Lava™ Chairside Oral Scanner C.O.S. and the digital workflow

The Lava™ Chairside Oral Scanner C.O.S. is an intra-oral scanning system that captures the clinical situation with revolutionary ‘3D-in-Motion’ technology. It provides the dentist with instantaneous feedback and the ability to assess preparation and tissue management in ways that were never possible before.

Unlike current point-and-click procedures, ‘3D-in-Motion’ technology captures continuous 3D video images; these images create a digital impression used for the fabrication of precise-fitting traditional or CAD/CAM restorations, which are generated in the digital workflow.

The digital workflow describes a highly efficient indirect restorative process used by dentists and labs to deliver a comfortable patient experience and high-quality restorations. The workflow starts with the digital impression made by the dentist followed by digital margin marking and the preparation of a virtual sawn cut model by the dental technician using the Lava C.O.S. Laboratory Software. An additional feature is new model manufacturing with stereolithography. Lava Design Software is used for the fabrication of a CAD/CAM restoration.
Benefits of the Lava™ Chairside Oral Scanner C.O.S. as input to the digital workflow

**Precision**
- Highly precise digital impressions that help ensure precise-fitting restorations
- Real-time video images provide immediate and detailed feedback

**Flexibility**
- Prescription of either PFM or CAD/CAM restorations, incl. Lava™ Restorations
- Collaboration with current lab

**Productivity**
- Seating times of single-unit crowns decreased on average by 41% when compared to the traditional process*
- 0.5% remake rate due to the digital workflow*
- Elimination of several time-consuming work steps and of most errors that are related to the traditional process of restoration fabrication

**Patient comfort**
- Patients prefer a Lava C.O.S. digital impression versus a traditional impression*

**Indications**

The digital impression made with the Lava C.O.S. allows the fabrication of CAD/CAM restorations made by the Lava system as well as traditional PFM or ceramic restorations using the stereolithographic model.

Released and clinically tested indications are: crowns, veneers, inlays, onlays, multiple adjacent restorations, 3-unit to 4-unit bridges and seated implant abutments.

Every indication released by 3M ESPE to be processed in the digital workflow is very well tested. The list of indications will be updated on a regular basis further to clinical testing. Please contact your local 3M ESPE representative for information on any new indication included.

**The decisive difference: ‘3D-in-Motion’ technology**

With the Lava Chairside Oral Scanner C.O.S., 3M ESPE is introducing an entirely new scanning technology in dentistry: ‘3D-in-Motion’ technology.

This technology allows the capturing of 3D data in a video sequence and the modelling of these data in real time, enabling the user to instantaneously control the scanning process while moving the wand. The Lava C.O.S. is able to capture approximately 20 3D data sets per second, or close to 2,400 sets per arch, for an accurate and high-speed scan.

In contrast, the traditional scanning method, which is a point-and-click technology, requires the wand to be first positioned then held steady, at which point the user can initiate a single capture or the system automatically initiates the scan. With ‘3D-in-Motion’ technology, the user can scan images while moving the wand and while controlling the scan immediately on the touchscreen.

*Source: 3M ESPE internal data
Similarly, the Lava Chairside Oral Scanner C.O.S. has three CMOS sensors that capture the clinical situation from different perspectives. With these three images captured simultaneously, 3D surface patches are generated at video rate by using the in-focus and out-of-focus information. For reliable and precise scanning, the Lava C.O.S. uses light in the blue range of the spectrum.

What does this mean? In classical photography, an object point is seen in focus when it is in the camera’s focal range. Changing the aperture size changes the focal range: a small aperture results in a larger focal range, whereas if the aperture is large, the objects in focus are mainly those on the focal plane while all other points become fuzzy. Figure 1 shows that the virtual object is in focus, due to the small aperture. If the aperture is opened, the object becomes blurred (as shown in figure 2), encoding information on the distance of the object from the focal plane. When one uses not one wide aperture but two (figure 3), the object point is virtualized as two points, encoding the depth information by means of the image disparity. Image disparity gives the system the Z information to calculate 3D data.

**Active (optical) wavefront sampling** refers to getting three-dimensional information from the Lava™ C.O.S. proprietary single-lens imaging system by measuring depth based on the defocus of the primary optical system.

Behind the ‘3D-in-Motion’ technology there are three important building blocks:

1. **Active (optical) wavefront sampling**
2. **Breakthrough image processing algorithms**
3. **Real-time model reconstruction**

Specially developed **breakthrough image processing algorithms** allow for instantaneous feedback from the system by stitching together the 2D images and the recovered 3D surface patches and globally optimizing the captured data.

**Real-time model reconstruction** quickly captures 3D data and instantaneously assimilates them into a 3D model on the screen. The system offers the flexibility to manoeuvre in the mouth and to actually see what is captured in real time.

Because what has been imaged or captured in the mouth is visible in real time, and thus users can see where images are missing, the Lava C.O.S. makes it possible to go back and fill gaps or holes with actual tooth anatomy. A high-accuracy 3D model is processed and uploaded to the dental laboratory for the design of the restoration.
Precision of the Lava™ C.O.S. and the digital workflow

The Lava Chairside Oral Scanner C.O.S. can capture 20 3D data sets per second with over 10,000 data points in each. Depending on the scanning time, an accurate high-speed scan leads to over 2,400 3D data sets and over 24 million data points per arch (acquired in approximately 2 minutes). The high data redundancy accounts for the system’s excellent accuracy.

Following margin marking and cut plane placement by the laboratory utilizing the Lava C.O.S. Laboratory Software from 3M ESPE the high-precision data are digitally oriented, ditched, trimmed, and articulated. The data are then sent to a centralized model manufacturing facility where the models are fabricated from an epoxy resin with the aid of stereolithography.

Statistical Process Control methods are used to ensure the high dimensional accuracy of the SLA models. Every batch generates a set of 117 XYZ dimensions that are fed back into the process to generate a Pass/Fail grade for the batch, as well as parameter control commands which are applied to the subsequent batch. This continuous calibration process yields batch-to-batch consistency above and beyond what can be achieved with conventional plaster pouring processes. The advantage of such a model fabrication process is that it enables the rapid delivery of a consistent high-precision, durable, fully engineered dental model, ready for the lab technician to immediately begin creating a high-value restoration. When the model is being manufactured and shipped, the lab can in parallel initiate the process of designing, milling and sintering the Lava Zirconia substructures. This ‘parallel process’ enables the laboratory to increase its productivity by cutting process lag and reallocating resources to the high-value-added steps of stacking porcelain and aesthetic refinement.

Accuracy of SLA models

Benefits of SLA models

- Less abrasion
- Less prone to chipping
- High consistency and reproducibility because of standard manufacturing process

Fig. 4: The high data redundancy resulting from many overlapping pictures, together with the scanner’s accuracy, ensures an excellent image.

Fig. 5: Chairside crown adjustment times. Crowns based on the digital workflow required lower adjustment times – as a result of better occlusal and interproximal fit – compared to crowns based on the traditional workflow.

Source: A. Synek et al., 3M ESPE, Germany, Evaluation of the clinical performance of the Lava™ C.O.S., publication pending.

Fig. 6: SLA model
**In vitro studies**

**Accuracy of crowns**

Source: G. KUGEL, S. FERREIRA, R. PERRY, SHARMA, N. CHAIMATTAYOMPOL, J. TOWERS, and P. STARK, Tufts University School of Dental Medicine, Boston, MA, USA
AADR abstract # 1119, April, 2008

Prof. Kugel et al from Tufts University in Boston measured the accuracy of single crowns. Thirty replicas were prepared from a prepared model and divided into two groups. For one group Lava™ Zirconia single crowns were fabricated by using a traditional VPS impression material and gypsum models, which were scanned afterwards by the CAD/CAM system. For the other group, Lava restorations were prepared directly from the digital impression made with the Lava Chairside Oral Scanner C.O.S. Restorations were evaluated in a blinded way under 2.5X magnification with a new explorer for each coping. Both the digital Lava C.O.S. impressions and the traditional impressions made with the VPS impression material showed excellent results. The marginal fit with digital impressions demonstrated better results but could not be considered statistically significant because of the sample size.

Source: J.A. SORENSEN, P.N. SORENSEN, and K. MIZUNO, Pacific Dental Institute, Portland, OR, USA
IADR abstract # 1599, 2009 and further measurements afterwards

In addition, Prof. Sorensen’s team from the Pacific Dental Institute in Portland measured the marginal fit of Lava zirconia crowns, with one group prepared via traditional impressioning (VPS materials) and one group via digital impressioning. They found an excellent fit for the Lava crowns fabricated via the digital workflow.

**System repeatability test**

Source: S. BALAKRISHNAMA, K. W. WENZEL, J. BERGERON, C. RUEST, B. REUSCH, Brontes Technologies, a 3M Company, Lexington, MA, USA and G. KUGEL, Boston Center for Oral Health, Boston, MA, USA
IADR abstract # 2951, 2009

In another study, a single preparation was scanned several times with a single wand over two weeks to determine the dimensional repeatability over time. Scans of a single anterior preparation and a single posterior preparation were taken 25 times and the dimensional differences were measured using Geomagic. As shown in figure 8, the dimensional differences are very low, indicating excellent repeatability.

In this accuracy repeatability study, the Lava Chairside Oral Scanner C.O.S. showed a precision of between 6 μm and 11 μm. The excellent dimensional repeatability, together with the high accuracy of the data supports the very high reliability of the digital workflow.

**Mean marginal gap of zirconia copings**

![Mean marginal gap of Lava™ Crowns based on the traditional workflow versus the digital workflow.](image1)

![Dimensional repeatability of 25 scans taken over two weeks.](image2)
In vivo survey

In an *in vivo* survey including 12 dental operatories, Lava™ Restorations were fabricated from a digital and a traditional impression – for the same clinical situation. Both restorations were sent back to the dentist in a blinded way for evaluation.

In 64% of the cases, the restorations based on a digital impression made with the Lava C.O.S. were preferred over those fabricated with VPS impression material, mainly due to the smaller number of adjustments required and the excellent fit and marginal adaptation.

![Fig. 9: Lava™ C.O.S. clinical case: prepared tooth (left), seated restoration (right).](Courtesy of Dr. Jack Ringer DDS, Anaheim, CA, USA)

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**Evaluation of the clinical performance of the Lava™ Chairside Oral Scanner C.O.S.**

Source: A. SYREK, G. REICH, J. BRODESSER, B. CERNY, D. RANFTL, C. KLEIN, 3M ESPE, Germany, publication pending

In a clinical study, each patient received two Lava™ Crowns on a posterior tooth, one crown produced from a digital impression made with the Lava™ C.O.S. and one based on a traditional impression. Marginal, occlusal and interproximal fit was evaluated clinically by two blinded evaluators. Plus, the marginal fit was determined by Fit Checker measurements under a microscope.

Lava™ Crowns produced from the digital workflow showed significantly better marginal fit.

Besides, both the patients’ and the practitioners’ comfort during the scanning process were evaluated and compared to the comfort of taking a traditional impression.

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**3D-in-Motion technology**

The system incorporates a 3D visualization feature that shows the scanned teeth in a 3D stereo mode. Users who wish to experience the 3D mode should use green-red 3D glasses.
## Technical Data

### Technical specifications

<table>
<thead>
<tr>
<th>Field of view</th>
<th>~10 mm × 13.5 mm at rated depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working depth</td>
<td>5 – 15 mm from tip of wand</td>
</tr>
<tr>
<td>Viewing direction</td>
<td>90° from longitudinal axis of wand</td>
</tr>
<tr>
<td>Lighting</td>
<td>narrow-band blue light</td>
</tr>
<tr>
<td>Video rate</td>
<td>20 Hz</td>
</tr>
<tr>
<td>Touchscreen size</td>
<td>432 mm (17 in.), diagonal</td>
</tr>
<tr>
<td>Surface area of trolley (footprint)</td>
<td>64 × 74 cm (25 × 29 in.)</td>
</tr>
<tr>
<td>Monitor height, adjustable</td>
<td>94 – 107 cm (37 – 42 in.)</td>
</tr>
<tr>
<td>Monitor angle, adjustable</td>
<td>+5° to – 30° C</td>
</tr>
<tr>
<td>Input power</td>
<td>120 V 60 Hz 400 W</td>
</tr>
</tbody>
</table>

### Weight

| Overall weight       | 40.4 kg (89 lbs)                                      |
| Cart                 | 33 kg (73 lbs)                                        |
| Touchscreen          | 7 kg (15 lbs)                                         |
| Scanning wand        | 390 g (14 oz)                                         |
| Cable                | 250 g (9 oz)                                         |

### Wand dimensions

| Width (tip of scanning wand) | 14.7 mm        |
| Height (tip of scanning wand)| 14 mm          |
| Length                      | 33 cm (13 in.) |
| Circumference               | 17.8 cm (7 in.)|
| Diameter                    | 5.7 cm (2.2 in.)|
| Length of tether cord       | 2.99 m (9 ft. 10 in.) |