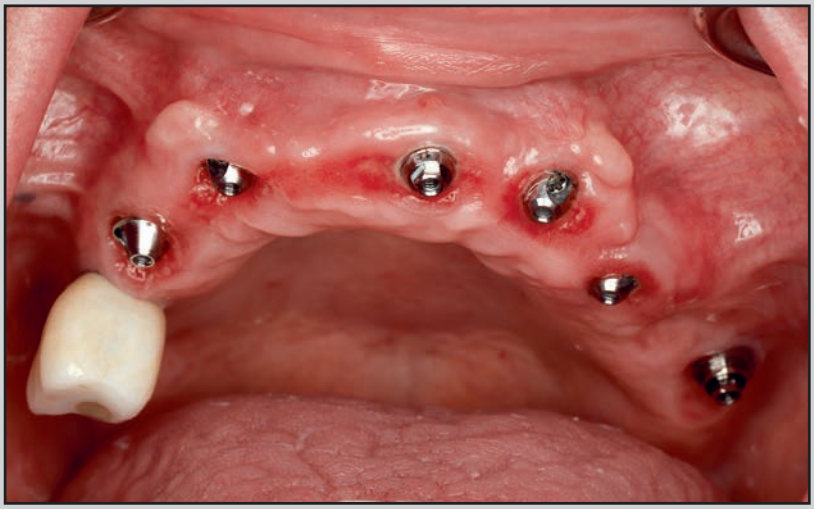

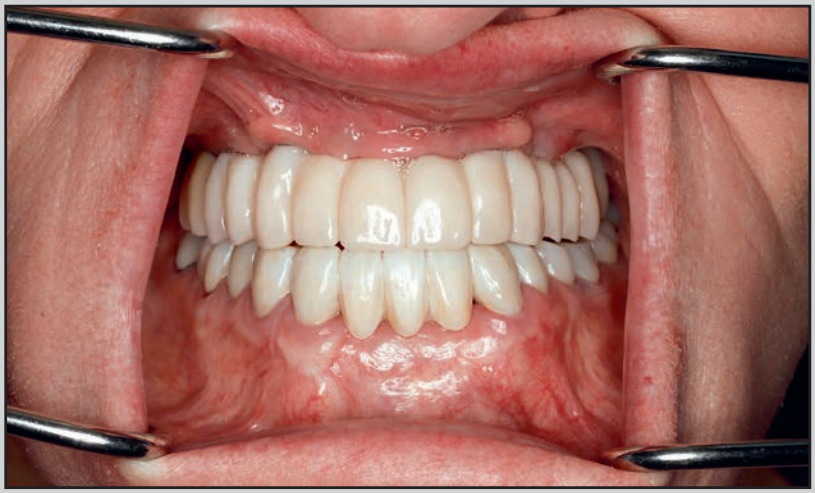

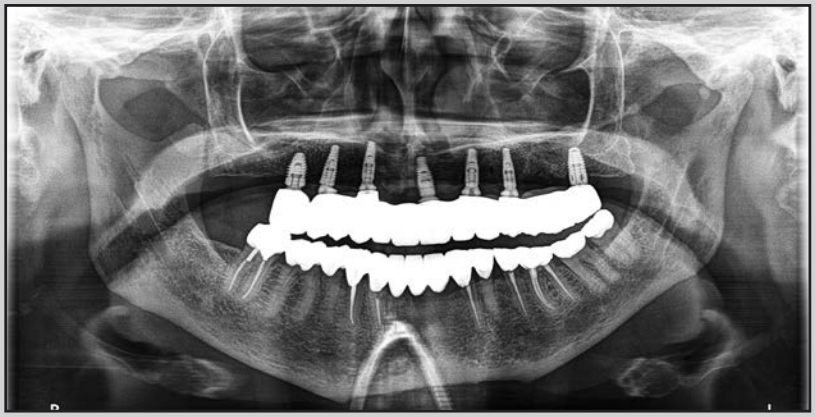

A Digital Approach to Immediate-Load, Full-Arch Implant Dentistry: A Case Report

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Conventional approaches to full-arch implant dentistry require a verified master model created by luting together impression jigs. This process involves numerous steps and is sometimes prone to errors that require subsequent correction. A novel approach involving an extraoral scanning technique using an Imetric 4D Imaging system demonstrates an alternative for same-day delivery of printed full-arch prosthetics. Advantages include the ability to offer a same-day provisional restoration without needing to verify an analog master cast. Int J Periodontics Restorative Dent 2022;42:587–593. doi: 10.11607/prd.6048

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Traditional approaches to full-arch implant dentistry require an initial accurate impression using vinyl polysiloxane.[1] This can present its own challenges, including ensuring that the impression copings are fully seated intraorally, to inherent limitations caused by the impression material itself and insertion of lab analogs correctly to fabricate the working model. Advances with intraoral scanning utilizing scanbodies allow for an improvement in the process using a digital approach. However, scanning multiple adjacent scanbodies has proven to be a clinical challenge.[2] This is especially true in the case of multiple splinted implants, as found in typical hybrid full-arch implant cases.[3,4] The following case presentation exemplifies an improvement from traditional approaches whereby a full digital approach is used to deliver a same-day temporization option without needing a traditional analog-based model or subsequent master model verification.

Conventional Digital Approach

In a conventional digital approach, implant scanbodies are connected to the implants for digital scanning. Typically, the scanbodies used for

Fig 1 *Capturing the 3D implant positions using the ICam4D system.*

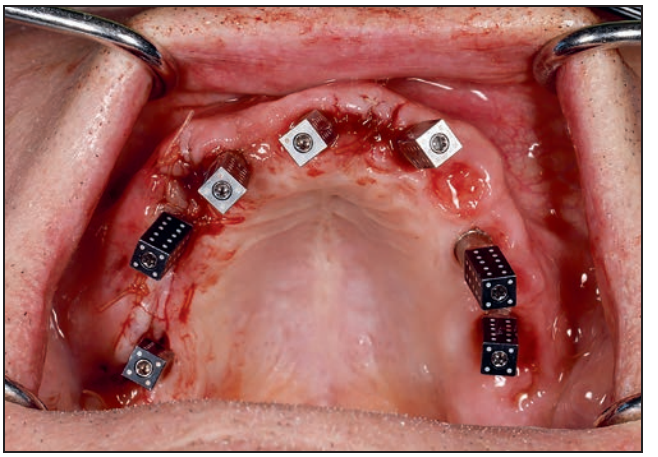

Fig 2 *An example clinical scenario using ICamBodies to capture implant positions in a full-arch case.*

full-arch implant cases are connected to multi-unit abutments (MUAs). This increases the passivity of the final prosthesis by ensuring parallelism of the implants through the angle correction provided by the MUA.[5] Similar to a panoramic image, an intraoral scan consists of multiple images that are stitched together using common overlapping data between one image and the next. That process of data extrapolation introduces slight errors that can add up as the number of images needed for full-arch scanning increases.[6] The literature is unclear on the accuracy of full-arch intraoral scanning in edentulous cases; this is especially important because most testing is done using benchtop models that do not replicate the difficulty of capturing accurate data in the intraoral environment due to the present blood and saliva.[7,8]

Currently, the gold standard for restoring adjacent implants is to lute together impression jigs, creating a verification jig (stent) that ensures that the implants are captured in an accurate relationship to each other. Then, the model is created via a "corrected cast."[9] The process involves an initial accurate impression, fabrication of a verification jig and custom tray, repouring the model if necessary, or cutting the verification jig if any distortion or misfits are apparent during the try-in. The verification jig is then captured in an open-tray impression, and a soft tissue model is fabricated.[10]

Once this model is verified, scanbodies can be inserted and scanned on a benchtop lab scanner. As previously mentioned, the ability to scan extraorally without accommodating for saliva or patient movement makes this approach advantageous. Further, a lab scanner can capture more data per shot, thus limiting *(1)* the number of images that need to be stitched together and *(2)* the potential magnitude of error.

Photogrammetry

Photogrammetry is a technique that generates 3D coordinates of specific points identified from multiple images of the same object obtained at different angles.[11] The ICam4D unit (Imetric 4D Imaging) is a handheld camera unit that consists of four cameras and one projector.[12] By combining photogrammetry and structured-light scanning techniques, this unit can capture 3D data for an accurate representation of implant positions relative to each other (Fig 1). By using the equivalent of implant scanbodies in the form of ICamBodies, which have a unique target arrangement (Fig 2), the unit can determine the position and orientation of the implants.[13]

Another critical component of the ICam 4D system is the ICamRefs, which are placed directly on the MUAs. These are similar to traditional healing abutments but with a smaller profile height, which facilitates soft tissue capture either by a

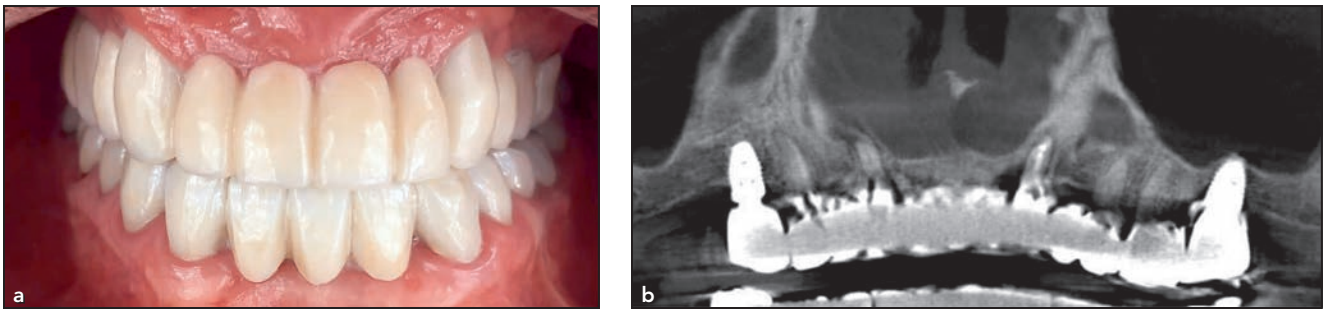

Fig 3 (a) *Initial patient clinical and* (b) *panoramic radiographic presentation with a failing maxillary long-span fixed prosthesis.*

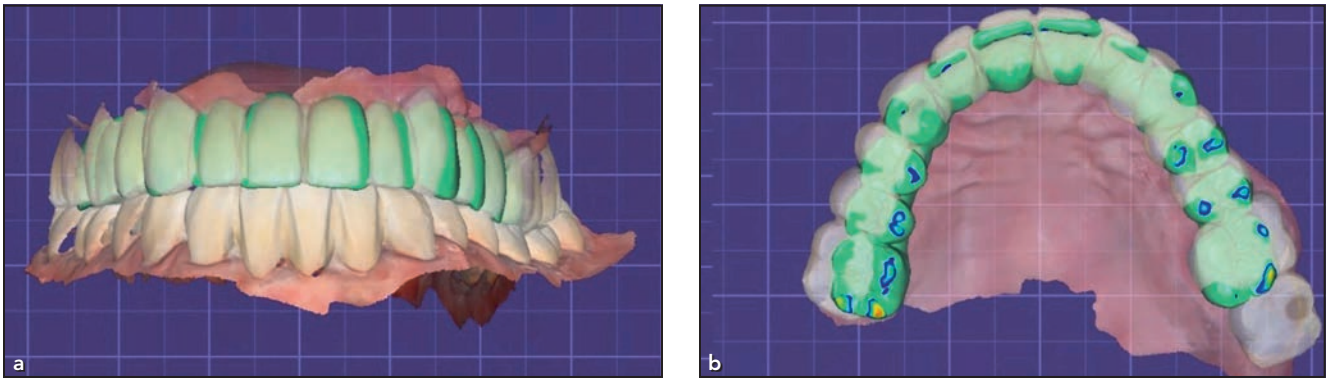

Fig 4 *Preoperative intraoral scan imported into Exocad software. Green highlighted areas illustrate the temporary design scan overlaying the original scan.*

traditional impression of the gingiva or by capture with an intraoral scanner. Imetric 4D software then allows the user to transform the captured implant positions into the coordinate system of the gingiva using ICamRefs. This information is then exported into a design software, such as Exocad, which was used in the present case.

To maintain a constant reference point between the temporary design and mouth, one of two strategies can be utilized. One approach involves keeping two or three teeth until the end of the procedure, which can be subsequently extracted once the implant positions have been confirmed. The other strategy involves placing constant reference points (such as palatal screws) at the start of the procedure, subsequently scanning them or recording them through physical impression. By maintaining a constant reference point, the clinician can refer to the temporary design in Exocad without losing reference of the orientation.

Same-Day Provisional Restoration Case

A 72-year-old healthy woman (Fig 3a) presented to the first author's (M.B.) private practice with a failing maxillary long-span partial denture (Fig 3b). After discussing the available options, a provisional restoration solution using implants was offered and accepted by the patient. Diagnostic records included smiling photos, intraoral scans (Medit i500, Medit), and CBCT scans (CS 8100 3D, Carestream) were taken, and temporary designs in Exocad were printed on the same day of surgery using temporary resin (Freeprint Temp, Detax) on a MAX printer (Asiga) (Fig 4).

Grand Morse implants (Neodent) were placed in a free-handed fashion based on the surgical plan designed in coDiagnostiX software (Dental Wings; Fig 5); in this case, the presence of artifacts from the existing metallic partial denture would

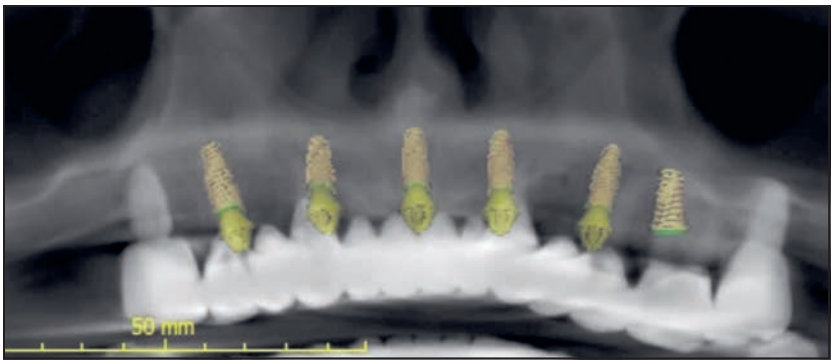

Fig 5 *Virtual surgical planning in coDiagnostiX software for the planned implant positions relative to the present anatomy.*

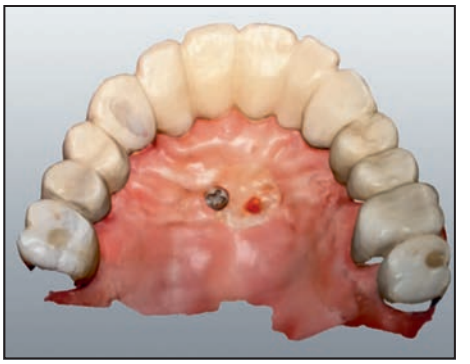

Fig 6 *Intraoral scan of the patient with pretreatment presentation. A palatal reference screw and the two posterior molars were used as reference points prior to initiating the surgical procedure.*

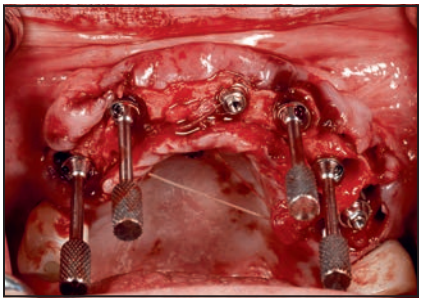

Fig 7 *After implant placement, MUAs were inserted on each implant to achieve parallelism and have a base to fix the temporary screw-retained prosthesis.*

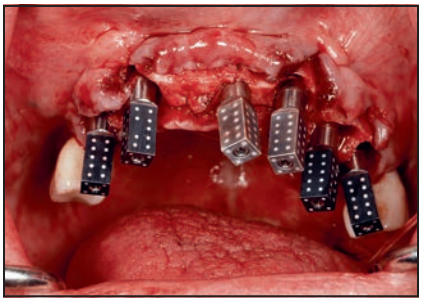

Fig 8 *ICamBodies were attached to the MUAs intraorally in preparation for scanning.*

have made it difficult to merge the DICOM (Digital Imaging and Communications in Medicine) data for a fully guided approach. A palatal screw and bilateral second molar implant crowns were used to maintain the orientation of the design relative to the temporary partial denture design prior to surgical implant placement (Fig 6). Once the anterior teeth were extracted, tenting screws helped orient the ridge to the preoperative condition in the design software. This is a crucial step in aligning the implant positions with the suggested temporary design created prior to surgery. The implants achieved a minimum insertion torque of 35 Ncm each, allowing for placement of the MUA (Fig 7). ICamBodies were attached to the MUAs intraorally in preparation for scanning for Imetric 4D records (Fig 8).

Once the Imetric 4D records were captured (Fig 9), the palatal screw could be removed while waiting for the printing and design processes to be completed (Fig 10). Once printing was complete, the temporary partial restoration was detached from the stacks and polished (Fig 11), then inserted intraorally (Fig 12). Screws were placed and tightened by hand, and the occlusion was checked and adjusted as needed.

Two months elapsed to allow osseointegration to occur, and then the final prosthesis records were completed by capturing any soft tissue changes underneath the temporary restoration and confirming implant osseointegration. One implant in the maxillary molar area did not osseointegrate and was subsequently removed prior to fabrication of the final monolithic zirconia partial denture. Because the verified implant positions were captured at the surgical appointment, a final Imetric 4D record was taken to include the single maxillary second molar implant crown in the second quadrant, where an MUA was placed instead. Figure 13 shows the final monolithic zirconia partial denture in place, and Fig 14 shows the panoramic radiographic view.

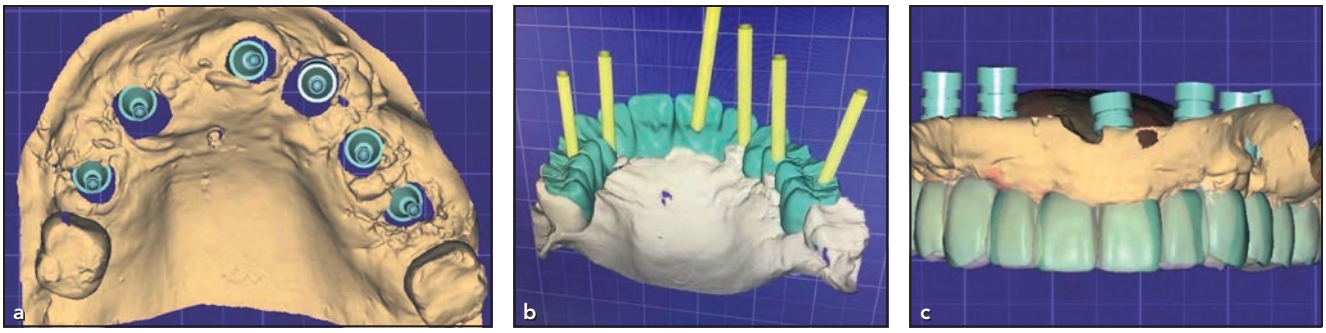

Fig 9 *The Exocad design shows the captured implant positions on the MUAs. The green area highlights the temporary prosthesis design with positions for screw access holes.*

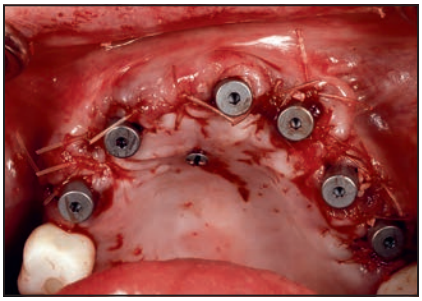

Fig 10 *ICamRefs healing abutments were placed prior to taking a soft tissue impression.*

Fig 11 *The final printed temporary prosthesis, after removing the supports and polishing, is ready for intraoral placement.*

Fig 12 *The printed maxillary immediate temporary prosthesis was intraorally placed.*

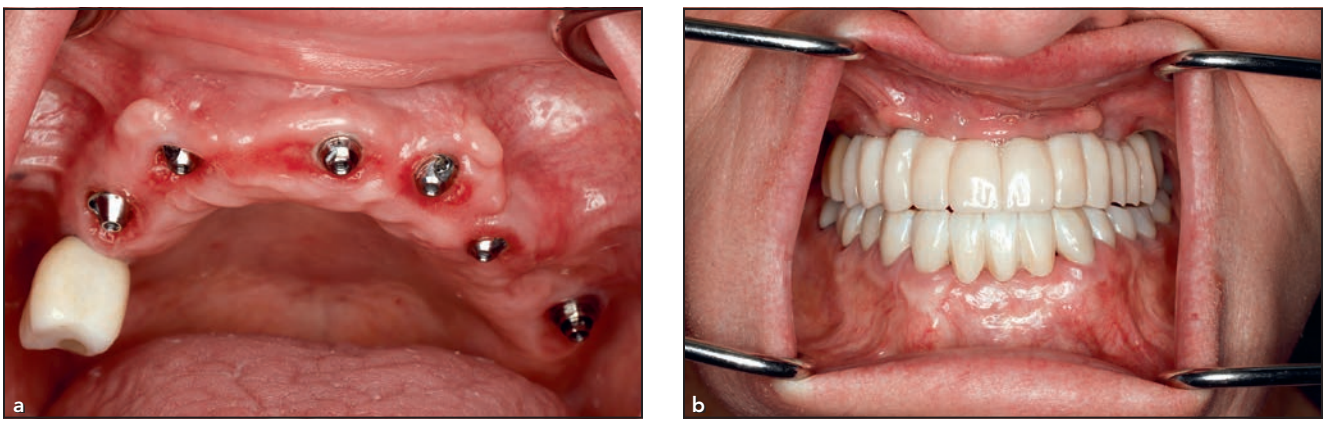

Fig 13 *Clinical view of the soft tissues* (a) *prior to placing the final monolithic zirconia partial denture and* (b) *after restoration placement.*

Discussion

The ability to provide a tension-free (passive) connection between the implants and the prosthetic structure is critical for long-term success.[14] This can be achieved only by ensuring a passive fit by minimizing inherent margins of error while eliminating any stress on the individual implants when connecting them with the temporary prosthesis.

Photographs and video scanners share some of the advantages of photogrammetry. Scanners generate 3D images by stitching multiple images together using a best-fit algorithm. However, the reliability

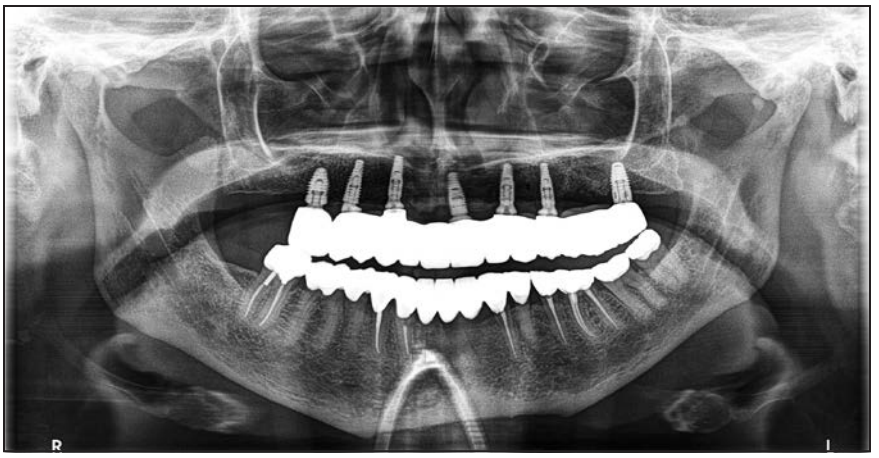

Fig 14 *Panoramic radiographic view of the final prosthesis after intraoral placement.*

diminishes as the number of implants involved increases, which increases the number of images stitched together. In contrast with intraoral scanners, photogrammetry generates direct vectors of the exact position of the implants in relation to one another. This information makes it possible to calculate the implant positions without superimposing photos. Therefore, the accuracy is increased, and potential errors are eliminated.

The clinical evaluation of passivity between the implants and the prosthetic components is challenging. The Sheffield test has been shown to be an efficient clinical test of passive fit, especially in cases with multiple implants.[15] The screw-resistance test has the disadvantage of introducing subjectivity into the evaluation but is considered a precise way of detecting discrepancies.

In the present case, the Imetric 4D workflow allows for the same-day delivery of a temporary prosthesis without the need for a verification jig or corrected cast. This saves both the clinician and patient a number of appointments, shortens the overall treatment time, and ensures that a passive fit is achieved on the final prosthetic restoration.

Registering the implant positions with the Imetric 4D workflow improves patient comfort in comparison with conventional impression techniques. By eliminating physical impression materials, the practitioner can avoid patient nausea and discomfort, which is also a critical issue in those with a strong gag reflex.

Conclusions

The clinical application of a novel photogrammetry system for registering multiple implant positions at the time of surgery allows for patient rehabilitation using the same-day delivery of a printed prosthesis. As the cost of digital dentistry becomes more accessible for clinicians, more patients can be treated with fewer clinical visits and better accuracy. Future trends include improving the material strength of the printed provisional restorations to allow for a longer temporization period, if needed.

Acknowledgments

The authors declare no conflicts of interest.

References

1. Kurella KS, Thiyaneswaran N, Abhinav RP. Comparison of accuracy/dimensional stability of high-rigid vinyl polysiloxane, polyvinyl siloxane, and polyether impression materials in full arch implant-supported prosthesis: In vitro study. J Long Term Eff Med Implants 2020;30:179–186.
2. Griseto NT, Gallucci GO. Digital maxillomandibular relationship registration for an edentulous maxilla: A dental technique. J Prosthet Dent 2021;125: 858–861.
3. Giménez B, Özcan M, Martínez-Rus F, Pradíes G. Accuracy of a digital impression system based on active triangulation technology with blue light for implants: Effect of clinically relevant parameters. Implant Dent 2015;24: 498–504.
4. Ciocca L, Meneghello R, Monaco C, et al. In vitro assessment of the accuracy of digital impressions prepared using a single system for full-arch restorations on implants. Int J Comput Assist Radiol Surg 2018;13:1097–1108.
5. Zhang YJ, Qiao SC, Qian SJ, Zhang CN, Shi JY, Lai HC. Influence of different factors on the accuracy of digital impressions of multiple implants: An in vitro study. Int J Oral Maxillofac Implants 2021;36:442–449.
6. Andriessen FS, Rijkens DR, van der Meer WJ, Wismeijer DW. Applicability and accuracy of an intraoral scanner for scanning multiple implants in edentulous mandibles: A pilot study. J Prosthet Dent 2014;111:186–194.
7. Camcı H, Salmanpour F. Effect of saliva isolation and intraoral light levels on performance of intraoral scanners. Am J Orthod Dentofacial Orthop 2020;158:759–766.

8. Chen Y, Zhai Z, Li H, et al. Influence of liquid on the tooth surface on the accuracy of intraoral scanners: An in vitro study. J Prosthodont 2022;31:59–64.
9. Silverstein LH, Kurtzman GM, Schneider A, Shatz PC. The utilization of a preprosthetic extraoral verification stent for dental implant-supported reconstructions. Dent Today 2002;21:88–91.
10. Schneider A, Kurtzman GM, Silverstein LH. Improving implant framework passive fit and accuracy through the use of verification stents and casts. J Dent Technol 2001;18:23–25.
11. Sánchez-Monescillo A, Hernanz-Martín J, González-Serrano C, González-Serrano J, Duarte S Jr. All-on-four rehabilitation using photogrammetric impression technique. Quintessence Int 2019;50:288–293.
12. Lee H, Fehmer V, Hicklin S, Noh G, Hong SJ, Sailer I. Three-dimensional evaluation of peri-implant soft tissue when tapered implants are placed: Pilot study with implants placed immediately or early following tooth extraction. Int J Oral Maxillofac Implants 2020;35:1037–1044.
13. Molinero-Mourelle P, Lam W, Cascos-Sánchez R, Azevedo L, Gómez-Polo M. Photogrammetric and intraoral digital impression technique for the rehabilitation of multiple unfavorably positioned dental implants: A clinical report. J Oral Implantol 2019;45:398–402.
14. Yannikakis S, Prombonas A. Improving the fit of implant prosthetics: An in vitro study. Int J Oral Maxillofac Implants 2013;28:126–134.
15. Figueras-Alvarez O, Cantó-Navés O, Real-Voltas F, Roig M. Protocol for the clinical assessment of passive fit for multiple implant-supported prostheses: A dental technique. J Prosthet Dent J 2021;126:727–730.