The introduction of digital surface scanners to the dental field and the simplicity of data transfer are closing the gap in the creation of a completely “virtual patient” with the optimisation of the digital treatment workflow.¹ Something that a few years ago sounded like science fiction in dentistry, is possible today owing to the technological advances that have been incorporated into our field. The prosthetic, surgical, radiological and laboratory worlds are being fused in sophisticated digital platforms, enabled by the capacity to import the data obtained from digital surface scanners and the DICOM files into surgical and prosthetic planning software.²⁻⁴ The complete digitalisation of patients’ information and the possibility to combine it offer several advantages to clinicians and are changing the way in which patients perceive invasive dental treatments. Because of their advantages in providing personalised treatment, intra-oral scanners for digital impressions and surgical simulation software will be used as a fundamental technology for diagnosis, planning, treatment and prevention.⁵

**Case report**

A 55-year-old healthy female patient presented to our practice desiring mandibular molar
rehabilitation. She complained about the absence of a mandibular left first molar (tooth 36) owing to an extraction performed several years ago because of failed endodontic treatment. After a complete diagnostic evaluation, including clinical and photographic analysis, a CBCT scan of the left mandible was performed using ProMax 3D’s (Planmeca; Figs. 1 & 3a). At the same appointment,

Fig. 3a. A CBCT scan of the mandibular left quadrant.
Fig. 3b. Surface scanning of the edentulous zone.
Fig. 3c. Digital reconstruction of the mandibular left quadrant after the surface scanning process.
Fig. 3d. The digitally reconstructed arches in maximum intercuspation.

Fig. 4a. A lateral view of the initial digital crown design.
Fig. 4b. A lateral view of the maxillae and the mandible in maximum intercuspation with the virtual crown design.
Fig. 4c. An occlusal view of the final crown design.
Fig. 4d. A lateral view of the final crown design.
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CBCT and digital surface scanner

A digital surface scan of the left maxilla, left mandible and of both arches in maximum intercuspation to establish interocclusal contact was done with a TRIOS digital scanner (3Shape; Figs. 2 & 3b–d). Once all the diagnostic information had been gathered, a treatment appointment was made for the next day.

The digital scan files and the DICOM files obtained from the CBCT were imported into the Implant Studio software (3Shape), in which an innovative technique of spatial recognition allows the creation of a 3-D superimposition of the real intra-oral situation and the radiographic images. A restorative design tool included in Implant Studio was utilised to create a functional and aesthetic virtual crown with the ideal prosthetic position on the reconstructed surface image (Figs. 4a–d). After the final crown evaluation, the 3-D digital implant position was defined to obtain the most convenient prosthetic and surgical result, respecting vital structures, such as the inferior alveolar nerve and vascularity. Thus, the designed virtual crown was used as a radiographic template (Fig. 5).

The planning can be performed using an intra-oral surface scan and can be checked with the cone beam 3-D reconstruction at the same time, assuring the optimum implant position and avoiding any bone fenestration or dehiscence (Figs. 6a & b).

The implant selected was a Tapered Internal implant (BioHorizons; D 4.6 mm × L 10.5 mm, platform D 4.5 mm). Once the implant position had been approved, a teeth-supported virtual surgical guide was designed (Figs. 7a–d). The final guide design

Fig. 5_Multiple views of the 3-D digital implant positioning. Note how the designed virtual crown was used as a digital radiographic template.

Fig. 6a_Implant planning performed using an intra-oral surface scan.

Fig. 6b_Implant planning checked with the cone beam 3-D reconstruction.

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Fig. 7a_A lateral view of the guide design. The green line shows the future guide margin.

Fig. 7b_The orange cylinder showing the screw exit for the future restoration.

Fig. 7c_Virtual 3-D reconstruction of the surgical guide showing the screw exit of the future restoration.

Fig. 7d_An angled view of the final surgical guide design and the insertion axis of the implant.
was sent as an STL file (Figs. 8a–c) to the 3-D print manufacturer, where the surgical guide was fabricated in two hours (Objet Eden260V, Stratasys; Fig. 9). Once the guide had been fabricated, a final try-in was performed on the study model to assess any fit inaccuracies or surgical access problems before sterilising the guide and the BioHorizons guided surgery kit (Fig. 10a).
The next day, the patient returned to our practice for the surgical procedure. After a mouth rinse with 0.12% chlorhexidine gluconate (Oralgene, Laboratorios Maver) for 2 minutes and the disinfection and preparation of the surgical field, local anaesthetic was delivered to the edentulous area (tooth 36 region) by buccal, crestal and lingual infiltrations (2% lidocaine hydrochloride and 1:100,000 epinephrine). After a few minutes, the surgical guide was placed in position and the 4.6 mm-diameter guided tissue punch was utilised through the master cylinder placed in the surgical guide at 1,200 rpm. The guide was then removed and the sectioned soft tissue was removed with a tissue elevator and kept in saline solution (Figs. 10b–d).
The surgical guide was repositioned and a 2.0 mm diameter guided key was placed into the master cylinder. A pilot guided drill of 21 mm in length and 2.0 mm in diameter was utilised to start the osteotomy at 1,200 rpm through the guided key cylinder. The surgical guide system compensates 10 mm in actual drill depth so the final osteotomy in this situation was performed at 11 mm depth (Figs. 11a & b). The procedure was sequentially repeated with the 2.5 mm guided key and tapered guided drill of 21 mm in length and 2.5 mm in diameter, the 3.2 mm guided key and tapered guided drill of 21 mm in length and 3.2 mm in diameter, the 3.7 mm guided key and tapered guided drill of 21 mm in length and 3.7 mm in diameter, and finally the 4.1 mm guided key and tapered guided drill of 21 mm in length and 4.1 mm in diameter (Fig. 11c).

The surgical guide was then removed to check the osteotomy site (Fig. 11d). The guide was then repositioned and the implant was mounted in the 4.6 mm guided implant driver (Fig. 11e). The implant was placed through the master cylinder at 15 rpm and 50 Ncm torque (Fig. 11f). Once the implant was at the final depth position (Fig. 12a), the guided implant driver was removed and a healing abutment (BioHorizons; D 4.5 mm × L 3 mm) was screwed into the implant (Fig. 12b). A small connective tissue graft taken from the soft tissue removed by the tissue punch was then placed in a buccal wedge to gain soft-tissue volume and thickness in the remaining keratinised tissue (Fig. 12c). No sutures were indicated. A post-operative radiograph was taken to evaluate the final implant position.

Conclusion

The combination of digital surface scans and CBCT images for virtual planning for implant surgery can be used for safe and effective non-invasive computer-guided implant placement. Implant Studio is a user-friendly realisation of this innovative technology and can significantly reduce the preoperative preparation procedures and treatment times while maintaining surgical accuracy. In this specific clinical situation, the computer-guided surgical preparation and surgery took no longer than two days, improving the waiting times associated with conventional CBCT guided surgical systems.

We invite anyone interested in this innovative technology to visit our clinic and specialist CAD/CAM training centre in Santiago in Chile, where participants will be involved in practical clinical cases, be given live surgery demonstrations, and attend lectures about guided surgery procedures and CAD/CAM surgical and restorative technologies.

Readers can find a video of the procedure at the following link: https://www.youtube.com/watch?v=2gNwAtWE0U&feature=youtu.be

Editorial note: A complete list of references is available from the publisher.