

Remote Diagnosis of Children Dental Problems Based on Non-Invasive Photographs – A Valid Proceeding?

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Abstract. Telemedicine models using commercially available technology have enabled high-quality illness care in paediatric primary care settings and markedly improved access. This fact should be explored in Pediatric Dentistry, considering that dental problems are very common in children at pre-school age and it becomes important to screen them as early as possible in order to promote the appropriate treatment. In this sense, we aim to know how telemedicine, or more specifically, teledentistry, could help on this process, evaluating the validity of children dental problems remote diagnosis based on non-invasive photographs, using accessible and low-cost technologies. Three photographs were taken for each of 66 children to be remotely analyzed by four dentists. Each dentist filled a web-based questionnaire for each child. The same children had a traditional in-person dental consultation that is used as a gold standard in this study. The results show sensitivity between 94% and 100% and specificity between 52% and 100%. The positive predictive value was between 67% and 100% and the negative predictive value between 94% and 100%. These results suggest that remote diagnosis of children dental problems based on non-invasive photographs constitute a valid resource when we pretend to exclude referred children to a dentist for treatment of dental problems, but further studies should be carried out to increase the validity of this proceeding to referring children for the same treatment.

Keywords. telemedicine, teledentistry, dental problems, diagnosis

1. Introduction

Telemedicine models using commercially available technology have enabled high-quality illness care in paediatric primary care settings and markedly improved access [1].

Until now, telemedicine has been successfully used in many medical specialities but not so widely used or accepted in dentistry (teledentistry). Nevertheless, teledentistry may be quiet useful as a practical and potentially cost-effective means to screen a large number of children for signs and symptoms of oral disease [2]. In fact,

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the developing field of teledentistry has the potential for benefiting dental care by enhancing early remote diagnosis, timely treatment of oral diseases, improved utilization of dental services and access to care. In the long term, teledentistry may also help to establish a “dental home” for participating children [3].

The early telediagnosis of dental problems assumes particular importance, because acting as early as possible is relevant, mainly in a preventive way and from deciduous teething phase, so that children can maintain appropriate oral health. In Portugal, an important study at national level shows a significantly high prevalence of caries (49%) in children with only 6 years of age [4]. Another study shows that most of the children (56%) only begin dental visits after this age [5]. Besides, malocclusion problems can also frequently occur in early ages, but, teledentistry might also provide significant and valid orthodontic guidance to dentists serving disadvantaged children. In fact, the results of a study conducted by Berndt et al., suggest that interceptive orthodontic treatments provided by sufficiently prepared general dentists and supervised remotely by orthodontic specialists through teledentistry are a viable approach to reducing the severity of malocclusions in disadvantaged children when referral to a specialist is not feasible [6]. According to these facts it is important to take measures that make dental problems diagnosis already in pre-school age possible in order to promote the appropriate early treatment.

There are studies which refer that digital images have great potential for identifying oral conditions that may be used for referral and treatment recommendations, as well as for consultation among specialists and primary oral health care providers [3]. Digital cameras are easy to use, in terms of both making and storing the photographic images and for a typical dental practitioner with minimal photographic expertise, the new digital photographic technology is one of the most significant potential improvements available for a dental practice [7]. Thus, teledentistry could help the process of early diagnosis of dental problems, by proving an infrastructure for remote and off-line diagnosis based on sending to dentists oral photographs of children taken in their kindergartens, preferentially using non-invasive methods for economic and asepis reasons.

With this study, promoting such a scenario, the authors aim to evaluate the validity of dental problems remote diagnosis based on non-invasive photograph, using accessible and low-cost technologies.

2. Methods

Sixty-six children of two kindergartens were selected considering the classes of 4 to 6 years old children of each one. The following four steps were taken, after having the approval of a commission of ethics, approval by the General Direction of Innovation and Curricular Development, informed consent and 94.3% of parent’s permissions (66 positive answers in 70 requests):

- Diagnosing dental problems through in-person examination of pre-school children in their kindergartens by an experienced dentist under appropriate conditions of light and using a sterilized exploration kit. This examination is our gold standard when comparing to the remote diagnosis.
- Gathering of data carried out by previously trained Childhood Educators, using a Nikon Coolpix L3 digital camera with 5.10 Megapixels resolution, in

automatic mode function. Three oral/dental photos of each examined child were taken making a total of 198 images. Such photos correspond to three different framings of the child's dental arches: frontal, superior and inferior perspectives (Figures 1 to 3).



Figure 1. Frontal perspective



Figure 2. Superior perspective



Figure 3. Inferior perspective

- Remote diagnosing of dental problems carried out by four different dentists, through the observation of the sets of obtained images using a web-based system called MedQuest and developed by the Biostatistical and Medical Informatics Department of Faculty of Medicine of Oporto University. MedQuest is implemented in Apache and PHP, and stores the data on an Oracle DBMS (Database Management System). MedQuest allows registered users (in this case dentists) to have access to their personal set of cases. Users accessed MedQuest web site from home using the Internet. After logging in, each user is asked to choose from a list of cases, which in this case were anonymised children identifiers. After selecting the case, the predefined questionnaire appears for the user to insert their data. The questionnaire included on the top three photos (Figures 1 to 3) of the child and then 44 questions about the interpretation of photos by the dentist. These questions included the whole deciduous teething, some definite teeth, most important orthodontic problems and other general dental problems. More specifically, the questionnaire pretends to screening initial and/or advanced caries, presence of tartar, gingivitis or dental fractures. At orthodontic level, it intends to diagnose cases of malocclusion, namely dental crowding, open bite, overjet or overbite. As a final and conclusive question, this questionnaire asks about the need to refer children to a Dentist for dental problems treatment.

- Doing the statistical analysis (sensitivity, specificity, and predictive values) on the collected data. MedQuest allows exporting (as Comma Separated Values) all collected data, a crosstab format to facilitate statistical analysis.

3. Results

The collaboration of the children involved in the project was considered excellent and the images presented acceptable resolution, colour, brilliance and contrast, suggesting that the used low-cost technology will be able to constitute a resource to explore. However, some difficulties were found also, namely the necessity of carrying out the in-person diagnosis and the taking of images over several days due to the partial absences of children due to health reasons.

A first analysis was already done relatively to the question we consider crucial – “Based on this diagnosis; would you give indication so that this child should be referred to dental problems treatment?” (see Table 1). The gold standard (in-person examination) found that 50% (n=33) of the children needed to be referred to dental problems treatment. Regarding the remote diagnosis and when comparing to the gold standard, the results show sensitivity between 94% and 100% (98% in average) and specificity between 52% and 100% (73% in average). The positive predictive values were between 67% and 100% (80% in average) and the negative predictive values between 94% and 100% (97% in average).

Table 1. Sensitivity, specificity and predictive values

Remote examiners	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Children observed
Dentist 1	100	76	80	100	66
Dentist 2	97	52	67	94	66
Dentist 3	94	100	100	94	66
Dentist 4	100	64	73	100	66
Average	98	73	80	97	

The possible difficulty on seeing posteriors areas of the mouth and the different individual interpretation of the specific classification criteria considered on this project could constitute the main reasons of errors. However, the excess or lack of zeal, intrinsic of each dentist character, may also interfere with the answer to this final and conclusive question.

4. Conclusions

Based on these results, we conclude that remote diagnosis of children dental problems in our population (with a prevalence of 50%) based on non-invasive photographs constitute a valid resource when we pretend to exclude referred children to a dentist for treatment of dental problems (the average negative predictive value is 97%), but further studies should be carried out aiming to increase the validity of this proceeding to referring children for the same treatment (the average positive predictive value is 80%).

Nevertheless, this method could be used to help in the early diagnosis of dental problems acting, so that children can maintain appropriate oral health. Although cost-effectiveness studies of this method should be performed, we feel that having the photographs taken by school teachers and using currently available technologies (e.g., low-cost digital cameras), increases the feasibility of regional or national scale children oral health campaigns.

The specificity of the test would probably be improved if the dentists had some feedback on their evaluation, as they would learn from their mistakes. An evaluation of the learning curve after having feedback should be considered as future work.

We also intend to study agreement rates between the dentists involved in the remote diagnosis, and also to do a sensitivity and specificity evaluation on each of dental problems that were considered on the questionnaire.

The authors are also currently involved in doing a similar study using first year medical students to do the remote diagnosis instead of qualified dentists.

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References

- [1] McConnochie, K.M. (2006) Potential of telemedicine in pediatric primary care. *Pediatrics in Review* 27(9):e58–e65.
- [2] Kopycka-Kedzierawski, D.T., Billings, R.J., McConnochie, K.M. (2007) Dental screening of preschool children using teledentistry: A feasibility study. *Pediatric Dentistry* 29(3):209–213.
- [3] Kopycka-Kedzierawski, D.T., Bell, C.H., Billings, R.J. (2008) Prevalence of dental caries in early head start children as diagnosed using teledentistry. *Pediatric Dentistry* 30(4):329–333.
- [4] Portuguese Ministry of Health (2008) *National Study of Oral Diseases Prevalence*. Dictorate-General of Health Ed., Lisbon.
- [5] Stomatology and Dentistry Portuguese Society (SPEMD) (2007) *Newsletter n°6 Publication of the Colgate Palmolive*.
- [6] Berndt, J., Leone, P., King, G. (2008) Using teledentistry to provide interceptive orthodontic services to disadvantaged children. *American Journal of Orthodontics and Dentofacial Orthopedics* 134(5):700–706.
- [7] Christensen, G.J. (2005) Important clinical uses for digital photography. *The Journal of the American Dental Association* 136(1):77–79.