

Solving incompatibilities between Orthodontic Electronic Patient Records

Antonio Magni, Robson de Oliveira Albuquerque,
Rafael Timóteo de Sousa Júnior,
Mark G. Hans, Franco G. Magni

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Abstract

Today orthodontists need not burden their work load with tasks such as figuring out how to send patient information to colleagues or how to share the same patient record across different software programs. As a long term attempt to alleviate these tasks, we are working on developing a standard for the orthodontic electronic patient record to enable a seamless interchange of patient data between software programs. This article describes a practical proposal that integrates two existing standards, HL7 and DICOM, to create a standard for the orthodontic electronic patient record.

1 Introduction

Over the past decades, personal computers have found their way into almost every field of medicine [16, 7, 11]. The advantages of using a computer in an orthodontic practice have been evident for many applications [13, 14, 4, 8, 18], such as digitizing x-rays, automatically tracing and collecting measurements, modeling patient growth [5, 15], storing clinical photographs, placing brackets automatically, and many more. The rapid development and spread of computer hardware has enabled the performance of increasingly complex operations, forcing software vendors to quickly meet the demands of the public. At the beginning it was believed that one company could provide a solution to meet all orthodontic requirements. Software engineers were planning their software to be independent, and the relationship with other software vendors tended to be very competitive. After some years, with various high quality software products sharing the market, the need to interchange electronic patient data gained importance.

At the time of writing, the interchange of orthodontic electronic data among different programs is very difficult. This difficulty can be broken down into two problems:

1. There is no easy, straightforward way for an orthodontist to share selected electronic patients records (EPRs) with another orthodontist;
2. There is no mainstream way for two or more orthodontic programs to access the same pool of EPRs.

The first problem is exemplified by the following scenario. Carl is a recently-graduated orthodontist. Unsure of the treatment of choice of one particular patient, he opts to seek the help of a more experienced colleague, Magda, to clear his highly specific clinical doubt. Magda enjoys assisting Carl with his difficult cases, and asks Carl to send the patient's records over, so she can take a look at them. Although the patient's electronic record in Carl's patient management program already includes impressions, x-rays, tracings and notes, it is not the same patient management program that Magda utilizes. After various failed attempts, Carl is unable to send his information over to her in a compatible format. He thus resorts to printing out the printable material, and sends it over to her. However, Magda would like to analyze the impressions too, which even when printed, are not easily analyzed. Although they are already digitized in the computer, her software does not allow her to view them, and must pay Carl a personal visit to solve this problem. Carl and Magda work in the same city, and are somehow able to work around their problem of software incompatibility. But what would happen if they lived in different cities or even different countries?

The next scenario will help us understand the second problem. Recently graduated, Carl wants to build his new practice. Among other choices, he must decide which software program to purchase, and has found a great patient management software that meets his needs.

After purchasing and using the program for some time, however, he discovers that its cephalometric analysis part is weak, and that he could increase patient care by using the same cephalometric analysis program Magda uses in her practice. Once purchased, he realizes that the two software programs he now owns do not communicate with each other! If, for example, one patient record claims the patient's date of birth to be May 13, 1993 and another one erroneously to be May 13, 1983, Dr. Carl will have to modify (add or remove) the patient record twice, once for each system. Should he forget, he may end up with inconsistent patient records, which makes a big difference from an orthodontic perspective. Suppose Dr. Carl decides to add a new image management program, or maybe a CBCT scanner to his institution... will he have to modify three, four or five EPR databases for each change?

If we accept the assumption that computer programs should improve patient care by making processes more efficient, the above mentioned situations are unacceptable. These issues need to be addressed immediately. The use of already developed clinical standards has been limited to observation and prototyping by vendors and experimentation in academia, mainly because the use of proprietary design maintains the vendors' competitive position in the market place. A standard only gains commercial value once it has been widely implemented.

This explains why vendors are reluctant to implement a new informatics standard. Currently we see increasing interest in these standards owing to current US federal government initiatives in health information interoperability, following a trend already present in other regions like Europe (where there is heavy government involvement in health care programs). Now is the right time to illustrate one practical way to solve the above mentioned issues.

Instead of starting the development of the Orthodontic Electronic Patient Record (Ortho-EPR) standard from scratch, we are convinced that the answer lies in a standard composed of two already existing and well established informatics standards: Health Level Seven (HL7 [17], see Sec. 2.2.1) for textual data and DICOM [12] (see Sec. 2.2.2) for image data (refer to Illustration 1). The integration of the two will be coordinated and published by the American Dental Association (ADA) Standards Committee for Dental Informatics (SCDI) in order to ensure its functionality in an orthodontic context. From a technological point of view, the standard would define the processes and interactions involved during everyday clinical and financial orthodontic practice: in short, a computer standard for software vendors and programmers. Among its tasks, the standard will document all the fields necessary to fully represent the orthodontic patient records as well as their transferability, and be recognized by a large community of orthodontic specialists. In addition, it will include an implementation manual for software vendors to demonstrate its intended operation. Once completed and implemented, the standard will allow seamless and efficient patient information exchange and synchronization.

2 Methodology

In this section we discuss the general process of developing an informatics standard, and describe our proposal for solving the problems introduced in the previous section. This requires a brief study of the building blocks of our suggestion: ADA SCDI, HL7 and DICOM

2.1 Developing an informatics standard

The development of an Ortho-EPR can be broken down into seven parts:

1. Forming a community
2. Defining the domain
3. Researching existing technologies
4. Defining a technology
5. Building the standards
6. Balloting and releasing
7. Implementing and testing.

This subsection discusses the above mentioned methods of execution and are based on the initial proposal prepared by P. deSmedt [1].

Forming a community

The process of developing a standard starts by forming a community of interested parties which eventually develops into a formal body. In order to achieve this, on May 2004 a new working group within the *American Dental Association* (ADA) *Standards Committee for Dental Informatics* (SCDI) was formed by Philippe deSmedt (Align Technology) and Steve Bartingale (3M). Called WG11.6 *Integration of Orthodontic Standards*, this working group as of today counts with the membership of 3M, University of Northern Carolina, University of Illinois at Chicago, University of the Pacific, University of Missouri Kansas City, Case Western Reserve University, University of Pittsburgh, Loma Linda University, Universidade de Brasília, Kodak, Dolphin Imaging, Ortho Computer Systems, Inc., Orametrix and Drake Visual LLC. The process of community-forming has successfully created a formal group (ADA WG 11.6) of interested parties from academic, commercial (industry) and clinical fields.

Defining the domain

Domain is the specific sphere of activity and working elements of a given project. The above mentioned group has decided that the domain for the standard should include all orthodontic data currently used in digital format. This encompasses the entire orthodontic domain, which can be grossly divided into imaging data (photos of patients, x-rays, CBCT scans, ...) and non-imaging data (patient demographics, clinical information, financial information, ...). A more refined definition is taking place among WG11.6 members.

Research

We are currently in the process of evaluating existing imaging, medical, dental, orthodontic, other data and data exchange standards in order to adopt them wherever possible and appropriate. We are evaluating the organizations, their internal processes and implementations as well as the structure of their standards to find a match for our project. The infrastructure of an existing standard developing organization can greatly simplify the development process of the Ortho-EPR. The research process will collect various proposals from our group members (ADA SCDI WG 11.6). These collected documents should include a brief summary of the standard, how it would benefit the development of the project as well as the details of the relationship between our group and the above mentioned organizations.

Define the technology

Based on the documents delivered in the previous phase, there will be a meeting for the group to decide which proposal(s) to advance. Upon reaching a consensus

on which path to take, the group will deliver a document specifying which standard organizations to adhere to and the details of the relationship between our group and the external organizations. The document will include how to divide the group into subgroups to work towards the delivery of the final product.

Build the standard

In this phase each subgroup will work individually according to the plan established in the previous phase. At the end of this task, the individual work will be harmonized in order to put together the Ortho-EPR standard. This phase will deliver a first draft of the Ortho-EPR standard.

Ballot and Release

The first draft of the standard delivered in the previous phase needs to be balloted, such that every member of our or other affiliated groups may have a chance to review it. This process will cause revisions and re-balloting, eventually delivering a first implementable release of the standard.

Implementation and Testing

The first release of the standard must get implemented and tested before it can be considered complete. Subgroups formed primarily by vendors and software developers should take over this task to produce software that can handle orthodontic information stored or transmitted in the newly developed format. Should this stage highlight errors, a new cycle of revision, balloting, release, implementation and testing will take place. Hence, it is foreseeable that once this stage has been reached, the group will find itself cycling between balloting, releasing, implementing and testing until a satisfactory version of the product is delivered.

2.2 Standards for Medical Informatics

This section introduces the reader to the two most successful medical informatics standards: HL7 for messaging and DICOM for imaging. It also focuses on the ADA committee responsible for the development of informatics standards.

2.2.1 HL7

The HL7 standard defines how to transfer medical non-imaging information across different computer systems, networks and programs. HL7 differs from Specification 1000 (see below) in that it specifies how the data should be transferred once they leave a specific computer program, while Specification 1000 defines how the data should be stored once they enter a computer program.

While Specification 1000 is based on a fully balloted and diagrammed clinical process model, HL7 starts its development from Storyboards. A Storyboard is a short description of a specific medical scenario (aka a Use Case), but does

not make use of diagrams and is not balloted. The latest HL7 release is version 3 (v3), which is based on modern object-oriented modeling and programming techniques.

HL7 is rapidly growing and spreading internationally. Its organization has affiliates in more than 20 countries, and the standard is being used by many well-accredited health institutions. According to its organization, 90% of hospitals in the USA make use of some form of the HL7 standard (mostly still the older version 2). Although no official dental technical committee exists in the USA, the Canadian Dental Association and HL7-Canada already have completed some work with dental insurance claims and have shown interest in joining efforts with the ADA to form a dental HL7-USA technical committee.

Making use of HL7 to develop the Ortho-EPR standard would yield a series of advantages. First of all, the HL7 community is very large and includes international members, which would confer the opportunity to obtain quality feedback to deliver an improved product. Secondly, HL7 makes use of modern technologies: mixing the clinical approach (starting from Storyboards) with object-oriented modeling (using v3), promises better planning and a more flexible end-product. Furthermore, HL7's widespread use among hospitals could facilitate the product's appeal to software companies, an issue of notable weight considering that a widespread implementation is equivalent to a successful standard, hence better integration between orthodontics and existing clinics and hospitals. On the other hand, HL7 does not provide any specifications for images. It does however integrate well with DICOM.

2.2.2 DICOM

The Digital Imaging and Communication in Medicine (DICOM) specification is the only internationally recognized standard for the communication of images and related information in the health domain. It originated in 1983 when the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) identified the need for interoperability among imaging equipment from various vendors.

DICOM is being extensively used in many countries and medical environments and is undergoing considerable development to include images from new devices and medical fields. Extensions to the DICOM standard now encompass all aspects of digital and digitized dental radiographs. The ADA endorses the use of DICOM as the standard means for exchange of all digital dental images. However, the DICOM standard extends well beyond the needs of dentistry, making it therefore necessary to select the relevant parts with applicability to dentistry [3]. The ADA SCDI (Standards Development for Dental Informatics) has formed a working group called *Application of the DICOM Standard to Dentistry* (also known as WG 12.1), whose members are part of an equivalent working group within the DICOM Standards Committee. This tight collaboration ensures that DICOM developments satisfy requirements of dental professionals by delivering documents such as *Technical Report No. 1023: Implementation Requirements for DICOM in Dentistry* [3].

Unlike HL7, DICOM already has a formed working group for the dental community. This and its widespread use encourages the use of DICOM for orthodontic digital images. DICOM offers standards for almost all kinds of medical images; refining it for orthodontics should involve relatively little work.

In summary, DICOM provides a good framework which could be used to define the image domain of the orthodontic electronic patient record.

2.2.3 ADA and Specification 1000

The ADA is the sponsor and secretariat of the standards program for all areas of dentistry, including all types of dental materials and products (ADA Standards Committee on Dental Products) and Dental Informatics (ADA Standards Committee on Dental Informatics). The ADA standards committees comprise a balance of interests between dentists, government, academia and industry and develop standards according to rigorous protocols that ensure consensus among all interested parties [10].

Specification 1000 refers to ANSI/ADA *Specification No. 1000 Standard Clinical Data Architecture for the Structure and Content of an Electronic Health Record*, the only American national standard that defines the fundamental data structures used to build EPRs. Specification 1000 defines the data structure of a generic health record. This means it defines rules about how to program a database so it can be used as a virtual health record file cabinet. This differs greatly from other computer standards (such as HL7 or DICOM) which primarily specify how programs should send information related to healthcare between different computer systems. When implemented, Specification 1000 would ensure that two programs could directly access the same health record data pool at the same time. It does not, however, define how to exchange the data across different medias or networks.

The only ADA SCDI standard that deals with informatics, Specification 1000 was the first standard to have been derived from a balloted clinical process model. This means modeling out all clinical processes first, then defining the informatics standard from the model. Specification 1000 comes with an implementation manual [6] but, to the best of our knowledge, Specification 1000 has been limited to observation and prototyping by vendors, and experimentation in academia. In addition, it does not contain any dental-specific definitions.

Being the biggest, most influential dental association in the world and having a well developed standards committee, the ADA can provide a solid infrastructure to house the development of the Ortho-EPR standard. The SCDI comprises members from different areas, which can contribute their knowledge and resources for the project: while orthodontists provide the more technical necessities and contribute their specialized knowledge, industry and government representatives will supply resources for meetings, implementations and testing. In addition, the committee is specialized in developing and distributing standards and is an ANSI-accredited institution. We recommend to develop the Ortho-EPR standard by following the clinical model approach used during the development of Specification 1000.

2.3 Our proposal

From the outcome of our analysis we propose the structure represented in Figure 1 for the Ortho-EPR standard: an ADA/ANSI standard that is composed by the integration of HL7 with DICOM. Using this approach, we can make sure that the data will be most compatible with existing systems, while at the same time delivering a complete orthodontist-approved Ortho-EPR standard. The ADA SCDI would provide the official standard and standard implementation documentation (similar to Specification 1000 and its accompanying Technical Report 1027). This process is divided in three main phases: planning, developing and integration.

The concepts in this and the next chapter have not been presented to the mentioned organizations (ADA, HL7 and DICOM) yet. None of these organizations shall be held responsible for any of the concepts in these chapters. Even though it is very likely that at least some parts of this proposal will be implemented, none of the organizations have agreed to complete or to execute the ideas mentioned below, neither in whole, or in part.

Planning In the planning stage it is necessary to develop a model of the clinical processes. We suggest starting from HL7-like Storyboards, then mature the Storyboards into a balloted and diagrammed clinical model. This will lay the groundwork for the next two stages.

Developing The orthodontic electronic patient record developers are divided into imaging and non-imaging groups, based on their interests. These collaborate with the DICOM and HL7 standard organizations to make sure that their respective standards will include all necessary fields and definition to accommodate for orthodontic electronic patient records. This stage will deliver the inclusion of missing elements in the ballots for the future HL7 and DICOM releases. This process entails the formation of a dental/orthodontic technical committee within HL7 and the inclusion of interested parties in the appropriate DICOM working group (DICOM WG 22/ADA SCDI WG 12.1).

Integration Once the two standards are ready, the ADA/SCDI will publish a higher level standard to instruct software developers and others interested in implementing the standard on the joint use of HL7 and DICOM in an ADA/ANSI approved way. Once balloted and released, the document will consist of a technical document to act as the official standard reference and a less technical companion (similar to TR-1023 [3]) to guide the reader through the process of implementing and using the standard.

3 Progress to Date

In this section we discuss two groups which are currently working in parallel: at the ADA SCDI, WG 11.6 is in the process of delivering a set of use case

scenarios that shall describe the usage of electronic data within orthodontics, and at the Universidade de Brasília (UnB, Brasília, DF, Brazil) the author is collaborating with Case Western Reserve University (CWRU, Cleveland, OH, USA) to develop a proposal for a DICOM standard for cephalograms.

Working Group 11.6 at ADA SCDI has recently focused its scope to:

”Define the content of the orthodontic record to meet the needs of the stakeholders, including but not limited to: orthodontists, industry vendors, private and public insurers, academic institutions by: (1) Define and categorize use cases for orthodontic treatment; (2) Define and categorize orthodontic data content; (3) Review existing standards; (4) Perform gap analysis (identify unique orthodontic information not covered by other standards); (5) Report and recommend action plan (new work items).”

The intention is to focus the scope directly on the imminent problem while at the same time proceed with a new call for action inviting any interested party to join the working group¹.

Cephalograms must meet some minimum requirements of resolution and information (such as magnitude and calibration landmarks) in order for them to be useful for research and clinical applications. These minimum requirements will be embedded in the DICOM standard and will be based on the ideas discussed at the Standards for Digital Storage, Retrieval and Analysis of Orthodontic Records workshop held at Case Western Reserve University in March 1993 [2] and proved by Hans in 2003 [9]. The proposal will be submitted to DICOM for approval and will be published at the UnB in August 2006 in form of a master’s thesis.

This master’s thesis directly addresses the issue of storing cephalograms in digital format. Since cephalometric information is a key component of the orthodontic patient record, such effort can directly be applied to the proposal discussed in this article. In addition, various precious longitudinal craniofacial growth studies are starting to decay because of their age. The imminent decay of these radiographs has spurred interest in preserving them in digital format. One of the main concerns is to archive them in standard format, such that they can be retrieved and used by various institutions and programs. Once a DICOM specification for cephalograms exists, the interoperability of the digitized cephalograms will be guaranteed.

4 Future Work

The proposed solution for the development of the Ortho-EPR standard delivers a complete, functional and easy way to implement the standard. The close collaboration with HL7 and DICOM ensures the highest level of compatibility with already existing health care systems in most medical fields.

¹For more information on how to join the working group, please contact Antonio Magni (joinpanio@antonoimagni.com).

Nonetheless, the entire developing cycle requires some time: we believe it would take 3 years for a first, fully official release to be approved. Most of this time would be spent in creating a new technical committee within HL7 and in the balloting cycles of HL7, DICOM and ADA SCDI. Nonetheless usable test releases will be available for earlier implementation, which will accelerate the urgent and necessary implementation of the standard.

As this document purports to be a project proposal, we strongly encourage readers to get in touch with the authors² to provide feedback or to express their interest in participating in the project.

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²Feel free to visit the projects home page at <http://panio.antoniomagni.org>

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A Figures

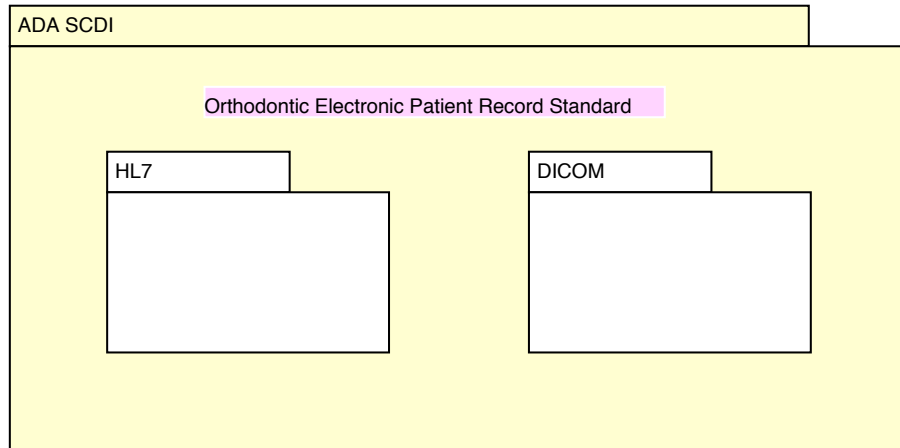


Figure 1: Basic structure of the organizations for the development of the orthodontic electronic patient record (ortho-EPR) standard. The ADA is the supervising organization, making sure that the standard fulfills the needs of the orthodontic community. DICOM and HL7 are used to represent imaging and non-imaging data respectively in order to ensure the maximum amount of data interoperability with existing systems.