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DENTAL TECHNIQUE

Fully digital fabrication of an occlusal device using an intraoral scanner and 3D printing: A dental technique

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ABSTRACT

This dental technique describes a fully digital method for fabricating occlusal devices using a complete-arch intraoral scan and 3D printing. The maxillary and mandibular arches of a healthy, fully dentate volunteer were digitized using an intraoral scanner. A second scan and modified recording of the centric relation enabled a virtual arrangement of the maxillary and mandibular arches, both in centric relation and in the desired vertical dimension of occlusion. An occlusal device was subsequently designed virtually and fabricated from a light-polymerizing acrylic resin using a 3D printer. The occlusal device was tested for fit, occlusion, and patient-friendly handling. As only minor occlusal corrections were required, the fully digital procedure described is suitable for the fabrication of occlusal devices. (J Prosthet Dent 2019;121:576-80)

Occlusal appliances are commonly used to treat temporomandibular disorders and bruxism. One of the most common types is the Michigan device that was designed half a century ago at the University of Michigan.[1]

Originally, all steps of device construction (impressions, cast fabrication, design, and finishing) were performed manually. The computer-aided design and computer-aided manufacturing (CAD-CAM) technology was initially used to optically scan gypsum casts and digitally design the occlusal device and to mill or print the virtually designed occlusal device.[2] Nevertheless, it is still necessary to send impressions to the dental laboratory and to deliver the occlusal device for dental practice. For both economic reasons and to avoid the need for disinfection, a fully digital procedure is preferable.[3,4] By using an intraoral optical scanning device to scan both the dental arches and then adjusting and registering the desired vertical dimension of an occlusion by means of an anterior jig, a completely digital procedure is possible.

This report outlines a proof of concept for a fully digital procedure, with adequate precision and effort, to fabricate a Michigan device.[5] A specific advantage of using 3D printing instead of milling is that stereolithography devices are becoming more reasonably priced and might soon be commonplace in dental practices.

TECHNIQUE

1. Use cheek retractors (OptraGate; Ivoclar Vivadent AG) to help keep the areas to be scanned dry. Remove saliva from the teeth and proximal spaces to minimize reflections (Fig. 1).
2. Perform the intraoral scan (CEREC Omnicam with Sirona Connect v4.4; Dentsply Sirona) without the use of a scan spray. Perform the complete-arch scan in accordance with the scanning procedure recommended by the manufacturer. Start with the occlusal surface of the distal tooth of the first quadrant. For the lingual surfaces, rotate the camera first 45 degrees lingually and scan the teeth first distally and then mesially to the lateral incisor. Then, rotate the camera another 45 degrees and guide distally along the lingual

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Figure 1. Intraoral view of maximum intercuspation. A, Right lateral view. B, Frontal view. C, Left lateral view.

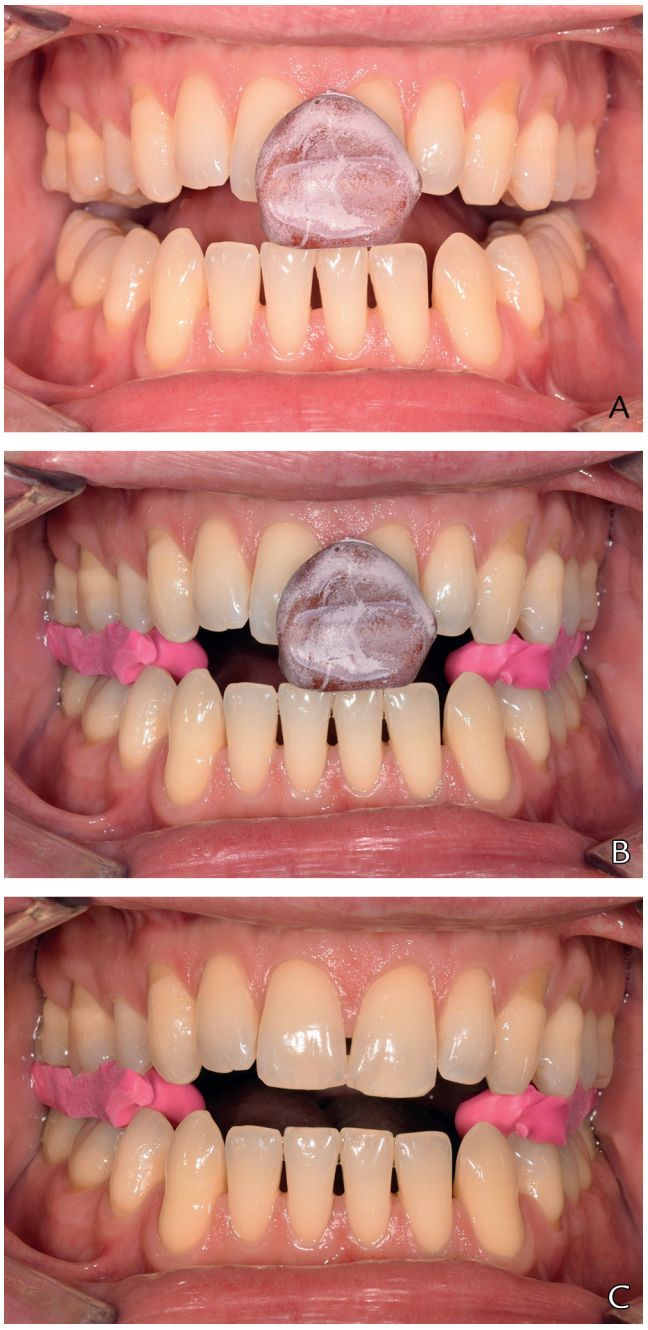

Figure 2. Intraoral view of inserted modified centric registration. A, Anterior jig in place. B, Mandible and maxilla stabilized by occlusal registration material. C, Mandible and maxilla prepared for digital scan.

surfaces of the teeth a second time. Then rotate the camera 90 degrees on the occlusal surface and scan the occlusal surfaces of the teeth to the lateral incisor. For the buccal surfaces, scan the teeth first at an angle of 45 degrees from mesial to distal and then at an angle of 90 degrees from distal to mesial. To complete the second quadrant, start the scanning procedure with the lingual surface of a premolar in the first quadrant that has already been scanned. Rotate the camera 90 degrees lingually and scan the teeth up to the distal tooth in the second quadrant. Scan the lingual surfaces twice: first at 90 degrees and then at 45 degrees to the occlusal surface. After scanning the buccal surfaces twice, first at 45 degrees and then at 90 degrees, scan the occlusal surface up to the most distal molar.

3. To record the centric relation and to digitally transfer it to the dental laboratory, use a modified method. Make a jig with an incisal plateau from modeling plastic impression compound (Impression Compound; Kerr

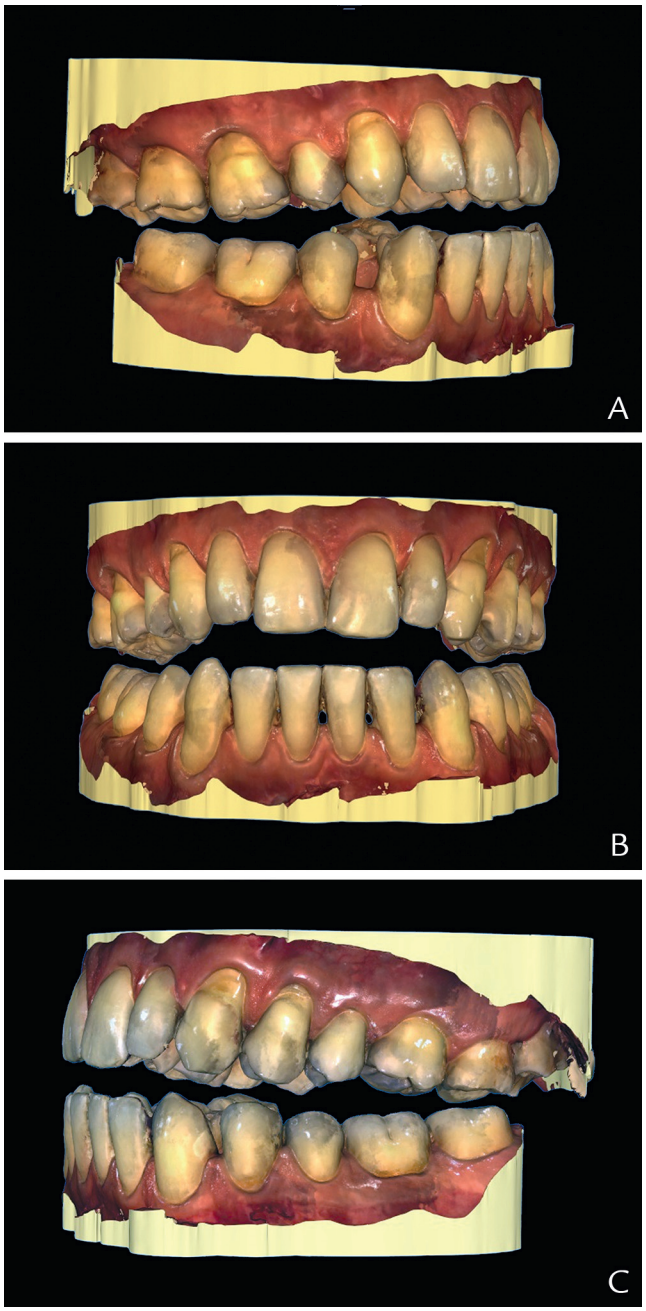

Figure 3. Images of scanned mandibular and maxillary arches. A, Right lateral view. B, Frontal view. C, Left lateral view.

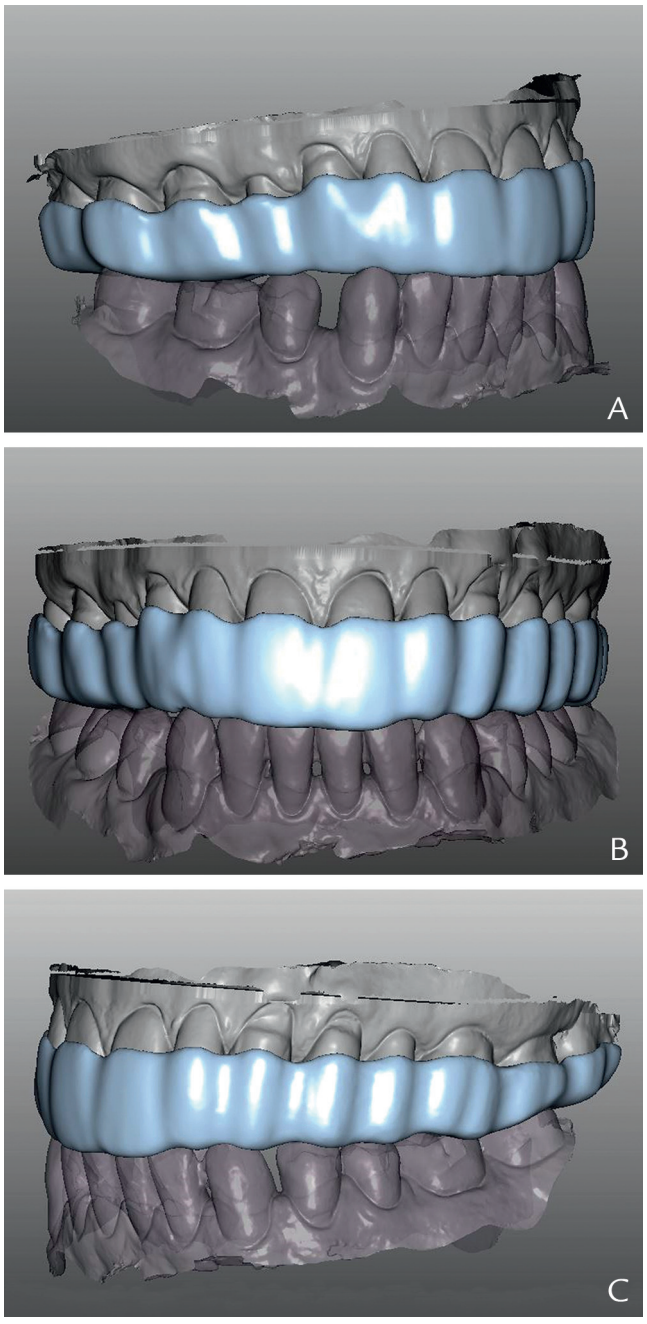

Figure 4. 3D view of device design. A, Right lateral view. B, Frontal view. C, Left lateral view.

Corp) and insert the jig between the central incisors. To measure centric relation as precisely as possible (by avoiding translational movement in the temporomandibular joint), adjust the jig with a scalpel to create a distance of no more than 2 mm between the maxillary and mandibular arches. To secure the jaw relation during the subsequent scanning procedure, stabilize the mandibular and maxillary arches using a fast-setting polyvinyl siloxane occlusal registration material (Futar D; Kettenbach GmbH & Co KG). Trim the occlusal registrations to the buccal cusp tips; this ensures the buccal tooth surfaces are recorded optically when performing the intraoral scan for the occlusal relation (Figs. 2, 3).

4. Download the scan data and design the occlusal device using a CAD software program (Zirkonzahn Modellier; Zirkonzahn Worldwide) (Fig. 4). Print the occlusal device using a 3D printer (Asiga Freeform Pro 2 UV385; Asiga). Finish and polish the occlusal device manually.

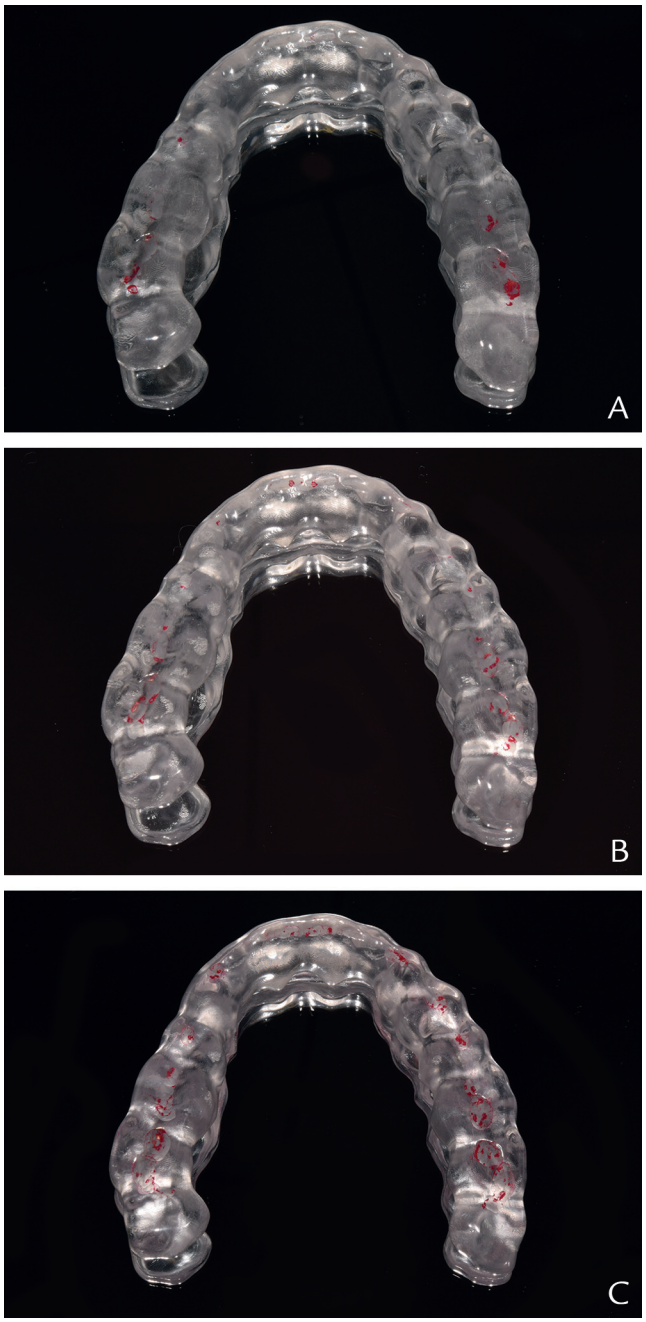

Figure 5. View of occlusion. A, Initial occlusion. B, Corrected occlusion. C, Definitive occlusion.

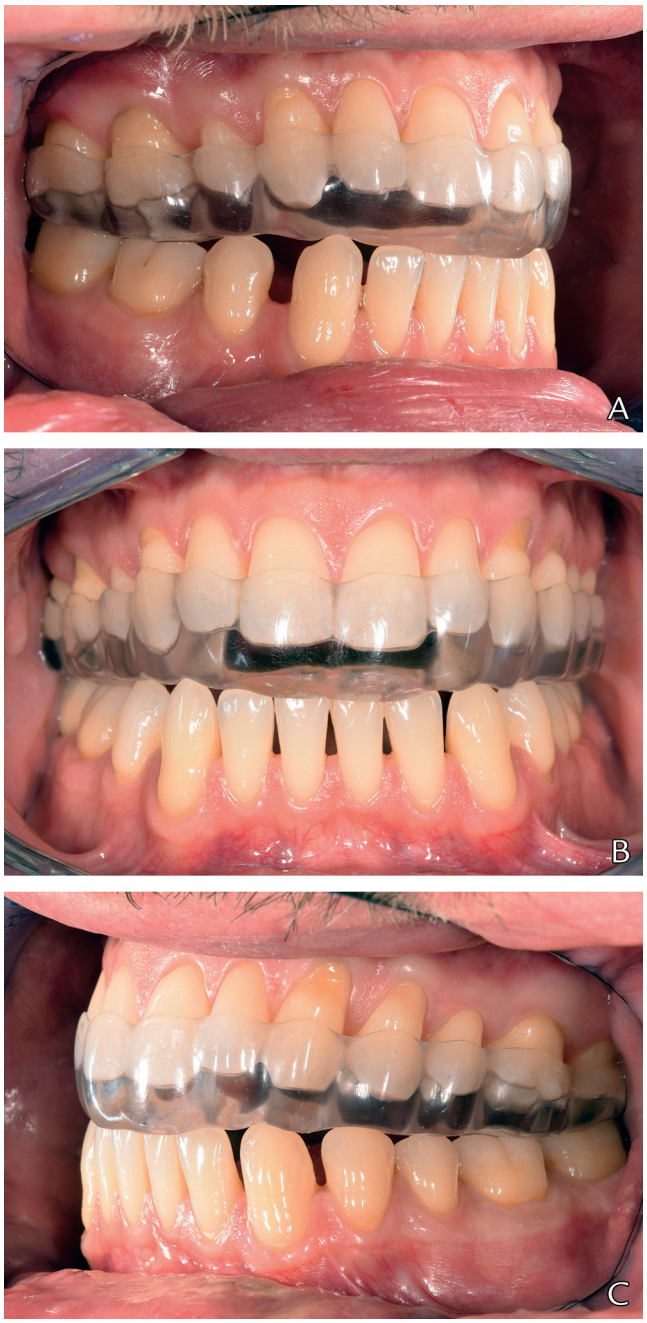

Figure 6. View of inserted occlusal device. A, Right lateral view. B, Frontal view. C, Left lateral view.

5. Clinically evaluate the quality of resin, anatomic design, positional stability and tension-free fit, and ease of insertion and removal by the patient. Evaluate the occlusion and refine it as necessary (Fig. 5).
6. Deliver the occlusal device (Fig. 6).

DISCUSSION

Patients prefer a digital scan to a conventional impression because they find it more convenient and experience less shortness of breath, less fear that the impression will have to be repeated, and a reduced feeling of helplessness during the procedure.[6-9] They also experience less overall discomfort, especially in the temporomandibular joint, less tooth and periodontal sensitivity, and a reduced gag reflex.[6,9,10] A disadvantage of complete-arch scanning, however, is the time required for the procedure. In contrast to a pure opposing jaw scan, with this technique, scanning took almost 20 minutes because the teeth and proximal spaces had to be scanned completely

for the occlusal device to fit correctly. The more detail with which the teeth have to be scanned, the longer time the scan takes, approximately 60 seconds per tooth.[11]

Although the accuracy of complete-arch scans is currently inferior to that of conventional impressions,[12,13] they are sufficiently accurate for the fabrication of an occlusal device. Correct occlusion was achieved with little effort. After 2 minor chairside corrections with a tungsten carbide bur, occlusal contact was achieved for all posterior teeth and anterior guidance. Digital buccal scan registration methods have been reported to be less error-prone than conventional methods and can be performed more easily and reliably to determine maximum intercuspation.[14] However, studies to evaluate the accuracy of occlusal devices fabricated from complete-arch scans are needed.

Compared with conventional device production, one of the biggest advantages of CAD-CAM is the ability to store and reproduce the devices. Because occlusal devices are subject to wear, this advantage is of economic benefit. For an occlusal device, the resin must be able to withstand the forces that occur in the oral cavity for a reasonable time. Studies have shown that 3D-printed resin has comparable or better wear resistance than milled or autopolymerizing resin.[15,16] Differences have been found between the morphology of wear areas. With a metal antagonist, cracks were observed in some 3D-printed devices, and the bonds between the layers were observed to have separated. For zirconia antagonists, the surface of wear areas appeared relatively smooth.[15] These defects could lead to a fracture of the resin; however, this needs to be investigated in clinical studies.

SUMMARY

This dental technique describes the fully digital manufacture of an occlusal device using an intraoral complete-arch scan. The occlusal device was manufactured using a 3D printer. This seems to be a successful method for fabricating occlusal devices. Studies are needed to investigate the quality and longevity of printed occlusal devices.

REFERENCES

1. Ramfjord SP, Ash MM. Reflections on the Michigan occlusal splint. J Oral Rehabil 1994;21:491-500.
2. Lauren M, McIntyre F. A new computer-assisted method for design and fabrication of occlusal splints. Am J Orthod Dentofacial Orthop 2008;133:S130-5.
3. van Noort R. The future of dental devices is digital. Dent Mater 2012;28:3-12.
4. van der Meer WJ, Vissink A, Ren Y. Full 3-dimensional digital workflow for multicomponent dental appliances: a proof of concept. J Am Dent Assoc 2016;147:288-91.
5. Atieh MA, Ritter AV, Ko CC, Duqum I. Accuracy evaluation of intraoral optical impressions: a clinical study using a reference appliance. J Prosthet Dent 2017;118:400-5.
6. Schepke U, Meijer HJ, Kerdijk W, Cune MS. Digital versus analog complete-arch impressions for single-unit premolar implant crowns: operating time and patient preference. J Prosthet Dent 2015;114:403-6.e1.
7. Sakornwimon N, Leevailoj C. Clinical marginal fit of zirconia crowns and patients' preferences for impression techniques using intraoral digital scanner versus polyvinyl siloxane material. J Prosthet Dent 2017;118:386-91.
8. Burhardt L, Livas C, Kerdijk W, van der Meer WJ, Ren Y. Treatment comfort, time perception, and preference for conventional and digital impression techniques: a comparative study in young patients. Am J Orthod Dentofacial Orthop 2016;150:261-7.
9. Wismeijer D, Mans R, van Genuchten M, Reijers HA. Patients' preferences when comparing analogue implant impressions using a polyether impression material versus digital impressions (Intraoral Scan) of dental implants. Clin Oral Implants Res 2014;25:1113-8.
10. Yuzbasioglu E, Kurt H, Turunc R, Bilir H. Comparison of digital and conventional impression techniques: evaluation of patients' perception, treatment comfort, effectiveness and clinical outcomes. BMC Oral Health 2014;14:10.
11. Gjelvold B, Chrcanovic BR, Korduner EK, Collin-Bagewitz I, Kisch J. Intraoral digital impression technique compared to conventional impression technique. A randomized clinical trial. J Prosthodont 2016;25:282-7.
12. Grunheid T, McCarthy SD, Larson BE. Clinical use of a direct chairside oral scanner: an assessment of accuracy, time, and patient acceptance. Am J Orthod Dentofacial Orthop 2014;146:673-82.
13. Kuhr F, Schmidt A, Rehmann P, Wostmann B. A new method for assessing the accuracy of full arch impressions in patients. J Dent 2016;55:68-74.
14. Zimmermann M, Ender A, Attin T, Mehl A. Accuracy of buccal scan procedures for the registration of habitual intercuspation. Oper Dent 2018;43:573-80.
15. Park JM, Ahn JS, Cha HS, Lee JH. Wear resistance of 3D printing resin material opposing zirconia and metal antagonists. Materials (Basel) 2018;11.
16. Reyes-Sevilla M, Kuijs RH, Werner A, Kleverlaan CJ, Lobbezoo F. Comparison of wear between occlusal splint materials and resin composite materials. J Oral Rehabil 2018;45:539-44.

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