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ARTICLE

DEVELOPMENT OF A TELEDENTISTRY SYSTEM FOR THE ELDERLY IN THE CONTEXT OF THE COVID-19 PANDEMIC: 3D DIAGNOSTIC MODELS INTEGRATION IN A WEB PLATFORM.

Desarrollo de un sistema de teleodontología para adultos mayores en el contexto de la pandemia de COVID-19: integración de modelos de diagnóstico 3D en una plataforma web.

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ABSTRACT:

Objective: To recognize the usefulness of incorporating Three-Dimensional models of standardized humans in electronic health records, in the context of the development of a teledentistry web platform designed for the attention of the elderly population in COVID-19 pandemic context. **Material and Methods:** A teledentistry web platform designed with different modules for clinical records. Through a new user-computer interface with a standardized virtual 3D phantom, an extraoral physical examination, an intraoral examination section was modeled. A label-associated marker is allowed to record descriptive aspects of the findings. A 3D odontogram represents multiple patient's conditions for each of the 32 dental positions. **Results:** From a total of 135 patients registered on the platform, 51 markers and 33 photographs associated with the surface of the virtual 3D phantoms were recorded. For the Location parameter: Hard palate 27.6%, inserted gingiva 15.7%, tongue 15.6%. For the Type of lesion parameter (according to the information entered in the pathology selector): unidentified 35.3%, subprosthetic stomatitis 23.5%, irritative fibroma 9.8%. Through the registration of the exact location of the finding in the virtual phantom by a 3D marker, the 3D modeling of the oral pathologies contributed to a better diagnosis, improving the remote communication between the attending dentist and specialists. **Conclusion:** The combination of the 3D modeling and anatomical-referencing in a teledentistry platform can become a powerful tool for the dental practice, due to their utility and specificity.

KEYWORDS:

COVID-19; three-dimensional; phantoms; electronic health records; teledentistry; user-computer interface.

RESUMEN:

Objetivo: Reconocer la utilidad de incorporar modelos tridimensionales de humanos estandarizados en registros electrónicos de salud, en el contexto del desarrollo de una plataforma web de teleodontología diseñada para la atención de la población adulta mayor en contexto de pandemia por COVID-19. **Material y Métodos:** Una plataforma web de teleodontología diseñada con diferentes módulos para historias clínicas. A través de una nueva interfaz usuario-computadora con un fantoma 3D virtual estandarizado, se modeló un examen físico extraoral, una sección de examen intraoral. Se permite un marcador asociado a la etiqueta para registrar aspectos descriptivos de los hallazgos. Un odontograma 3D representa múltiples condiciones del paciente para cada una de las 32 posiciones dentales. **Resultados:** De un total de 135 pacientes registrados en la plataforma, se registraron 51 marcadores y 33 fotografías asociadas a la superficie de los fantomas virtuales 3D. Para el parámetro Ubicación: Paladar duro 27,6%, encía insertada 15,7%, lengua 15,6%. Para el parámetro Tipo de lesión (según la información ingresada en el selector de patología): no identificado 35,3%, estomatitis subprotésica 23,5%, fibroma irritativo 9,8%. A través del registro de la ubicación exacta del hallazgo en el fantoma virtual mediante un marcador 3D, el modelado 3D de las patologías orales contribuyó a un mejor diagnóstico, mejorando la comunicación remota entre el odontólogo tratante y los especialistas. **Conclusión:** La combinación del modelado 3D y la referenciación anatómica en una plataforma de teleodontología puede convertirse en una poderosa herramienta para la práctica odontológica, debido a su utilidad y especificidad.

PALABRAS CLAVE:

COVID-19; Tridimensional; Fantasmas de Imagen; Registros Electrónicos de Salud; Teleodontología; user-computer interface.

INTRODUCTION.

In 2007, an IBM research team in Zurich created the Anatomic Symbolic Mapping Engine, a system that would allow physicians to view electronic medical records (eHR) of their patients using 3D images of the human body.[1]

Wallis *et al*,.[2] in 2016 created a app that uses a specific model for the objective evaluation of burns; combining anthropometric parameters. Currently, new technologies allow the visualization and manipulation of hypergraphic 3D templates of "*body/organ* " and patient-specific 3D/4D, Virtual Reality (VR) and Augmented Reality (AR) models in an attempt to define an information infrastructure in a growing telemedical information society.[1]

In this context, the communication of diagnostic information between a dentist and dental or medical specialists when access to them is limited due to geographical location or other reasons, could be facilitated through the representation of 3D models in different layers of information in order to integrate it in a teledentistry system that can be easily accessed online.

The objective was to recognize the usefulness of incorporating three-dimensional models or virtual representations of standardized humans, in registry and digitalization environments of clinical information, in electronic dental-medical records, in the context of the development of a teledentistry web platform specially designed for the attention of the elderly population.

MATERIALS AND METHODS.

A teledentistry web platform

Designed in a modular way, the platform consists of a patient admission module, a consultation agenda module, a patient reception module, an anamnesis module (general, medical-geriatric, dental-geriatric), an inter-consultation module and a module for clinical records that summarizes the existing information in the previous items.

Specifically, a 3D model is integrated in the dental-

geriatric anamnesis submodule to index relevant information for each dental care.

For the implementation of the 3D model on the platform, react-three-fiber was used, which is a React renderer for the three.js library written in Javascript to create and display 3D graphics with WebGL technology.[3,4]

A STANDARDIZED VIRTUAL PHANTOM

Extraoral physical examination section

Structured by a pre-designed outer layer from Makehuman software (version 1.1.1), corresponding to a face and part of the bust of a standardized elderly person.

The creation and edition of label-associated markers by anatomical-referencing is allowed to link observations and photographs related to the inspection and palpation of the head and neck, (Figure 1A).

Intraoral examination section (soft tissue and mucosa). A 3D mesh was designed and modeled by the project's 3D modeling team, from bibliographic and photographic references to represent the oral cavity, which consists of the soft tissues of the cheeks, soft palate and oropharynx; two independent 3D meshes for the upper and lower alveolar ridges linked to the hard palate.

Similar to the previous section, label-associated markers by anatomical-referencing are allowed to link related clinical observations and photographs, but in this case they are created to record descriptive aspects of the findings observed by the general dentist.

By means of a pathology selector, a parameterizable 3D model can be included to represent a lesion whose color and size can also be adjusted, (Figure 1B and Figure 1C).

Figure 1. Extraoral physical examination section.

A. Extraoral examination virtual phantom. **B.** Representation of a tumour-like lesion. **C.** Marker located in the right inner cheek shows an irritation fibroma in the virtual 3D phantom of intraoral examination. **D.** Partial edentulous patient clinical photography. **E.** Dental configuration in the virtual phantom of odontogram section. **F.** Dental state selector interface. **G.** Transparency tool.

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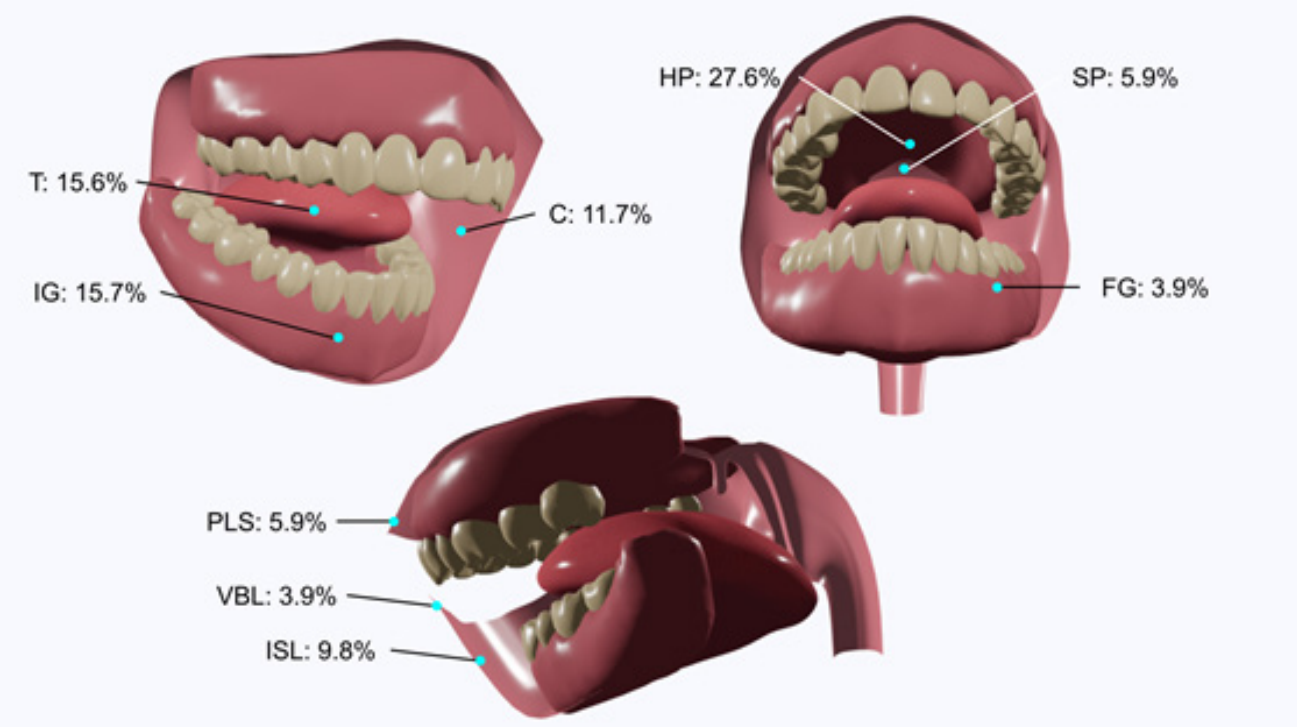
Figure 2. Percentage frequencies of anatomical-referencing markers in intraoral examination virtual 3D phantom.



Odontogram

To represent multiple conditions presented by the patient for each of the 32 dental positions, 4 types of objects were designed: a normal tooth (MIT and CC0 licenses), a fractured tooth, a root remainder, and a standardized implant (cylindrical body), (Figure 1D and Figure E).

By means of a selector it is possible to change between the different states for each dental position (Figure 1F). Furthermore, the transparency of the model can be adjusted to allow for the visualization of structures inserted in the alveolar ridges (Figure 1G).

RESULTS.

From a total of 135 patients registered on the platform (48 men and 87 women, average age 72) and 51 markers and 33 photographies associated with the surface of the virtual phantom, different distributions were recorded; for the Location parameter:

Hard palate (HP) 27.6%, inserted gingiva (IG) 15.7%, tongue (T) 15.6%, cheek (C) 11.7%, inner surface of lip (ISL) 9.8%, perilabial skin (PLS) 5.9%, soft palate (SP) 5.9%, vermilion border of lip (VBL) 3.9%, free gingiva (FG) 3.9%. Regarding the Color parameter: white 29.4%, red 27.5%, pink 17.6%, mixed 15.7%, violet 5.9%, others 4%.

On the other hand, percentage distribution for the parameter Type of lesion, according to the information entered in the pathology selector: unidentified 35.3%, sub-prosthetic stomatitis 23.5%, irritative fibroma 9.8%, papillary hyperplasia 7.8%, candidiasis 5.9%, others 11.9% (Figure 2).

DISCUSSION.

Through the registration of the exact location of the finding (anatomical-referencing) in the virtual phantom by a 3D marker in combination with an indexed image and a clinical description, the 3D modeling of the oral pathologies contributed to a better diagnosis, greatly improving the remote communication (synchronous or asynchronous) between the attending dentist and medical and dental

specialists.

Conventionally, the media used to record and share patient information in electronic dental records has been in the form of questionnaires, telemedicine applications, non-specialized platforms, email, mobile messaging applications,[5] which are not specialized or specifically dedicated to dental or medical purposes, which is associated to risks related to the confidentiality of patients and information losses.

Furthermore, the use of a location referred to a nonspecific parameter (eg: lower inserted gingiva), or an isolated photograph, leaves the orientation and relationship of the lesions within the oral environment to the interpretation of the specialist (dental prosthesis mismatch, injuries caused by rubbing against fractured parts, metallic elements, etc.), which makes their diagnostic interpretation even more difficult.

Even though smartphones might have very high resolution cameras, it is difficult to contextualize the location of the lesion in the shot, which can lead to errors in the diagnostic interpretation by the specialist reviewing the images.

Here in Chile, the following digital platforms are the most commonly used, both in private and public services: "Rayen", a non-specialized piece of software based on traditional forms; "Dentalink", a specialized software application that does not include indexing of information through 3D models; and the recent deployment of the "Hospital Digital" platform, which includes a specific section oriented to maxillofacial and oral pathologies.[6]

This is a government initiative, with records based on conventional forms, which was created for the prompt diagnosis of oral cancer and the treatment of lesions of the oral mucosa, salivary glands and maxillary bones. However, the platform's application to digitize photographs is not specifically designed to generate dental records and it does not allow for anatomical-referencing through 3D modeling.

According to the last, it can be concluded that by combining the 3D modeling and anatomical-referencing, a new path for the development of novel teledentistry platforms and electronic dental record systems can become a powerful tool for the dental practice, due to their utility and specificity.

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Conflict of interests:

The authors declare no conflicts of interest.

Ethics approval:

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Authors' contributions:

Conceptualization: Beltrán V, Acuña-Mardones P, Acuña-Mardones D. Research, methodology and supervision: Beltrán V, Acuña-Mardones P, Engelke W. Data gathering: Acuña-Mardones P. Data analysis: Beltrán V, Acuña-Mardones P. Writing—original draft: Acuña-Mardones P, Acuña-Mardones D, Fernández-Gil F. Writing—review and editing: Beltrán V, Acuña-Mardones P. Image work: Acuña-Mardones P.

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