Developing a Standardized Cephalometric Vocabulary: Choices and Possible Strategies


Abstract: The science of cephalometry has been invaluable for guiding orthodontic diagnosis, treatment planning, and outcomes tracking. Though software packages easily calculate most cephalometric measurements, the ability to exchange cephalometric data between software packages is poorly developed. Hindering this effort is the lack of an agreed-upon standard for electronic exchange of cephalometric measurements. Unlike more technological issues, the problem of creating such a standard is one of formalizing decisions already established through historical precedent. Solving this problem will require education, cooperation, and consensus in order to reap the potential improvements to patient care, dental education, and research. The first step in overcoming these remaining issues is awareness. This article reviews those factors that place cephalometric measurements in an excellent position for standardization, outlines those decisions that must be made in order to realize the goal of electronic exchange of cephalometric information, and describes some of the options for these decisions as well as some advantages and disadvantages of each.

Dr. Stewart is a National Library of Medicine Fellow in Biomedical Informatics, Health Sciences Library and Informatics Center, University of New Mexico; Dr. Edgar is Curator of Human Osteology, Maxwell Museum of Anthropology and Research Assistant Professor, Department of Anthropology, University of New Mexico; Dr. Tatlock is Associate Professor, Division of Dental Services, Department of Surgery, University of New Mexico Health Sciences Center; and Dr. Kroth is Director, Health Sciences Informatics Program Development, Health Sciences Library and Informatics Center, University of New Mexico. Direct correspondence and requests for reprints to Dr. Randall F. Stewart, Health Sciences Library and Informatics Center, MSC09 5100, 1 University of New Mexico, Albuquerque, NM 87131-0001; 505-272-3965 phone; 505-272-8254 fax; rstewart@salud.unm.edu.

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Cephalometry is a radiographic technique for determining precise dentofacial measurements, which subsequently assist in making orthodontic diagnoses, planning treatment, and tracking outcomes.1 In use since the early twentieth century, cephalometry involves taking radiographic images of the head using standardized orientations, energies, and distances. Particular anatomic structures (“landmarks”) are identified on the radiographic films, and tracings are made of the distances and angles (“measurements”) between these landmarks. Tracings are then measured to determine the appropriate quantities.

The original purpose of cephalometrics was research on growth patterns of the craniofacial complex. It soon became clear, however, that cephalometric analyses could be used to evaluate dentofacial proportions and clarify the anatomic basis for a malocclusion. This would help inform the dental clinician who needs to know how the major functional components of the face (cranial base, jaws, teeth) are related to each other.2

The goal of cephalometrics, at its most fundamental level, is to compare the patient with a normal reference group, so that differences between the patient’s actual dentofacial relationships and those expected for his or her racial or ethnic group are revealed. This type of cephalometric analysis was first popularized after World War II in the form of the Downs analysis, developed at the University of Illinois and based on skeletal and facial proportions of a reference group of twenty-five untreated white adolescents selected because of their ideal dental occlusions.2

In its early years, cephalometric analysis was correctly criticized as being just a “numbers game,” leading to orthodontic treatment aimed at producing certain numbers on a cephalometric film that might or might not represent the best treatment result for the patient. At present, competent clinicians use cephalometric analysis to better understand the underlying basis for a malocclusion. To do this, they look not just at individual measurements compared with a norm but at the pattern of relationships, including soft tissue relationships. Any measurements are a means to this end, not the end in itself.2

Currently, software packages automate much of this work. More and more, radiographic images are obtained and stored digitally rather than on radiographic film. Software packages routinely calcu-
late the angles and distances between landmarks. Although the identification of landmarks themselves remains a manual task, computerized identification shows research potential and is rapidly improving. Surprisingly, the conceptually simpler ability to exchange cephalometric measurements between different software systems is less well developed. At best, cephalometric measurements are sent electronically as text-based reports, which are read and interpreted by a person, then manually entered into the receiving system. This process is laborious, time-consuming, and open to transcription errors and increases the effort required to aggregate information for education, data mining, or other research purposes. The reason for this lack of compatibility is surprisingly mundane: neither the precise vocabulary nor the data formats used for cephalometric measurements have been standardized.

As an example, Figure 1 shows eight different synonyms for the interincisal angle. Because any single measurement may have numerous synonyms, researchers or software vendors may devise their own codes for cephalometric measurements. For example, the Bolton Standards of Dentofacial Developmental Growth identifies the interincisal angle as “Angular measurement No. 7,” while the Atlas of Craniofacial Growth identifies this same angle as “Variable 61.” While these codes work well with solitary data sets, they obscure meaning when one is attempting to combine data from multiple studies or exchange clinical information between electronic record systems.

The ability of software packages to exchange and act on electronic data from other systems is known as interoperability. The key to interoperability is standardization.

The American Dental Association (ADA) recognizes the importance of information standards and has taken action to create and promulgate them. In the year 2000, the American National Standards Industry (ANSI) recognized the ADA as an independent Standards Development Organization (SDO). Subsequently, the ADA has played a major role in the establishment of standards for electronic health records, including ANSI/ADA Specification 1000 (2001), “Standard Clinical Data Architecture for the Structure and Content of an Electronic Health Record.” The ADA has established two standing committees for standards development: the Standards Committee on Dental Informatics (SCDI) and the Standards Committee on Dental Products (SCDP). Between these two bodies, the ADA is responsible for dozens of additional ANSI standards and technical reports including the familiar “Current Dental Terminology” used in billing (CDT codes, more formally “Code on Dental Procedures and Nomenclature”) and a vocabulary standard for dental anatomy (ANSI Specification No. 3950, “Designation System for Teeth and Areas of the Oral Cavity”).

As computer systems have proliferated, interest in standards has burgeoned. When the number of systems was small, ad hoc interfaces were routinely built to translate data into the coding scheme of

| internsical angle |
|------|-------|
| 1\text{-}\overline{1} | (using the number "one") |
| 1\text{-}\overline{1} | (using a lower-case letter "l") |
| \overline{1}\text{-}1 | (using an upper-case letter "T") |
| 1.1 | (using the number "1") |
| LIA-LIE/UIA-UIE |
| Lower Incisor/Upper Incisor |
| LI/UI |

Figure 1. Synonyms for “interincisal angle”
the receiving system. As the number of computer systems increased, however, along with the amount and types of digital information to be exchanged, the cost, complexity, and maintenance burden of multiple interfaces has become increasingly prohibitive. A better method is for different computer systems to code data using the same, agreed upon, standard format. In 2003, when Sittig et al. wrote of the most important informatics challenges facing dentistry, they asserted, “Without such a standardized controlled terminology, all other clinical data and knowledge bases will not be of much use.”

In their simplest form, standardized terminologies are restricted lists of terms known as “controlled vocabularies,” often used for consistency in indexing. In progressively more elaborate forms, controlled vocabularies can include multiple synonyms (“entry terms”) that map to a single, preferred term (an “interface terminology”); use explicit rules for naming terms (a “nomenclature”); provide a unique code for each concept (a “coded data set”); show hierarchical arrangements of terms (a “taxonomy”); or characterize each term with its possible attributes and relationships to other concepts (an “ontology”). Even more advanced are “messaging standards” (e.g., HL7 or DICOM), which specify how standardized terminologies, along with codes for controlling data flow, should be combined and sequenced during actual exchange of electronic data. Table 1 shows some of the more common standards in use in dentistry and medicine today.

Cephalometric measurements enjoy several unique characteristics that will simplify the work necessary to add them to an existing terminology standard. First, the set of cephalometric measurements is relatively small. Comprehensive atlases list fewer than 200 measurements; current research articles commonly list twenty to thirty separate measurements; the number actually recorded in a patient’s chart may be fewer still. This represents an extremely manageable number of concepts. Second, the body of cephalometric measurements is stable. Taub recently contended that “little significant new cephalometric analysis has been added for more than thirty years.” Therefore, the bulk of work can be reliably predicted at the outset, and the need for revisions or ongoing maintenance is likely to be minimal. Finally, cephalometric measurements are discrete, independent elements with precise, unambiguous definitions. Limited dependencies between measurements allow each measurement to be coded individually without affecting decisions made about other measurements.

Much as the radiographic procedure for obtaining cephalograms allows for precise, accurate measurements, we seek to establish a standardized procedure for electronic exchange of the measurements. While many landmarks and measurement names have been established through historical precedent, four broad steps remain to complete the task:

1. Establish a comprehensive set of cephalometric measurements;
2. Assign an identifier to each measurement;
3. Choose the form of the terminology; and
4. Publish and promote use of the terminology.

The choices involved in each of these steps are described below. While these steps appear in a logical order of progression, some reiterative development will occur, and insights gained in later steps may modify decisions made in earlier steps.

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**Establishing a Comprehensive Set of Measurements and Assigning Identifiers**

While there is probably no single, authoritative, and comprehensive list of all known cephalometric measurements, such a list can be approximated by consolidating measurements from multiple sources. We consulted three commonly used cephalometric atlases (An Atlas of Craniofacial Growth, Bolton Standards of Dentofacial Developmental Growth, and A Clinical Atlas of Roentgenocephalometry in norma lateralis), as well as an electronically searchable orthodontic glossary (the Daskalogiannakis Glossary of Orthodontic Terms). These references included, respectively, 189, 43, 84, and 31 measurements. Allowing for duplicates between references, a total of 262 measurements were found.

Based on this straightforward assessment, 262 serves as a lower-limit estimate of the number of cephalometric measurements. Estimating an upper limit is more difficult, although any level of certainty can be approached by consulting additional references. We estimate an upper limit of 300 concepts, although the precision of this estimate is not crucial for three reasons. First, even doubling this estimate to 600 represents a small fraction of the tens of thousands of concepts found in modern vocabulary standards. Second, vocabulary standards are designed to be updated from time to time, and both the additional
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<thead>
<tr>
<th>Name</th>
<th>Source</th>
<th>Description</th>
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<tbody>
<tr>
<td>MeSH (Medical Subject Headings)</td>
<td>National Library of Medicine¹</td>
<td>A taxonomy developed as a 'single subject authority' for indexing the medical literature. Contains close to 30,000 hierarchically arranged concepts.</td>
</tr>
<tr>
<td>SNOMED-CT (Systematized Nomenclature of Medicine-Clinical Terms)</td>
<td>College of American Pathologists²</td>
<td>Recently acquired by the International Health Terminology Standards Development Organization, SNOMED-CT is an extensive ontology of 300,000 medical and veterinary concepts connected with each other by over 900,000 different relationships.</td>
</tr>
<tr>
<td>ICD-10 (International Classification of Diseases, 10th ed.)</td>
<td>World Health Organization³</td>
<td>Currently in its tenth version, the ICD began in the late nineteenth century to track causes of death. It now includes hierarchical codes for non-lethal diseases and accidents and is closely associated with billing.</td>
</tr>
<tr>
<td>LOINC (Logical Observation Identifier Names and Codes)</td>
<td>Regenstrief Institute⁴</td>
<td>A coded data set of about 31,000 laboratory tests and 10,000 other clinical observations.</td>
</tr>
<tr>
<td>CPT and CDT (Current Procedural Terminology; Current Dental Terminology)</td>
<td>American Medical Association and American Dental Association⁵,⁶</td>
<td>Coded taxonomies containing listings for surgical, medical, dental, and specialist services. Used extensively for billing of these services.</td>
</tr>
<tr>
<td>ICD-DA (Application of the International Classification of Diseases to Dentistry and Stomatology)</td>
<td>World Health Organization⁷</td>
<td>A subset of dental terms that have been extracted from the ICD-10, then elaborated and reorganized to be more applicable to dental practice.</td>
</tr>
<tr>
<td>SNODENT (Systematized Nomenclature of Dentistry)</td>
<td>American Dental Association⁸</td>
<td>A compilation of more than 6,000 terms related to dental diagnosis, signs, symptoms, and complaints. This terminology was designed by the ADA, using some terms found in SNOMED, and subsequently licensed for inclusion within SNOMED-CT.</td>
</tr>
<tr>
<td>Unified Medical Language System (UMLS) Metathesaurus</td>
<td>National Library of Medicine⁹</td>
<td>A catalog of 1.3 million concepts divided among 6.4 million unique names assembled from over 100 source vocabularies. Rather than acting as an independent vocabulary, the UMLS Metathesaurus is intended as a searchable database for finding terms in existing vocabularies that match concept(s) representing the search term.</td>
</tr>
<tr>
<td>HL7</td>
<td>Health Level Seven⁹</td>
<td>A suite of messaging and document standards, allowing for the international exchange of clinical and administrative data within the health care arena.</td>
</tr>
<tr>
<td>DICOM (Digital Imaging and Communications in Medicine)</td>
<td>National Electrical Manufacturers Association¹⁰</td>
<td>A joint project of the American College of Radiology and the National Electrical Manufacturers Association to standardize the storage and transmission of digital images.</td>
</tr>
</tbody>
</table>

Sources:
number of measurements and the rate at which they might be needed to be added is likely to be small. Finally, it is common for vocabulary standards to add concepts on a pragmatic, “as needed” basis rather than trying to meet exhaustive goals from the outset.

Once a comprehensive set of measurements has been compiled, the next step is to assign a unique identifier to each concept. This unique identifier can be a name, a code, or both. The most important consideration is that each name or code must refer to one, and only one, concept. To do otherwise, to allow a single identifier to refer to more than one concept, is known as polysemy (“many meanings”) and would render the terminology useless by introducing ambiguity into the meaning of an identifier. The opposite—allowing a single concept to be known by many names (polyonomy, “many names”)—can make a terminology standard more difficult to maintain, but in some cases is actually desirable, such as in the creation of an interface terminology. A multilingual terminology, in which the terms exposed to the user can be customized by language, but the computer’s internal representation of the concept is invariant and independent of the user’s language, is another example.

Choosing the Form of the Terminology

Terminology standards can take many forms, from simple controlled vocabularies to extensive ontologies used in computer modeling and decision support systems. Cimino and Elkin et al. have published collections of “desiderata” and quality indicators to guide vocabulary development. The considerations most likely to influence the choices for cephalometry are discussed in the following sections.

Content Coverage

“Content coverage” refers to the proportion of potentially useful concepts that are actually included within a terminology standard. For cephalometric measurement, we surveyed the content coverage of current established standards (see Table 1) by creating lists of cephalometric measurement terms, then searching for them in the Unified Medical Language System (UMLS) using the default “Quick Search” settings of the web-based UMLS Knowledge Source Server.

As our set of terms, we used the 189 measurements catalogued in Riolo et al., *An Atlas of Craniofacial Growth.* Each search term was entered using the exact wording of the atlas (e.g., “Upper Incisor/Mandibular Plane”). Where possible, we also searched using the corresponding abbreviations (e.g., “GOI-ME/UIA-UIE”). Of these 189 terms, only three were found in any of the UMLS’s more than 100 source vocabularies: Sella-Nasion-A point; Sella-Nasion-B point; and Sella-Nasion-Frankfurt Horizontal.

Our match rate may have been poor because the search terms were antiquated, idiosyncratic, or otherwise not included in the UMLS thesaurus of entry terms. To check this, we created a second list containing 175 cephalometric terms more representative of those in actual use. First, we performed a PubMed search for English language articles published within the last five years, indexed under the Medical Subject Heading major topic of “Cephalometry,” and locally available in electronic form. Starting with the most recent article and working towards older articles, we manually extracted the first 175 terms (including abbreviations) describing cephalometric measurements that were found in the text, tables, or diagram captions. With few exceptions (described below), we entered each search term exactly as found in the original article. Search results were classed as “exact match,” “more specific match,” “less specific match,” and “non-match.”

From this list, only six terms found exact matches (Table 2). Three additional terms found matches that were “more specific” than the search term (Table 3). The remainder of the terms were non-matches, except for nine terms that could not be entered verbatim into the search screen since they included the special character ⊥, indicating the perpendicular distance from a point to a line. The terms (all abbreviations) containing the ⊥ character were entered verbatim, including spaces, hyphens, and slashes, but with the ⊥ character replaced with a space. We chose the space as a reasonable replacement character based on the UMLS string normalization process, which replaces punctuation with spaces. None of these nine terms returned a match. We were similarly unable to search for one other term, an angular measurement abbreviated with a capital Greek sigma (Σ°).

While this cursory assessment cannot rigorously quantify actual content coverage, it does demonstrate that 1) cephalometric measurements appear to be underrepresented in common, mainstream
Hierarchical Relationships

Most of the standardized vocabularies shown in Table 1—indeed, most medical vocabularies—are arranged in hierarchies.15 When first learning a subject, hierarchies can highlight similarities among items in the same category while pointing out important, but possibly obscure, differences between subcategories. They also allow the application of the appropriate level of generalization. For example, a researcher can search a database of orthodontic diagnoses for “all malocclusions,” “all type II malocclusions,” or “all type II division 1” malocclusions depending on the appropriate level of detail.

Though cephalometric measurements can be categorized by dimensionality (angles vs. distances), analysis type (Downs, Ricketts, Steiner, etc.), or landmark type (skeletal, dental, or soft tissue), many of the benefits attributed to hierarchical arrangement do not apply to cephalometric measurements. All cephalometric measurements fall at essentially the same level of detail. The pedagogical grouping by analysis type has limited applicability in actual clinical practice.

It makes little clinical sense to speak of “all angular measurements” or “all Ricketts measurements” in the same way you can sensibly generalize about “all infections” or a nonspecific “inflammatory process.”

Term Composition

One technique for managing complex classifications is to decompose concepts into simpler concepts so that each simpler concept is more easily categorized. For example, the concept of a “left ankle lateral X-ray” includes a site concept (“left ankle”) and a procedure concept (“lateral X-ray”). “Left ankle” can itself be decomposed into an anatomic concept (“the ankle”) and a laterality concept (left vs. right). “Lateral X-ray” can be decomposed into an orientation concept (“lateral”) and a concept for the diagnostic study type (plain film “X-ray”).

Decomposition also implies the need to recompose complex concepts from their simpler components in order to preserve the full, original meaning. Who recombines the individual concepts and when they are recomposed are important, if not crucial, distinctions. “Post-coordination” refers to the recomposition of concepts by the end user, after the terminology is released. “Pre-coordination” refers to the recomposition of concepts by the vocabulary developer, before the vocabulary is released.

Post-coordination allows greater flexibility since the end user can combine terms on an as-needed basis as clinically appropriate. New combinations can be constructed for unanticipated, novel situations. When entering data, however, it places additional burdens on the end user to mentally deconstruct a concept into its component parts and to separately select each part. This requires the end user to have greater knowledge of the vocabulary structure in order to determine how far to decompose a concept and where to draw the lines of division.

Pre-coordination potentially decreases the work of the end user. It may be easier to select “left ankle lateral X-ray” from a single menu than to select four separate concepts from four separate menus (i.e., left + ankle + lateral + X-ray). In contrast, pre-coordination decreases flexibility since all possible combinations of terms must be decided at design time. This increases the work of the developer and increases the chance that a relevant combination is missed. It also leads to the possibility of “combinatorial explosion”: as the number of simpler concepts increases, the number of necessary menu combinations becomes unmanageable.
Cephalometric measurements could be pre-coordinated as discrete entities or post-coordinated as associations of landmarks. Pre-coordination is likely to be the better choice. Of the several thousand possible combinations of landmarks, we found fewer than 300 measurements in comprehensive cephalometric atlases.\(^6,^7,^15\) Requiring users to select individual landmarks may seem unduly burdensome, particularly for measurements that involve many points with highly selective relationships (e.g., the “perpendicular distance from the lower incisor incisal edge to the line running parallel to the Nasion-B Point line and through the pogonion”). A single list of 300 pre-coordinated terms would be eminently manageable, particularly if an explicit nomenclature and ordering rules were developed to help users predict approximately where in a list they will find a particular concept.

**Scope**

Any appraisal of a vocabulary’s content coverage must also consider the subject area the vocabulary is intended to cover and the manner in which the vocabulary is designed to be used, i.e., its scope.\(^18\)

Scope also determines the underlying structure of the vocabulary. For example, SNOMED-CT, built as a comprehensive ontology of medicine, contains nineteen top level hierarchies. MeSH, built to index life sciences literature,\(^21\) utilizes sixteen top level “descriptors.” LOINC, initially built to code for laboratory tests and subsequently extended to include more general clinical observations, contains six “axes” of information used to determine the uniqueness of a concept. For example, any two lab tests that are identical on all six axes are considered to be the same concept; a difference on any one or more of the axes constitutes a separate concept. Scope determines the underlying structure of a terminology. The underlying structure, in turn, determines the degree of fit and ease of use of the terminology in any particular setting.

Though suggested by anatomy and defined in terms of anatomical landmarks, cephalometric measurements are themselves abstract entities—distances and angles. Much orthodontic research of the last eighty years has been to determine normal values for cephalometric measurements, stratified by age, sex, and race, that statistically correlate with subjective judgments of beauty.\(^1\) Determination and interpretation of cephalometric measurements are intimately related to measurement technique.\(^22-24\) In this way, cephalometric measurements act more like laboratory values than anatomical entities. For this reason, vocabularies with an anatomical scope (such as ANSI/ADA Specification No. 3950, “Designation System for Teeth and Areas of the Oral Cavity”)\(^12\) may not offer the features necessary. Instead, a vocabulary with a scope of “clinical observation” may prove more useful since it would more easily allow for specification of normal ranges, accuracy, measurement method, and point in time of determination.

**Publishing and Promoting the Terminology**

Unfortunately, there is no single, established process for formal acceptance of an information standard. Shortliffe and Cimino\(^25\) list four ways that standards are usually established. In the ad hoc method, exemplified by the Internet and its HTTP and HTML protocols, a standard is simply created as a way of getting something done. Later, if others want to participate in the resulting activity, they naturally adopt the standards of the pioneers. Slightly more formal, the de facto method occurs when a particular standard gathers enough market share that competing standards are abandoned for the sake of mass compatibility (e.g., VHS vs. Beta videotapes, or the more recent Blu-ray vs. HD-DVD standards for high-definition video). More formal yet, the consensus method occurs when an official industry, academic, or government-sanctioned body (known as a Standards Development Organization or SDO) endorses a particular standard. Examples are the many standards produced by the ADA, an ANSI-accredited SDO. Finally, governments or regulatory agencies will sometimes mandate that a particular standard be followed (such as the use of CPT codes in billing).

For many reasons, the consensus method is desirable for the formalization of cephalometric measurements. As an SDO, the ADA has both the authority and a vested interest in the development of such a standard. In 2005, the ADA initiated a program of orthodontic standards development\(^8\) and last year reiterated the invitation for interested parties to join the SCDI work group (WG 11.6) that is defining orthodontic record content and making recommendations for further development.\(^4\) Furthermore, official ADA sanction of a standard would provide leverage for software vendors to adopt the standard, speeding
the advancement of software interoperability and helping practitioners avoid the risk and expense of proprietary, vendor-specific standards.

We believe that adding cephalometric measurements to an existing standard is preferred to creating a new standard solely for cephalometry. This is consistent with the idea that standards should be developed to avoid duplication of effort and to maximize compatibility between systems. By using common standards, the number of standards that a single software package would need to include is reduced. Future linking with non-dental records, administrative systems, or databases would be facilitated. Moreover, an existing standard provides brand recognition and a ready-made development, distribution, and maintenance infrastructure to speed adoption. Developers need not learn additional standards and, through learning transfer, can in fact use knowledge of the existing standard to more rapidly understand the characteristics of cephalometric measurements.

Of the terminology standards shown in Table 1, LOINC offers an excellent fit for cephalometric measurements. In addition to the above considerations (see Table 4) and international acceptance, LOINC codes for almost 200 other dental observations, was specifically designed to be compatible with HL7, has a free license agreement, and offers a well-documented and accessible process for adding concepts. LOINC also utilizes content-free (nonsemantic) identifiers and adheres to the principle of concept permanence, both of which improve its ability to undergo revision and expansion while maintaining backwards compatibility. Finally, since measurement technique influences cephalometric interpretation, the inclusion of measurement method as one of LOINC’s key discriminating axes is perhaps its most clinically significant feature.

**Summary and Conclusions**

To date, a very small number of cephalometric concepts have been successfully assigned terms in standardized terminologies. Cephalometric measurements are nonhierarchical by nature and are therefore not enhanced by adding a hierarchical structure. Because the number of useful cephalometric measurements is small and not likely to change, precoordination of terms is a reasonable strategy that will save users the burden of combining terms at the point of use. Of a small sampling of major, freely available vocabulary standards, LOINC meets many cephalometric needs and provides a model against which other vocabularies may be compared.

The canon of cephalometric measurements has largely been fixed through historical usage, and vocabularies currently exist that have demonstrated the ability to code for cephalometric measurements. The remaining work is largely that of making design decisions and promoting the standard’s use.

The ADA encourages interested individuals to become members of the Standards Committee on Dental Informatics (SCDI), which is currently looking at the gap between necessary orthodontic information and that actually included in other standards. Those focused on more immediate use of a cephalometric measurement standard will find a straightforward process for submitting new terms to LOINC in the LOINC users’ guide. This is our current intent as part of a project archiving rare orthodontic records at the University of New Mexico. The experience and public vetting of our choices will be of use even if consensus or de facto methods eventually lead to acceptance of a different standard.

As principal investigators and researchers, academicians can insist on the use of standards in their own data collection and research databases. Doing so avoids the burden of creating their own coding schemes and increases the value of their data since it can be more readily linked with other databases for data mining or correlational research. When investing in office software, practitioners can show a preference for interoperable packages, helping to provide vendors with financial incentives to incorporate standards. When institutions design their own clinical or educational applications, educators can...
can advocate for standardized data formats, allowing for sharing of software components, reduced software costs, and quicker development time. As electronic dental records become more common, imagine the benefits of accessing de-identified cephalometric measurements from patients across the globe and being able to sort them by race, sex, age, diagnosis, and treatment type. Much of the cephalometric research of the past century, which documented normal values for particular ethnic groups, could be repeated within minutes with sample sizes of thousands rather than dozens.

Dental educators are in an ideal position to advance this work. As shown by the ubiquitous nature of email and the Internet, the very success of standards often renders them invisible to users as standards seamlessly perform their functions behind the scenes. Educators have the license and skills to expose these benefits and design considerations to others. The more one understands the power of standards, the more he or she becomes acutely aware of their presence.

REFERENCES