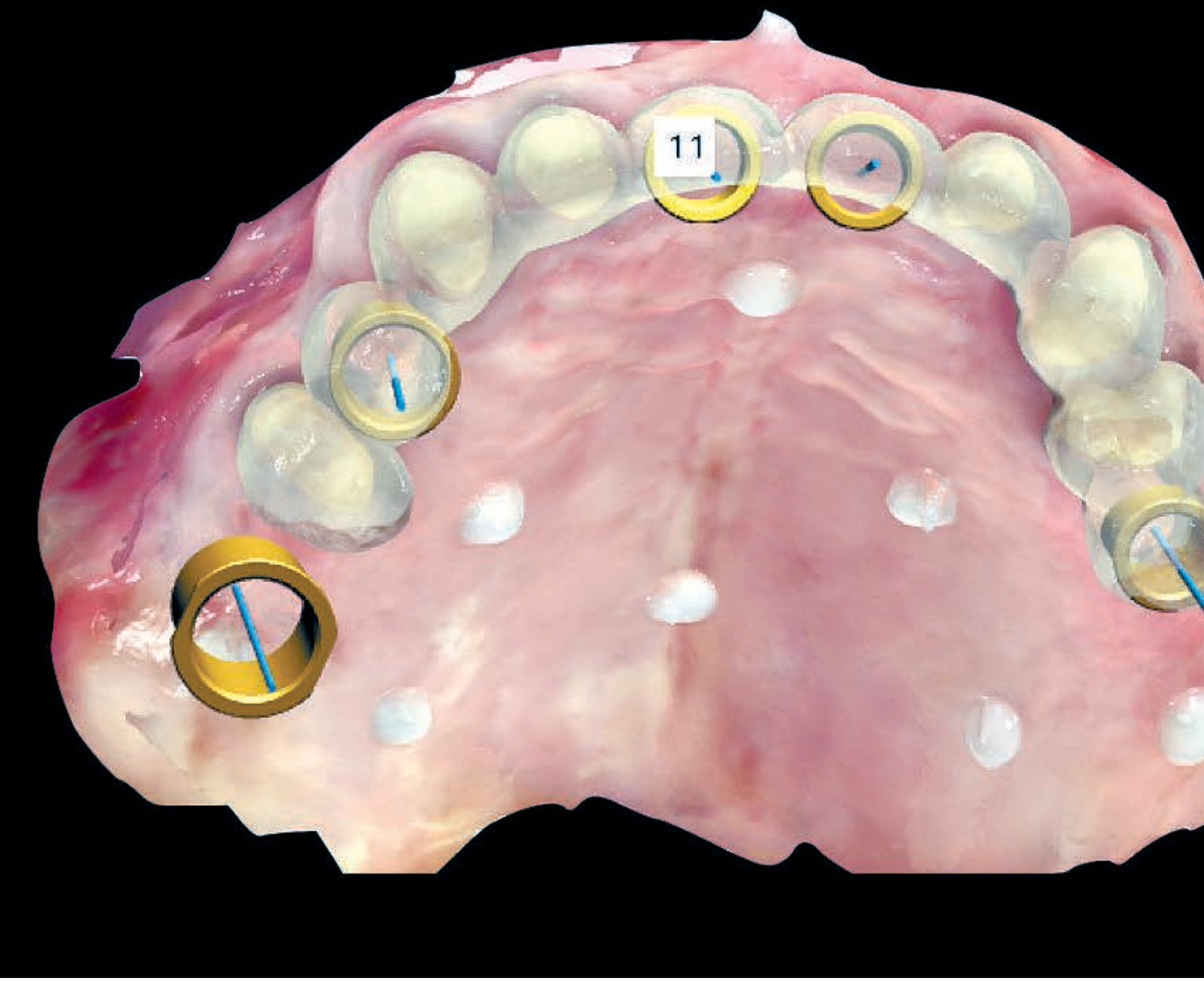
# The Full digital workflow in Implant and Restorative Dentistry

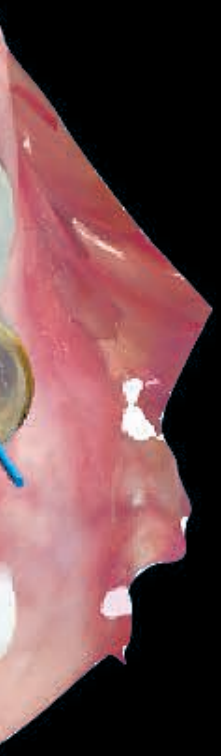


By Dr Anthony Mak and Dr Andrew Chio

# A novel approach using optimized scan strategies and 3D printing

## Introduction

The evolution of digital technologies in dentistry has paved the way for the development of simplified and predictable protocols in restorative dentistry. This article supplemented with a case study, illustrates the many aspects where digital dental technologies, from intra-oral scanning, implant treatment planning and 3D printing, has allowed the seamless delivery of treatment that traditionally has been regarded as difficult and complex.



### Why choose a digital workflow?

Conventional analogue techniques are associated with certain disadvantages, such as patient discomfort during the impression taking; the potential for distortion of the impression material and delays in transfer time between the surgery and the lab. Taking a digital impression with an intraoral scanner such as the Trios (3Shape) bypasses these disadvantages.

Combining a digital impression and CAD software simplify workflows such as diagnostic facially-driven mock-ups, implant treatment planning and the design and fabrication of surgical guides. CAD software allows for the design of the master die model, as well as the temporary and definitive restorations, which can then be manufactured either with a 3D printer or milling machine.
The data from the digital impression is also simply sent over the Internet, significantly reducing the time needed to manufacture the wax-ups and prosthesis.

### Treatment planning protocols

Whether using an analogue or a digital workflow, proper treatment planning protocols are the foundation of any fixed restorations in the arch involving dental implants.
These generally include:
- Articulated study models from diagnostic impressions
- Diagnostic wax-up / intraoral wax-up / diagnostic appliance to evaluate aesthetics and phonetics
- Radiographs (including periapical x-rays and CBCT scans) to evaluate bone support
- Radiographic and surgical guide fabrication.

### Digital implant planning

In implantology, the full digital workflow simplifies accurate diagnosis and implant position planning using the intraoral scan and CBCT data.

This allows for the fabrication of a surgical implant guide to facilitate implant placement (guided surgery), creating a simplified, accurate and predictable protocol. This provides better angulation and accuracy of placement for both single and multiple implants.
The CAD design of the restoration can be planned, visualized and even designed prior to the patient even attending for the surgical phase of treatment.

Furthermore, the number of patient visits required for the procedure is reduced.

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*Summary of the case history*

2

*Pre-operative OPG*

3

*Pre-operative occlusal and lateral occlusion*

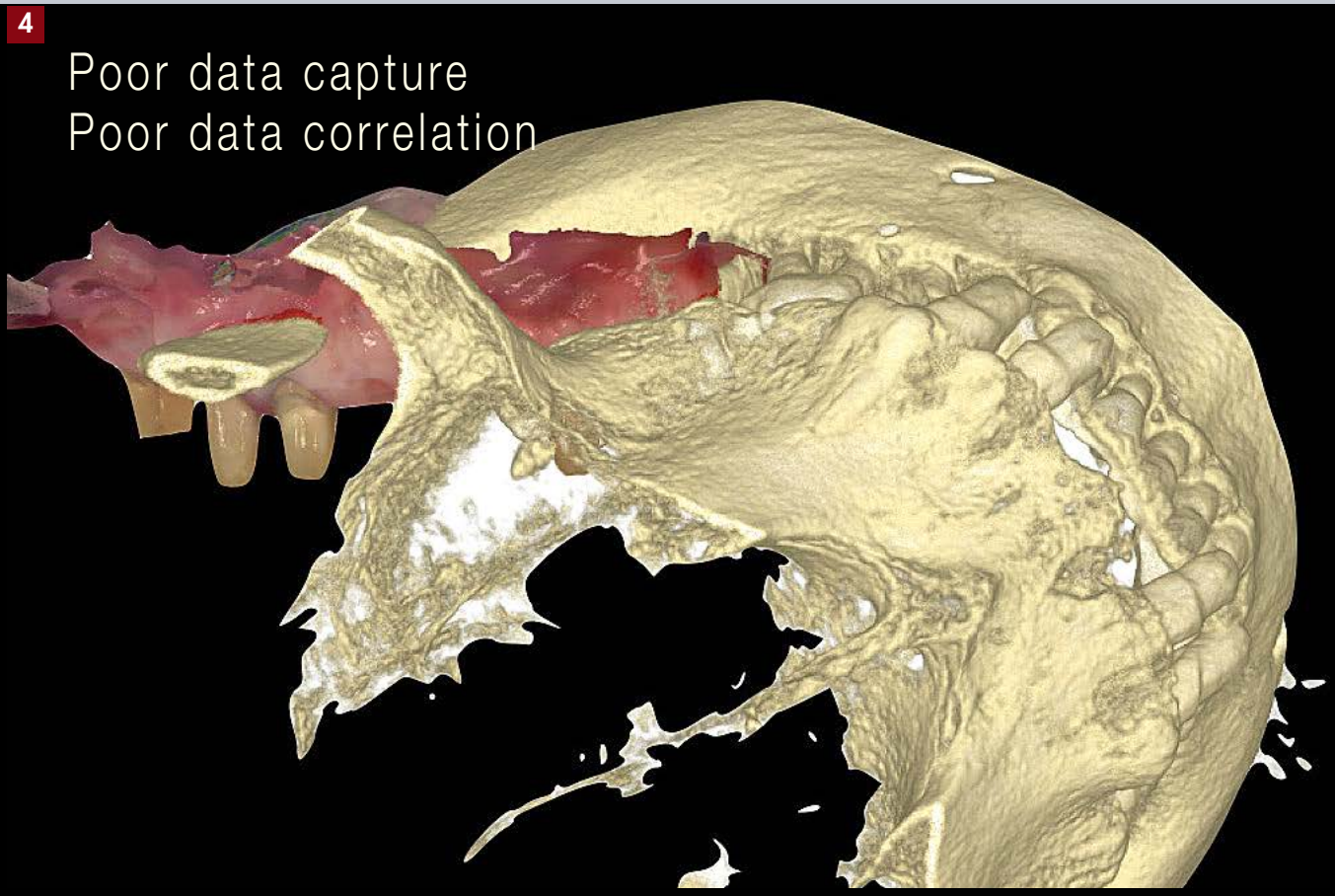
# Case report

The following case study demonstrates a scenario where a complete digital workflow was utilized in the treatment planning, design, implant placement and natural tooth restorations to rehabilitate the full upper arch. In this first part of three articles on this case, I will demonstrate the digital workflow for treatment planning, implant placement and the fabrication of the first provisional restoration.

A 79-year old patient presented with the complaint of mobile teeth and occasional discomfort from the areas around his existing upper fixed partial denture (figs. 1 to 3). Clinical and radiographic examination revealed bone loss affecting his upper and lower dentition. Secondary decay was also diagnosed on the abutments of his fixed dental prosthesis.

The patient's health history was unremarkable.

Periodontal treatment, including the extraction of the periodontally hopeless 16 and 28, was undertaken, and a restorative treatment plan formulated.
The goal of treatment was to rehabilitate the upper arch with a combination of crowns and implant-retained restorations to provide the patient with a fixed option.




*Radiographic scatter can lead to the inability to mesh the IOS surface scan to CBCT DICOM data*


*Radiographic reference markers are placed in the mouth. They are recorded in both the IOS scan and the CBCT scan*

# Intraoral and CBCT scanning stages

A 3D CBCT radiographic scan, to obtain the necessary DICOM data for the initial records, was taken.

A common problem that occurs is radiographic scatter. This case shows two techniques to minimize the negative effects that radiographic scatter can have on the accuracy of the assimilation of the CBCT data sets to the IOS surface scans (fig. 4).

## ● Technique 1:
## Use of Radiographic Markers

Radiographic IOS reference markers placed on the surface of the mouth (fig. 5). G-aenial Universal Injectable composite (GC) was utilized as the material for the radiographic reference marker, ensuring there is no radiographic scattering during the CBCT scan. A 3D, CBCT radiographic scan was taken to obtain the necessary DICOM data.
The intraoral situation, including the patient's occlusion, was then captured with a digital impression, using the Trios 3 from 3Shape.

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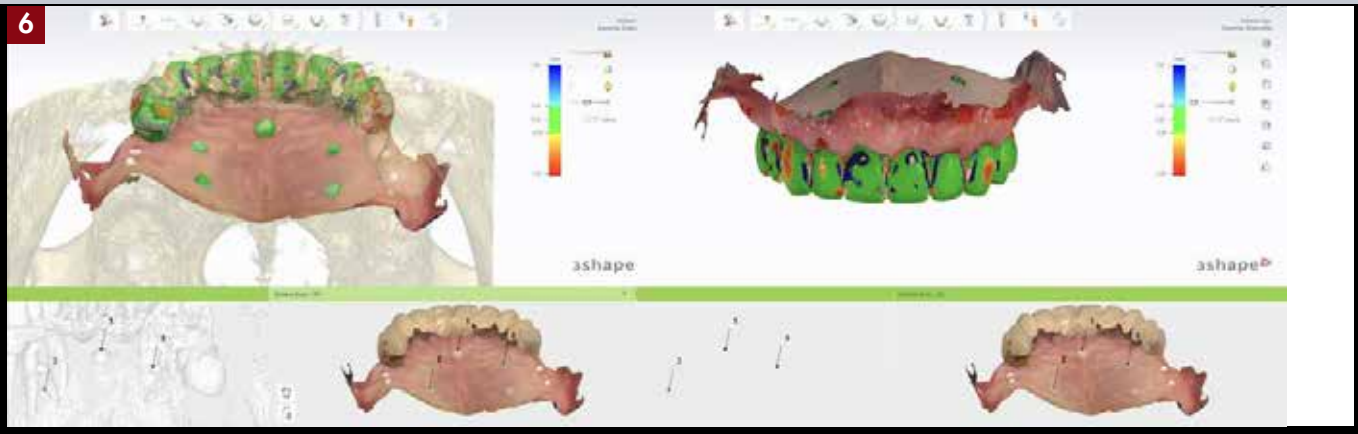


*The differential colour map indicating an accurate stitching or meshing of the IOS surface scan and CBCT DICOM data. Note that the green areas indicates a <0.50um difference*

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*Removing the existing fixed restoration removes metal which could cause radiographic scatter*

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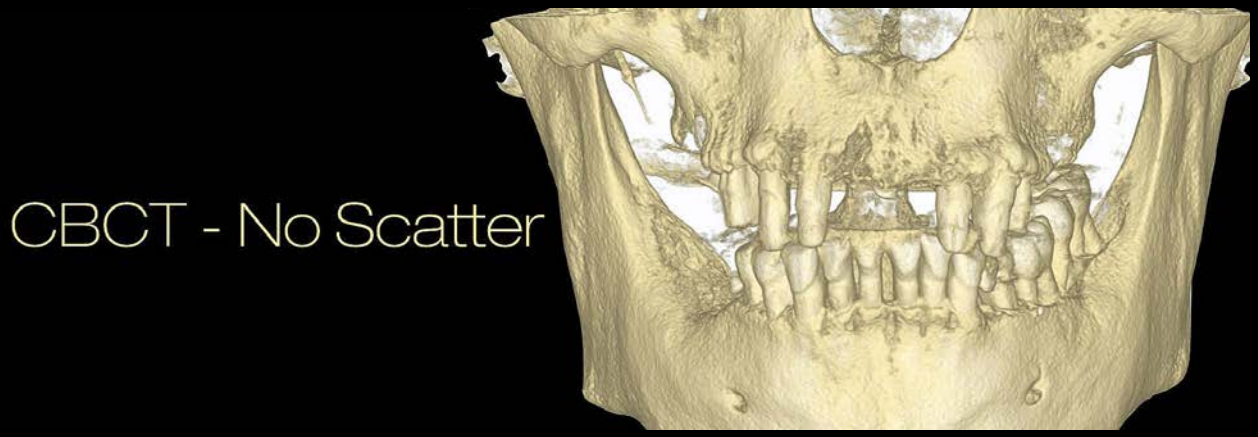



*CBCT demonstrating no radiographic scatter when completed after the removal of the Porcelain-Fused-to-Metal (PFM) fixed partial denture*

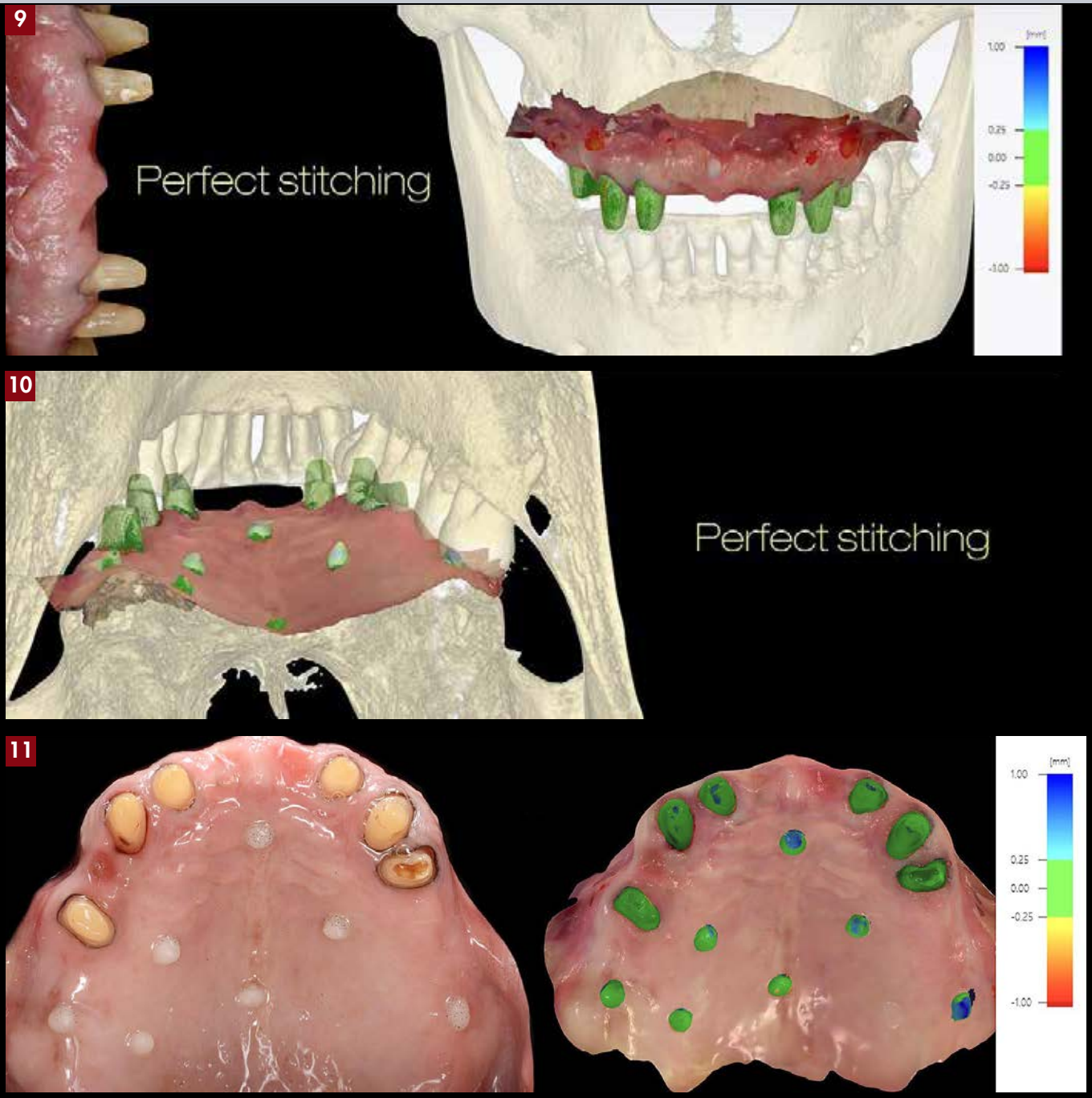
The intraoral scan and the CBCT scan were then imported into the software IMPLANT STUDIO (3Shape) and assimilated together using the three-point alignment of these reference markers.

The accuracy of this merge is confirmed using a differential colour map that shows how close the alignment is visually (fig. 6).

Avoiding scatter ensures the accurate stitching (meshing) of the two files. Better stitching facilitates implant planning and improves accurate implant placement.

## ● Technique 2: Sectioned removal of existing bridge

In addition to the use of radiographic markers, a second technique can also be used to prevent radiographic scatter.
Sectional removal of the fixed partial denture prior to the intraoral scan (fig. 7) means the metal in the prosthesis will not cause radiographic scatter in the CBCT scan (fig. 8). Rough preparation of the tooth abutments can also be done prior to the intraoral scan.




*Figs. 9-11: Accurate stitching or meshing of the IOS surface scan and CBCT DICOM in the absence of radiographic scatter on the CBCT due to metallic components of the PFM fixed partial denture*

Intraoral scanning of the prepared natural teeth abutments at this phase allows the scans to be utilized for the 3D printing of a surgical guide for fixture placement and a temporary prosthesis prior to the surgical phase of treatment.

The confirmed file merge will then create an accurate virtual rendering on which the digital planning of the implant placement from a restorative perspective can be performed. There is an extensive library of all major implant brands and guide sleeves incorporated into the 3Shape Implant Studio software. A digital BioHorizon implant fixture and the associated digital library were used for the planning of this case.

# Treatment Plan

Once the intraoral and CBCT scans had been completed, the initial treatment plan was formulated.

## 1. Surgical guide and implant planning

It was decided that a surgical guide would be designed and fabricated using the Asiga Max UV 3D printer for the guided surgical placement of implant fixtures in the 16, 14, 11, 21 and 25 sites.

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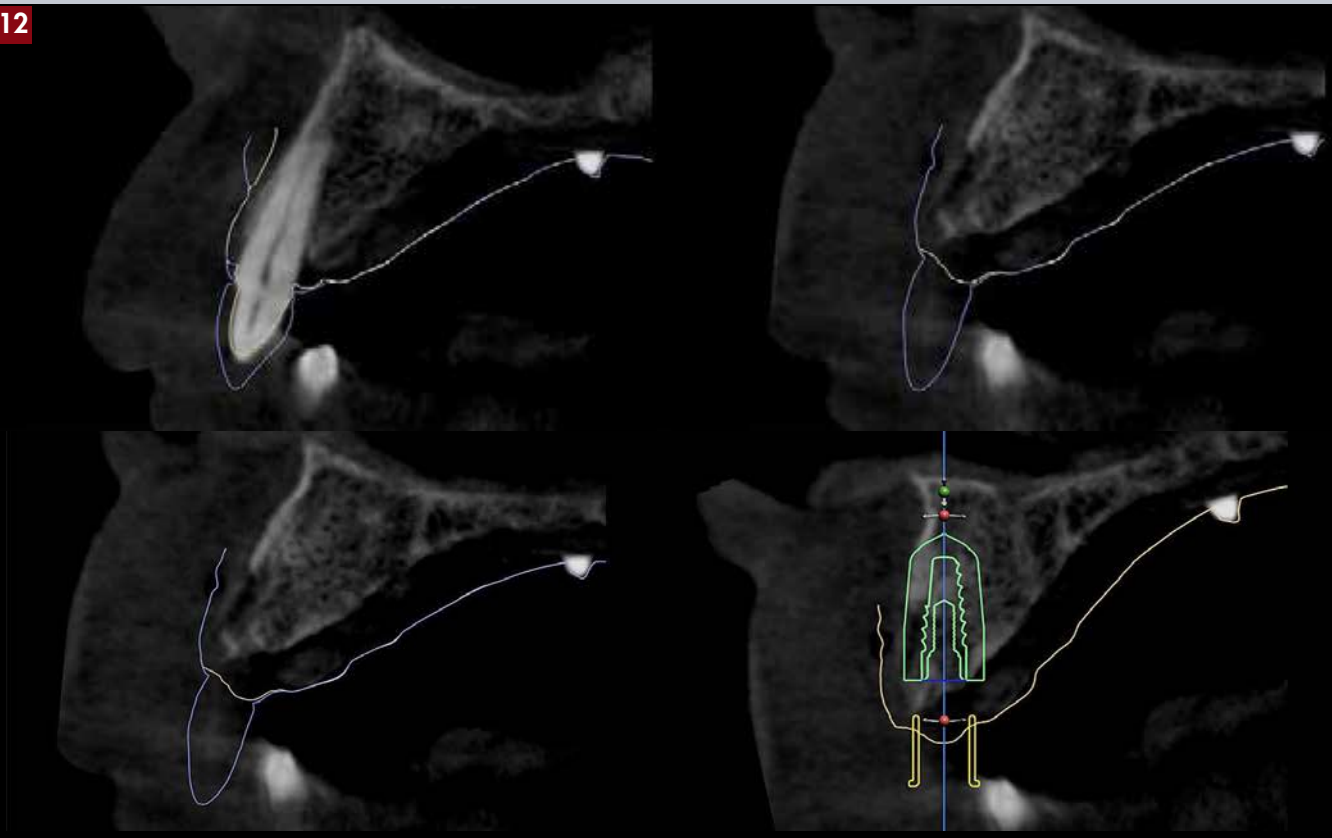

*The pre-operative scan, the scan with the natural tooth abutments and the DICOM data from the CBCT can then be accurately merged in the Implant Studio software (3Shape) to facilitate the placement of the implant fixtures from a restorative perspective (Restorative-driven implant placement)*

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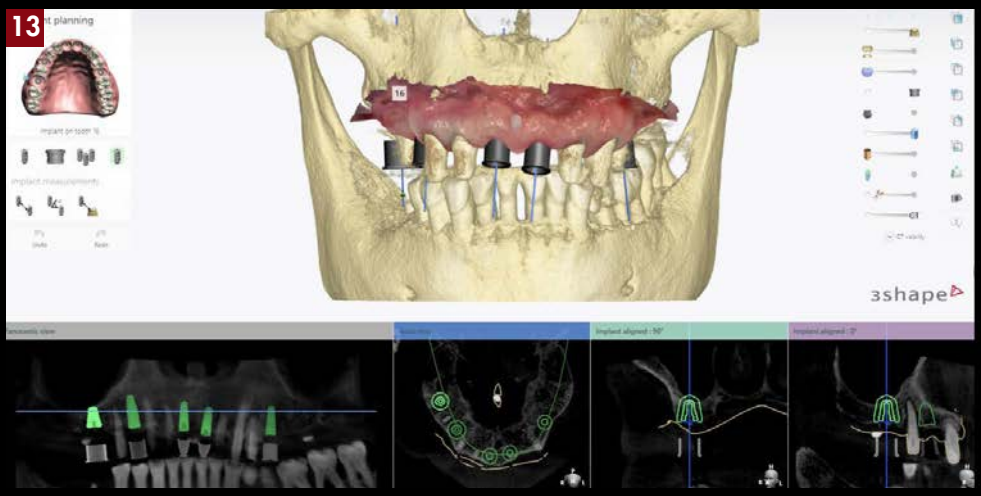


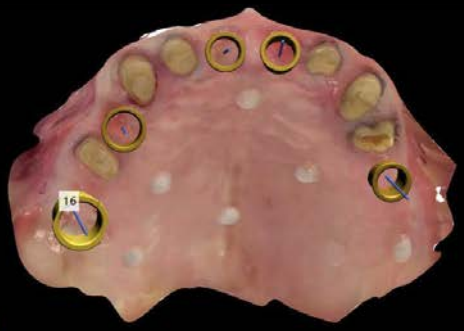

A bone graft was also planned in the 11 site due to bony defects, and a two-stage surgical protocol to be utilized during the integration phase for the implants in the 11 and 21 site.

## 2. Immediate provisional bridge following implantology

A 3D printed temporary bridge would be manufactured using the Asiga Max UV 3D printer and GC Temprint resin. This would serve as an immediate provisional in the upper arch following implant surgery. A copy of the existing shape and contours of the current failing bridge were superimposed to create a temporary bridge that was almost an exact copy of the existing and used immediately after implant surgery.

## 3. Individual temporary restorations after implant integration

A second phase of provisionalisation was decided upon. Individual temporary restorations, to be supported by implants and abutment natural teeth were to be printed in GC Temprint resin using the Asiga Max UV printer.

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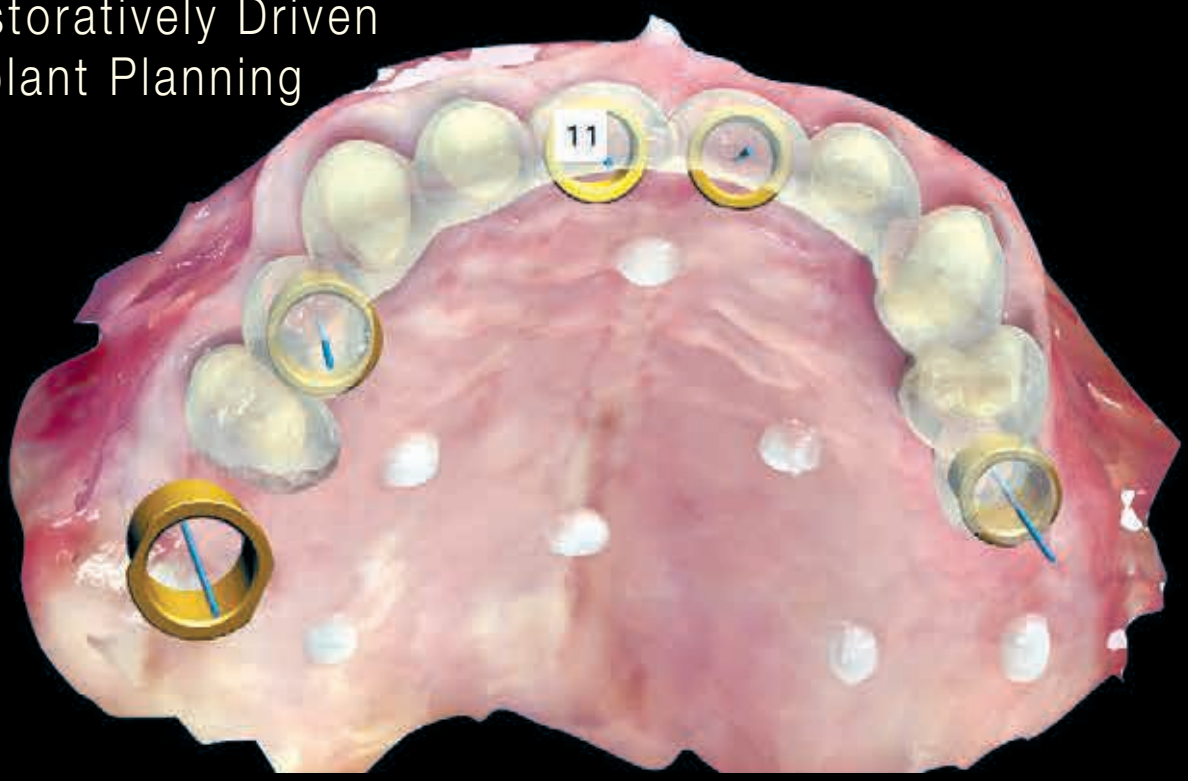
Restoratively Driven Implant Planning

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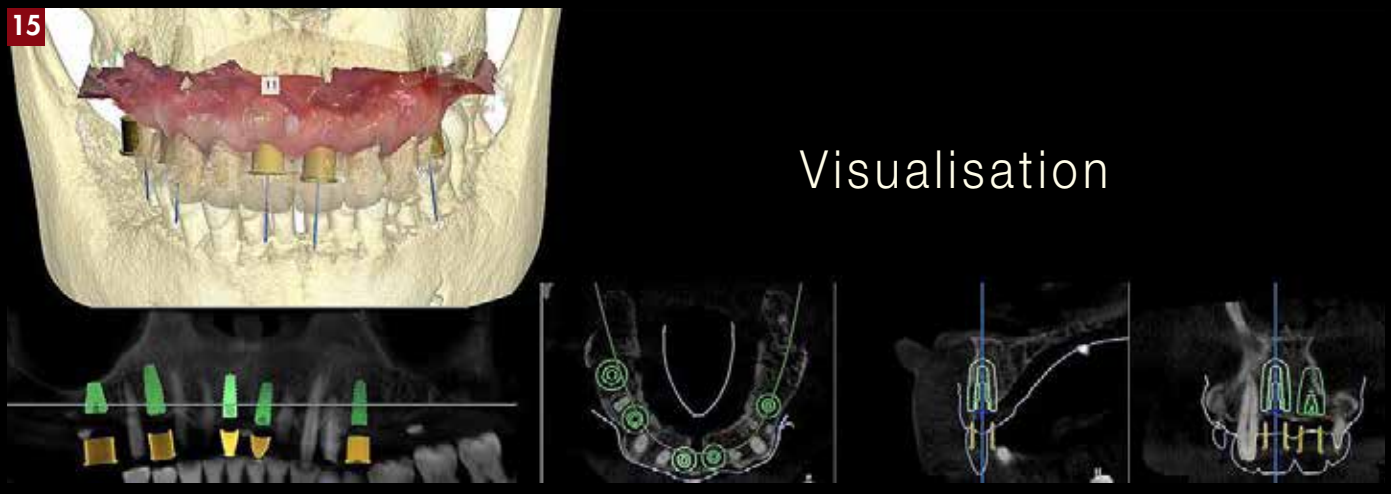
Visualisation



*Completed implant planning demonstrating the 5 planned implant fixtures, the virtual position, angulation and the planned position of access*

This second provisional phase would allow for:

**a.** soft tissue development

**b.** extraction of tooth 15

**c.** verification of aesthetics and occlusion (trial smile...)

## 4. Definitive Restoration

The final phase of rehabilitation would be completed with a combination of lithium disilicate and monolithic zirconia based restorations, supported by both natural teeth and implant abutments.

# Digital Implant Planning

The number, virtual position, angulation and the planned access position of the implant fixtures were virtually planned based on a restoratively driven protocol (figs. 12 to 15).

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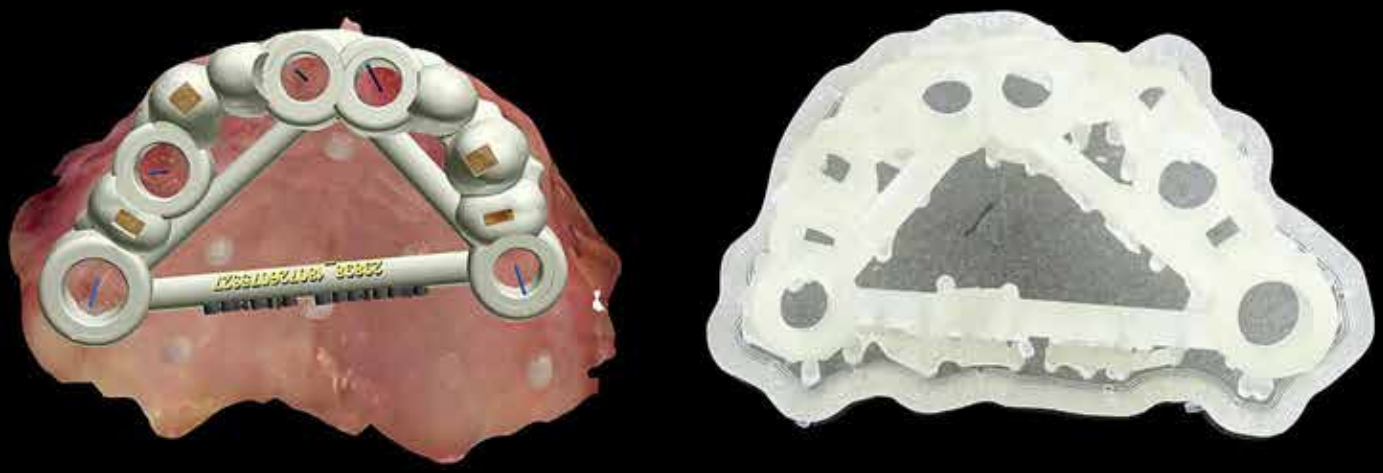


*The surgical guide for guided implant surgery was designed using the implant studio software...*

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*...And printed at the lab using an Asiga Max UV 3D printer. Note the design of the surgical guide with cross-arch support for guide stability*

## Surgical guide planning and fabrication

Once the positions of the implants were planned and established in the planning software, a surgical guide with the planned implant positioning was then designed on 3Shape's implant studio software.

The use of virtual windows offers easier visualisation of the onscreen design. (fig. 16).

Additional bars allow for the reinforcement of the 3D printed surgical guide. The virtually planned surgical guide was then printed using the Asiga Max UV 3D printer.

Once the guide was post processed, the master sleeves from the Biohorizon guided surgical system was placed and fixed to the printed surgical guide (fig. 17).

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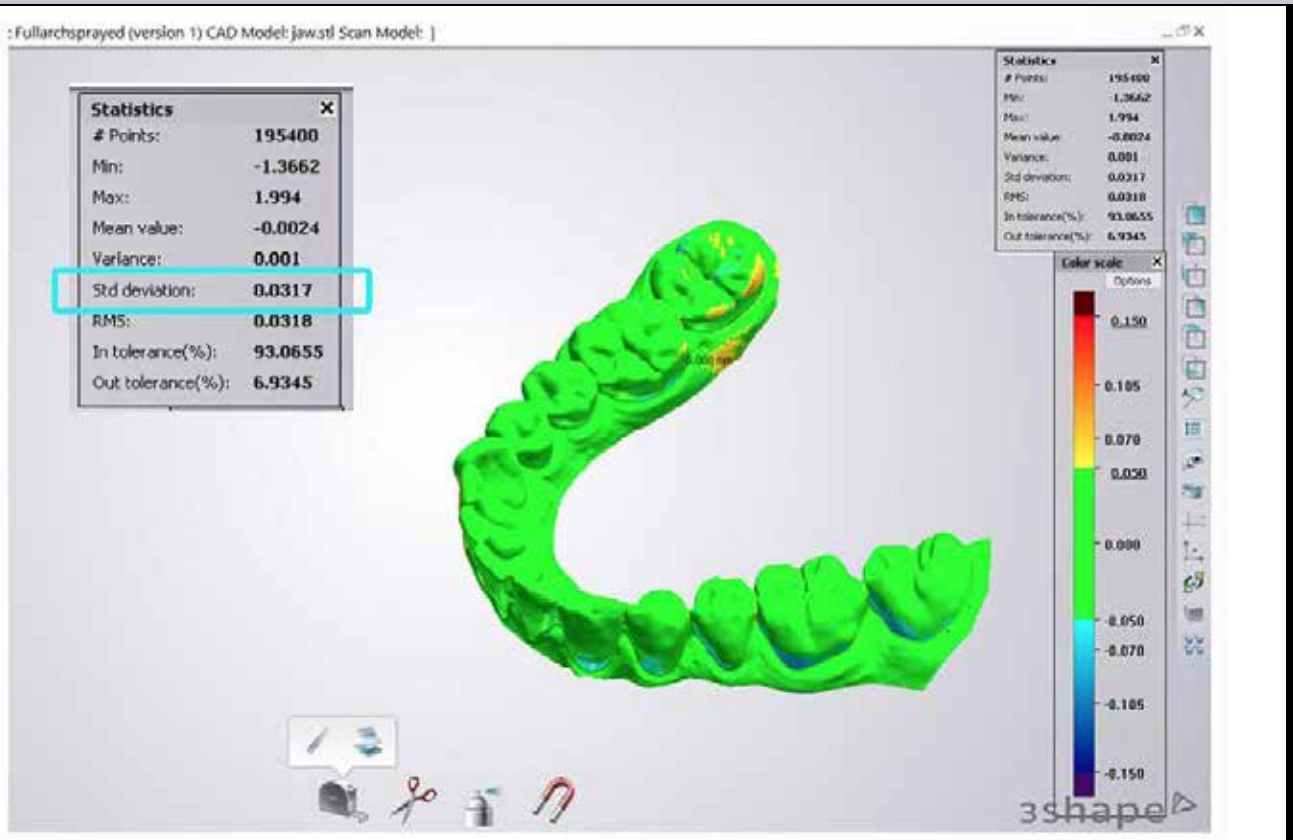


3D printed on an Asiga MAX UV in Asiga DentaMODEL resin, scanned using 3Shape scanner and validated in 3Shape Convince software.

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# First provisional restoration

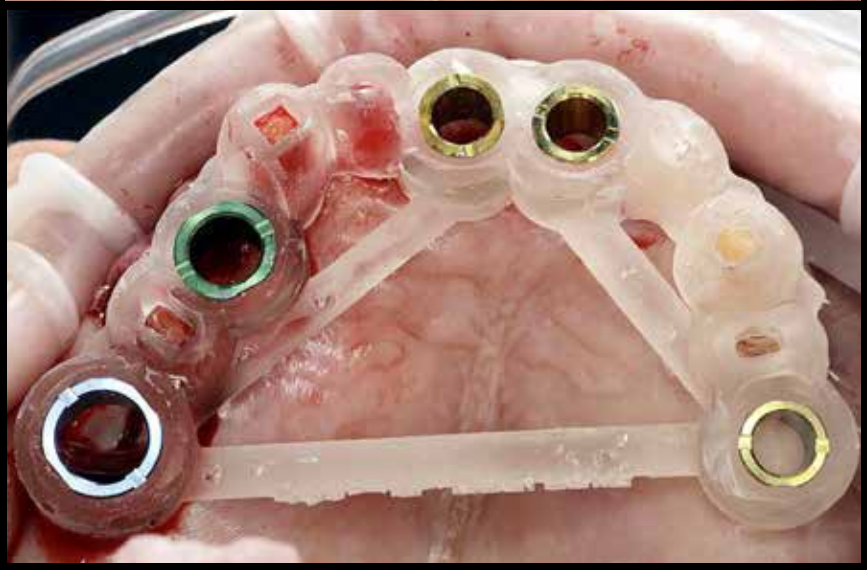
The first provisional restoration was then planned and designed. The patient's original PFM bridge was used as a basis for the digital planning and design of the provisional restoration (fig. 18).

Once the CAD design was completed and approved, the provisional restoration was printed using the Asiga Max UV and GC Temprint resin medium (GC Corporation) set at 50ums on the 3D printer (fig. 19).

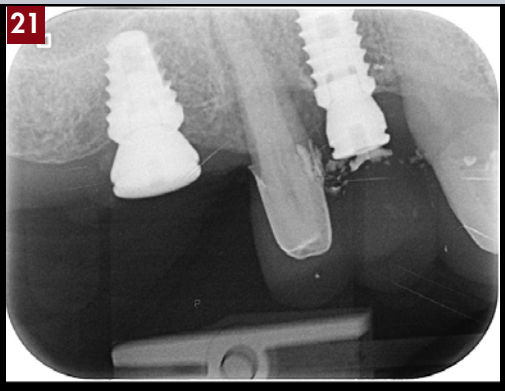
This provisional restoration would be fitted immediately after implant placement, and left in place for several months during the implant healing period.

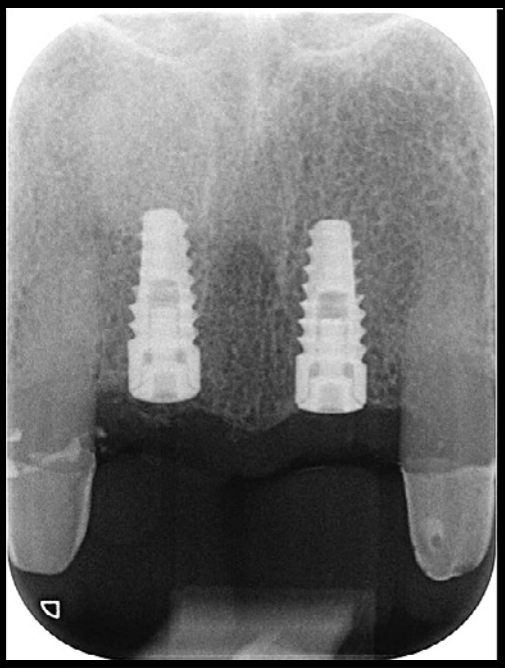
It should be noted that optimised settings for Asiga 3D printers are now factored into 3Shape Implant Studio software.

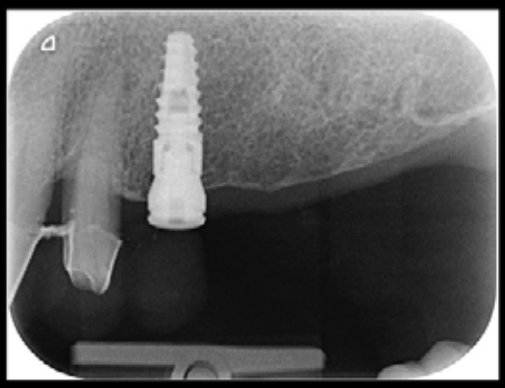
These optimised settings allow for easy workflow integration between 3Shape Implant Studio and Asiga 3D printers. In addition, the printing accuracy of the Asiga 3D printers have also been tested and proven. 3D scans of full-arch dental models printed in the Asiga DentaModel demonstrated over 93% of data points are within 50 microns of the original CAD file with a standard deviation of 31 microns.

*5 Biohorizon implant fixtures were then placed with a fully guided surgical protocol*





*A flap was raised in the 11 region as buccal bone grafting was required due to a bony defect*

# Guided Implant Surgery and Bone Grafting Phase

On the day of implant surgery, the implant fixtures were placed utilising the digitally planned surgical guide. The BioHorizon's fully guided surgical protocol was used (fig. 20).

A flap was raised in the 11-21 region, and bone grafting done using bovine cancellous particulate.

This was then covered with a porcine collagen membrane and closed with PTFE sutures. Primary stability of the fixtures was then confirmed (fig. 21).

Healing abutments were placed at the other implant sites on 16, 14, 25.

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*Immediate post-operative, following guided implant surgery and temporary cementation of the provisional fixed bridge printed from GC Temprint resin medium (GC)*

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*Post-operative review at 10 days and 4 months respectively*

**Part 2**

# Fitting the provisional post surgery

The printed provisional bridge was then cemented with GC Fujitemp (fig. 22).
A delayed healing protocol was employed with osseointegration confirmed after a period of 16 weeks.

In this article, we have see how the full digital workflow can be used to ensure highly accurate planning and implant placement.

In my next article we will discuss the next phase of treatment, including the design and fabrication of single unit implant retained provisional crowns and an implant-retained provisional bridge, with the aim of encouraging soft tissue growth.
It will also allow us to validate the aesthetics and occlusion before making the definitive restorations.

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