Dental Assessment

对预先标记的牙模边缘线进行多材料 3D 打印
向医疗和牙科解决方案的负责人 Avi Cohen 学习，了解如何用多种材料打印实现更准确的牙冠和齿桥模具边缘线。

Multi-Material 3D Printing for pre-marked dental die margin line

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A dental crown is a type of dental restoration which caps or encircles a tooth or dental implant. It is often necessary when a large or deep cavity threatens the ongoing health of a tooth and also often used to improve the strength or appearance of teeth. The crown is typically bonded to the tooth using dental cement. The most common method of crowning a tooth involves using a dental impression of the teeth, e.g. a stone model, and fabrication of a fitting crown outside of the mouth. The crown can then be inserted at a subsequent time. This indirect method of tooth restoration allows use of strong restorative materials requiring time consuming fabrication methods and requiring intense heat, such as casting metal or firing porcelain which would not be possible to complete inside the mouth. Another kind of dental restoration is a bridge, which is used to replace a missing tooth by joining permanently to adjacent teeth or dental implants. There are different types of bridges, depending on how they are fabricated and the way they anchor to the adjacent teeth. Conventionally, bridges are similarly made using the indirect method of restoration however bridges can be fabricated directly in the mouth.

The outermost 'coronal' position of untouched tooth structure, i.e. the continual line of original, undrilled tooth structure at or near the gum line, is referred to as the margin. This margin provides the continual line of tooth-to-restoration contact, and should be a smooth, well-defined delineation so that the restoration, no matter how it is fabricated, can be properly adapted and not allow for any visible opening, visibility of such a margin line at the base of the crown being unaesthetic. Thus, when inserting a crown or bridge into a digital printed stone model (traditionally, a gypsum model) the dental lab technician is required to ensure it fits to the margin line prep made by the dentist based on the patient's actual teeth, so that when the crown or bridge is fitted onto the patient's teeth such margin line will not be visible.

However capturing the margin line in an impression for making the stone model of the prepared tooth, i.e. stone model replication of teeth, is problematic since the margin line cannot be ensured to be 100% accurately demarcated, resulting in its all too frequently being visible in the patient's mouth, at the base of the fitted crown. Perfect visual fit of a dental crown (or bridge) onto the die (a positive likeness of the tooth in question cut from the artificial dental stone model and used in the fabrication of a dental restoration) is critical not only aesthetically but also to the health of underlying remaining teeth. In existing methods, the entire model is made of one gypsum material. Alternatively, in a digital model, while the fabrication process differs, the entire die is still printed or fabricated from one material.

By using a multi material three-dimensional (3D) solid freeform fabrication solution, such as the Connex multi-material 3D printing system (Objet Geometries Ltd., Israel), the die can be separated into two segments, each being fabricated in a different colored material, such that the margin is automatically delineated during fabrication.

When fitting the crown onto the die, it is consequently easy to ensure that the crown is 'sitting' properly on the die and thus will sit properly when fitted onto the patient's actual teeth, as graphically illustrated for example in **Figures 1** and **2**. The 3D multiple materials solid freeform fabrication solution according to the invention is carried out by the Connex multi-material 3D printing system (Objet Geometries Ltd., Israel). Using this system, the model and die can be fabricated at the same time, as one unit or separate but connected units, and by depositing more than one modeling material simultaneously, e.g. more than one color, rapidly, efficiently and accurately, in a single printing job. Such method of printing significantly both reduces the work and time involved in producing an accurate dental model and die, and allows accurate demarcation of the margin line, during the process of fabricating, by printing the upper part of the die in a different color to the base, as can be seen for example in **Figure 1**.

Thus when fitting the crown on the die, if the crown does not fit exactly, the margin line (being the bottom of the differently colored upper part of the die) will be visible, as graphically shown for example in **Figure 2**.

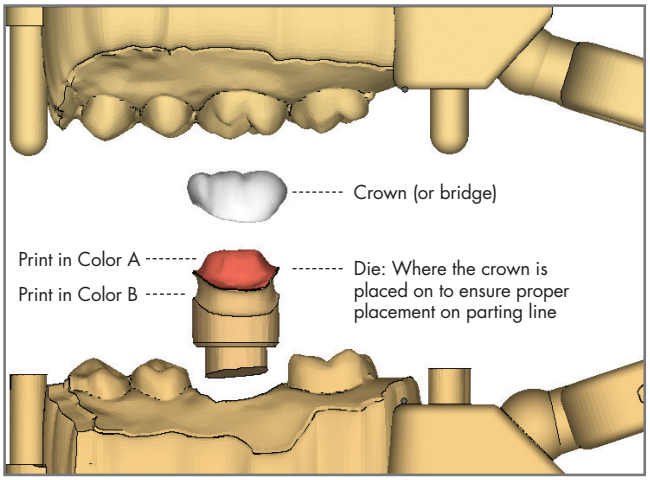

Figure 1

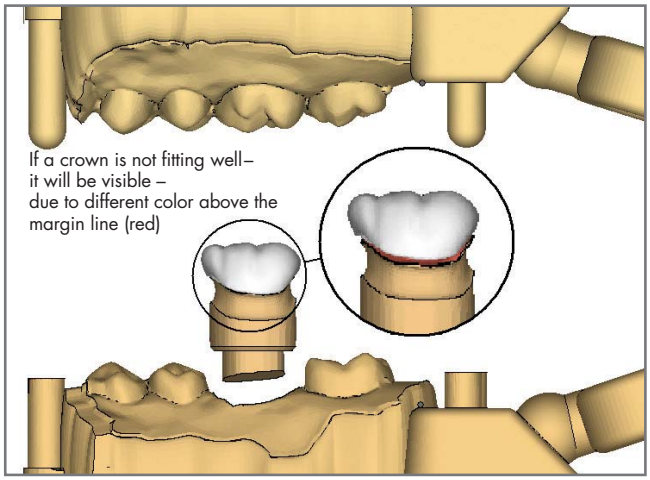

Figure 2

Multi-material 3D solid freeform fabrication system software may divide the model, e.g. the die, into two segments and allocates a different modeling material to each of the two segments. For example, the two segments of the die – top and bottom – can be printed using VeroWhite and VeroBlack modeling materials (Objet Geometries Ltd., Israel) in the printing job. For example, the digital representation of a three-dimensional object such as the teeth, gums and jaw line, may be created by using suitable software such as CAD (Computer Aided Design) software, a scanning system, or an imaging system e.g., CT system or MRI system, which produces data which may be converted to a standard communication file format, e.g., STL format, legible by the solid freeform fabrication apparatus. STL files are read by the system and 'sliced' into thin layers (or 'slices'), e.g. bitmaps, and transferred to the fabrication engine for transforming into layers forming the three-dimensional object. A controller converts the thin slices into physical layers of building material to be deposited, according to the digital slices, during the course of fabricating the three dimensional object.

ABOUT OBJET

Objet Ltd., is a leading provider of high quality, cost effective inkjet-based 3D printing systems and materials. A global company, Objet has offices in North America, Europe, Japan, China, Hong Kong, and India.

Objet's 3D printing systems and 3D printing materials are ideal for any company involved in the manufacture or design of physical products using 3D software or other 3D content. Companies using Objet's solutions can be typically found in sectors such as consumer goods & electronics, aerospace & defense, automotive, education, dental, medical and medical devices, architecture, industrial machinery, footwear, sporting goods, toys and service bureaus.

Founded in 1998, the company has thousands of customers worldwide including a substantial share of the relevant Fortune 100 and Fortune 500. Its award-winning technology (12 awards in 5 years) is based upon over 110 patents and patent pending inventions.

Objet's advanced 3D printing systems and range of over 60 materials enable professionals to build prototypes that accurately simulate the true look, feel and function of an end-product, even complex, assembled goods.

The Objet Connex™ line of multi-material 3D printers features the world's only technology to simultaneously jet 2 materials. With this, users can print many different materials into a single part and print various mixed parts on the same build tray. Users can also create advanced composite materials, or Digital Materials™ featuring unique mechanical and thermal properties. Objet's range of over 60 3D printing materials simulate properties ranging from rigid to rubber-like, transparent to opaque and standard to ABS-grade engineering plastics, with a large number of in-between shore grades and shades.

Objet's 3D printers are available in a range of form-factors, from cost-effective desktop 3D printers ideal for entry-level professionals all the way to industrial-scale multi-material machines for front-line designers and top manufacturers. Objet's 3D printers feature the industry's highest-resolution 3D printing quality, based on 16-micron (0.0006 in.) super-thin layering, wide material versatility, office friendliness and ease of operation.

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