Intra-oral impression-taking:
Digital datasets soon to catch on everywhere

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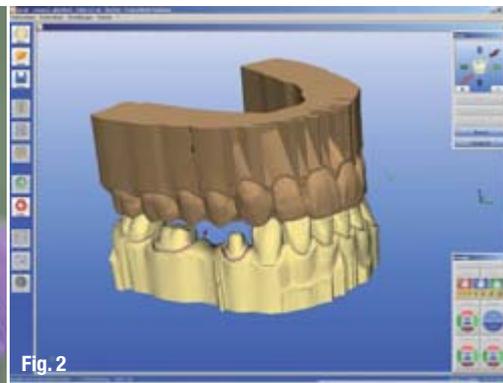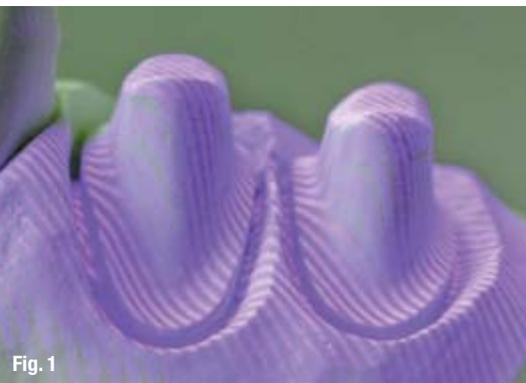
Fig. 1

Fig. 2

Fig. 3

Fig. 1_Short-wave blue light with structured light projection. (Photo courtesy of Ender)
Fig. 2_Single images are matched to create a digital full-arch model, basis for construction and milling of the framework. (Photo courtesy of Mehl)
Fig. 3_Optoelectronic intra-oral scan using the C.O.S. Lava system. Crown preparation and preparation margin are portrayed exactly. In addition to framework manufacture, the dataset enables production of an SLA resin model including the antagonist teeth.
**Fig. 4**_Intra-oral scan (C.O.S. Lava) of a molar with a cusp-supported

_**The annual meeting** of the German Society of Dentistry and Oral Medicine (DGZMK), held in conjunction with the Society for Dental Ceramics (AG Keramik), the DGZMK's professional society, is a major event that critically examines experiences with all-ceramics and CAD/CAM methods in clinics and practices. At this year's meeting, the _10th Annual Ceramics Symposium_, Prof Bernd Wöstmann, Head of Prosthodontics at the University of Gießen in Germany, focused in his paper on the progress that has been made in the digitisation of intra-oral impression-taking.

Naturally, perfectly fitting restorations that can be seated without further correction are every dentist's wish. This requires exact impressions of the preparation and dental arch. Quite some time ago, digitisation made

inroads into this discipline, beginning in 1985 with the first digital impressions by Prof Werner Mörmann at the University of Zürich. Prof Wöstmann explained that _en route_ to an exact restoration, creating an image of the intra-oral situation either as a real or a virtual model is a very crucial step—it is only possible to produce the final restoration indirectly, whether it is an inlay or a multi-unit fixed dental prosthesis bridge (FDP).

Owing to material and haptic conditions, it is still impossible to produce a "flawless" conventional (stone) model from classical impressions with elastomeric impression material. Every virtual model produced on the basis of a classical impression is inexact, regardless of the accuracy of the scanning procedure itself. It thus makes sense to perform scanning directly in the oral cavity.
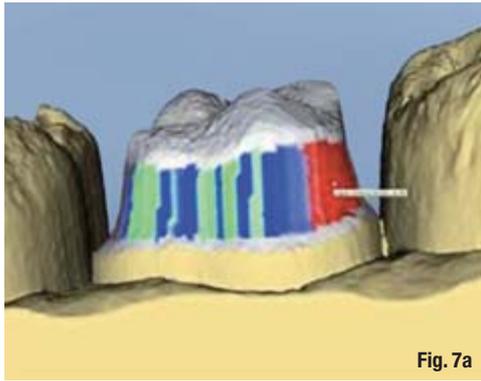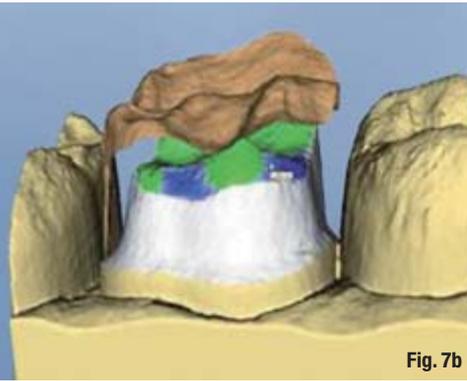

Fig. 4

Fig. 5

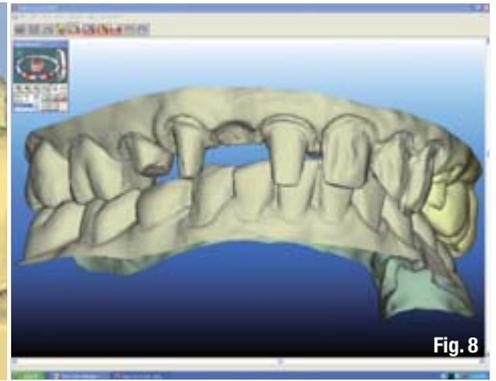
Fig. 6
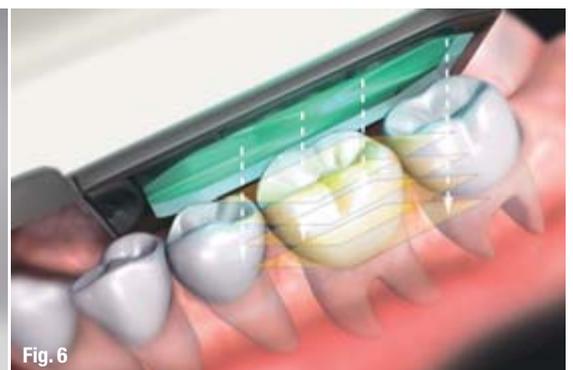
Fig. 7a

Fig. 7b

Fig. 8

Now that producing all-ceramic restorations without CAD/CAM has become almost unthinkable, the next step has already been taken towards complete digitisation of the process from preparation to seating the prosthesis: optical scanning to create a digital, intra-oral impression. In terms of clinical use, the devices—CEREC AC (Sirona), C.O.S. Lava (3M ESPE), iTero (Cadent-Straumann)—are similar, but they function according to different principles. Technically, the systems are similarly constructed, but the procedures for acquiring the 3-D datasets differ.

The acquisition unit of CEREC AC uses short-wave blue light and functions according to the principle of structured-light projection (Fig. 1). The scanning procedure captures single images; the angled imaging function acquires tooth areas below the equator and thus increases accuracy. Through matching, several images are computed of a quadrant or whole arch (Fig. 2), as are the antagonist dentition and bite record.

The wavefront sampling of C.O.S. Lava captures the tooth shape by moving the video camera over the teeth. The distance to the camera can be calculated from the changing position of individual pixels during filming, giving rise to a 3-D image of the dental arch (Figs. 3 & 4).

The functioning of the iTero scanner is based on the principle of laser triangulation. The image captures the tooth and vertically scans 300 levels, each 50 µm deep (Figs. 5 & 6).

According to Prof Wöstmann, the scanning accuracy of CEREC AC and C.O.S. Lava corresponds to a conventional hydrocolloid or polyvinyl-siloxane impression. The differences were not significant.[1] Measurements of crown copings fabricated with C.O.S. Lava yielded an average of 33 µm (± 16 µm) for all marginal gaps. Copings produced using the conventional impression-taking technique had a mean marginal gap of 69 µm (± 25 µm). Syrek *et al.* found comparable results in a clinical study.[2] The mean marginal gap of conventionally manufactured crowns was 71 µm, as compared with 49 µm for the C.O.S. Lava crowns. For CEREC 3D, the literature cites a tolerance of 40 µm (± 21 µm).[3]

Another advantage of digital impressions is that the scanned preparation can be checked directly on the screen, where imperfections can also be immediately corrected (Figs. 7 & 8). For patients with an easily triggered gag reflex, these scanning methods greatly improve treatment comfort. Further benefits result from fewer working steps involved, especially in the practice. Choosing an impression tray, mixing the elastic impression compound, waiting during setting and disinfection, as well as producing a model are no longer necessary.

Fewer treatment and working steps also mean fewer sources of error and better standardisation, which in turn can improve the predictability of treatment outcome. Prof Wöstmann cautioned that with crown margins that are clearly sub-gingival, the optical systems reach their limits; thus, conventional impression-taking techniques are still used in such cases.

preparation for a ZrO_2 crown framework. (Figs. 3 & 4 courtesy of Wöstmann)
Fig. 5_ITero is equipped with a laser camera. It is the third intra-oral scanner on the European market.
Fig. 6_ITero scans the tooth at several levels using laser triangulation.
Figs. 7a & b_The virtual "prep-check" checks the preparation margins and the occlusal reduction against the antagonist tooth. (Photo courtesy of Lauer)
Fig. 8_The full-arch scan for an FDP construction using the iTero system. (Figs. 5, 6, 8 & 10 courtesy of Straumann)

Fig. 9_SLA resin model using the C.O.S. Lava system. (Photo courtesy of 3M ESPE)
Fig. 10_Digitally milled resin model using the iTero system.
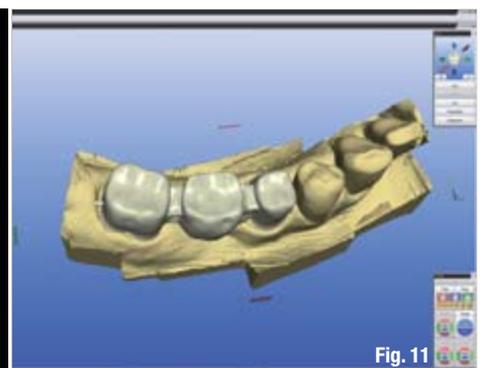**Fig. 11**_Construction of an FDP.

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 12_SLA model (acrylic) for trying in the framework.
Fig. 13_Trying in the ZrO$_2$ framework.
Fig. 14_Veneering and articulation.
(Figs. 11–14 courtesy of Baltzer)

_Digital impressions are more accurate

At the 12th annual meeting of the International Society of Computerized Dentistry, Prof Gerwin Arnetzl, University of Graz, compared the accuracy of digitally generated impressions with that of conventional elastic impressions. When conventional impressions demonstrate an elastic recovery of 98.5 % after deformation, a fitting accuracy of 35 to 75 μm for an inlay cavity can be expected. For cast pieces, additional tolerances of up to 46.5 μm accumulate,[4] so that indirectly manufactured crowns can attain deviations of up to 114 μm.[5]

Different elastomeric impression techniques can cause considerable deviations. For instance, in analogue impression-taking using different impression materials and trays, dimensional changes compared with the reference (a cast metal control) varied between 0.32 and 1.17 %. A deviation of 49 μm was found for standard and 122 μm for control impression-taking.[6] As a rule, however, the studies on analogue impression-taking techniques were performed using 2-D measurements; the new studies on the imaging accuracy of optical methods were conducted with 3-D volume difference analyses.

Digitally or optically produced images by different operators exhibited a measurement accuracy of 11 μm.[7] With the analogue impression-taking technique, the deviations for a whole quadrant ranged from 72 to 101 μm, while the measurement error tolerance of digital images is only about 35 μm, thanks also to the enhanced accuracy made possible by angled images. Potential sources of error in the digital impression-taking technique are scanner adjustment, magnetic interference fields during image processing, image noise and the software. According to Prof Arnetzl, these results prove that given the correct use of a camera or scanner, digitally generated data exhibits fewer errors and greater accuracy than the conventional impression-taking technique with elastomeric impression materials.[8]

A virtual model of the maxilla/mandible is computed from the scans of the quadrants or complete dental arch with the antagonist dentition. Via the Internet, the dentist sends the datasets from C.O.S. Lava or iTero to the manufacturer, where they are checked before being used to produce a resin model (Figs. 9 & 10). After CAD construction of the restoration, the dental technician can either mill the framework in his/her own laboratory or have it done at the milling centre. The resin model is needed to layer on the veneers and perform articulation. CEREC AC also computes a virtual model (Fig. 11). Framework-free crowns and short-span FDPs can be milled immediately, directly from the dataset, in the practice's laboratory or in another dental laboratory with an online connection to the practice. For veneered crowns and multi-unit bridges (xxFDPs), a stereolithographically produced resin model (SLA) is necessary, which is provided by InfiniDent (Sirona) and makes veneering the framework and articulation possible (Figs. 12–14).

On the whole, optoelectronic impression-taking systems are extremely promising. Owing to the offered advantages in standardisation, quality assurance and patient comfort, digital intra-oral impression-taking systems have great potential for the future. In the coming years, they will be seen in ever-increasing numbers in daily dental practice. The datasets they create, thanks to the exchange of information online, simplify communication between the dentist and the dental technician, regardless of distance. Supplemental facial photos, information on tooth colour, individualisation, material, occlusal concept, etc. can also be attached. All of this happens without conventional impression-taking and the associated gag reflex, wax check-bite and stone model._

_contact   CAD/CAM

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