

Evolution of imaging and management systems in orthodontics



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Orthodontists have long been among the most progressive of the dental specialists, quick to embrace new technologies for enhancing clinical efficiencies and practice workflow. Orthodontic software innovations, whether for imaging and clinical applications or for managing the business side of a practice, have led the consistent need for more powerful computing requirements for more than 4 decades. This article recounts the history of how computers and orthodontic software have been used in America from their nascence to today and provides an outlook for the future. (Am J Orthod Dentofacial Orthop 2016;149:798-805)

It has been said that in life two things are inevitable: death and taxes. May I add a third (though not so vital): the application of the computer to orthodontic research and diagnosis.

Wilton Marion Krogman, forensic anthropologist

These were the opening words of American Association of Orthodontists' annual meeting in New Orleans in May 1971.¹

Orthodontics has long enjoyed a reputation for being among the most progressive of the dental specialties. Its practitioners were using computer technology for clinical pursuits as early as the late 1960s, although it remained primarily within the realm of researchers and academicians for the first decade or so. It was not until much later, in the early 1980s, that mainstream computer technology caught the attention of Main Street orthodontists—this time as a possible solution for the clerical tasks involved in running an orthodontic practice.

Harnessing computer technology to tackle the scheduling and financial tasks was the first pursuit in the early days of practice management software systems. An orthodontic practice is a business, and most orthodontists

did not graduate from business school. They wanted—needed—to have an accurate idea of their financial situation. Clerical tasks such as accounts receivable, past-due control, basic patient history, and reporting were the minimum capabilities expected from the computers of the time. More progressive orthodontists were using computers to calculate staff salaries and fee schedules, and to perform sophisticated reporting.² Tracking appointments and recalls were also part of the functions of those early systems. “The 1980s was definitely a period of early adopters,” recalled Todd Blankenbecler, manager of Dolphin Management Development (Chatsworth, Calif) and former national sales manager at Orthodontic Practice Management System (OPMS) and PracticeWorks. “Key features in those early systems were billing statements, insurance tracking, automated letter writing, and basic reporting.”

Dr Marc S. Lemchen, a New York City orthodontist, was a forerunner of the movement driving computer technology into the orthodontic practice. He was using an early form of a computerized treatment card while the rest of the crowd was still impressing itself with billing statements and “thank you” letters. “In the beginning, there were only 2 practice management systems on the scene,” remembered Lemchen. “There was no digital imaging, or digital x-rays, or any kind of image-management systems. But we had the treatment card, so we didn’t have to pull a chart for the patient unless we wanted to see the x-rays.” That was the early 1980s. At that time, any “state of the art” system had about

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10 MB of memory and a footprint the size of a small refrigerator.³ For the sake of perspective, today's entry level smartphones have 16,000 MB (16 GB) of memory and fit in the palm of your hand.

The 1980s: embracing technology and forging forward

In typical fashion, technology advanced at such a pace that by 1984, a dozen computer companies were hawking their wares to orthodontists. "The industry really took off in 1984," remembered Reid Simmons, computer science professional and founder of OrthoTrac (Carestream Dental, Atlanta, Ga) and Cloud9Ortho (Kennesaw, Ga).⁴ That year, the American Association of Orthodontists held a winter meeting in Dallas, and handouts offered at the meeting reviewed the practice management systems that were currently available.⁴ By this time, orthodontic practice management systems could perform a variety of tasks, including registration, financials and accounting, appointments, insurance information, and treatment information.

Additional tasks available in programs at that time included payroll, general ledger, inventory, and more.⁵

Most of the first practice management systems were installed on UNIX platforms. "In 1982 OrthoTrac ran on the Oasis operating system and was limited to 5 workstations," said Simmons. "In 1983, we switched to UNIX, which could handle up to 11; later it was unlimited." In the late 1980s, DOS-based systems began to appear, and by the mid-1990s, the first Windows-based systems (Microsoft, Redmond, Wash) were being introduced. By the 2000s, most of the platforms being sold worked with Windows.

Although orthodontic imaging systems joined the game later, their roots reach back far earlier to the onset of the computer technology in the late 1960s. That is when Robert M. Ricketts, affiliated with Rocky Mountain Orthodontics Data Services (Denver, Colo), announced a computer portal service for orthodontists. The idea was that a doctor would send a lateral head x-ray, a photocopy of the impressions, and a diagnostic sheet, and receive back a computed analysis of the x-ray along with a growth prognosis and treatment plan. The emerging computer technology of the era inspired others in the orthodontic community to consider the diagnostic possibilities. A few years later, Geoffrey F. Walker published a report in the *American Journal of Orthodontics* suggesting 177 cephalometric landmarks for computer analysis.⁶

Digitization of cephalometrics

Introduced in 1931 by B. H. Broadbent, cephalometrics remains a vital diagnostic tool for orthodontists.

Tracing of the cephalograph was done manually until the early 1970s, when Robert M. Ricketts created a computerized cephalometric tracing/visual treatment objective system. Today's cephalometric tracing programs often contain hundreds of analyses, any number of which can be performed simultaneously by the doctor or skilled staff (Figs 1 and 2).⁷

In 1988, Dolphin introduced the DigiGraph, which used sonic echolocation—similar to what dolphins use—to gather cephalometric information, thereby eliminating radiation from the process. The DigiGraph's components consisted of a cabinet with a digitizer probe, computer, monitor, head holder, microphone array, video cameras, and software. "Since the DigiGraph predated the general availability of digital cameras, the most practical way to get the patient's lateral photo into a computer was to use an analog video camera signal fed into a frame-grabber circuit board in a computer," explained Ken Gladstone, manager of Imaging Software Products at Dolphin and a member of the original DigiGraph team. "The image would then display the video on the computer screen, allowing the user to grab a single still image from the video feed." The digitizing probe placed lightly on the patient's face would send sonic signals to the microphone array positioned above the patient's head. "Then the computer used the signals to triangulate the probe's exact location in 3 dimensions," said Gladstone. Combining the data sets allowed the practitioner to perform cephalometric tracings and analyses, superimpositions, and virtual treatment objectives (Fig 3).⁸

Whereas the concept of the DigiGraph proposed an interesting direction, before long it became apparent that the traditional method (x-rays) of gathering cephalometric imagery was more complementary to the other parts of the orthodontist's tool set.

Standardization of data

In 1983, the American College of Radiology joined with the National Electrical Manufacturers Association to form a committee dedicated to creating a standard method for transferring images and associated information between devices manufactured by different vendors. In 1985, they released the first version of what was called standard version 1.0, with version 2.0 released in 1988. This version prompted medical device manufacturers to adopt the standard, thus further streamlining medical imaging for everyone involved—including software developers, practitioners, and patients. In 1993, version 3.0 was released with a name change to Digital Imaging and Communication in Medicine (DICOM), in hopes of improving international acceptance.⁹

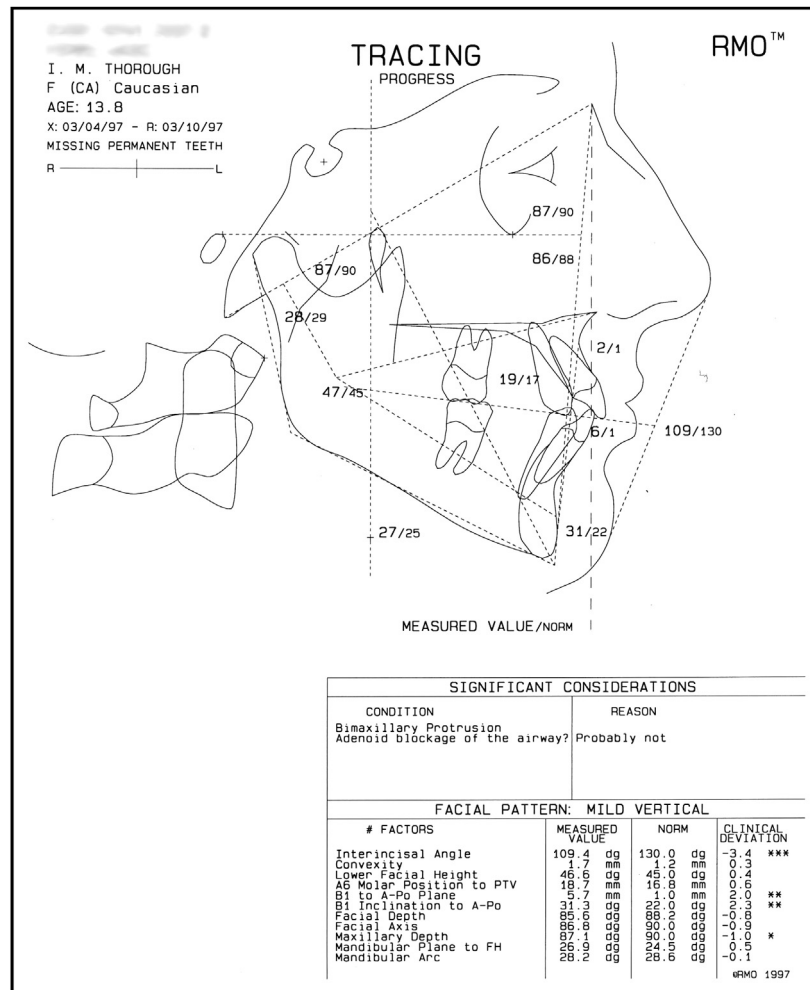


Fig 1. Computerized cephalometric tracing. (Image courtesy of Rocky Mountain Orthodontics Data Services®, RMO® Inc, Denver, Colo.)

Game changer: the digital camera

Orthodontics seized diagnostic and task-based opportunities from computer technology at a steady pace throughout the next 2 decades. It was the introduction of the first consumer digital camera in 1988 and its steady cost decline over the next decade, however, that jump-started imaging in orthodontics and set the stage for integration of all parts of the practice workflow.¹⁰ Digital image data meant that the practitioner could organize the patient’s image data so that it was easily accessible and not vulnerable to deterioration caused by time and environment. Also, the practitioner could import those images into the practice management system, further customizing patient charts and enhancing communications such as letters.¹¹ As more and more information became digitized, the streamlined practice became the end goal of both equipment and software

manufacturers. Many developed relationships with the most progressive practitioners to best anticipate the needs of the profession (Fig 4).¹²

The 1990s: digitizing of information continues

The last decade of the last century saw more practices embracing computerized management systems as features and functions were added and improved. Scheduling programs became more sophisticated, as did treatment charting and reporting. Electronic insurance filing became an option, as did multioffice support. Imaging systems, though still separate programs, began to interface with practice management systems. “Doctors had to buy their imaging system separately, and then the separate software companies would write some basic integrations to improve workflow,” recalled Dr Lemchen.

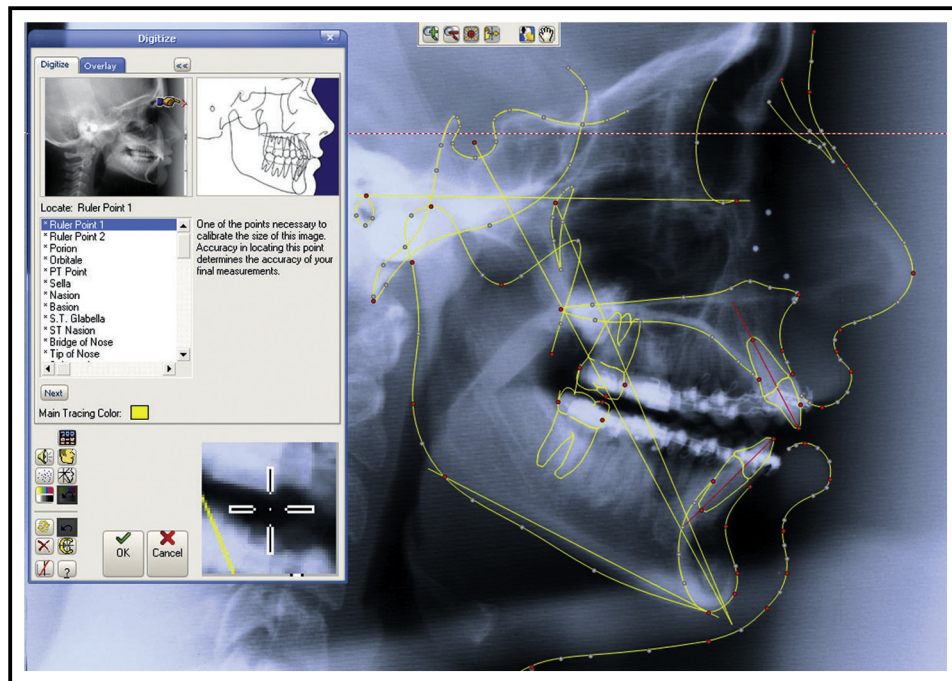


Fig 2. Screen shot from the Dolphin Imaging Ceph Tracing software program. (Image courtesy of Dolphin Imaging & Management Solutions, Chatsworth, Calif.)

During the 1990s, imaging grew to enable the integration of digital x-rays. In 1996, Sirona (Charlotte, NC) introduced Orthophos Plus DS, the first digital panoramic cephalogram. This was a milestone in that it allowed practitioners to put x-rays into a patient's electronic chart. Shortly afterward, computer-aided design/computer-aided manufacturing (CAD/CAM) technology—already entrenched in dentistry since 1987 when Sirona introduced its CEREC unit—wiggled its way into orthodontics. CAD/CAM gave practitioners a way to digitize study model data and incorporate those data into the patient's record. In 1999, Align Technology (San Jose, Calif) was the first company to offer a digitizing service (OrthoCAD) to the orthodontic community,¹³ followed by eModels (GeoDigm, Falcon Heights, Minn) in 2001. That same year, the NewTom 9000 (Quantitative Radiology, Verona, Italy) was installed at Loma Linda University (Loma Linda, Calif), marking the first installation of a cone-beam computed tomography (CBCT) scanner for dentistry in the United States. Thus, computer technology continued to push orthodontic imaging forward and into the next century (Fig 5).

Turning the century: consolidation, integration, 3 dimensions, and the Internet

By the time the 1990s had rolled into the 2000s, practice management companies began to disappear

because of consolidation. “These companies began to mature to the point where they were sold and combined,” explained Dr Lemchen. “The industry was consolidating, and so in the early 2000s we saw OrthoTrac change hands several times.” The survivors soon developed their own imaging software, and Dolphin Imaging's customers were requesting a practice management system from the company. In 2004, Dolphin Management was released. The industry on the whole was seeing a lot of movement.

“We began to see the first wave of migrations to the second generation practice management systems,” recalled Blankenbecler. Some of the key new features being introduced included (1) support of commercial grade databases such as the Microsoft SQL server, (2) patient sign-in with finger-scanning, (3) third-party integrations, (4) integrated payment processing, and (5) improved multioffice support.

This decade also saw the initial Health Insurance Portability and Accountability Act of 1996 (HIPAA) awareness and need for compliance among practitioners. Software developers responded by incorporating increased security features into practice management systems. These included encrypted e-mail and secure user rights for staff login.

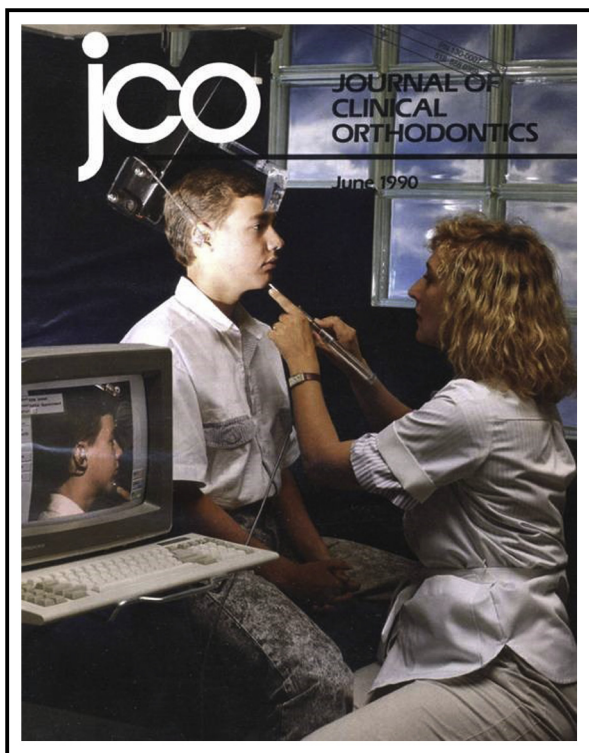


Fig 3. The Dolphin DigiGraph was featured on the cover of the June 1990 *Journal of Clinical Orthodontics*.

Online patient communications

By this time, the Internet and the electronic services it made possible had become firmly entrenched in mainstream business operations. Although most orthodontists had a Web site with general practice information, they were still spending too many staff hours fielding and returning patient phone calls. Furthermore, Web sites at that time were static—much like a phone book listing—so potential patients visited once but never returned. There had to be a way to integrate the Internet into the workflow of an orthodontic practice. In 1999, PT Interactive (Tukwila, Wash) was created to develop a software system that would save staff time and give patients convenient access to needed information any time of day, without a phone call. The system was called Ortho Sesame (Seattle, Wash), and it worked by extracting patient data from the practice management system and converting it for integration into the practice Web site. This enabled patients to access appointment and account information any time of day, eliminating approximately a third of the practice's incoming calls. A side perk of this system was that patients used their e-mail address to access their information. The e-mail address was then



Fig 4. Digital data made it possible to integrate imaging and management systems for a more streamlined workflow. (Image courtesy of Drs Gary and Todd Weinberger, Plainview, NY.)

stored in a database, allowing the practice to use this platform to communicate important messages such as appointment reminders, birthday wishes, and practice news, events, and contests. Positive results of these online patient communications included fewer no-shows, increased staff efficiency, and enhanced patient satisfaction. Many practices augmented these online communications with telephone reminder programs offered from companies such as JulySoft (Tucson, Ariz), TeleVox (Mobile, Ala), and Tel-A-Patient (Santa Ana, Calif).¹⁴

In the early 2000s, Dolphin introduced Anywhere-Dolphin, allowing doctors to securely share files with patients and referrals through the Internet.

Embracing the Internet

As early as 2001, the concept of delivering orthodontic practice management software through the Internet was being discussed in the model of an application service provider. The idea was that the software would be run by a service provider off site, rather than by the orthodontist in the office. The orthodontist then would be free of the hassles of backing up data, updating the software, and maintaining complicated hardware. All of this would be handled by the application service



Fig 5. The NewTom 9000, first installation of a CBCT unit for dentistry in the United States. (Courtesy of QR s.r.l., Verona, Italy.)



Fig 6. Smaller, more capable hardware offered mobility and portability to the orthodontist. (Image courtesy of Dolphin Imaging & Management Solutions, Chatsworth, Calif.)

provider.¹⁵ Just 2 years later, in 2003, the first Web-based practice management system was introduced by Advanced Orthodontic Systems (Brooklyn, NY), when it released its Internet Program delivery upgrade. The

significant difference from previous versions was that the server for the network was not located in the doctor's office, and connection to it was through the Internet.³ Today, we call this "cloud computing."

Volumetric data sets

By the mid-2000s, 3-dimensional (3D) imaging was piquing the interest of the progressive players in the orthodontic community. Within a few years of the New-Tom installation at Loma Linda University, there were a handful of companies manufacturing CBCT machines, and soon the i-CAT (Imaging Sciences, Hatfield, Pa) would become the most popular unit on the market. An appealing aspect for practitioners was that a CBCT scan could serve as a patient's singular data set from which to derive all the traditional views of an orthodontic workup.¹⁶ Software companies scrambled to deliver user-friendly programs that would enable the practitioner to render these volumetric data sets. Some of the main players with orthodontic focus included 3dMDvultus (3dMD, Atlanta, Ga), Dolphin 3D, and InVivoDental (Anatomage, San Jose, Calif).¹⁷ These 3D rendering programs provided tools for orientation, landmark identification, measuring, tissue segmentation, superimposition, and more.

The 2010s: going mobile and getting social

Only a few key players remained as the decade rolled over. "Most new practice management installations were conversions of existing systems," said Blankenbecler. "This was when we began to see demand for support of mobile devices such as tablets and phones." Faster bandwidth and smaller, more capable devices finally made mobile computing a feasible concept in the orthodontic practice workflow. Powerful onboard computing capability, large memories, oversized screens, and open operating systems that encouraged application development had shifted the paradigm of the "mobile phone" to that of the "handheld computing device."¹⁸ OrthoTrac and Dolphin were the first to introduce mobile applications that allowed orthodontists to access their practice data from a smartphone or tablet. Soon, Dolphin released a patient-facing app, offering yet another channel of communication between the patient and the orthodontist (Fig 6).

A decade after the first cloud system was introduced, the time was finally ripe for cloud computing. Eager software companies raced to accommodate this new trend. Cloud9Ortho, Ortho2 (Ames, Iowa), and Dolphin were the first to deliver a Cloud solution to the orthodontic community.

Accordingly, patient communication branched out to the new platforms presented by the mobility trend. "Short message service" (also called "text") and e-mail were integrated into practice management systems, as were the social media hubs that patients used to communicate with their cohorts. This, in turn, created

space for consulting companies that specialized in helping the orthodontic practice engage with patients on these new platforms. Practice Genius (San Diego, Calif) and Digital Sign ID (Richboro, Pa) are 2 examples of this new specialty in the orthodontic consulting arena.

What's next?

As predicted by Dr Krogman in 1971, the future of practice management systems will continue to move forward in step with computer technology. Currently on the horizon are the increasing applications—and accessibility—of 3D printing with medical-grade, biocompatible materials. Software developers have already begun to deliver tools for the creation of oral appliances directly from the virtual patient, with the ability to output in the standard .STL and .OBJ file formats accepted by most 3D printers. The ability to create highly accurate, customizable appliances for each patient enables the orthodontist to deliver more effective treatment.¹⁹ The printers themselves continue to be designed with smaller footprints and more affordable price tags, making them more compatible and accessible for the orthodontic office.²⁰ Already in use by progressive practitioners, this technology will no doubt find its way into the mainstream orthodontic office.

Keeping in step with technology for more than half a century, orthodontics will surely continue forward at the same pace, setting the standard for all the other dental specialties and raising the bar for dentistry in general.

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This article is dedicated to the memory and vision of Dr Robert P. Scholz. A good friend and mentor, he was the founder of Ortho2 and played a key role in establishing Dolphin Imaging as a viable choice in the early days. His unconventional view of the orthodontic world inspired the Dolphin team and a generation of orthodontists worldwide.

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