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Dental Informatics and Intra-oral Photography in Communicating with Dental Students in the Dominican Republic

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Abstract: The purpose of this article is to report on the use of the smartphone camera for intra-oral photography by a group of dental students located in the Dominican Republic during the summer of 2013. We investigated the transmission of intra-oral photographs to Creighton University Dental School. We also investigated the capture and transmission of a high-definition video demonstrating a surgical procedure to the students at the remote site. The smartphone photographs were evaluated to determine if they would be useful for diagnosis and other applications in dentistry. In the absence of a standard intra-oral camera system, it was found that smartphones could be useful in capturing and transmitting digital intra-oral images that could assist in dental education and teledentistry.

Keywords. Smartphones, Teledentistry, Intra-oral photography, Digital photography.

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1. Introduction

Due to the technological revolution of the past 30 years, the quick capture and transmission of digital images has become ubiquitous. Until the year 2000, acceptable intra-oral images could only be accomplished using film-based single lens reflex (SLR) cameras; it is now possible to use compact digital cameras and smartphones [1]. Although they may not be as useful for achieving precise control of focus, depth of field, and exposure, smartphones can capture and quickly transfer images digitally. There are times when a clinical dental SLR camera is not available and a compact digital camera or smartphone may have to substitute for a more sophisticated camera system. Quick and convenient capture and transmission of intra-oral images with a compact digital camera may be preferable in certain situations.

Smartphones are high-end mobile phones with advanced computing ability and connectivity relative to a contemporary cell phone. Current models combine many functions which include low-end compact digital cameras and high-speed data access via Wi-Fi and mobile broadband [2]. Smartphones have been sporadically mentioned in the dental literature, primarily to highlight their mobility and communication functions, relative to supporting treatment at distant locations, a process known as telemedicine or teledentistry [3, 4, 5]. Cell phone-facilitated clinical information systems particularly targeting remote resource-poor settings have been developed [6]. For example, the use of mobile phones for capturing patient data in India has been reported [7]. Teledentistry in oral and maxillofacial surgery, orthodontics, endodontics, pediatric dentistry, oral medicine, and prosthodontics in the United States has been described [8]. Currently, the University of Nebraska Medical Center manages a network for teledentistry which is distributed throughout Nebraska, and it is particularly beneficial to rural areas. Reports of military teledentistry using the internet reach back to 1999 [9]. At that time, an analysis of the experience using different methods of data transfer demonstrated that there was promise, particularly in cost savings, but that the immature digital storage and transmittal technology during the 1990s was seen as an obstacle. At the present time there are still limitations on the size of files that can be transmitted via email, particularly considering that a photograph taken with a 14 megapixel camera may produce more than 5 megabyte JPEG files (Joint Photographic Expert Group). This presents something of a hurdle when considering transmission of digital photographs. Another consideration is the HIPAA requirements (Health Insurance Portability and Accountability Act - the federal law that protects personal medical information). HIPAA requires that the transmission of any patient-identifiable information uses a secure method. At Creighton University School of Dentistry, for instance, that means that email messages sent outside of the university must have no identifiable patient information. Despite these hurdles, occasions do arise when communicating digital intra-oral images over long distances could significantly support practitioners and dental students at remote locations, thereby optimizing treatment for patients. Technology is now available so that not only can the dental student at a remote location transmit intra-oral views for faculty review at a dental school, but faculty can now also transmit instructional videos to provide guidance to the clinician at the remote site. We found a need to develop and test a protocol for students to be able to communicate with faculty at Creighton University School of Dentistry using smartphones, should consultation be deemed necessary.

The primary purpose of this study was to investigate the feasibility of dental students acquiring and transmitting intra-oral images to dental school faculty from a remote treatment site using smartphone technology. Additionally we evaluated the possibility of using a file hosting service to share high-definition (HD) clinical procedure demonstration videos created at the dental school with students located in the Dominican Republic.

2. Methods

The remote site for this project was the Dominican Republic, where for 30 years a select number of Creighton University School of Dentistry senior students have had an opportunity to participate with the Institute for Latin America Concern (ILAC). Under supervision by licensed dentists, the selected seniors deliver dental treatment in the rural areas of the Dominican Republic during the summer months. Approval for the smartphone project was obtained from the Creighton University Institutional Review Board (IRB) on June 6, 2013, for IRB #13-16722. Three senior students met the IRB criteria (completion of the internet Collaborative IRB Training Initiative (CITI) course titled Human Subject Research Education, Biomedical, originating from the University of Miami in Florida). Within the sixty days prior to departure for the Dominican Republic, the three senior students further received one hour total of briefings, which included information on the standard intra-oral photographic techniques and views. Only material from these three senior students was used in this report. The students had never attempted intra-oral photography with any camera system prior to this project. Only one of the authors (GG) had prior experience in using a smartphone camera for intra-oral photographs.

2.1 Description of Conditions, Equipment Available, and Procedures at the Remote Site

Intra-oral photographic images, with no extra-oral imaging or capture of any other personal characteristic which could lead to identification of the subjects, were acquired on patients at least 18 years of age. Before any images were acquired, an informational letter written in Spanish was distributed to each patient who agreed to participate in this project. The smartphones used by the three senior dental students in the smartphone project were the Apple iPhone 4 (1 student) and 4S (2 students) smartphones. These smartphones belonged to the students, and were the only smartphones available at the remote site. Therefore, no comparison could be made with any other brand of smartphone. The students were asked to take as many intra-oral photographs as they desired of intra-oral views that were of particular interest to them, using as much as possible the standard intra-oral techniques and views.

The lens on the 4S cell phone is a 4.28 mm f2.4 lens, corresponding to essentially a 35 mm wide-angle lens. Other technical specifications include: 8 megapixels; LED (Light Emiting Diode) flash; 5x digital zoom; ISO (International Standard Organization) speed rating 64 to 800; maximum aperture 2.4; CMOS (Complementary metal–oxide–semiconductor) sensor; and a 4:3 aspect ratio. The iPhone 4S smartphone

dimensions are: 2.3 x 4.5 x 0.4 inches (59 x 115 x 9 mm), and it's weight is 2.9 ounces (mass of 140 gm).

All intra-oral photographs were acquired with the smartphone cameras in a horizontal position. The students reported that the only intra-oral photographic resources consisted of four metal retractors which were distributed to each of the three students; one student received two retractors. There were no intra-oral photography mirrors available. Two of the treatment areas were located inside buildings, whereas one was situated in an open-air courtyard of a church. All the students attempted to maximize whatever light was available for the photography, using adjunctively indirect sunlight or flexible incandescent lamps.

All the students worked 7 to 8 hours per day with weekends off; they treated 15 to 30 patients per day, and the patients began lining up at 4:30 to 5:00 a.m. The population of patients consisted of both Dominican Republic citizens as well as Haitians. Although the local population did have cell phone service available, the senior students had cell phone service available only in the major cities, via internet cafes, which charged a fee for a connection. The three senior students took a total of 158 intra-oral photographs using their smartphones. Of those, three photographs were sent successfully via email from the internet cafes to faculty at Creighton University School of Dentistry. More of the other 158 digital photographs would have been transmitted, but connectivity to the Internet in the Dominican Republic was suboptimal and costly. The other intra-oral photographs were stored internally and carried back to the dental school when the students returned from the Dominican Republic. All of the intra-oral photographs had no identifying characteristics which would relate to specific patients, and therefore there were no compromises of HIPAA requirements.

2.2 Description of Equipment Available and Procedures at Creighton University School of Dentistry

To test recording an HD (High Definition) video at the dental school and then sharing the video with students at the remote site, the following scenario was envisioned: An intra-oral photograph would have been sent electronically from the remote site showing overgrowth of the maxillary anterior gingiva, with a query of how to remove the excess gingiva. Our challenge was: could a video recording using a cross-over camera be made which would describe an appropriate surgical technique, and that recording sent electronically to the remote site? Therefore, an unscripted 5-minute video was made using materials in the Simulation Laboratory at Creighton University School of Dentistry. In the video, surgical techniques for removing the excess gingiva in the maxillary anterior sextant were demonstrated which could theoretically guide the personnel at the remote site in performing the proposed surgery. The typodont used for the simulation was a Kavo product [KaVo Dental GmbH]. A standard periodontal surgical kit was used. One of us (LP) performed and narrated the proposed surgery while another of us (SH) recorded the demonstration.

For the 5-minute video production, a Panasonic DMC-FZ40 camera was used. The specifications on the camera include: 14 megapixels; Optical 24x zoom lens; Digital zoom 4x. The camera has an audio recording function. The image sensor is a

charged couple device (CCD). Ambient lighting was used, boosted by a standard operatory light. Recording media was an 8-GB SanDisk SDHC Memory Card.

The resulting 500 MB HD video file was too large to transmit from the dental school to the students at the remote site using email, and therefore a file hosting service, Dropbox (Dropbox, Inc., San Francisco, California, USA) had to be used instead. The Dental Informatics faculty created a shared Dropbox folder that could only be accessed by participants in this study. Each student at the remote site was sent an email containing the link to access the shared folder with instructions on how to access and view the video file from their smartphone.

2.3 Review of Images by Faculty

None of the digital images were enhanced or modified prior to being evaluated. A general dentist, an oral pathologist, and a periodontist evaluated the best three intra-oral photographs out of the 158 total in order to assess how smartphone intra-oral photographs could optimally be used. The results of that evaluation are found in Table 1.

2.4 Review of the Video Sent to the Remote Site

The three students were able to access the shared Dropbox folder and view the video, however the students reported that the large file took time to download.

3. Results

3.1 Evaluation of the Photographs Taken at the Remote Site

The assessment by the general dentist, an oral pathologist, and a periodontist is presented below. They agreed that, given the characteristics of the intra-oral photographs produced by the smartphone, they could use those photographs to assist in diagnosing or treatment planning a periodontal / restorative / or oral pathology case. Only nine of the intra-oral photographs were deemed totally not useful; of those nine, most were deficient due to being out of focus. Of the remainder, even though partially distorted, partially obscured due to technique, or exhibiting color deviations, all could be used to convey information to a referring base.

According to a General Dentist, smartphone photography may be helpful in:

- Quick consultations.
- Real time communication with a dental lab, via email.
- Real time communication with a patient in a separate location, who can also view the photograph on their smartphone.
- Humanitarian settings, such as the ILAC program, for obtaining almost real-time consultations with specialists or other dentists.

According to an Oral Pathologist, when coupled with clinical signs and symptoms, this type of photography:

- Could lead to a rank-ordered clinical differential diagnosis provided to the practitioner via text messaging or email, with treatment recommendation. This would be beneficial for solo practitioners in remote locations without access to specialty services.
- Could assist in the submission of biopsy material for histopathologic examination. Biopsy submission forms are often incomplete regarding sample site location and clinical/intraoperative findings; this would enable the pathologist to provide a more definitive diagnosis. Intra-operative surgical site photos may provide valuable information regarding consistency and form of lesions within intrabony cavities.

According to a periodontist, assuming communication with students or practitioners at a remote site, where photographic equipment may be limited to only a smartphone and retractors, as in this report, visual assessment of the periodontal tissues would be seen as helpful for:

- Assessing mucogingival defects, since simple charting may be inadequate because standard assessments record the measurement of greatest recession but may fail to identify the topography of the defect (width and depth), which may have a significant impact on the treatment modality chosen.
- Aiding in the diagnosis of acute periodontal conditions such as necrotizing ulcerative gingivitis which have a distinct clinical appearance that can readily be appreciated through imaging.
- Treating periodontal abscesses, which represent 8 – 14% of all dental emergencies, and require visual assessment of the site over time to help determine the resolution of the lesion [10].
- Monitoring space infections over time as treatment is rendered.

4. Discussion

The absence of mirrors was seen as a hindrance. When taking a lateral view, a retractor had to be dedicated to retracting the ipsilateral cheek, which meant that it was impossible to record a view approaching a 90-degree angle of the buccal aspects. Given all the required photographic equipment, under more normal conditions the retractor would be used to retract the contralateral cheek, while a mirror would be used to retract the ipsilateral cheek. Also, on the mandibular occlusal view, the tongue could not be retracted with the edge of a mirror, which meant that the lingual aspects of the molars were sometimes obscured.

A percentage of the photographs demonstrated focusing problems, possibly related to the way the Apple iPhone becomes focused: it requires a “tapping” of the screen in order to focus, and the resulting jiggling of the iPhone when capturing a close-up image may lead to blurring of the image. Some of the latest versions of smartphones do have

a voice command control of the camera function, which avoids the "tapping" required of the Apple iPhone 4.

Using smartphone cameras for intra-oral photography is not seen as overriding the need for using sophisticated intra-oral photographic equipment. Certainly in formal presentations and for medico-legal purposes, the gold standard remains with a single-lens-reflex camera having a macro lens with a focal length of 100 mm, utilizing appropriate auxiliary lighting, mirrors, and retractors [1]. As in all intra-oral photography, the minimum requirements for the smartphone images to be useful include: (1) proper focus of the intended area; (2) sufficient lighting; and (3) consistency (accuracy) of color.

The main drawback with compact cameras is the very limited control [11]. Beyond that, though, the most noticeable disadvantage of using a smartphone for intra-oral photography is the use of a wide-angle lens. As of September 2013, there are several models of after-market detachable lenses available for smartphones. Reference material on those can be found on the internet at Digital Photography Review Connect. Two Sony zoom lens systems, Cybershot QX10 and QX100 pods can attach to either Android or iOS smartphones. It is possible that these lens systems may function as macro-lenses, which would mitigate the distortion encountered when using the smartphones by themselves.

Surprisingly, there were very few problems encountered with lighting, possibly due to the smartphone LED light being situated relatively close to the lens. Surprisingly also, the color appeared to be comparable to that of 35-mm film. According to Bengel a digital SLR camera with a resolution between 8 and 12 mega-pixels can "…produce results comparable with good slide film [12]." The smartphone is by no means an SLR camera, but the 4S iPhone does have 8 mega-pixels.

The smartphones are so compact that the students reported they stored them in pockets on their clothing. It is possible that a lanyard could be attached to a smartphone holder, which could then hang from the practitioner's neck, for even greater convenience. The students reported that the smartphones were exceptionally easy to use, taking two to five photographs within less than 5 minutes.

One student reported taking the photos further away from the oral cavity; however that distance from the oral cavity meant that more of the peri-oral tissues were in the field of view. They also suggested maintaining a solid finger rest, in consideration of having to tap on the iPhone4 in order to focus the camera. Otherwise the jiggling of the camera would lead to degradation of the focus.

Unlike the case for the SLR camera with a macro lens, there is no "gold standard" for video recording intra-oral procedures. Use of the Panasonic DMC-FZ40 camera in making the demonstration video in the simulation lab produced an adequate recording which incorporated an audible narrative. This particular camera is smaller than most SLR cameras, and therefore easy to manipulate. The ambient lighting was adequate for recording images in the anterior regions of the typodont, and may be adequate for recording posterior regions if the metallic head at the simulation lab station is removed. Transferring the 500 MB HD video recording to the ILAC students was problematic.

The servers used for email at Creighton University have a limit of 15 MB. Therefore, a Dropbox folder had to be designed so that the digital material could remain available for an extended time, and only the specified students had access to the material.

5. Conclusion

A group of senior dental students from Creighton University School of Dentistry, with no prior experience in taking intra-oral photographs, used their smartphones to capture and transmit intra-oral photographs from the rural areas of the Dominican Republic. The camera function of smartphones was found to be useful for intra-oral photography in situations where a sophisticated intra-oral camera system is unavailable, and the resulting photographs need to be conveniently transmitted. Thus, this project demonstrates that the uninitiated practitioner can take usable intra-oral photographs using a smartphone in situations of remote, suboptimal conditions. Further prospective research comparing smartphone cameras to standard intra-oral camera systems would be warranted.

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