All-on-Four Case Rehabilitated with Fully Digitally Fabricated Prosthesis Milled from Graphene-Reinforced Poly Methyl Methacrylate Puck Using Indigenously Developed Intraoral and Extraoral Scanning Methods

Abstract

Digital dentistry is disruptive to conventional methods for performing prosthetic rehabilitation. Fabrication of prosthesis for all-on-four implants involves multiple steps when done conventionally and is prone to error. The use of digital technologies such as intraoral scanners (IOS) and extraoral scanners can marginalize these errors and also reduce the chairside time. This clinical report outlined a method which used a conjunction of extraoral and IOS to collect data for implant position, soft tissue profile, and vertical and centric relations. These data were then combined and used to fabricate a hybrid denture for the patient. The hybrid denture was milled from graphene-reinforced poly methyl methacrylate puck which provided the advantages of monobloc prosthesis and the material advantages of graphene. The entire prosthetic rehabilitation was completed within three appointments.

Keywords: *Computer-aided design-computer-aided manufacturing, digital dentistry, extraoral scanners, graphene-reinforced poly methyl methacrylate, hybrid denture, intraoral scanners, monobloc prosthesis*

Anil Goud Maddikunta, Siddharth Vaish

Department of Prosthodontics and Crown and Bridge, Nanded Rural Dental College and Research Centre, Nanded, Maharashtra, India

Introduction

Digital technologies in dentistry eliminate the use of conventional impression methods and substitute many other procedures such as shade selection,[1] smile designing, wax mock-ups,[2] jaw relations, and prosthesis fabrication. Reductions in human efforts, improved precision, reduced chairside time, less wastage of resources, and predictable outcomes are the reasons why digitalization in dentistry has gained tremendous success in the past few years. The current clinical report describes a combination of few such technologies that reduced the conventional eight-step implant full-mouth rehabilitation to just a simple three-step procedure without subjecting the patient to cumbersome open-tray impression, strenuous jaw-relation exercises, and frequent trial appointments.

Case Report

Diagnosis, planning, and surgical phase

A 76-year-old male patient reported to the outpatient department with a chief complaint of ill-fitting maxillary denture. On examination, it was found that the patient was a single-denture wearer for 8 months [Figure 1a and b]. The patient started to experience frequent dislodgement of the maxillary denture about 3–4 weeks ago and tried to self-alleviate the situation using denture adhesive, which did not work. The mandibular arch was rehabilitated with fixed dental prosthesis. The vertical relation of the denture was well preserved. After counseling of the patient and explaining to him regarding all the options available, the patient agreed for an all-on-four implant therapy[3] followed by implant-supported hybrid denture for the maxillary arch.[4] The patient was not having significant bone in the maxillary posterior region beyond the second premolar but had a good amount of bone in the anterior region which made it a perfect case for all-on-4 protocol.[3] The patient's informed consent for the treatment was obtained. The positions for implants and dimensions of the implants to be placed were determined on implant planning software BlueSkyBio plan [Figure 2].

Visit 1

The surgical procedures were performed under local anesthesia with lignocaine with adrenaline 1:80,000. Dental implants

How to cite this article: Maddikunta AG, Vaish S. All-on-four case rehabilitated with fully digitally fabricated prosthesis milled from graphene-reinforced poly methyl methacrylate puck using indigenously developed intraoral and extraoral scanning methods. Contemp Clin Dent 2023;14:171-5.

Submitted : 20-Apr-2022
Revised : 13-Feb-2023
Accepted : 24-Feb-2023
Published : 30-Jun-2023

Address for correspondence:
Dr. Anil Goud Maddikunta, Kosmo Dental Academy, Kothapet, Hyderabad, Telangana, India.
E-mail: drgoudanil@gmail.com

Access this article online
Website: https://journals.lww.com/cocd
DOI: 10.4103/ccd.ccd_249_22
Quick Response Code:

(Noris Medical-Dental Implant Solutions, Israel) of dimensions (3.75 mm in diameter and length 13 mm) were placed in the anterior maxilla in the canine and premolar region on the left and right sides with flapless free-hand implant surgery protocol [Figure 3].[5] Postoperative antibiotics (Augmentin Duo, Glaxosmithkline Pharma, Bangalore, India) twice daily for 5 days, analgesics (Zerodol SP, Ipca Laboratories Ltd, Mumbai, India) twice daily for 5 days, and antacid medication (Pantosec D, Cipla GX, Himachal Pradesh, India) once daily for 5 days were prescribed.

Primary stability of 45 Ncm reverse torque was obtained with each implant. Multi-unit abutments were placed at 8° and 30° to compensate for tilt of the implants, and to obtain parallelism [Figure 4]. Flapless approach provided the advantage of minimal bleeding, and a completely healthy ridge with multi-unit abutments enabled us to take immediate intraoral scan. An intraoral scanner (IOS) (3Di IOS Intraoral Scanner, Castellini, Italy) was used to record the soft tissue profile of the ridge along with scan bodies (ARUM SCAN BODIES) attached to the multi-unit

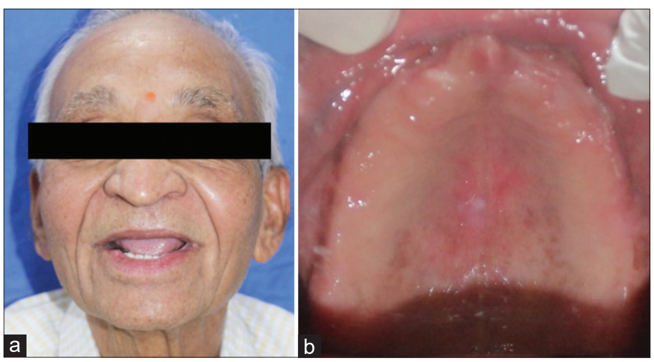

Figure 1: (a) Preoperative extraoral. (b) Maxillary arch

abutments [Figure 5a and b]. This determined the position, angulation, and gingival profile of the multi-unit abutments.

To determine the exact position of the implant, an extraoral photogrammetric scan was taken using iCam4D (Imetric 4D Imaging, Switzerland). The scanner was first oriented to the reference points. The scan bodies were replaced by specialized iCamBodies [Figure 6a], and the extraoral scanning was performed [Figure 6b].

The previous denture was then adjusted over temporary cylinders and temporized using bis-acryl composite resin (Cooltemp Natural, Coltene Whaledent, Switzerland). Occlusal adjustments were done to get complete intercuspation [Figure 7].[6] After temporization, surface scan of the denture along with the occlusal surface was taken with IOS.

As the centric and vertical jaw relations of the temporized dentures were clinically satisfactory, they were virtually duplicated in the new denture. Extraoral photographs were taken to ascertain the high lip line and smile line of the patient.

Visit 2

The patient recalled after 2 days for trial prosthesis.

The scanned data were merged and a virtual full-arch prosthesis was designed according to the external surface scan of the denture and implant position scans. A trial denture of poly methyl methacrylate (PMMA) disc was milled from this design which was used to verify the jaw relation and teeth position. Ti bases were luted to this prosthesis with dual-cure composite cement (Variolink N Ivoclar Vivadent, Switzerland). The trial prosthesis was fixed on the multi-unit abutments. A one-screw test was performed to check the passivity of the prosthesis.[7] All the interceptive contacts were

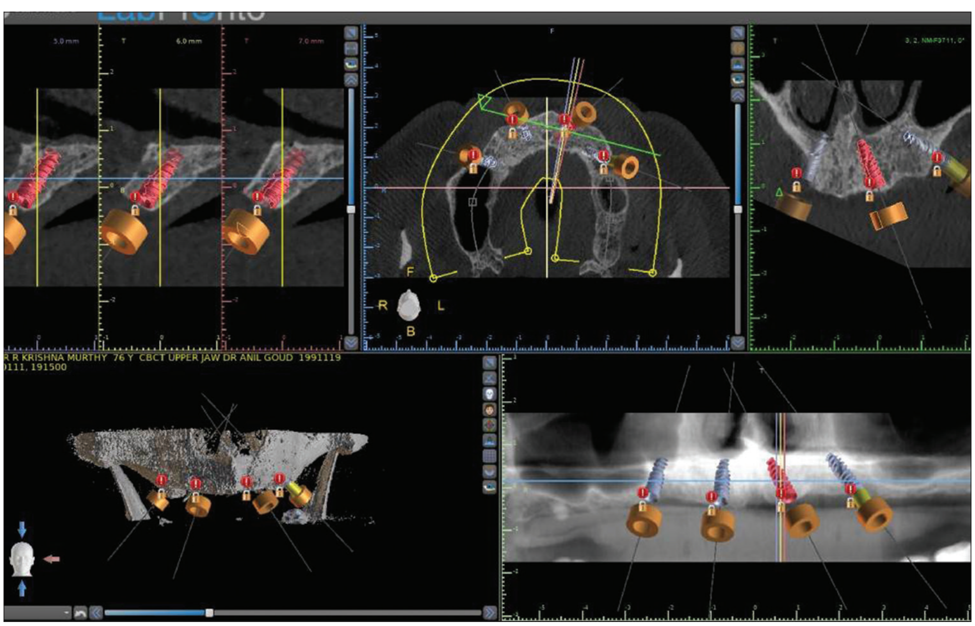

Figure 2: Implant planning

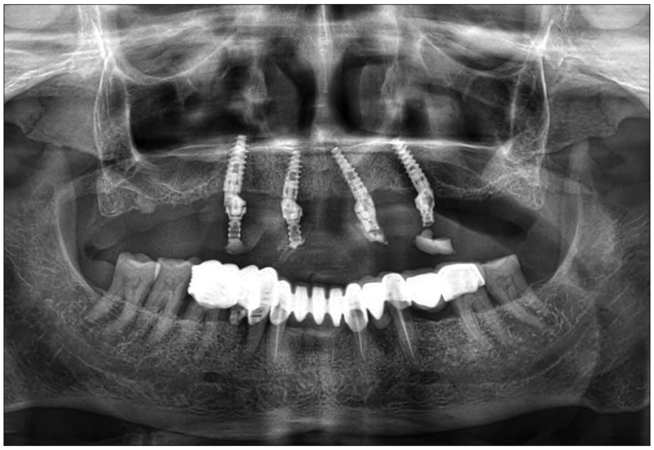
Figure 3: Postoperative OPG. OPG: Orthopantomogram


Figure 4: Multi-unit abutments

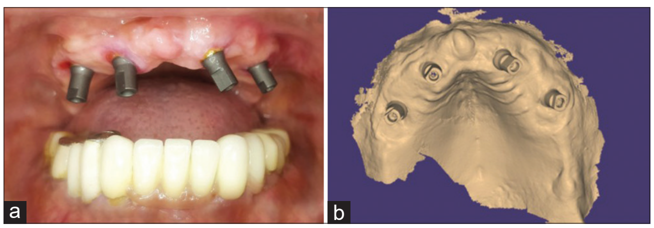

Figure 5: (a) Scan bodies. (b) Intraoral digital impression

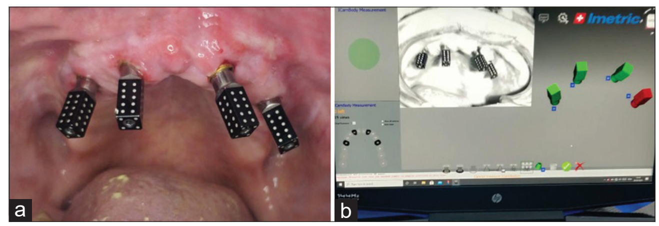

Figure 6: (a) iCam bodies. (b) Photogrammetric recognition of specialized bodies

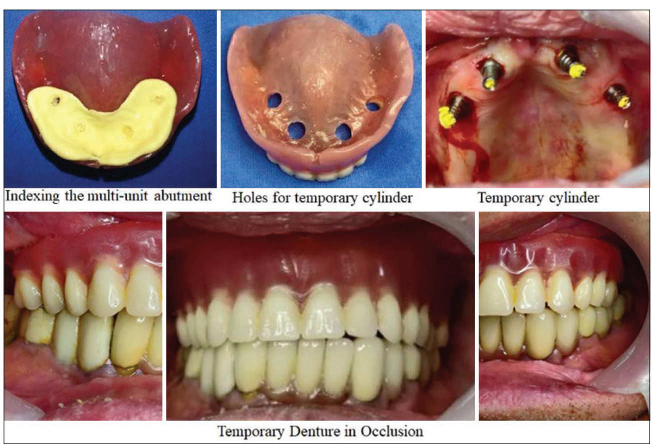

Figure 7: Immediate temporization

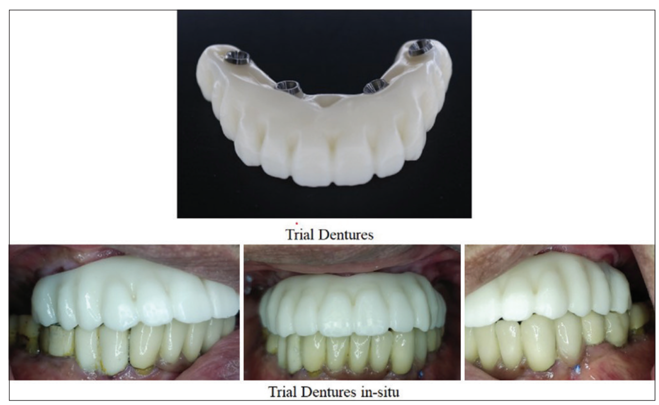

Figure 8: Trial PMMA denture. PMMA: Poly methyl methacrylate

adjusted [Figure 8]. The patient was then asked to use this prosthesis for 1 week to check for comfort and masticatory efficiency. After confirming patient comfort and satisfaction, the datasets were put to use to fabricate a permanent prosthesis which was milled from a graphene-reinforced PMMA resin puck (G CAM Disc, Graphenano, Neodental Technologies, Hyderabad) and characterized using gingival and tooth-colored composite stains (Visio.Lign Stain Kit, Bredent, Germany). Ti bases were luted to the permanent prosthesis with dual-cure composite cement (Variolink N Ivoclar Vivadent, Switzerland).

Visit 3

The provisional prosthesis was replaced with the permanent prosthesis after 1 week. The prosthesis was tightened in place and inspected for proper phonetics, seal at the intaglio surface, and interceptive occlusal contacts [Figure 9a]. After optimal adjustment, the prosthesis was finally tightened in place with a torque value of 15 Ncm. Postoperative and denture hygiene instructions were given to the patient. The patient was recalled for a 2-month elective follow-up; the patient continues to use his denture without any difficulty in function and is satisfied with the esthetics [Figure 9b].

Discussion

The digital revolution is rapidly changing the world of dentistry, especially in the field of prosthodontics. Cutting-edge technology and the progress in artificial intelligence (AI) have provided us with software which can do multitudes of work that were done conventionally in the lab. These software do an excellent job of auto-merging occlusal datasets, STL datasets of scans, designing the tooth, and assessing the position and magnitude of contact points.

The introduction of IOS has allowed dentists to acquire data directly from the mouth without the need for a conventional impression material and technique. Especially in cases of Implants, where making an impression is very difficult.[8,9] Making digital impressions for 4–5 teeth in one quadrant is very promising when compared to full-mouth impressions.[9] When assessing the precision of digital impressions in case of fully edentulous arches which are rehabilitated with implant-supported prosthesis, it has been noted that the accuracy depends on factors such as the number of implants, space between implants, and the depth at which the implants are placed. The impressions are more accurate when the implants are placed close to each other and are more in number.[8] The visible portion of the scan body and the platform it is supported upon need to be well exposed for better recording of the impression.[10] The recording of vertical and centric relations using scanners is one of the main challenges in adopting a complete digital workflow. Another problem of the IOS currently used in clinics is the precision loss that is produced by the so-called “overlapping,” which is a scanning alignment through common areas.[11] To counter this problem, we have incorporated extraoral scan to aid in orientation and accurate registration of implant position. The intraoral scanning was thus used to capture the soft tissue data and implant position with the help of scan bodies. The extraoral scanner (iCam4D, Imetric 4D Imaging, Switzerland) works on the principle of photogrammetry; it captures the implant position and its orientation in three-dimension with the help of specialized scan bodies;[12] however, these scanners are not equipped for recording the soft tissue and hard tissue simultaneously.[13,14] The merged data sets of the two scans give a very precise and accurate digital impression of the multi-unit platform and the soft tissue.[12-14]

The vertical and centric relations of the existing dentures were clinically satisfactory and were to be duplicated in the definitive prosthesis. The external form of the denture *in situ* was recorded using IOS to obtain datasets for centric and vertical relations.[12,15] The occlusal and cameo surface was recorded which allows the software to suggest the accurate shape and size of each tooth along with its relation to the antagonist.[12,13,15]

The options of material for milling the prosthesis ranged from Polyether ether ketone (PEEK) to zirconia.[16] To avoid interfaces, differences of modulus of elasticity, separate framework trial, and additional appointments, a monolithic prosthesis was milled from graphene-reinforced PMMA. Any metallic or zirconia implant prosthesis opposing metal-ceramic prosthesis will have a lot of impact force which may result in high impulse loading on the implant and supporting bone.[17] With modulus of elasticity 3200 ± 7% MPa and bending strength: >140 ± 7% MPa of graphene, prosthesis makes it a more natural choice for this case.[18-20] The monolith option also reduces the number of interfaces and increases strength.[21]

G Cam Disc is a biopolymer of graphene in a millable disc form. Graphene polymer has very high flexural strength, high esthetics, and high superficial abrasion resistance.[18-20] The polymerization of PMMA triggers an exothermic chemical reaction, which is improved by graphene owing to its excellent heat conduction property. Complete polymerization eliminates drawbacks like polymerization shrinkage and improves its stability.[18] These properties make this material an ideal option for implant prosthesis in monolithic form.

The technique described in the article did not utilize any impression material or models, which would have inevitably contributed to dimensional changes, rather a streamlined process which gave precision to the prosthesis [Figure 10].

Limitations and future prospects

As the material is new to the market, it needs more long-term studies and evidence-based trials. Digital evolution, especially AI, is changing rapidly. In the near future, we may see more advanced IOS which may capture full-arch data without any error, and thus eliminate the use of external scanner.

Conclusion

The novel workflow is a proof of concept that dentures can be made fully digitally with the choice of superior materials

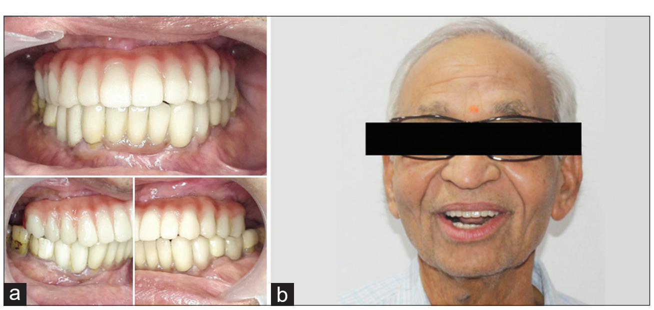

Figure 9: (a) Final prosthesis. (b) Postoperative extraoral

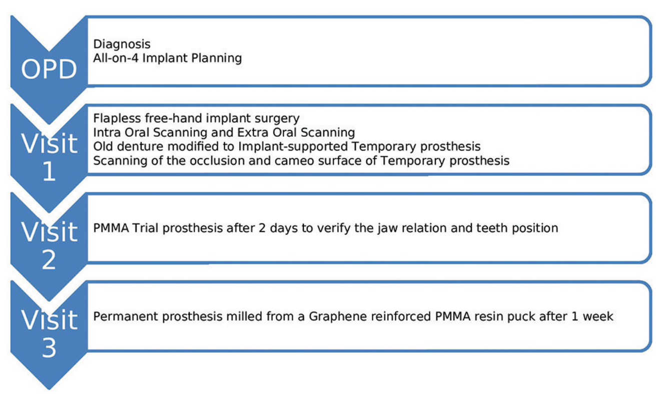

Figure 10: Visit sequence and workflow

and reduced chair time. It gives ease of patient management and also does not cause the patient any discomfort.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understand that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Kim M, Kim B, Park B, Lee M, Won Y, Kim CY, *et al*. A digital shade-matching device for dental color determination using the support vector machine algorithm. Sensors (Basel) 2018;18:3051.
2. Jafri Z, Ahmad N, Sawai M, Sultan N, Bhardwaj A. Digital Smile Design – An innovative tool in aesthetic dentistry. J Oral Biol Craniofac Res 2020;10:194-8.
3. Maló P, Rangert B, Nobre M. All-on-4 immediate-function concept with Brånemark System implants for completely edentulous maxillae: A 1-year retrospective clinical study. Clin Implant Dent Relat Res 2005;7 Suppl 1:S88-94.
4. Implant Treatment Planning for Hybrid Prostheses. Decisions in Dentistry; June, 2020. Available from: https://decisionsindentistry.com/article/implant-treatment-planning-hybrid-prostheses/. [Last accessed on 2022 Apr 20].
5. Becker W, Goldstein M, Becker BE, Sennerby L. Minimally invasive flapless implant surgery: A prospective multicenter study. Clin Implant Dent Relat Res 2005;7 Suppl 1:S21-7.
6. Full Arch Rehabilitation All-on-4™ Technique Restorative Steps; 2017. Available from: https://adldental.com/wp-content/uploads/2017/12/All-on-4-Restorative-Steps-Recipe-Book.pdf. [Last accessed on 2022 Apr 20].
7. Kan JY, Rungcharassaeng K, Bohsali K, Goodacre CJ, Lang BR. Clinical methods for evaluating implant framework fit. J Prosthet Dent 1999;81:7-13.
8. Rutkūnas V, Gečiauskaitė A, Jegelevičius D, Vaitiekūnas M. Accuracy of digital implant impressions with intraoral scanners. A systematic review. Eur J Oral Implantol 2017;10 Suppl 1:101-20.
9. Ender A, Mehl A. Accuracy of complete-arch dental impressions: A new method of measuring trueness and precision. J Prosthet Dent 2013;109:121-8.
10. Michelinakis G, Nikolidakis D. Using the surgical guide for impression-free digital bite registration in the edentulous maxilla-a technical note. Int J Implant Dent 2019;5:19.
11. Romero L, Jiménez M, Espinosa Mdel M, Domínguez M. New design for rapid prototyping of digital master casts for multiple dental implant restorations. PLoS One 2015;10:e0145253.
12. Converting to the Imetric System: All-Digital, Model-Free Hybrids. Dental Economics; 2019. Available from: https://www.dentaleconomics.com/science-tech/intraoral-scanning-and-photography/article/14068199/converting-to-the-imetric-system-alldigital-modelfree-hybrids. [Last accessed on 2021 May 08].
13. Papaspyridakos P, Rajput N, Kudara Y, Weber HP. Digital workflow for fixed implant rehabilitation of an extremely atrophic edentulous mandible in three appointments. J Esthet Restor Dent 2017;29:178-88.
14. Tordiglione L, De Franco M, Bosetti G. The prosthetic workflow in the digital era. Int J Dent 2016;2016:9823025.
15. Radu M, Radu D, Abboud M. Digital recording of a conventionally determined centric relation: A technique using an intraoral scanner. J Prosthet Dent 2020;123:228-31.
16. Alan Jurim BJ. Millable materials for the modern laboratory. Inside Dent Technol 2017;8:1-5 Available from: https://www.aegisdentalnetwork.com/idt//05/millablematerials-forthe-modern-laboratory. [Last accessed on 2022 Apr 20].
17. Skalak R. Biomechanical considerations in osseointegrated prostheses. J Prosthet Dent 1983;49:843-8.
18. Bacali C, Constantiniuc M, Moldovan M, Nastase V, Badea M, Constantin A. Reinforcement of PMMA denture base resins: From Macro to Nano Scale. International Journal of Medical Dentistry 2019;23:5:374-8.
19. Paz E, Forriol F, Del Real JC, Dunne N. Graphene oxide versus graphene for optimisation of PMMA bone cement for orthopaedic applications. Mater Sci Eng C Mater Biol Appl 2017;77:1003-11.
20. Hamedi-Rad F, Ghaffari T, Rezaii F, Ramazani A. Effect of nanosilver on thermal and mechanical properties of acrylic base complete dentures. J Dent (Tehran) 2014;11:495-505.
21. Fahl N Jr., McLaren EA, Margeas RC. Monolithic vs. layered restorations: Considerations for achieving the optimum result. Compend Contin Educ Dent 2014;35:78-9.