Digital impressions and handling of digital models: The future of Dentistry

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Introduction

New digital impression methods are currently available in the market, and soon the long-awaited dream of sparing patients one of the most unpleasant experiences in dental clinics, the taking of dental impressions, will be replaced by intraoral digital scanning.

Both in orthodontics and restorative area (prosthodontics and restorative dentistry in particular), the use of plaster models is not only essential but routine practice in these clinical specialties. It has long been every dentist's desire to be able to scan plaster models, or even patients' teeth directly in the mouth. Avoiding discomfort, speeding up work, improving communication between colleagues and prosthetic labs, and reducing the physical space needed for storing these models, are some of the alleged benefits of this technology.

Since the introduction of the first digital impression scanner, product development engineers in various companies have developed dental office scanners that are increasingly user-friendly, and produce images and restorations with growing accuracy. The use of these products represents a paradigm shift in the way that dental impressions are taken.

This article addresses the technical aspects and applications of digital impressions in dentistry, with emphasis on orthodontics.

How digital impression systems evolved

The major goals of the impression-taking process in restorative dentistry are obtaining a copy (imprint) of one or several prepared teeth, healthy adjacent and antagonist teeth, establishing a proper interocclusal relationship and then converting this information into accurate replicas of the dentition on which indirect restorations can be performed.

In orthodontics and orthognathic surgery, the use of accurate plaster models is an essential prerequisite for establishing suitable diagnosis and treatment planning, as well as for monitoring treatment progress.

The techniques used for impression-taking with elastomers and creating plaster casts have been in widespread use since 1937.[1] Impregnum, a polyether material introduced by the ESPE company in 1965, was the first polyether material specifically produced for use in dentistry.

Many dentists are reluctant to embrace the new technologies because they simply believe elastomeric impression materials and techniques have been in use for so long and work so well that they are irreplaceable. Or else, that 3D digital

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scanning technologies are so recent that they are not yet ready for clinical use. Actually, impression taking using elastomers, for all its inherent problems, has been used in dentistry for 72 years!

Digital impression and scanning systems were introduced in dentistry in the mid 1980s and have evolved to such an extent that some authors predict that in five years most dentists in the U.S. and Europe will be using digital scanners for impression taking.[2]

In Orthodontics digital impression taking has been used successfully for several years with systems like Cadent IOC/OrthoCAD, Dentsply/GAC 's OrthoPlex, Stratos/Orametrix SureSmile and EMS RapidForm.

CAD-CAM (Computer Aided Design and Computer Aided Manufacture) systems available today are capable of feeding data through accurate digital scans made from plaster models directly to manufacturing systems that can carve ceramic or resin restorations without the need for a physical copy of the prepared teeth, adjacent teeth and antagonist teeth.

With the development of new high-strength restorative materials with aesthetic properties, such as zirconia, lab techniques have been developed whereby master models obtained through impressions with elastic materials are digitally scanned to create stereolithic models (prototyping) on which restorations are performed. Even with such high-tech improvements, it is clear that these second-generation models are not as accurate as stereolithic models made directly from data obtained from 3D digital scans of the teeth using 3D scanners specially designed for this purpose.

Two types of systems are available on the market today: CAD/CAM systems and dedicated three-dimensional digital impression systems (3D). This article reviews the characteristics of dedicated 3D digital impression systems not only because this is the state-of-the-art today but because it shows great promise for the future, notably in the areas of restorative dentistry, orthodontics and orthognathic surgery.

Dedicated Digital Impression Systems

Dedicated digital impression systems eliminate several cumbersome dental office tasks, such as selecting trays, preparing and using materials, disinfecting impressions and sending impressions to the lab. Moreover, lab time is reduced by not having to pour up plaster, place pins and replicas, cut and shape dies or articulate models.

With these systems, final restorations are produced in models created from digitally scanned data instead of plaster models made from physical impressions. Additionally, they enhance patient comfort, improve patient acceptance and understanding of the case. Digital scans can be stored on hard disks indefinitely, while conventional models, which can break or chip, must be physically stored, which requires additional office space.

The iTero digital impression system (Cadent Inc., USA) (Fig 1) entered the market in 2007.

FIGURE 1 - iTero scanner equipment.

FIGURE 2 - iTero scanner.

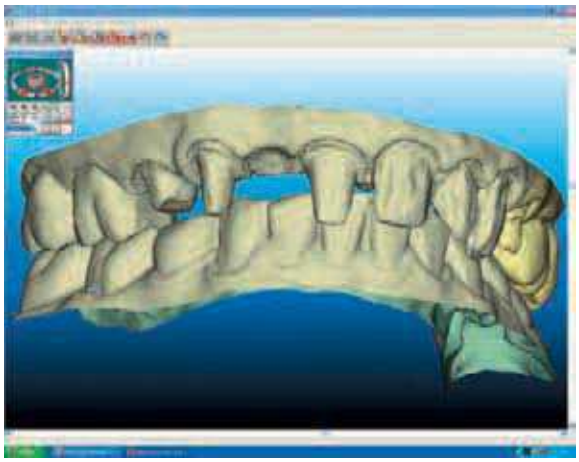

FIGURE 3 - Image showing the digital model for prosthetic dentistry.

It uses a parallel confocal imaging system to perform fast digital scans, capturing 100,000 points of laser light and producing perfect focus images of more than 300 focal depths of tooth structures. All of these focal depths are spaced no more than 50 micrometers (50 µm) apart. Parallel confocal digital scanning captures all elements and materials found in the mouth without the need to apply any materials to the teeth, and it can accurately capture supragingival and subgingival preparations (Figs 2 and 3).

Because it features direct scanning and does not require the use of scanning powder, Cadent's iOC scanner provides orthodontists and their assistants with flexibility in a host of clinical applications. It provides highly accurate orthodontic scanning with real-time viewing in adults and adolescents, in patients with various mouth openings and in full and partial arches. In addition, iOC's software architecture allows data to be exported and used in integration with other orthodontic office management software, such as OrthoCAD (Fig 4).

Another option for digital impression taking is the 3M ESPE Lava Chairside Oral Scanner (COS) system. This system is mounted on a mobile cart with a CPU, touch-screen monitor and a 13 mm thick scanning unit. A camera fitted on the device comprises 192 LEDs and 22 lens systems.

The method used to capture 3D impressions involves a technology called Active Wavefront Sampling. Lava's "3D in Motion" concept features a revolutionary optical design, image processing algorithms and real-time model reconstruction, which captures 3D data in a video sequence and models data sets in real time. The scanning unit contains a complex optical system that comprises multiple lenses and blue LED cells. The Lava COS system can capture 20 3D data per second, or close to 2400 data sets per arch, for accurate, high-speed scanning.

Benefits to Clinicians and Labs

The greatest benefit for dental lab technicians and dentists in adopting digital technology lies in eliminating many chemical processes. By virtually eliminating these processes, error accumulation in treatment and in the manufacturing cycle is no longer an issue. Some of these processes are: curing the impression material, curing the plaster and base, curing the investment material in restoration dies, and retraction or shrinkage of conventional feldspathic ceramic materials.

By eliminating conventional impression-taking procedures, clinicians no longer need to

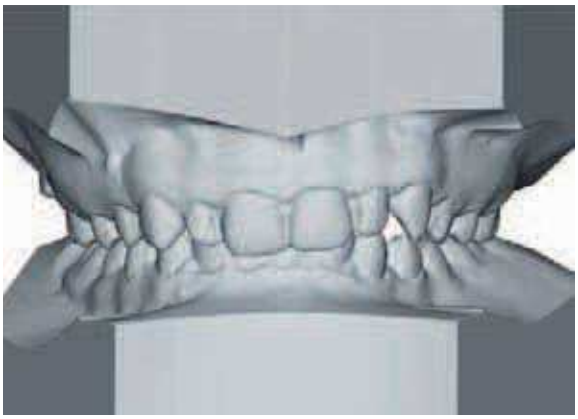

FIGURE 4 - Image showing a digital model for Orthodontics.

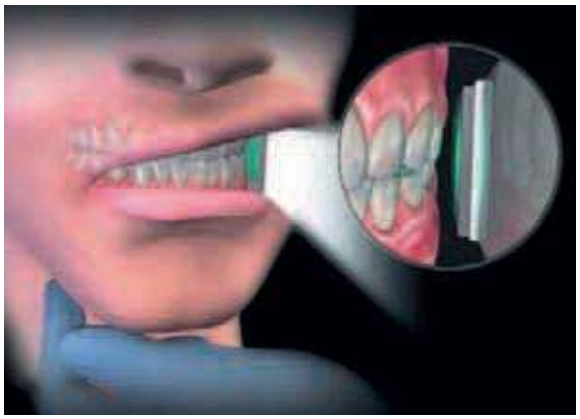

FIGURE 5 - Using the digital scanner to take a checkbite impression.

worry about the possibility of error due to air bubbles breaking the impression materials, displacement and movement of the tray, tray deflection, insufficient impression material, inadequate impression adhesive, or distortion resulting from disinfecting procedures.[3]

Furthermore, and particularly important in orthodontics and orthognathic surgery cases, taking checkbite impressions (centric occlusion) has historically been accomplished through the use of silicone materials or bite wax. When impressions are taken digitally, nothing is placed between maxillary and mandibular teeth. This dramatically reduces the risk of an inadequate interocclusal relationship (Fig 5).

Discussion

As in implant dentistry and oral and maxillofacial surgery, for example, where digital images obtained by Cone-Beam CT scans are imported into a special software for 3D design and implementation of virtual surgeries, the use of digital models in orthodontics has proven an excellent technique and possibly the future method of choice to handle digital models in this dental specialty.

The integration of scanned models with digital images obtained by Cone-Beam CT, which enable the simulation of orthodontic/surgical movements in orthognathic surgery cases, for example, substantially facilitates diagnosing and planning of these complex cases.

Rheude et al[5] compared the use of digital models with traditional plaster models in orthodontic diagnosis and treatment planning. They concluded that in most cases digital models can be successfully used as part of the orthodontic records. It is noteworthy that the more the examiners used digital models the more the diagnoses resembled those of conventional models. This indicates a modest learning curve before digital models can be compared to conventional models.

Leifert et al[4] took space measurements in conventional (plaster) models and in digital models (OrthoCad system, Cadent, USA) and concluded that the accuracy of software for space analysis in digital models is just as clinically acceptable and reproducible as in conventional plaster models.

Incorporating digital scanning in daily practice does not require any additional processes or procedures to be learned by either orthodontists or their assistants. Consultations for obtaining orthodontic records remain virtually unchanged in terms of time and goals, with the added benefit that patient satisfaction is significantly enhanced.

Cost-wise, investment may seem sizeable at first. From a commercial point of view, however, digital impressions ensure profitability in the medium term. Similarly to direct digital intraoral radiographs, the possibility of reducing the operational cost of materials and the ability to view the quality of the procedure in real time, reduces the rate of repeat visits and, consequently, chair time. And chair time represents the major cost in any office. Not to mention the priceless value of word-of-mouth marketing derived from patients' favorable comments on digital impression taking versus uncomfortable conventional impression taking with alginate or other materials.

Further added benefits are the ability to save the impressions digitally, reducing costs and freeing up space, which can be exploited in other ways, e.g., by expanding the patient care area.

Conclusions

By addressing the everyday dental office issues described above, digital impression taking, given its undeniable benefits, will transform digital intraoral scanning into a routine procedure in most dental offices in the coming years. Furthermore, digital impressions tend to reduce repeat visits and retreatment while increasing treatment effectiveness. Patients will benefit from more comfort and a much more pleasant experience in the dentist's chair. Thanks to digital impressions, products fabricated in prosthetic labs will become more consistent and easier to install, requiring reduced chair time.

Since long before the Industrial Revolution men has handcrafted and manufactured millions of different products using analogical processes. In the last 30 years, many of these products have been converted to digital manufacturing—from auto parts to civil construction—given its consistent quality and lower cost. It is therefore no surprise that digital solutions are now being integrated into many dental procedures.

With the popularization of digital systems, and the tremendous growth in two areas of dentistry that can potentially benefit from digital impression taking and digital models (orthodontics and dental implantology) one can confidently predict that in the coming years we will witness a true digital revolution in the dental office. A revolution that will benefit patients in terms of more efficient planning, reduced discomfort and treatment efficiency.

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