Current Clinical Research in Orthodontics: A Perspective

Sheldon Baumrind, DDS

ABSTRACT

This essay explores briefly the approach of the Craniofacial Research Instrumentation Laboratory to the systematic and rigorous investigation of the usual outcome of orthodontic treatment in the practices of experienced clinicians. CRIL's goal is to produce a shareable electronic database of reliable, valid, and representative data on clinical practice as an aid in the production of an improved environment for truly evidence-based orthodontic treatment.

The past 15 years have seen greatly increased interest in the concept of "evidence-based treatment" in medicine, in dentistry, and more recently, in orthodontics. The implicit assumptions underlying the advocacy of evidence-based treatment are that the better the available evidence, the better the clinical judgments will be, and that the better the clinical judgments, the better the outcomes the treatments will be. To be sure, these assumptions seem intuitively reasonable, but we have thus far accumulated very little evidence with which to test them. The primary purpose of all clinical research in orthodontics is to improve the delivery of orthodontic treatment.[1-4]

For that reason, it seems reasonable that the main tasks of clinical orthodontic research in the next two decades should include the study of 1) how expert orthodontists make clinical judgments; 2) how good those judgments are; and 3) how strategies and tools can be developed for making better clinical judgments.[5-8]

Author / Sheldon Baumrind, DDS, is a professor, Department of Orthodontics, and director, Craniofacial Research Instrumentation Lab, University of the Pacific Arthur A. Dugoni School of Dentistry.

Remarkable recent advances in information processing technology make it possible to investigate these areas using exciting methods and techniques not previously available. At the Craniofacial Research Instrumentation Laboratory, CRIL, we seek to utilize these methods and techniques to improve the quality of service that orthodontists of the future will be able to provide to their patients.[9]

With regard to the study of how expert orthodontists make clinical judgments, CRIL engages in the systematic examination of the actual operations of the treatment process. That process can be thought of as having two components: treatment planning and the visit-by-visit conduct of treatment. The target of each component is the complex, multidimensional, and highly integrated patient seated in the chair.

For purposes of treatment planning, the density of information in the intact patient is so great and so heavily layered as to be too complex for direct analysis. Instead, it is customary to generate a series of transforms called "physical records." The minimum set of physical records that experienced orthodontists consider necessary for the development of a comprehensive orthodontic treatment plan includes study casts, lateral cephalograms, panoramic or intraoral dental X-rays, and facial photographs (**Figure 1**).

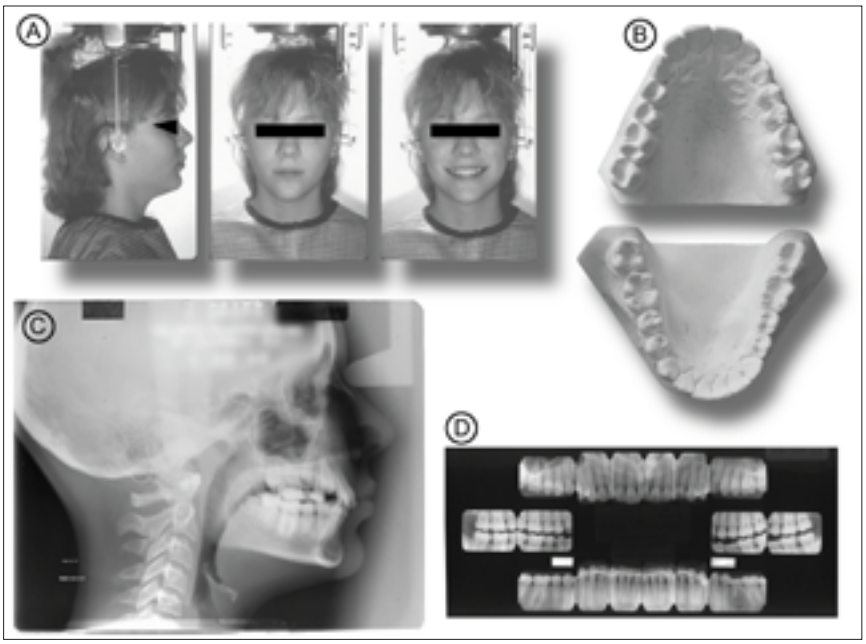


Figure 1. The basic physical records used in classical orthodontic diagnosis and treatment planning. A) Semistandardized facial photographs; b) study casts; c) standardized lateral cephalograms; and d) panoramic and/or intraoral X-ray images.

Each such transform makes some aspects of the patient's morphology more readily apparent by discarding information about other aspects. For example, the study casts allow us to view the teeth and arch form most clearly (even from the lingual aspect, which is impossible in the living subject). But study casts discard all information about how the jaws and teeth are attached to the rest of the head (i.e., about their relationship to the surface of the face and to the bony armature of the skull).

Similarly, facial photographs give us the best currently available information about the outside surface of the face, but they lose all information about the skull and teeth. Likewise, lateral cephalograms give us relatively good information about the spatial relationships between the jaws and the skull, but only at the cost of throwing away almost all information about the surface of the face and the details of dental arch form. In the past, the orthodontic clinician has examined each kind of physical record separately and then reintegrated the data extracted from all of them as a conceptual operation. How this task of reintegration is performed, by mentally filtering out inconsistencies, discounting redundancies, and identifying underlying patterns of interaction among data from the different kinds of record is a key mystery in need of comprehensive study, because it is a key element of clinical judgment in orthodontics.

The recent introduction of 3-D volumetric X-ray scanners (such as i-CAT, MercuRay and NewTom) may simplify the clinicians' task of interpretation because these instruments allow us to see the hard and soft tissues of the teeth, jaws, and skull in a single common registration. These new images are fully digital and can be viewed and manipulated by the clinician on a conventional computer monitor[10,11] (**Figures 2 and 3**).

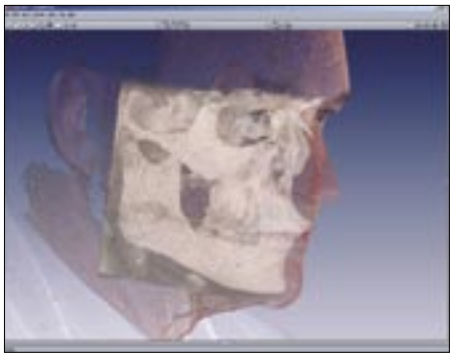
Work at the University of the Pacific and earlier work at the University of California, San Francisco, contributed consequentially to the development of these new techniques.[12-17] Yet the imag-

2a.

2b.

Figure 2. Milestones in the current migration toward integrated 3-D craniofacial mapping in orthodontic diagnosis and treatment planning. A) Generating a volumetric cone beam CT X-ray image with the i-CAT X-ray scanner at the Department of Radiology, Arthur A Dugoni School of Dentistry; and b) capturing a 3-D surface map of a patient's face using the school's 3dMD stereo-camera system.

3a.



3b.

Figure 3. The digital information from the i-CAT X-ray scanner and the 3dMD stereo-camera system can be integrated into a unified craniofacial map. A) Surface view of the combined 3-D digital data set; and b) a cutaway representation of the volumetric i-CAT dataset viewed through a mesh rendering of the patient's facial surface.

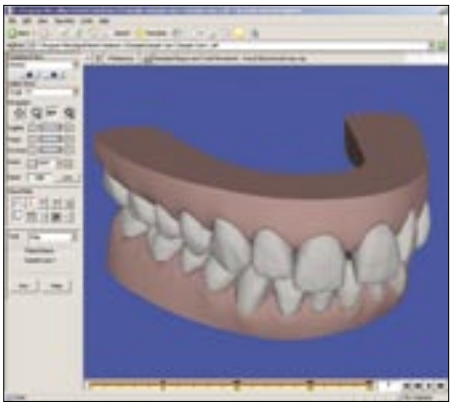


Figure 4. Computer monitor display of a patient's dentition in ClinCheck, a software program developed by Invisalign for planning orthodontic treatment in three dimensions.

es produced by radiographic systems of any sort tend to be ambiguous.[18,19] Hence, we and other orthodontic research groups are currently engaged in studying the new devices carefully in order to gain a relatively complete understanding of their attributes and limitations.[20]

How skilled clinicians exercise clinical judgment during the visit-by-visit conduct of orthodontic treatment is even less well understood than is the process of treatment planning. Though this question has thus far been completely unaddressed in any systematic way, clinicians know from experience that the actual conduct of treatment is crucially different from treatment planning. Indeed, many observers believe the generally high success rate of contemporary orthodontic treatment is based less on the goodness of our treatment plans than on the high level of clinical judgment and technical skill of experienced orthodontists — more specifically on their experience-driven ability to make "in-course adjustments" when the limitations in our biological understanding lead to unexpected aberrations during treatment.

Almost all the available information on in-course corrections during orthodontic treatment is contained in our written visit-by-visit treatment records, even though in many cases those notes leave much to be desired. The belief at CRIL is that in order to be able to analyze the way of in-course corrections are made during treatment, it will be

necessary during the next few years for orthodontists to develop rigorous quantitative methods for improved encoding and subsequent analysis of the visit-by-visit written records of orthodontic treatment progress. Preliminary studies in this area are currently in progress at CRIL.

How good our clinical judgments really are have also been underinvestigated in the past. We need to learn how well expert orthodontists' treatment preferences, taken as predictions, actually correlate with subjective and objective measures of treatment outcome. Studies in this area necessarily need to be blinded and performed with replication in such a manner that inter-rater and intra-rater statistics on reliability and validity can be gathered. One early study in this difficult and important area is currently in progress at CRIL. In this study, we are assessing the reliability with which experienced clinicians have used a 3-D virtual treatment planning method called ClinCheck in the planning of orthodontic treatment with the Invisalign appliance (**Figure 4**).

The main point of this paper has been to propose that future clinical studies in orthodontics seek to capture and retain much more information about each patient sampled than has been possible during earlier clinical investigations in the field. This strategy is considered to be desirable because it is consistent with the manner in which decision-making works in clinical orthodontics. Such a strategy has now been made much more practical by the emergence of many new electronic tools, particularly the digital scanner, the 3-D cone beam digital X-ray image, the relational database, and the Internet.

Our aim is to promote conditions in which data obtained from representative and random samples in a blinded and unbiased manner can be shared by serious clinicians and craniofacial investigators of different persuasions. It is hoped that in this way we can contribute to the consistency with which our specialty of dentistry continues to provide the public with treatment of the highest quality. ■■■■

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To request a printed copy of this article, please contact / Sheldon Baumrind, DDS, University of the Pacific Arthur A. Dugoni School of Dentistry, 2155 Webster St., San Francisco, CA 94115.