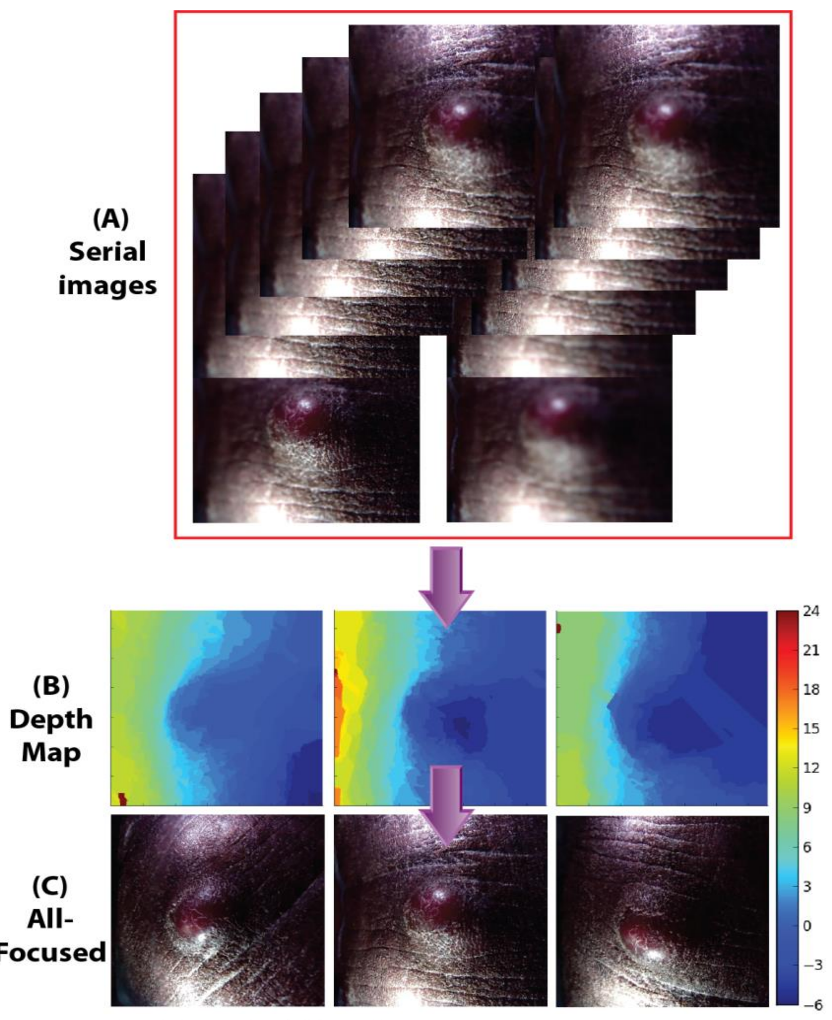

Figure 2. Construction of all-focused images

- Digital light field photography is able to capture targets at different focal lengths for reconstruction into 3D images
- The Lytro camera, based on this technology, has the potential to serve as a point-of-care tool in monitoring Kaposi's sarcoma lesions in a quantitative way (see Figure 1)
- In this pilot study, the utility of an adapted Lytro camera was compared to the iPhone 4S camera

- The original Lytro files were computationally extracted to output a series of images with a range of focus settings (A, serial images) and the corresponding depth for each position in the image (B, depth map).
- Even with just a single Lytro snapshot, an all-focused (C) image and a 3D model (Figure 3) can be constructed by combining the information from A and B.
- There are three all-focused images on panel C. They are derived from three different Lytro shots of the same KS lesion (< 1 cm).
- The tumor's volume above the skin surface (an index of "nodularity") can be calculated using the depth information shown in panel B. Combining the three sets of data in B and C will increase the accuracy of the volume calculation.
- Figure 3 shows the same lesion as in the middle panel of Figure 2C. The 3D construction was generated using a single Lytro snapshot.

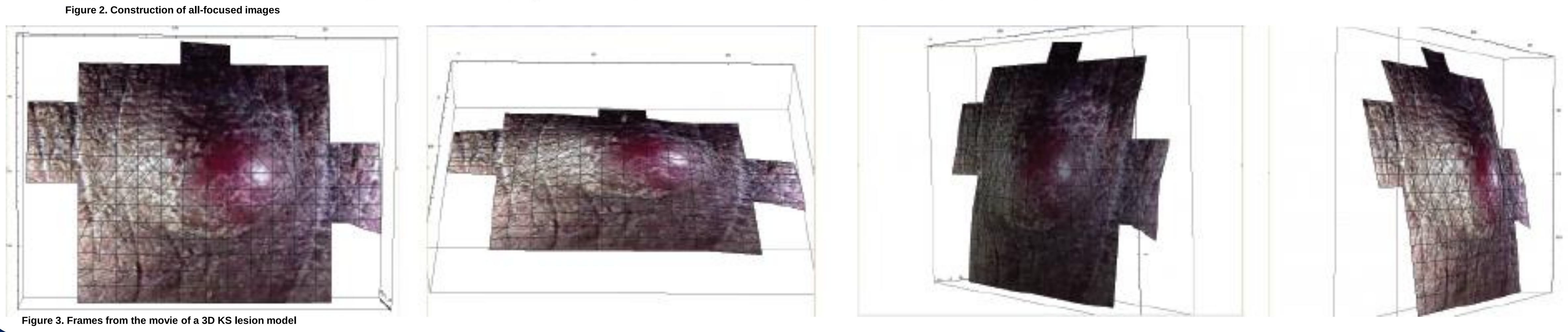

Figure 3. Frames from the movie of a 3D KS lesion model

Methods

Subjects and Methods

- Cameras: iPhone 4S camera function and adapted Lytro camera
- Subjects: Males and females (ages 17 to 50) admitted to the Dermatology inpatient ward at the MCH
- Lytro adaptation: The Lytro was pre-fitted with an adaptor designed by a UCSD engineer to standardize the images (patent pending)
- Technique: Background imagery was eliminated as much as possible with the Lytro camera
- Lesion selection: Based on nodularity (raised preferred over flat lesions), size, and location
- Sanitation: Between patients, the Lytro adaptor was cleaned with 70% ethanol
- Time period: Post-treatment photos were taken 5-8 days after initiation of chemotherapy
- Processing: Photos were uploaded and sent to UCSD for further computational processing and quantification of lesion volume

Analysis

- Comparisons between the adapted Lytro and iPhone 4S cameras were made based on ease of use, image processing, and functional capabilities in the analysis of KS lesion changes.

Funding provided by:

Results

Adapted Lytro

iPhone 4S

Measure	Adapted Lytro	iPhone 4S
Ease of use	3 images taken at bedside	1 image taken at bedside
Distant background	Must be eliminated	No problem posed
Focus post-capture	Variable	Fixed
Zoom	Functional at close proximity	Limited
Resolution	Limited	High (8 megapixels)
Image file(s)	5 files per image, 16-19 MB per image	1 file per image, 2-3 MB per image
Sterilization/safety issues	Sterilization with ethanol required	None
Post-image processing	Upload and software analysis required	None
Depth of lesion	Multiple focal lengths captured	Interpreted by user
Analysis of change in lesion	Quantitatively determined	Interpreted by user
Utility in volume analysis	High	Low

Table 1. Comparison of adaptor-fitted Lytro versus traditional camera technology.

Discussion

- **Strong points of pilot:** functional at close proximity, multiple focal lengths captured providing depth of lesion, post-capture focus variable (unlike the iPhone digital photos which has a fixed focus once the digital photos are captured)
- **Difficulties:** multiple photos required to reconstruct Lytro digital files into 3D, Lytro digital image file sizes large compared to that of the iPhone, uploading and software analysis required to extract quantitative results (not optimal given the frequency of high speed internet outages at MCH)
- **Plans for improvement**: establish a protocol of the imaging process and design a stand-alone application that can process the image files at the point of care – an important initiative given the lack of reliable high speed internet
- **Application:** this technology may lead to more effective dosing regimens, tailored therapy based on individual patient responses, and development of best practices in clinical care for patients diagnosed with Kaposi's sarcoma
- **In Summary**: with the click of six photographs (3 taken before and 3 after treatment), a precise, quantitative method for measuring the course of KS after chemotherapy would improve the prognostic capabilities of the treating physician in this resource-limited setting; however, further infrastructure improvement of the high-speed internet or a local version of software processing will be necessary if such imaging is to be used clinically