Perfecting Dental:

3D Models & Dies

3D printing holds great promise, and has many applications across multiple industries, including the medical and dental fields. By Avi Cohen, director of Global Dental, Stratasys

The art and science of dentistry has evolved over the past few years as clinical and laboratory workflows have progressed from an analogous, manual manipulation of materials to a systematic, digitally verifiable process. Today, these digital processes are being embraced as a means of elevating the total quality of dental offerings so that patients may benefit from enhanced treatment procedures; clinicians can treat patients faster, more smoothly and with greater consistency; and dental labs can provide dependably superior products.

The case study presented herein illustrates the ease of utilising consistent and reproducible 3D printed verification protocols as a means of ensuring the success of the restorative treatment plan.

Emerging Technologies

Forward-thinking dental professionals, clinicians and laboratories are actively pursuing emerging digital dentistry technologies and quickly realising the benefits. These advancements have yielded new, high-quality materials that are industrially *pre*-fabricated, tested and controlled, as well as a standardised process for the creation of exacting treatment solutions, both of which help the dental professional construct dental devices of higher quality and consistency.

Traditional ways of creating dental casts have multiple opportunities for discrepancies. Technique, material behaviour and material properties can generate substandard results. And because techniques are individualised, noteworthy discrepancies can be seen from day to day, and person to person. Traditional materials exhibit expansions and shrinkages that are challenging to counterbalance and often difficult to control. These discrepancies prevent validating the cast within the oral cavity, potentially making the dental treatment stressful for both the clinician and the patient, since more chair time is necessary to address issues related to fit.

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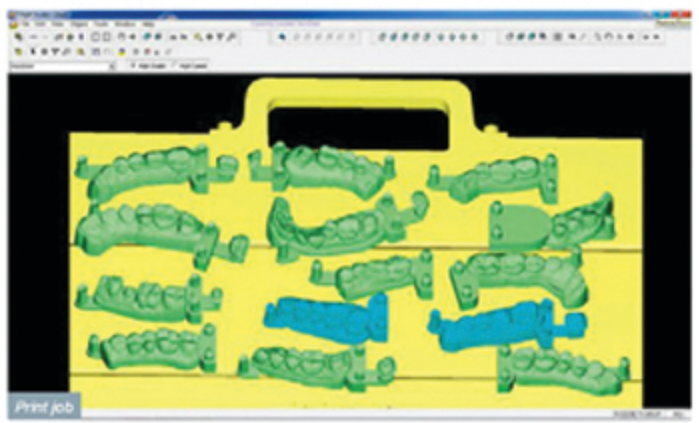
3D imaging software and 3D printed dental casts constitute the foundation of digital dentistry. With them, dental professionals are able to follow a controlled verification process that duplicates the topography of the intra-oral cavity precisely so that the actual seating of the device is fast and anxiety-free.

Finally, by employing digital dentistry technology, dental laboratories can accurately and rapidly produce a range of dental and orthodontic appliances, eliminate the bottleneck of manual modelling, and help the lab grow and stay ahead of the competition.

3D Printed Removable Dies

The removable die is an important component of the model system. Previously, dies were cut out individually to gain access to the prepared margin and accurately fit the restoration inter-proximately. This process was time consuming and often imprecise. The use of 3D printing helped address these issues but new challenges arose. While CAM software could segregate the dies from the main cast and print them separately, a large mass of dies were generally printed on one tray at the same time. These dies then needed to be cleaned, labelled and matched to each specific model. Furthermore, this method produced a slight horizontal shift or inconsistency in the die socket which frequently led to discrepancies in the final fit.

For these reasons, Stratasys set to work rethinking the printed model. A simple manipulation within the CAM software now allows the preparation to be duplicated and the removable die to be attached to the external cast, which can be used for verifying the margin. Additionally, now that the removable component has been eliminated within the un-sectioned solid cast, there is no potential for horizontal discrepancy shifts in fit.



Case Study

Clinical Considerations

A patient presented worn dentition, defective amalgam fillings and visible cracks in the molar regions. The patient, a bruxer, requested a conservative treatment rather than a full-mouth reconstruction to rebuild lost vertical dimension.

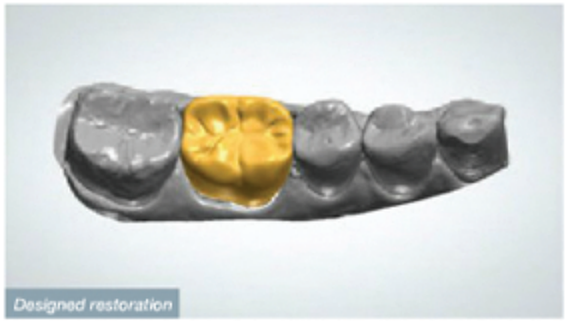
A treatment plan was proposed to replace the defective amalgams with tooth-coloured direct composite fillings, and place full-coverage zirconia Lava Plus (3M ESPE) crowns where needed. Full-contour zirconia was chosen for the full crown material based on its strength, minimal reduction requirements and its ability to provide the desired tooth-coloured appearance.

Treatment began on the mandibular lower right quadrant. Teeth #28, 29 and 31 received new composite fillings. A composite core was placed in tooth #30, and the tooth was prepared for a full-contour zirconia crown. The gingiva was retracted to reveal the margin for the digital impression. Itero (Align Technologies) was used to scan the operative quadrant, the opposing arch, and finally, the patient's bite. The resulting digital proposition produced a virtual cast for evaluation of complete capture of data and an accurate rendering.

Laboratory Considerations

An open-formatted STL scan file from Itero was imported into the Dental Manager (3Shape) CAD software. Dental Designer (3Shape) software was used to annotate the location of the proposed crown for tooth #30, and both a sectioned cast and unsectioned cast. Model Builder software (3Shape) was used to reorient the scan data, set the plane of occlusion and identify the prepared tooth's margins. Additionally, it proposed bases for both arches and a separated die was virtually extracted from the arch. STL files were generated for each cast part accompanied with an operative arch, opposing arch and an unsectioned model with attached die. The crown was designed with 3Shape design software, then milled and sintered overnight according to the material manufacturer's recommendations.

This solution for a solid model — including a detached die and opposing arch — was generated, even though current Model Builder software does not support this solution automatically. The solid arch and detachable die were loaded into an industrial



Designed restoration

CAD software program. A small rectangular shape was created and used to bridge the space between the solid arch and the detachable die. The three individual shapes were combined into one file and sent to an Objet Eden260V 3D Printer (Stratasys) along with other casts.

Restoration Seating

Once sintered, the crown's margins were easily finished on the printed detachable die, and contacts were subsequently fitted to the solid model, thereby providing validation of the device while still in the lab. The crown was then stained, glazed and advanced to the clinician for seating.

In the dental office, the Lava Plus zirconia crown was received from the dental laboratory and evaluated again on the model. The fit of the crown on the detached die was perfect, with no rock or rotation, and the margins were undetectable. Interproximal contacts were validated on the solid model as broad and firm. Minimal adjustment was required and the crown was bonded with Scotchbond Universal with RelyX Ultimate Adhesive Resin Cement (3M ESPE). This verification protocol was utilised systematically in the laboratory, and then subsequently in the dental office to produce a superior, verified and consistent dental treatment.

Conclusion

As shown in this case study, the new cast CAD/CAM method ensures accuracy and precision by confirming the fit of the crown in the patient's mouth, before it leaves the dental lab. All horizontal inconsistencies, which previously led to chair-side adjustments, have been alleviated by using a new verification protocol with the detached die for margin finishing, and the unsectioned solid model for contacts.

Digital dentistry is rapidly becoming the norm within the profession, and serves as a valuable business tool for dental laboratories by cutting production times, lowering labour costs, and increasing efficiency, accuracy and profitability. What is more, digital dentistry offers dentists the use of consistent, state-of-the-art dental devices, and their patients a superior healthcare experience.

ENQUIRY NO. 6701

Stratasys Opens 3D Printing Experience Centre In Singapore

Singapore: Stratasys Asia Pacific has opened a 3D Printing Experience Centre at its new office located in Toa Payoh, Singapore, providing local support to serve the growing needs in South Asia and Pacific region.

This Centre was inaugurated on 30 July, 2014 at a grand opening event with customers, channel partners and alliance partners in attendance. The Centre features the company's 3D printing technologies — PolyJet and Fused Deposition Modeling (FDM), showcasing the full product portfolio ranging from desktop 3D printers to large, advanced 3D production systems, as such enabling designers and engineers to create models and prototypes for new product design and testing and to build finished goods in low volume. The Centre also exhibits the company's specially engineered 3D printing materials — PolyJet photopolymers and FDM thermoplastics.

ENQUIRY NO. 6702

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Defects:

A Vanishing Occurrence

The manufacturing industry in Singap has grown over the years to become one of the largest sectors in the coun contributing 21 percent of Singapore's in 2013, an estimated US$60 billion. I this time, the manufacturing process become more automated, paving the for greater efficiency. By Ulrich Kreut editor - Pictures of the Future, Sieme

Automation has helped to reduce costs in areas such as time, materials and manpower. With the introduction of automation, the industry has also been able to cut down on wastage in the form of defective products.

However, defects within assembly lines still occur and this can result in significant losses in terms of money and opportunity costs. Siemens' recent innovation can potentially make defective products a thing of the past.

The Siemens' Amberg Electronics Plant (German abbreviation: EWA), which was established in 1989, produces Simatic Programmable Logic Controls (PLCs). The devices are used to automate machines and equipment in order to save time and money and increase product quality. They control ski lifts and the onboard systems of cruise ships as well as industrial manufacturing processes in sectors ranging from automobile production to pharmaceuticals.

Siemens is a supplier of PLCs, and the EWA is the company's showcase plant for these systems. Production quality is at 99.9988 percent, and a series of test stations detect the few defects that do occur.

"I do not know of any comparable plant worldwide that has achieved such a low defect rate," commented professor Karl-Heinz Büttner, who heads the EWA. The factory manufactures 12 million Simatic products per year, about one unit every second.

Machines and computers handle 75 percent of the value chain on their own; while the rest of the work is done by humans. Only at the beginning of the manufacturing process is anything touched by human hands, when an employee places the initial component (a bare circuit board) on the production line. From that point on, everything runs automatically. What is notable here is that Simatic units control the production of Simatic units. About 1,000 such controls are used during production, from the beginning of the manufacturing process to the point of dispatch.

Over 60,000 Customers Worldwide

At the beginning of the manufacturing process, conveyor belts take the bare circuit boards to a printer, which uses a photolithographic process to apply a lead-free solder paste. In the next step, placement heads mount individual components, such as resistors, capacitors, and microchips, onto the circuit boards. The fastest production line can mount 250,000 components per hour — a process that is controlled by Simatic units.

Once the soldering process has been completed, the printed circuit boards arrive at an optical test system, where a camera examines the position of the soldered components while an X-ray machine