Digital full-arch implant rehabilitation with immediate loading

A staged workflow for accurate results

Full-mouth implant rehabilitation has historically required multiple surgical and prosthetic stages, each susceptible to cumulative error. The introduction of a whole range of digital devices (intra-oral, extra-oral, face scanners and cone beam computed tomography [CBCT] with low dose radiation) and processing software (computer-assisted design/computer-assisted manufacturing [CAD/CAM] prosthetic software, software for planning implant surgery), together with new durable aesthetic materials, powerful manufacturing and prototyping tools (milling machines and 3D printers), is radically transforming the dental profession.

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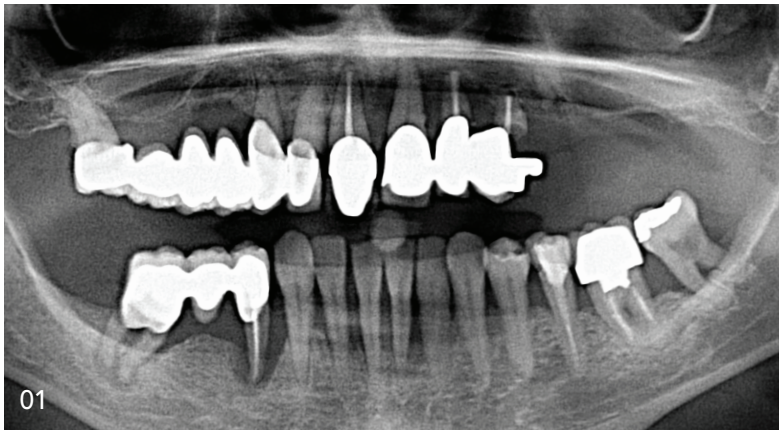
Today, the digital revolution is changing the workflow and consequently changing operating protocols. In modern digital dentistry, the four basic phases of work are image acquisition, data preparation/processing, production and the clinical application on patients.[1]

Image acquisition with traditional intra-oral scanning (IOS) systems struggle to capture soft-tissue topography to maintain the needed details for precise prosthetic contact. These limitations have made full-arch implant rehabilitation one of the most technically demanding procedures in dentistry. Intra-oral photogrammetry (IPG) overcomes these challenges by using coded scan markers that ensure precise implant positioning without relying on image stitching.[2] Accuracy of digital impressions may decline when scanning arches with more than four implants and photogrammetry appears to mitigate this effect.[3]

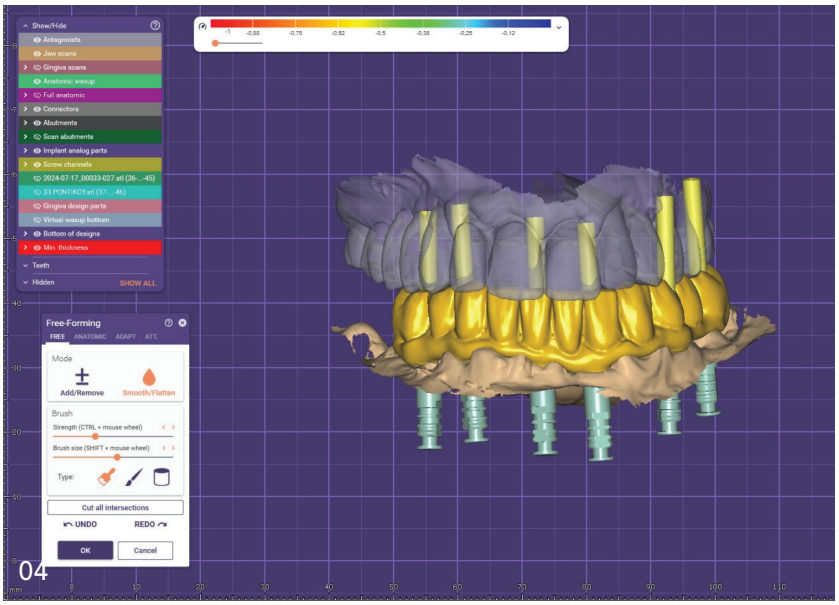
Facial scanners are gaining much popularity over the past few years. These devices create high-resolution, three-dimensional models (which can be aligned with the IOS and CBCT) utilising imaging technology that uses structured light or laser scanning to create a comprehensive view of the patient's smile and surrounding facial features.[4] Facial scans allow for objective, quantitative assessment of facial morphology, better communication with patients, precise treatment planning and the recent technological advances have



01
Pre-operative OPG showing generalised bone loss.

02
Teeth assessed as having a poor prognosis.

03
Fabrication of the mandibular surgical guide.



04
Digital design of the mandibular provisional prosthesis on exocad.

05
Immediate loading with a hybrid resin prosthesis.

made facial scanning more accessible, with the introduction of portable devices and improved software integration capabilities.[5] Advances in digital implantology have transformed implant-supported full-mouth rehabilitation by enabling precise, efficient, and minimally invasive workflows.

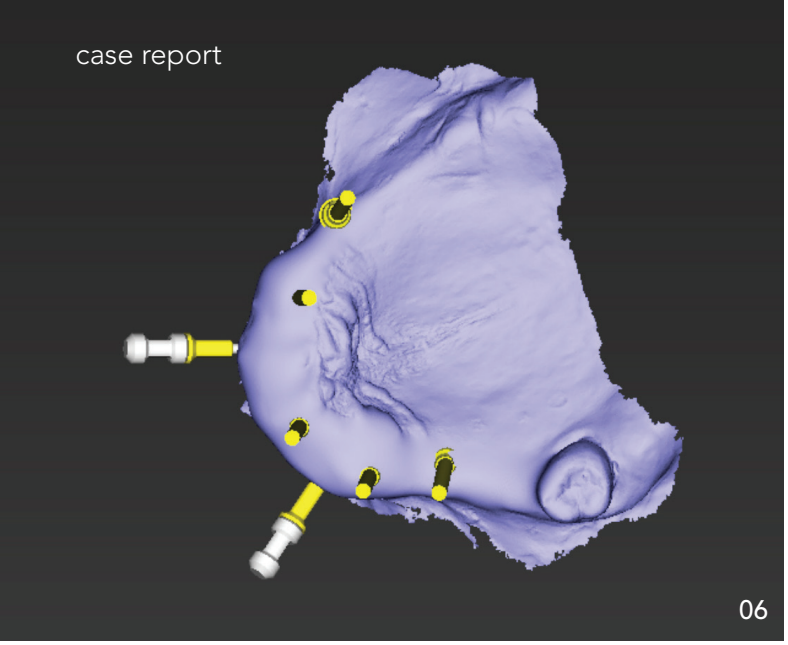
This case report presents the treatment of a sixty-six-year-old patient in which the clinical and radiographic evaluation revealed poor prognoses for all teeth. (Figs. 1+2) A full-mouth implant-supported rehabilitation was planned using a staged, digitally guided protocol for two types of implant systems from bredent medical (blueSKY and copaSKY) owing to their unique attributes which make them suitable for immediate loading.

Surgical stage

a) Mandibular phase

A surgical guide was designed using the coDiagnostiX software (Fig. 3). Lower teeth were extracted and a combination of blueSKY and copaSKY implants (bredent medical) were placed through guided surgery with the aid of the SKY Pro Guide kit (bredent medical). The blueSKY and copaSKY implant system have a unique osseo-connect-surface (OCS) which is a blasted and etched surface, thereby facilitating osteoblasts attachment for rapid osseointegration. The blueSKY implants are placed flushed with the bone (epicrestal) and achieve good mechanical stability due to cortical anchorage. The self-tapping double thread increases the speed of insertion and ensures a high primary stability adequate for immediate restoration.

One-time uni.cone multi-unit abutments (bredent medical) were placed, and an intra-oral scan (TRIOS 3, 3Shape) was recorded immediately after surgery. A cross-arch FP-3 prosthesis was designed using exocad software (Fig. 4) and a 3D-printed resin (onX Tough 2, Sprint Ray) immediate provisional prosthesis reinforced by titanium cylinders was fabricated and immediately loaded two hours postsurgery with satisfactory outcome (Fig. 5).



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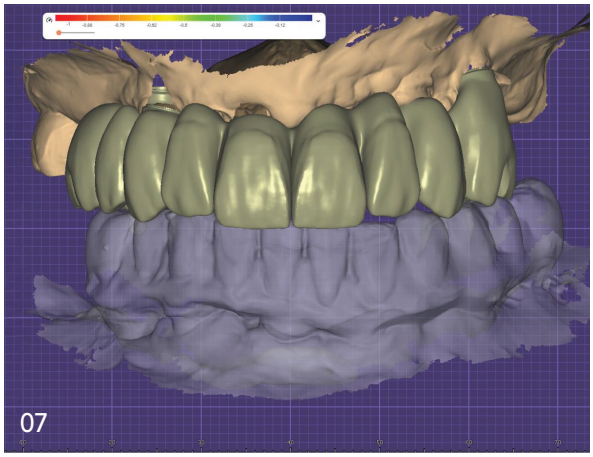
Maxillary implant planning and surgical guide design in coDiagnostiX.



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Digital design of the maxillary provisional prosthesis on exocad.

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08
Immediate maxillary loading with a hybrid resin prosthesis.

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Aesthetic outcome following the provisional phase.

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Clinical status at ten months post-op.

b) Maxillary phase

A surgical guide was milled using CAD/CAM, followed by total extraction of the upper teeth and guided subcrestal placement of five copaSKY implants (bredent medical). The copaSKY implants, owing to their micro-structured backtaper, allow subcrestal placement and bone-chip apposition, ensuring complete bone healing. Uni.cone multiunit abutments were placed, and an IOS (TRIOS 3, 3Shape) was performed immediately after surgery. An FP-2 provisional prosthesis was designed in exocad and 3D printed with OnX Tough 2 material (Sprint Ray) and titanium intermediate cylinders. This provisional prosthesis was immediately loaded onto the abutments within two hours after surgery (Figs. 6–8). The patient was functionally and aesthetically satisfied with the outcome (Fig. 9).

Definitive stage

After ten months of successful function without complications, radiographic evaluation and implant stability testing (ISQ) confirmed osseointegration in both arches (Fig. 10).

“Full-arch implant rehabilitation is one of the most technically demanding procedures in dentistry.”

Intra-oral scanning (Aoralscan Elite, Shining 3D) of the existing provisional restorations (Fig. 11) was done followed by removal of the intermediate prosthesis and scanning of the scan post (bredent medical) on the maxillary multiunit uni. cone abutment (Fig. 12). The deficiencies of the provisional prosthesis were corrected, and the final maxillary prosthesis was designed (Fig. 13). A milled alloy verification jig was fabricated for the maxilla; however, it did not fit on the abutments. It was mandatory to cut and take a physical pick-up impression to fabricate a passive fit final prosthesis. The final titanium bar reinforced maxillary prosthesis with multilayered zirconia was fixed (Fig. 14) and the scan of the mandible was immediately done with the upper prosthesis as the reference point for occlusion. The lower arch was scanned with intra-oral photogrammetry (IPG) scanning flags (Fig. 15) on IPG mode (Aoralscan Elite, Shining 3D) The IPG minimises cumulative errors from scan data alignment and enhances overall

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Intra-oral scan of the provisional prosthesis.

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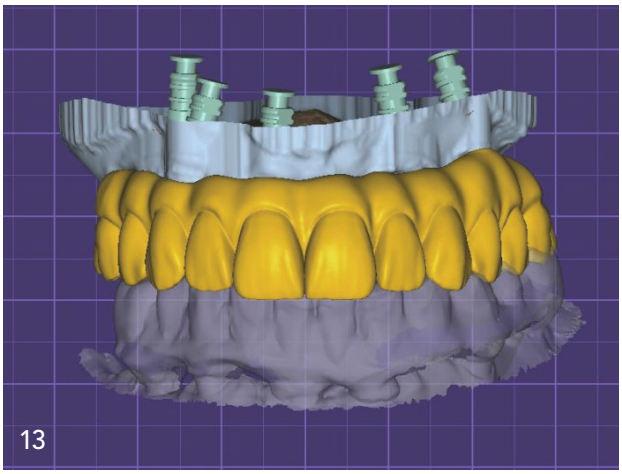
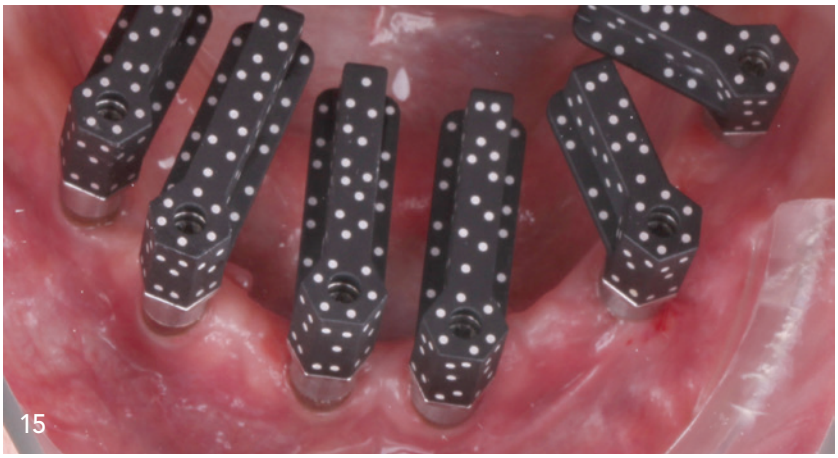
Maxillary intra-oral scan of the bredent scan posts at the multi-unit abutment level.





13
Digital design of the definitive maxillary prosthesis on exocad.

14
Definitive maxillary FP3 prosthesis.

15
Photogrammetry scan flags for mandibular scanning of Unicone multi-unit abutments.

accuracy. A milled alloy fabrication jig-trial was done to ensure a passive fit of the prosthesis (Fig. 16). A milled titanium bar with layered zirconia was fabricated which connected directly to the multiunit uni.cone abutments, maximising the use of vertical space and ensuring structural durability, with fewer components involved, making the process less complicated. The final prosthesis was fixed in the patient's mouth. (Figs. 17+18) A 3D facial scan (MetiSmile MR, Shining 3D) was performed to facilitate final occlusal adjustments using the software's jaw-tracking mode (Fig. 19). The one-year follow-up OPG showed successful treatment outcomes with stable crestal bone levels (Fig. 20).

Discussion

A complete digital workflow was planned with a prosthetically-driven full-arch implant rehabilitation deemed crucial for long term functional and aesthetic results. Guided surgeries entail the final restorative outcome in planning, and the correct implant position is decided with respect to anatomical restriction for safe and accurate implant placement. Implant survival with guided surgeries shows high survival percentages.[6] The bredent medical implant systems used are very compatible with all digital equipment, since the systems´ libraries is present on almost all intra-oral scanning, CAD/CAM implant planning software and 3D printing.

Immediate loading with in-house 3D printed cross arch provisional prosthesis was done for restoration of instant function and aesthetics. These performed exceptionally well for ten months with neither aesthetic nor mechanical complications. This additive method is an alternative way of digitally fabricating restorations and has advantages over the subtractive method of milled restorations such as mass production with little material waste, reduced manufacturing time, easy access to materials for 3D printing and the availability of low-cost 3D printers.[7]

Two different intra-oral scanning methods were employed during the definitive restorative phase and had clinically different results as assessed by the fit of the milled alloy confirmation jig. The mandible scanned by IPG showed significantly superior results in the milled alloy jig, passing the Sheffield test clinically and radiographically as compared to the maxilla which was scanned by traditional IOS and had a misfit in the jig trial. A recent *in-vitro* study evaluated the accuracy of direct digital impression of various intra-oral scanners as compared to the IPG mode on the Aoralscan Elite on an edentulous mandible. The study concluded that the IPG was statistically more accurate in all parameters as compared to traditional IOS, highlighting clinical relevance of IPG as a reliable and precise technique for full-arch cases.[8] The significance of accuracy of IPG in the mandible is more relevant as compared to traditional IOS due to presence of tongue, movable mucosa and lack of reference points such as the rugae as present on the palate making IOS less reliable than IPG especially in the mandible as compared to the maxilla. IPG, relying solely on the spatial relationship of

16
Milled framework *in situ*.

17
Milled titanium bar with direct connection to the multi-unit abutments.

18
Frontal view of the definitive multilayer zirconia-on-titanium FP3 prosthesis.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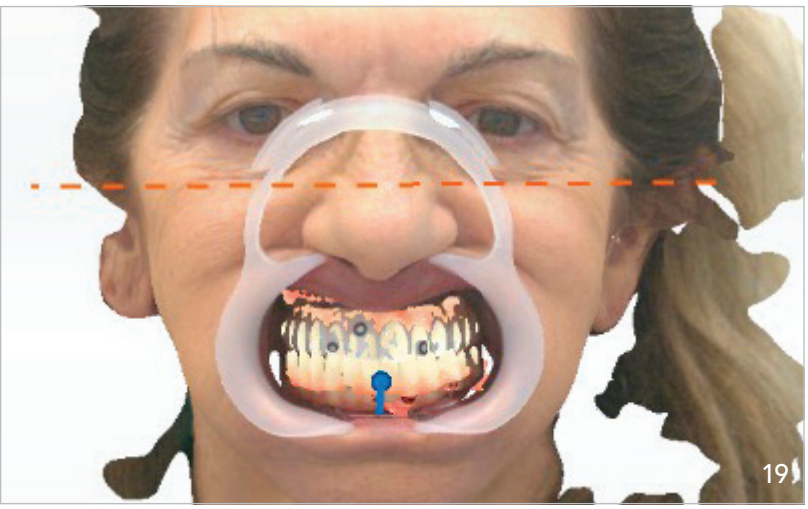

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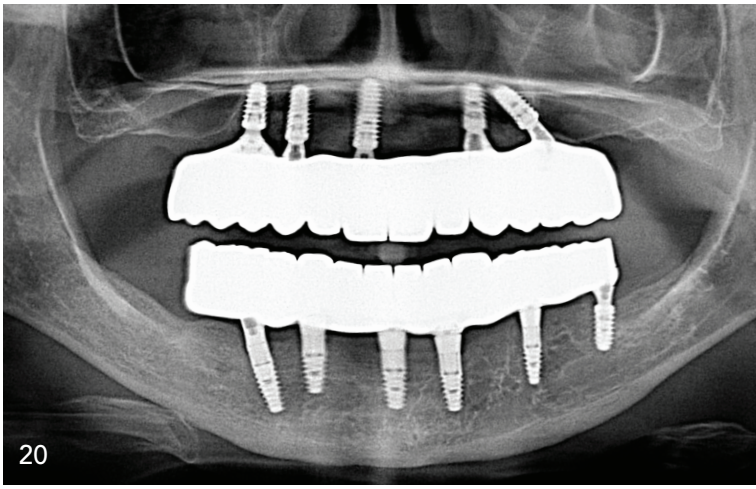
Facial scan used for final occlusal adjustment.



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One-year postoperative follow-up demonstrating stable crestal bone levels.

fixed scan posts targets, remains unaffected by these variables, explaining its superior precision in this clinical setting.[9] A study by Pozzi et al. concluded that IPG trueness might avoid rigid prototype try-in and IPG technology was feasible for complete-arch digital implant impression with mean linear, angular, and 3D deviations far below the acceptable range for a passive fit. For complete-arch implant rehabilitation, the photogrammetry system showed the best accuracy of all the impression techniques evaluated, followed by the conventional impression technique, and the intra-oral scanner provided the least accuracy.[10]

A 3D facial scan (MetiSmile MR, Shining 3D) at the end of treatment was used for final occlusal adjustment through the assessment of the jaw motion. A recent cross-sectional study evaluated the accuracy of various facial scanners and concluded the Metismile face scanner to be the most accurate. The scanner's algorithm allows operators to oversee the process in real time, adjust positioning, and address image gaps seamlessly. MetiSmile utilises structured light scanning technology, which has demonstrated superiority over the stereophotogrammetry used by other facial scanners. This technological advantage likely explains MetiSmile's superior performance in this study.[11] 3D facial scanning and jaw-motion tracking have expanded prosthodontic planning from tooth-driven to facially-driven workflows. Facial scans help align restorative design with soft-tissue contours, aesthetics, and patient-specific function.

Conclusion

This case demonstrates how combining advanced guided surgeries, IPG technology, 3D-printed provisional restorations, and motion-based facial scanning can streamline the digital workflow for full-arch implant reconstruction. Appropriate choice of implant systems can be crucial for achieving good primary stability to facilitate immediate loading and their prosthetic geometry to allow smooth integration of CAD/CAM and 3D-printing protocols. This compatibility with the bredent medical´s systems reduced intraoperative adjustments and simplified the transition from surgery to the final prosthesis. IPG scanning improved the passive fit outcome, while facial-scan integration enhanced functional and aesthetic predictability. This experience reinforces the shift from conventional full-arch scanning toward guided, verification-oriented digital protocols that can reduce the need for analog corrections and improve workflow consistency. Hence, an integrated digital workflow system can seamlessly deliver predictable full-mouth implant-supported rehabilitations and improve patients' acceptance and satisfaction.

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References