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Haptic input improves digital dental restoration design

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_**For more than a hundred years,** dental laboratories have designed dental restorations the same way by using a lost-wax process in accordance with which the design is first modelled by hand in wax, then reviewed, refined, invested and finally burned out in the process of creating a mould that will be used for casting. Twenty-five years ago, early dental CAD/CAM solutions, such as Sirona's CEREC system, applied technology proven in automotive and aerospace design to the design of zirconia substructures (or copings) for crowns, allowing part of the process to go digital. However, while copings are simple, thimble shapes and relatively straightforward to design digitally, other types of commonly prescribed removable restorations, such as partial dentures, are not, owing to their highly irregular and intricate shapes. In addition, dental laboratory technicians are skilled artisans—having honed their manual dexterity, artistic style and design techniques over many years—not tech savvy engineers. These factors make it extremely difficult for them to use traditional dental CAD/CAM systems to create complex, organic-shaped dental restorations.

Creating dental restorations is partly science and partly an art. Each individual's mouth and tooth shape is uniquely his/her own, meaning that a dental restoration is an individualised work of art, sculpted from scratch in bite-sized form. Computers can greatly speed the design process and add

precision, for example by eliminating steps such as the need for a refractory model, applying digital wax thicknesses consistently and automatically, and assuring fast design iterations or a remake, if needed. Furthermore, having digital clasp designs and mesh patterns at your fingertips also helps accelerate the design process.

Until recently, dental CAD/CAM systems were either surface or solid modellers, utilising the same parametric technology and the accompanying rigid, hierarchical workflow as CAD/CAM systems that are used for industrial design. These traditional dental CAD/CAM systems also require that the laboratory's restoration designer use a 2-D computer mouse to manipulate the design, which prevents the designer from leveraging the dexterity and artisanship they have spent years perfecting. While the laboratory technician may be able to see the restoration on screen, with a mouse they cannot feel the contours of the teeth and tissues, or the thickness or smoothness of a restoration's surface—pivotal feedback that allows them to design accurately and efficiently.

In 2008, SensAble introduced what some dental authorities have called a revolutionary 3-D touch-enabled solution for dental restoration design. The company's SensAble Dental Lab System remains the only proven digital solution to support the design and production process for removable partial frameworks and has since been expanded to handle full contour crown and bridge work and, with additional software, veneers.

The system is based on voxel technology (think of voxels as 3-D pixels), which provides unparalleled speed and design flexibility. This 3-D modelling approach means that laboratory technicians can handle even the most challenging cases and can literally design any type of restoration they can imagine. If they can wax it, they can design it on the SensAble system. This ability to use one system to create multiple types of restorations allows dental laboratories to leverage their investment across more lines of business, an important option in challenging economic times.

With the SensAble system, dental laboratory technicians use a haptic device, which the company calls a 3D Virtual Touch stylus, instead of a mouse, allowing them to literally feel the evolving restoration that they are designing on screen as they carve and smooth digital wax. The result, according to numerous European dental laboratories, is business changing. When dental restoration designers are suddenly offered a way to design digitally in which they can still use their sense of touch in the design process, they can transition more easily to working in the digital domain and

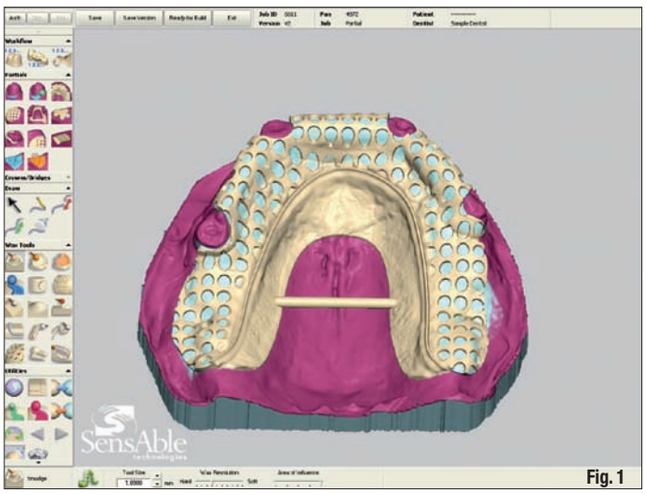

Fig. 1_Full upper digital partial.

design restorations with unmatched speed, consistency and precision. Laboratories are reporting that they are able to create vastly more work with the same number of staff and in some cases compete for large-volume business, such as government-funded restorations, because the laboratory's cost structure has suddenly become more favourable.

Suddenly, the painstaking task of working in wax has been elevated to state-of-the-art design. Numerous laboratory owners stated that the appeal of haptics has helped them to attract, quickly train and retain younger computer-savvy technicians entering the dental laboratory field. Other laboratories have reported that because of haptics, they have been able to teach individuals who are not trained laboratory technicians to use the system correctly and productively, expanding the pool of people from which they can hire.

_What is haptics

Haptics refers to sensing and manipulation through touch. The word haptics originated from the Greek words haptikos and hapthesthai, which means to grasp or to touch. Haptic devices enable computer users to touch and manipulate virtual objects by feel within a true 3-D space.

SensAble's found- ers pioneered the development of a type of haptics now called force feedback, where the computer receives the force exerted by a person's natural touch and then returns a resulting force to the user as he/she manipulates 3-D models on screen. What dental laboratory technicians experience is that when they move their hand, the

movement sends haptic input—data about force and position—to the computer via the haptic device. The computer makes appropriate graphical changes to the 3-D model of the dental restoration on screen—sometimes called rendering—while it calculates and sends the correct amount of force feedback back to the user through the haptic device. An easy way to think about this type of haptics is to imagine the forces that you experience against your hand and arm when pushing open a heavy glass door.

_How touchability speeds dental restoration design

Labo W. Hoet & Co., a full-service dental laboratory in Ghent, Belgium, which has been in business for more than 35 years, provides restorations to dentists in the Flemish part of Belgium, Brussels and other European countries. The family-run laboratory employs 24 people and has worked with the SensAble Dental Lab System for the past year. Initially, the firm purchased the solution for use with partials, but when its owners took a closer look at the crown and bridge software, they decided to expand the use of the SensAble system throughout its everyday workflow. At present, the laboratory has one person who scans full time in preparation for designing both partials and crown and bridge work. Another laboratory technician designs full time. With this approach, Labo Hoet is able to manufacture nearly all of its crown and bridge restorations digitally. For several years, Labo Hoet owner Jan van Ooteghem was convinced about utilising digital solutions in the crown and bridge division, but had not found a CAD/CAM system for partials that actually worked. Labo Hoet had viewed a number of software packages but none produced a satisfying result.

When the laboratory saw partials created using the SensAble system, it was convinced that it was possible to use this as the main solution in its partials division. Initially, the firm thought the haptic device—which the team calls "the designing pen"—was just a gimmick to be different. But the technicians soon realised that the device really made a difference. Now, technicians can feel in three dimensions and, for partials, this is a particular benefit since their curves, multiple thicknesses and individual nature vary greatly from patient to patient. The haptic device has actually become "a third hand for the designer."

Labo Hoet reports that the SensAble system saves the laboratory at least 30 % of the time it would take to create a partial manually. In general, the partials software has made it possible for Labo Hoet to boost its productivity, making more partials with the same number of technicians. Furthermore, the final restorations are much more consistent, accurate and

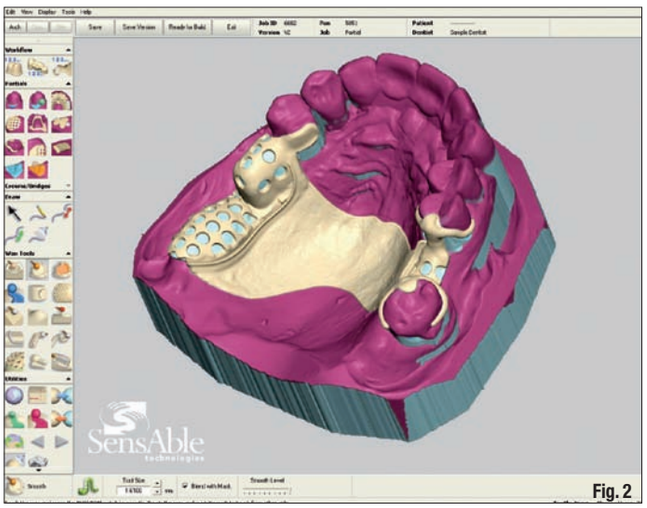

Fig. 2_Digital wax upper with housing for attachments.

detailed. With the software's true 3-D capabilities, technicians can save time by not having to switch views all the time or having the software render another section. The haptic device allows the designer to feel into an area of the restoration—behind the corner of a restoration—in a way that is better than if they were only able to see it. Using the SensAble Dental Lab System, Labo Hoet is able to design partials quickly, more consistently, and as a combined result the restorations are much easier to finish once cast. Various conventional steps in the partial design and manufacturing process have disappeared, such as making the refractory model, resulting in additional time and cost savings from materials that are no longer used.

Although they originally used separate systems for fixed and removable restorations, Labo Hoet's team found it was easier to use the same scanner and the same kind of design software for both partials and crowns and bridges instead of using multiple systems. Very important in this workflow is 3D Systems' rapid prototyping printer. The laboratory already used this before they purchased the SensAble system, but with designing partials digitally, it became even more useful. The laboratory enjoys having the printer in-house, but for smaller laboratories, it is also possible to outsource the printing. Labo Hoet reports that the printed resin patterns are very easy to cast with and the results fit perfectly.

Additionally, the ongoing software upgrades provided by SensAble continue to expedite the design process, giving the laboratory more time to focus on design details. "Every software update that we have received from SensAble is a

pleasant surprise," van Ooteghem said. "The possibilities of the software are virtually limitless. I think the most important limitation is our own imagination. Everyday partials, partials with backing plates, full contour teeth, etc.—it is all possible. If we look back one year, it is hard to imagine the manual labour we had to do to make a partial. Just thinking about that has made it all worthwhile for us," he continued.

_SOCA Networks, France

SOCA Networks, located in Bordeaux and Paris, France, has been using SensAble's Dental Lab System for nearly two years to create partials, crowns and bridges and veneers. This network of dental laboratories is one of France's largest producers of restorations under contract to the French health-care system, and produces thousands of restorations per year. The network also serves as a primary production centre for the design and production of Remedent GlamSmile porcelain veneers.

While 70 % of its business comes from France—and the bulk of that from government-reimbursed restorations—SOCA produces crown and bridge work, partials and veneers for clients across four continents, including work for Europe, the US and Canada, Australia, the UAE, Russia and Brazil. SOCA Networks operates production facilities in both France and Vietnam.

SOCA initially purchased SensAble's system to accommodate its high-volume veneers business for Remedent, but gradually began using the software for partials in late 2009 and for manufacturing crowns and bridges in February 2010. Using SensAble's system, SOCA designs approximately 100 partials, about 100 to 120 crown and bridge restorations and between 200 to 300 veneers per day.

Nicolas Thibert, an executive at SOCA Networks, reports that the accuracy and quality of SensAble-produced parts are definitely better than the two other dental CAD/CAM solutions he had previously tried out and require less time to create. Because SOCA has multiple locations, it can leverage talent in one office for partials or crown and bridge work and then transfer the SensAble-created files via FTP over its IT network. In addition to time-savings, SOCA believes the SensAble system has helped the firm automate small steps in the production process to decrease human error. For example, the SensAble system can automatically store individual dentist specifications and ensure there is an order number or a patient number on all parts.

SOCA also uses SensAble-created files for pressables, an increasingly popular type of fixed restoration, and even has a few dentists who upload intra-oral scans to SOCA's network so that designers can automatically access the file and route it to the SensAble design stations.

_Dental parts are art—designing them correctly requires touch

As humans we rely heavily on our sense of touch, sometimes without even realising it. Additionally, there will always be individual style and artisanship in the making of dental restorations. By giving dental laboratory technicians a touch-enabled CAD/CAM solution that allows them to maintain design control and create restorations the way they know they need to be made—together with voxel technology for speed and design flexibility—SensAble's system helps European dental laboratories to transition to a digital workflow easily; increase productivity, accuracy and consistency; and capture new business all at the same time._

_about the author | CAD/CAM

Bob Steingart, President of SensAble Dental Products, has over 25 years of experience in successfully transforming innovative technologies into commercial solutions. He has held executive positions in business development, product management and marketing at Avid Technologies, EMC, Lotus Development, Sitara Networks and Kurzweil Applied Intelligence. He holds an MBA from Harvard Business School, and a BSEE and MSEE from MIT. He can be contacted at steingart@sensable.com or by contacting SensAble at www.sensabledental.com.