The DenOptix Digital Radiographic System

JON J. MENIG, DDS

Since its introduction in the 1980s, digital technology has become increasingly important to the practice of orthodontics. Initially used to manage business operations, computers have now taken on the tasks of tracking treatment progress, making appointments, recording digital photographs, and analyzing cephalometric films. By eliminating the paper chart, appointment book, and ledger cards, computers have increased office efficiency and paved the way to a paperless practice.

With all the digital technology available today, however, orthodontists still rely on silver halide film for radiography, as they have for nearly a century. This article will describe the DenOptix system,* a digital radiographic technology that can completely eliminate silver halide film and thus remove one of the last impediments to a fully paperless orthodontic office.

Digital Radiography

Digital intraoral radiography has been possible since Trophy introduced the first charge coupled device (CCD) sensors in the mid-'80s. Although many competitors (most notably Schick) have now entered the market, there remain fundamental limitations to this technology. Because CCD sensors cannot store data, they must be connected directly by wire to a computer. CCD sensors are also extremely expensive, and thus are limited mainly to use for intraoral radiographs.

Some manufacturers have recently introduced CCD-based sensors for their pan/ceph machines. Because of the large array of CCD sensors required, however, the price of these pan/ceph units has been prohibitively high. Furthermore, the purchase of a new x-ray unit is usually required, because most existing pan/ceph machines cannot be retrofitted with CCD sensors.

In the orthodontic practice, where panoramic and cephalometric radiographs are standard tools, digital technology has been limited to taking and developing conventional films and then scanning them into the computer. Despite the extra step, the advantages of this method are substantial. Uses of digitized films include on-screen cephalometric analysis, growth and treatment predictions, case presentations, and marketing.

The DenOptix System

The DenOptix digital radiographic system uses storage phosphor imaging plates, rather than film, to capture and store radiographic images. Storage phosphor imaging technology has been used in medicine for years, but the high cost of the hospital-based scanners needed to read the imaging plates has precluded their use in dentistry. The development of an affordable imaging plate scanner that produces extremely high-quality images is the key to the DenOptix system.

Storage phosphor technology eliminates the need for wires and rigid sensors, allowing radiographs to be taken in the same way as traditional films. Storage phosphor imaging plates are

*Gendex Corporation, 901 W. Oakton St., Des Plaines, IL 60018.

Dr. Menig is in the private practice of orthodontics at 105 Providence Mine Road, Suite 203, Nevada City, CA 95959. He has been involved as a consultant in the development of the DenOptix system.

thin and flexible like film (Fig. 1), and are available in all sizes, from intraoral to cephalometric.

Intraoral imaging plates, housed in disposable sanitary barriers, are indistinguishable from film to the patient, yet are exposed at only a fraction of the radiation levels. These plates come in standard sizes (#0, #1, #2, #3, and #4), with the entire surface area available for capturing the image (Fig. 2). A full-mouth series is taken in the same sequence as with film, and the exposed imaging plates can be stored indefinitely. Cephalometric and panoramic exposures can be made simply by removing the lanex intensifying screen from the regular film cassette and inserting the appropriate-size imaging plate in the cassette (Fig. 3). Any existing x-ray machine can be used. Because cephalometric and panoramic films are already exposed at a low dosage, the settings are not changed when using the DenOptix imaging plates.

Storage phosphor imaging plates, when struck by x-rays, capture and store the radiation energy. During the scanning process, a laser stimulates the imaging plate, causing the release

Fig. 1 Storage phosphor imaging plates are thin and flexible like conventional film; unlike CCD sensors, they do not have to be connected to computer by wire.

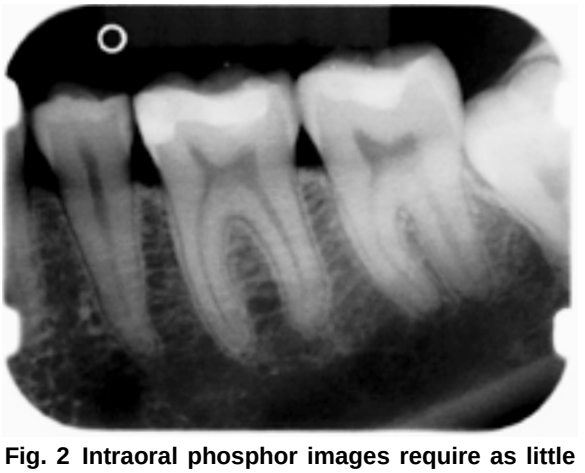

Fig. 2 Intraoral phosphor images require as little as 10% of typical film radiation exposure, and can be taken in all standard sizes.

Fig. 3 Panoramic and cephalometric imaging plates require only removal of lanex screen from film cassette of any pan/ceph machine.

Fig. 4 Carousel with attached cephalometric imaging plate loaded into DenOptix scanner.

of the stored energy in the form of light photons. The number of photons released per pixel is recorded and assigned a grayscale (light to dark) value, thereby producing a digital image.

Once exposed, the imaging plates are placed on a carousel and loaded into the DenOptix scanner (Fig. 4). The carousel can hold as many as 29 intraoral imaging plates, or a combination of extraoral and intraoral imaging plates, per scan. Because imaging plates are only slightly sensitive to visible light, the plates can be loaded in a subdued-light environment; a darkroom is not required.

A complete panoramic scan takes about three minutes. One to eight intraoral images can be scanned in about one and a half minutes. As soon as the scan is completed, the DenOptix software sends the digital image to the computer in the appropriate operatory for viewing (Fig. 5).

After an imaging plate has been scanned, it is removed from the carousel and placed on a bright viewbox for two minutes to erase the residual image. Unless it is physically damaged, an imaging plate can be used thousands of times; if damaged, it can be replaced at a fraction of the cost of CCD sensors.

The DenOptix Digital Image

DenOptix images have distinct diagnostic advantages over traditional films because of their linear dynamic range of data. The dynamic range is the relationship between the amount of radiation hitting the target (film or imaging plate) and the optical density, or range of light to dark. Because silver halide film has a small linear dynamic range, the exposure and developing technique must be accurately controlled to produce a good diagnostic radiograph. Any error will result in an inferior image.

The long linear dynamic range of data captured with the DenOptix system makes it possible for the viewer to select the dynamic range with the most useful diagnostic information. The portion of the dynamic range being viewed can either be adjusted automatically or controlled manually. This virtually eliminates the possibility of under- or overexposing the image.

For example, when viewing a cephalometric image, the operator can adjust the display to bring out the soft tissue, so that tissue thickness and cartilage can be seen in exceptional detail (Fig. 6). Conversely, visualization of dense structures such as the TMJ can be optimized by moving in the opposite direction along the linear dynamic range. In panoramic images, some regions are commonly under- or overexposed. Moving along the linear dynamic range allows

Fig. 5 Scanner immediately sends digital information to computer for viewing.

Fig. 6 DenOptix software analyzes linear dynamic range of data collected in cephalometric scan and optimizes display of both hard and soft tissues. Image can be manipulated manually if desired.

structures to be seen that would otherwise be missed (Fig. 7). In other words, there is much more information stored in each DenOptix image than can be viewed on the monitor at one time.

The DenOptix software allows a variety of other strategies for viewing and storing images. Image-manipulation tools include enlargement, inversion (changing from positive to negative), and a number of software filters for viewing diagnostic details. Linear and angular measurements, text, and drawings can be added on screen to aid in patient education. Scanned images are assigned to the patient's file and can be organized by date, type, or tooth number. DenOptix files can be exported to most popular file formats for use with other treatment-planning software. The technology required for seamless integration with other dental software packages has been made available to those companies.

Implications

Orthodontists have been quicker than any other dental specialists to adopt on-screen diagnosis, treatment planning, and case presentation. Nevertheless, their reliance on large extraoral radiographs has precluded them from enjoying the benefits of digital radiography. The DenOptix system, with its ability to produce high-quality radiographic images in all sizes, finally offers a practical alternative to film.

Removing film from the office eliminates the need for a darkroom, a processor, and a flatbed scanner (if images are currently being digitized)—all capital expenses. The costs of chemicals, EPA-compliant chemical removal, processor maintenance, film mounts, and film are all avoided, and the savings in staff time is substantial. Additionally, there is a significant environmental benefit from eliminating the heavy-metal waste stream produced by chemical processing.

The potential to transmit high-quality digital images over the Internet is one of the most exciting aspects of this technology. For the orthodontist, who routinely sends copies of films to other specialists and general dentists, the implications are significant. With transmission of images over the Internet being almost instantaneous, there is no problem of films being lost or delayed at the post office. Additionally, the images being transmitted are of full quality, unlike often-compromised film copies, and can be sent to a virtually infinite number of locations.

Fig. 7 Manual manipulation of panoramic images is useful for visualizing structures such as mandibular canal and lamina dura.

Until all dentists have the capability to receive digital images over the Internet, DenOptix images can be printed. Prior to printing, it is possible to crop and enlarge any areas of interest, such as the third-molar regions when referring to an oral surgeon for extractions. Annotations can also be placed on the printed images, including the patient's name, the doctor's name, the date of the image, and any other pertinent information.

Conclusion

Since its inception 100 years ago, dental radiology has remained substantially unchanged. The DenOptix system, based on affordable storage phosphor image scanning, enables dental radiology to move beyond silver halide-based film and into the next century, where we can enjoy the full benefits of digital technology. ❑