Research Article

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Assessment of the use of an intra-oral camera for epidemiological caries research

Abstract

Objectives: The objective of this study was to test the hypothesis that there is no significant difference between photographic examination using an intra-oral camera and the standard clinical examination technique for recording caries in primary teeth of 5-6 year old school children. Evaluation of inter-examiner and intra-examiner reliability for the photographic examination of dental caries was also undertaken.

Methods: Forty six children, aged 5-6 years (mean:5.8 yrs) had their teeth assessed by visual inspection and this was followed by a photographic record of their teeth by a dentist using a WIN-100 D Intra-oral camera. The photographs were examined by the same clinical examiner and another dentist for dental caries using an agreed diagnostic protocol.

Results: The agreement in diagnosis between the two examination methods for both the examiners was perfect. The level of intra-observer and inter-observer agreement for the photographic examination was almost perfect. The sensitivity of the photographic method was 77% for examiner A and 86% for examiner P, with specificity being 98% for both examiners.

Conclusion: The results indicate that photographic examination using an intra-oral camera could be a useful blinding tool in the field of dental caries epidemiological studies.

Keywords: dental caries, children, intra-oral camera, dental epidemiology

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Pathik Mehta1 Roy Byun[1,2] Anthony Blinkhorn[1]

[1]Department of Dentistry, University of Sydney, Australia
[2]Centre for Oral Health Strategy, Australia

Correspondence: Anthony Blinkhorn, Centre for Oral Health Strategy, No 1 Mons Road, Westmead, New South Wales, 2145, Australia, Email Anthony.blinkhorn@sydney.edu.au

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Introduction

Technological innovations have played an important role in dental care. These have brought about significant changes in the way dental diseases have been diagnosed and treated. Such examples as the prevention of dental caries through the use of fluoride toothpaste,[1] and digital radiography[2,3] have all impacted on patient care. Another area of technology which has changed dramatically over the recent years is dental photography.[4] Digital technology, linking photographic data to computers and the miniaturization of sophisticated high magnification cameras has resulted in many dental practitioners recommending use of photography as an educational tool, for facilitating medico-legal records and assisting with the diagnosis of clinical problems.[5] The versatility of intra-oral cameras might be the reason for which they have become extremely popular in private dental practice.[6] However, the use of this multifaceted tool has not been utilized a great deal in the field of dental research. Intra-oral cameras have been found valuable in the field of forensic dentistry.[7] They have also been used for scoring dental plaque,[8] deciduous molar hypomineralization[9] and have shown to have effectively augmented oral hygiene instruction and improved patient compliance.[10] Also a number of researchers[11–13] have found the small intra-oral cameras to be a useful tool for teledentistry offering a potentially efficient and reliable means for screening caries in children in remote or under-serviced areas. Other studies have been reported using them for scoring caries.[14] However these studies were either limited to posterior teeth or were conducted on extracted teeth.[15,16] To date published scientific literature on epidemiological projects utilizing the ability of modern light weight intra-oral cameras to record the oral health of individual patients is very limited.

On reflection it would seem a practical decision not to use this technology outside the dental office, given the costs and time involved in capturing intra oral images. However there is one problem in community epidemiological research and that is looking for a solution, on how to undertake a 'blind' assessment of the value of public water fluoridation schemes. This difficulty in a blind assessment has been an issue in providing the highest level of scientific evidence on the efficacy of water fluoridation. The limited number and the poor quality of studies on water fluoridation research was noted in the systematic review published in 2000 by the Centre for Reviews and Dissemination, York University, UK.[17] The need for a well conducted prospective intervention study on a new fluoridation scheme with a robust modern design was highlighted by the UK Medical Research Council report, Fluoridation and Health, 2002.[18] One problem to undertaking a classical randomized controlled trial on water fluoridation is to disguise from both participants and investigators whether a locality is fluoridated or non-fluoridated. An intra-oral camera has the potential to be the 'blinding tool' to assess the efficacy of water fluoridation, as photographs of teeth can be easily coded to ensure anonymity and then examined for caries at a central location. The investigators would be unaware of the fluoridation status of the study sample photographs thereby countering scientific concerns about examiner bias. A literature review yielded little information on the use of an intra-oral camera to record dental caries in epidemiological settings. Therefore, the present study was undertaken to test the following hypothesis:

There is no significant difference between photographic examination using an intra-oral camera and the standard clinical examination technique for recording caries in primary teeth of 5-6 year old school children. Assessment of the intra and inter-examiner reliability for the photographic diagnosis undertaken by two examiners was also investigated. The purpose of this pilot study was to compare diagnostic performance for the detection of caries using an intra-oral camera with a routine visual examination method and thus assess its usefulness as a tool for blinding.

Materials & methods

Participants

All the forty six children, aged 5-6 years (mean: 5.8yrs) from a primary school in New South Wales who consented to participate were included in this pilot study. The school was randomly selected out of 62 schools which were part of a larger New South Wales Fluoridation study for which the sample size calculations were undertaken. The ethics approval for the study was obtained from the Western Sydney Area Health Service, NSW, and Australia.

Clinical oral examination

All the children were examined in a supine position by a trained and calibrated dentist (A) utilizing a visual system based on previous epidemiological studies and outlined in Table 1.[19] The data were recorded by a dental assistant on mark sense cards. The oral examination proceeded sequentially beginning at upper right quadrant and ending at lower right. The teeth were cleaned with gauze to remove any plaque or debris, isolated with cotton rolls and air dried for thirty seconds using a dental air syringe one quadrant at a time, and then examined utilizing a Mirrorlite which has an in built illumination system. Repeat examinations of 10% children were randomly undertaken on the same day to check intra-examiner reproducibility.

Table 1 Clinical and photographic criteria for assessing status of primary teeth

Decay (d):
1. Cavitations of enamel and/ or dentine
1. Arrested (hardened) lesions with dentinal involvement
Lesions not showing franK cavdation:
a. Pit & fissures: Opacity/ Discoloration indicating dentinal caries with undermining adjacent enamel.
b. Smooth surtaces: Surtace ethched or a 'Nhite spot and discoloration of dentine.
c. Proximalsurtaces: Darkening/shadowing of marginal ridge as evidence of carious dentine.
Caries contiguous with a restoration (cr)
Caries adjacent to a surface which is restored
Unsatisfactory restoration (ur)
Restored surface contains one or more of the following:
a. Fractured restoration
b. Dentine or base exposed
c. Missing or fractured and mobile restoration
Precavitated decalcification (pd):
Smooth Surtaces:
Chalky white/ brown discoloration (at least 1mm wide) in canes susceptible location
Pd & fissures:
Chalky white appearance limited to enamel

Oral examination using an intra-oral camera

Following a brief period of rest the teeth were photographed in the same sequence as the clinical examination by examiner (A) who had undergone training provided for using the camera by the manufacturer as well as having three practice sessions before the start of the study. Each quadrant was air dried for 30 seconds before the photographs were captured. A WIN-100 D Intra-oral Camera handpiece (WIN-US Technology Co Korea) was utilized to obtain intra-oral photographs of teeth. It has a small head with an incorporated LED light and is easy to use in the oral cavity. The camera has a depth of field of 5-30mms, giving the option for a single or up to four teeth to be photographed. The camera has a fixed focal length and the LED illumination gives excellent image quality. The LED is so bright that it highlights shadowing under the enamel due to caries. It is a form of trans-illumination. The resolution is 752x582 PAL. A foot pedal (WIN-US foot pedal) was supplied to assist the operator, to concentrate on holding the camera steady while recording pictures.

Infection control

Standard infection control procedures during the oral examination (visual and photographic) were implemented, namely use of disposable gloves and mirror heads.

During photographic examination, cross infection control procedures as specified in the USBCam User Guide were followed, including the use of a new protective plastic sterile sheath for each subject, and cleaning of the camera casing with a mild cleaning solution after each examination.

Assessment of photographs

Assessment of photographs was undertaken 6 months after the clinical examinations. The Mediadent Imaging software was used for image acquisition and photographs were viewed using Adobe Photoshop (version 3.0, Adobe Systems Limited) on a computer screen and caries was diagnosed visually, by two trained and

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calibrated clinicians independently on same type of computer. One of these clinicians (examiner A) was the clinical examiner who also captured images of each surface of the tooth using an intra-oral camera. The effective pixel size of the photographs captured was 768X494. Photographic assessment of caries used the same protocol as for the clinical diagnosis, except that an additional code called 'not diagnosed' was included in the photographic assessment. This variable was needed to indicate surfaces that could not be viewed in sufficient detail to offer a diagnosis or surfaces which were not recorded. Twenty five percent of the pictures were scored again to check for intra-examiner reproducibility of the photographic examination. To reduce observer bias the second scoring of the photographs was done at least ten days after the initial assessment.

Statistical analysis

The data were analyzed using the SPSS program (version 17.0, SPSS Inc., Chicago, Ill.). The results were examined in terms of sensitivity, specificity, positive and negative likelihood ratios using the clinical examination as a gold standard. The Kappa test was used to assess the intra-observer and inter-observer reproducibility for the photographic examination of dental caries by the two examiners.

Results

A total of 4968 surfaces were examined in 46 school children. The comparison of the scores obtained by visual examination and by using an intra-oral camera is shown in Table 2. The scores on photographic examination (Table 2) for both the examiners were quite similar. This gave an almost perfect value of kappa (0.896) for inter-examiner agreement of the photographic examination. There was a difference seen in the surfaces coded as filled; examiner A recorded 17 and examiner P recorded 28. However, the main disagreement was seen in the number of surfaces (Table 2) where an examiner was unable to assign a score and recorded 'not diagnosed'. This proportional difference was approximately 70%; however the actual not diagnosed numbers were low. The level of intra-observer agreement for the photographic method of examination of tooth surfaces was also almost perfect (examiner A: kappa=0.908, examiner P: kappa=0.963). As compared to the visual examination fifty more surfaces were diagnosed as carious with the photographic method (Table 2). There were no major differences in the clinical examination data recorded by examiner A and the mean of the photographic score for the two examiners. The photographic examination had a much larger number of pre-cavitated (white spot) lesions diagnosed than was recorded in the clinical examination. The photographic mean dmfs score was 4.85, while the clinical dmfs score was 3.79. The agreement in diagnosis between the two examination techniques was perfect for both the examiners (examiner 1: kappa=0.854, examiner 2: kappa=0.858). The sensitivity, specificity, positive and negative likelihood ratios of the photographic method compared to clinical examination for both the examiners is as shown in Table 3. Time taken for both the examination methods were also noted and on an average it took around three minutes for a clinical examination to be undertaken for each child, while the photographic examination took almost six minutes, and this does not include the time taken to diagnose the photographs off site of approximately eight minutes per patient.

Table 2 Comparison of visual examination and intra-oral camera scores

Surface		Photographic Score		Mean	Clinical
		Examiner (A)	Examiner (P)	Photographic Score	Score
s	Sound	3906	3833	3869.5	4119
d	Decayed	152	155	153.5	104
m	Missing due to caries	40	40	40	40
f	Filling placed to treat decay	17	28	22.5	25
er	Caries contiguous with a restoration	8	7	7.5	7
ur	Unsatisfactory restoration	6	3	4.5	2
pd	Precavitated decalcification	47	50	48.5	2
u	Unerupted	620	615	617.5	625
x	Exfoliated	48	44	46	44
nd	Not diagnosed	124	193	158.5	na
Total		4968	4968	4968	4968
dmfs		4.71	5	4.85	3.82

Caries positive = d + m + f + cr, Caries negative= s

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Table 3 Sensitivity, specificity, positive and negative likelihood ratios of the photographic method compared to clinical examination

Examiner (A)

Protographic Exam	ClnicalExamCaries+veCaries-ve		
		Total	
Caries +ve	122	82	204
Caries -ve	36	3856	3901
Total	158	3947	4105

Sensitivity = 77.21%; specificity=97.92%

positive likelihood ratio=37.17; negative likelihood ratio = 0.23

Examiner (P):

Photographic Exam	ClnicalExamCaries+veCaries-ve		
		Total	
Caries +ve	136	82	218
Caries -ve	22	3796	3818
Total	158	3878	4036

Sensitivity=86.07%; specificity=97.89%

positive likelihood ratio=40.71; negative likelihood ratio = 0.14

Discussion

The children coped well with the intra-oral camera. A few did find it tiring to have the two examinations undertaken but none refused to participate. Age related dental fear where younger children are found to be more apprehensive,[20,21] was not seen in this study. The reasons for high compliance are unknown, but to an extent it can be attributed to the children being told that their teeth were going to be photographed and displayed on the computer screen. One major issue with the camera use was the surfaces recorded as not diagnosed. On average 3% (examiner 1:2.5%, examiner 2:3.9%) of the total surfaces examined could not be diagnosed as either they were not recorded or included images that were not clear enough to interpret. Camera accessibility in this young study population meant that the lingual/palatal and distal surface of molars were usually in the not diagnosed category. Use of lip and tongue retractors could have reduced the number of images as not diagnosed; however they were not used due to the young age of the study population and the cost involved in using them. Other less common reasons for unclear images were artifacts, over or under exposed images due to the positioning of the camera and distorted images mainly due to problems of focusing the camera and operator movement. Initially contamination of tooth surfaces with saliva was also a problem. To reduce this, each quadrant was air dried for thirty seconds before the photographs were taken and the camera was removed from the mouth after each quadrant had been photographed to allow children to swallow the saliva and prevent the pooling at the back of the mouth. This step also increased photographic examination time by a minute, but air drying also helped to reduce light reflection and promoted the capture of a sharper image. The 70% variation seen in 'not diagnosed' surfaces between two examiners could be possibly due to either examiner P coding surfaces as not diagnosed even if the image frame was just slightly unclear compared to examiner A who was less rigid when scoring such images. This difference could be kept to a minimum by calibrating more often. However, since this study was undertaken as pilot repeated calibrations were not undertaken. In large studies, surfaces recorded as not diagnosed could have a significant impact on the dmfs scores and every effort should be made to capture a sharp image. It is believed that with practice such images could be kept to a minimum; however it is not possible to completely eliminate them. The large number of pre-cavitated lesions recorded by the photographic examination could be due to the ability of the intra-oral camera to magnify and provide illumination, making them easier to see. Appropriate preventive care of such early lesions will help to prevent future caries. However it would be unwise to suggest that the camera is better than the, 'Gold Standard' clinical examination as the two systems are different. One could argue that the camera was giving false positives in terms of caries; our view is that the very bright light attached to the camera and the ability to examine the clinical photograph in some detail contributed to the difference in caries diagnosis. The increased number of surfaces diagnosed as decayed in the photographic examination could also be due to the clearer image, plus the greater spectral sensitivity range of the intra-oral camera compared to the human eye.[22] It is worthwhile to note that on photographic examination the increase in decay was seen on occlusal, lingual and labial surfaces. This was equally distributed in anterior and posterior region and more in maxilla as compared to mandible. The high sensitivity and specificity seen despite additional decayed surfaces observed on photographic examination could be attributed to high level of agreement on surfaces that were not carious which constituted about 75% of the surfaces observed. A test is considered to be accurate when the sum of the sensitivity and specificity is 160 or more.[23] For both the examiners this sum was more than 175. These results indicate that the pictures obtained using an intra-oral camera can be reliably used to score caries. Also, ideally histological examination should have been used at the gold standard, since some meta-analysis reviews have shown that a clinical visual examination is poor for caries detection, presenting high specificity and low sensitivity.[24] However in our study, the clinical examination comparator was the only practical option.

Focusing the camera was a problem early in this study, but by asking the child to open wide and with greater practice, focusing was not too much of a concern. Another issue was the time factor, on average the photographic examination took twice as long as the clinical examination, but the gain in information is a worthwhile compromise. The clinical and photographic criteria used for assessment were identical; however inherently there are some differences. Coding of surfaces as missing by history taking is impossible on photographic assessment. Also, it is not possible to score mobile restorations on photographs; however in this study no such surfaces was recorded clinically. It is also expected that such surfaces would be very limited and if present could well be accompanied by some amount of decay. The small size of the study population is also a limitation, larger studies are required to confirm if similar results can be obtained.

Conclusion

The results of the study indicate potential of an intra-oral camera as a tool for blinding and randomization in dental caries research, and should be further explored.

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Conflicts of interest

None.

Declaration

The findings reflect the views of the authors and not those of the funding organisations.

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