Case Report
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Fully digital workflow protocol to increasing vertical dimension of occlusion of dentate patients

Abstract

There are no clear objective guidelines that determine the ideal increase in the vertical dimension of occlusion that can be physiologically accepted by the patient. The aim was to report a clinical protocol of four steps for the re-establishment of the vertical dimension of occlusion of a dentate patient with a complete digital workflow. Involving the dynamics of the CAD/CAM system with your three phases, the data acquisition through intraoral scanners, software for designing virtual and computerized manufacturing of the restoration, and subtractive and additive processes, the present clinical protocol represents an interesting and high efficiency alternative in the simplification and dynamization of the rehabilitation of re-establishment of the vertical dimension of occlusion of a dentate patient. As a benefit, there is a favor for the production of more accurate restorations with the demand of less clinical time and promotion of greater patient comfort.

Keywords: intraoral scanning, digital workflow, CAD/CAM, vertical dimension occlusion, digital dentistry.

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Alexandre Chaer Cruvinel,[1] Sicknan Soares da Rocha[2]

[1]MSc in Dentistry Prosthodontic, Private Practice, Brazil
[2]Associate Professor, School of Dentistry, Federal University of Goias, Brazil

Correspondence: Sicknan Soares da Rocha, School of Dentistry, Federal University of Goias, Department of Prevention and Oral Rehabilitation, 1ª Avenida esq. com Praça Universitária s/n, Setor Universitário, CEP 74605-220, Goiânia, GO, Brazil, Tel/Fax 55-62-3209-6325, Email sickna@ufg.br

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Introduction

Tooth wear can occur as a consequence of the masticatory function, which progressively leads to the reduction of cusps and incisal teeth. When the loss of tooth substance is physiological, the dentoalveolar compensatory mechanism occurs, which involves the over eruption of worn teeth.[1] On the other hand, when there is an early and generalized loss of crown height as a consequence of attrition, abrasion, erosion, tooth loss,[2] and dentoalveolar and skeletal anomalies,[3] there is a loss of vertical dimension of occlusion (VDO). Especially in the most severe cases, the re-establishment of anatomical harmony of the teeth is essential for adequate functioning of the stomatognathic system.

There are a variety of methods in the literature for evaluating and increasing the vertical dimension.[2] There are no clear objective guidelines that determine the ideal increase in the VDO that can be physiologically accepted by the patient.[4] More than 5 mm is rarely indicated;1 however, it is impossible to determine the upper limit.[5]

Although there are some limitations in the method of increasing VDO, in the last decades, several studies concluded that an increase in the VDO did not seem to be a hazardous procedure when good occlusal stability was achieved.[6] additionally, the evaluation period with temporary restorations, definitive restoration, and maintenance phase has to be considered carefully.

The rapid evolution of CAD/CAM (Computer Aided Design, Computer Aided Manufacture) has led to a dramatic impact in all disciplines of dentistry, especially in the fields of prosthodontics and restorative dentistry,[7,8] and many benefits of digital workflows have been presented, such as reduced clinical treatment time, simplified technical production, high quality, and precision of the prosthetic reconstruction.[9–11] The need for adjusting to the new treatment modality has promoted the development of techniques involving intraoral scanning.[12,13]

Considering that the entire digital flow, from digital impression to the milling process with the CAD/CAM system, took about 16% less time than the flow analog, the superiority of the fully digital flow was also demonstrated.[14] However, the literature is still scarce in techniques of application of the complete digital workflow, which starts with intraoral scanning followed by CAD/CAM-based fabrication and final placement of the reconstruction.[14]

Within this context, considering the notable advantages of the digital process, on what both clinical treatment times as well as laboratory working steps are shorter, the continuous technical development is essential to assist the professional faster domain of CAD/CAM technologies. Then, with the aim to contribute to the greater knowledge and the wider use of the new treatment modality with CAD/CAM, this work proposed to report on a four-step clinical protocol for the re-establishment of the VDO of a dentate patient involving the complete digital flow.

Case report

A 60-year-old man, MPM, presented with extensive tooth defects and asked for treatment options to restore the associated changes in his occlusion. He complained of significant functional and esthetic impairments caused by the appearance of his compromised teeth. A Spee curve alteration with generalized wear facets and traumatic anterior contacts was found in the intraoral examination.

For restoring adequate function and esthetic and meeting the patient's desire, the rehabilitation included reestablishment of the VDO developed following the 4 step protocol (Figure 1).

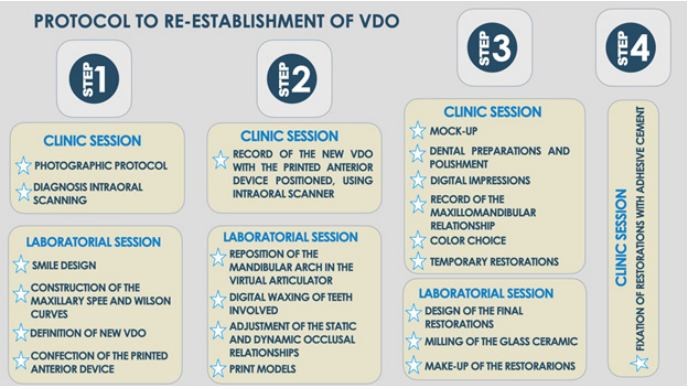


Figure 1 4 steps of the protocol to re-establishment of VDO.

Step 1 Photographic protocol, diagnosis of the intraoral scanning, esthetic-functional planning, and making the occlusal device

A. Clinical session

In the context of digital dentistry, facial and intraoral images are essential in all stages of treatment, especially in diagnosis and planning. Starting with standardized and quality images, it is possible to view in detail the therapeutic needs of the patient, favoring the conviction of the patient for a realistic view of their intraoral clinical situation. Additionally, there are specific images for the purpose of giving references and the high predictability of rehabilitation results.

Thus, the first clinic session consists of three key elements: 1) a careful clinical examination, including anamnesis and intra and extra oral physical examinations, 2) standardized and quality photographic protocol (Camera D7200, Nikon), and 3) dental digital impression of the dental arches, including the occlusal relationship, using an intraoral scanner (Trios 3; 3Shape A/S) (Figure 2).

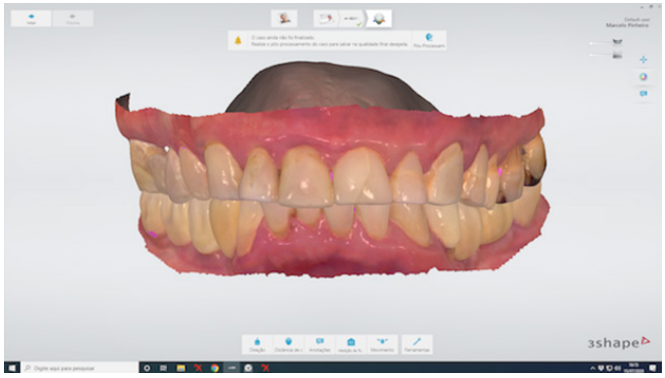


Figure 2 Intraoral scanning: Frontal occlusion.

B. Laboratorial session

The Smile Design software (3Shape A/S) was used to make the virtual smile design. With the image frontal smile with mouth open, it is easy to define the necessary changes in the worn upper anterior teeth, including incisal increases. This phase can be performed manually using the Keynote (IOS – Apple) or PowerPoint programs (Windows – Microsoft).

Considering the need to combine functional and aesthetic references in determining the new VDO, the incisal increases of the anterior teeth need to be in harmony with the occlusal surfaces of the posterior teeth, enabling construction of the Spee and Wilson curves. With the importation of the face image with smile design to the CAD software (Ceramill Mind; Amann Girrbach AG), the functional parameters were defined using the virtual articulator, Bonwill's triangle, and Monson's plan. Figure 3 illustrate the application of these resources in the files: STLs (Standard Tessellation Language) of the arches and the smile design image.

The virtual articulator with Bonwill's triangle it is adjusted in means: Benett's angle of 15º and condylar inclination of 30º. The STL file of the maxillary arch was positioned on the Bonwill's triangle, with the central incisal edge 110 mm from the condyle and coincident median lines of the upper arch and triangle. The sobreposition of the maxillary arch with the face image/virtual smile design enables the reproduction of the jaw position with the cranial base (Figure 3).

Then, the Monson's plan is positioned under the maxillary arch. At this moment, it is possible to define the necessary increase in the maxillary teeth to reconstruct the Spee (anteroposterior) and Wilson (laterolateral) curves, which were altered. Considering that the anatomical details of each tooth will be worked on in the digital waxing step (Figure 1: Step2B), the objective at this point was only to define the occlusal limits of all the maxillary teeth to be involved in the rehabilitation.

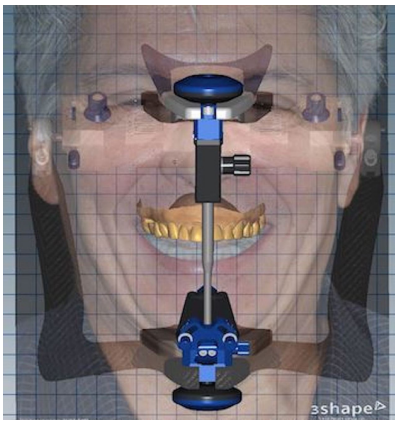


Figure 3 Sobreposition of the smile design with the virtual articulator in means.

Once the occlusal limits of the maxillary arch are defined based on aesthetic and functional references, it is possible to safely and without empiricism determine a new VDO. The articulator incisal pin is gradually increased until sufficient vertical space to the mandibular teeth is obtained, according to references given by the adjustment of the functional guides.

With the definition of the new VDO, digital tools were also used in order to obtain their clinical reproduction. With a similar technique to make occlusal splints, an anterior device is drawn and obtained by means of 3D printing (P40; Straumann) (Figure 4). With the printed device, it is possible to proceed with step two of the protocol.

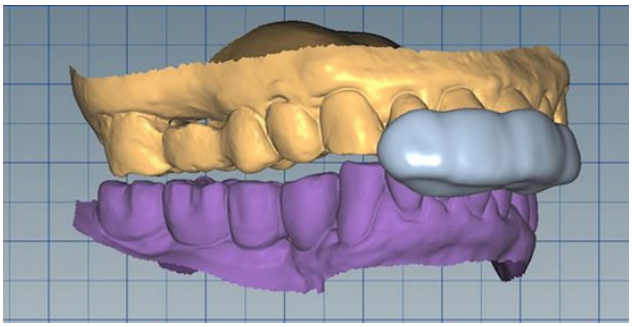


Figure 4 Anterior device drawn.

Step 2 Intraoral registration of the new VDO with the anterior device and digital waxing

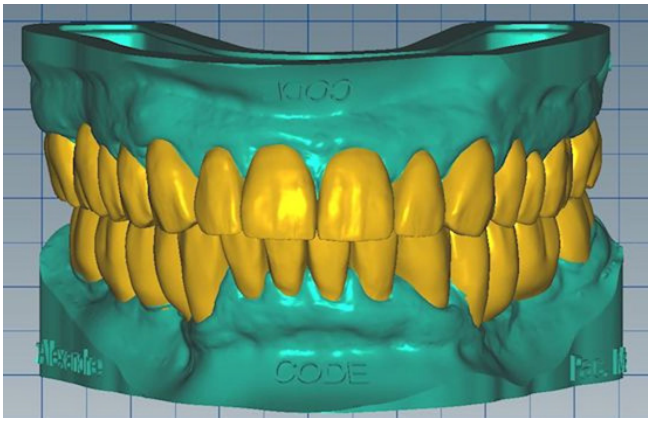
A. Clinical session

A new maxillomandibular relationship needs to be obtained clinically with the printed anterior device. As the VDO was obtained in the virtual articulator, the new position assumed by the mandible needs to be registered to minimize clinical adjustments of the restorations. The position centric relation (CR) was used because the patient was not class II. Considering the full digital workflow approach, the intraoral scanner was again employed.

B. Laboratorial session

Importing by software the new STL file of the generated maxillomandibular relationship allows the repositioning of the mandibular arch in the virtual articulator. Then, digital waxing of all teeth involved in the rehabilitation was performed. For the anterior

teeth, libraries with different shapes were used, allowing the smile to be customized to the patient's characteristics, including gender and race. At that moment, there is a refinement of the teeth's individual anatomical particularities as well as static and dynamic occlusal relationships, with the simulation of mandibular movements, using the concepts of mutually protected occlusion (Figure 5). With digital waxing, models of the maxillary and mandibular arches were printed (P40; Straumann), enabling the execution of step three.



Figures 5 Teeth with individual anatomy defined.

Step 3 Mock-up, dental preparations and polishment, digital impressions, interocclusal register, color choice, and temporary restorations

A. Clinical session

The intraoral mock-up was made up silicone matrices (Zatalabor; Zhermack) in the printed models. The mock-up gives both the professional and the patient an indication of the new spatial position and the new shapes of the restored elements. In this case, in addition to the evaluation of the aesthetic and functional aspects, including the positioning of the incisal edges at rest and in the smile, there is a realistic prediction as to the result of the new VDO.

For the proper reproduction of the new VDO in the relationship of the prepared arches, it is necessary that all posterior teeth are prepared and polished initially. The maintenance of the original shape of the anterior teeth at this time allows the positioning of the anterior device and interocclusal record of the posterior teeth in the centric relation. After the preparation of the anterior teeth, with the posterior records positioned, an anterior record is made to enable the scanning of the maxillomandibular relationship of all prepared teeth.

Printed models were used to obtain the silicone matrices (Zatalabor; Zhermack) for the dental preparations, enabling minimally invasive wear. The double cord technique was used for the digital impressions. Figure 6 shows the STL file generated from the intraoral scanning process of the prepared arches and the interocclusal record. After the colour choice, the temporary restorations with the silicone matrices used in making the mock-up were obtained. The patient used the interim restorations for 30 days. In this phase, it was possible to assess the new VDO and the restorations periodontally, functionally, and phonetically.

B. Laboratorial session

The STL files of the prepared arches and the interocclusal record were imported to the CAD software (Ceramill Mind; Amann Girrbach AG) for the design of the final restorations. The beginning of the process occurs with the sobreposition between the preparation and digital waxing arches, enabling great facilitation of the process since the anatomical shape of each tooth has already been defined. Then, the CAD phase continues with the delimitation of the edges and refinement in the axial contours and the proximal and occlusal contacts. These occur in static and dynamic relationships according to references given by the adjustment of the functional guides.

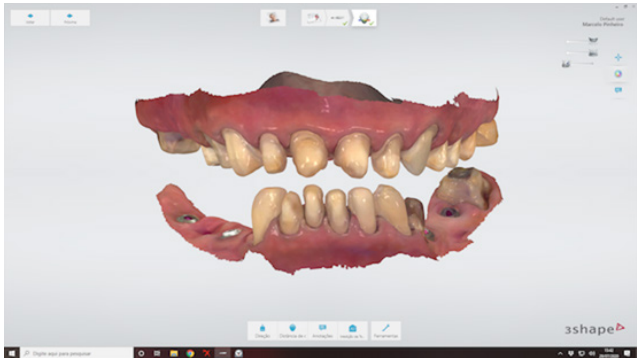


Figure 6 STL file of the scanned prepared teeth.

At the end of the design phase, the restorations are positioned in the blocks to performed the CAM phase, represented by the milling process (Ceramill Motion 2; Amann Girrbach AG) of the glass ceramic based on lithium disilicate (Ivoclar EMax CAD, Ivoclar Vivadent). After the milling, the restorations were finished using the make-up and glaze technique.

Step 4 Adhesive luting of final restorations

For the fixation of the ceramic lithium disilicate restorations, the adhesive luting protocol was used. Figure 7 illustrate the final aspect intraoral of the VDO rehabilitation completed with a high degree of satisfaction for both the patient and the professional.

Figure 7 Final cemented restorations: intraoral aspect.

Discussion

Conventional high precision impression materials, such as polyether and polyvinyl in combination with stone casts, offer a well-known procedure to transfer the clinical situation into the laboratory.[15] However, it has been shown that the higher inaccuracy of the conventional approach based on conventional impression, gypsum master cast, and extra oral digitalization can be explained by the numerous potential sources of errors and the long process chain related with that procedure, until a construction dataset is obtained.[16,17]

With intraoral scanners, this instability and possible discomfort factor might be avoided by direct data capturing, which represents a logical direct access to dental CAD/CAM. With this technique, the intraoral surfaces are captured directly in the patient's mouth using optical technologies without cast fabrication.[14] With this procedure, it is possible to practice the complete digital workflow, including the

data acquisition through intraoral scanners, software for designing virtual restorations on a virtual working cast, and computerized milling device for manufacturing the restoration.

The aim of this protocol was to show the applicability of the fully digital workflow in the rehabilitation of a dentate patient involving the reestablishment of the VDO. The adoption of a reduced number of clinical sessions in the development of treatments of relative complexity was decisively favored by the application of the most recent technological resources.

At the present moment, when significant changes are necessary for the incorporation of digital tools in the professional's daily routine, there is an incessant search for the improvement of application techniques, considering that new learning is necessary. Thus, the expectation is that the present protocol will contribute to the facilitation of the learning curve of digital flows.

In this context, the central proposal and probably the greatest benefit of the described clinical protocol (Figure 1) is the virtual making and printing of an anterior registration device that allows the clinical reproduction of the vertical space defined in the virtual articulator. With the same technique applied in the making of occlusal plates, the device is obtained by 3D printing, making it possible to clinically record the correct three-dimensional position of the mandible in the new VDO (Figure 4).

For the effectiveness of this device, special care is taken in the dental preparation session. Initially, only the posterior teeth should be prepared and polished, maintaining the initial shape of the anterior teeth so that it is possible to stabilize the anterior device and obtain bilateral record in the posterior teeth. Then, after the preparation of the anterior teeth, an anterior record is made in the position maintained by the previous records, thus creating an adequate stability for scanning the maxillomandibular relationship.

Depending on the structural condition of the teeth to be prepared, the type of restoration, and the professional's preference, step 3 can be performed in more than one clinical session, considering that it may require an excessively long clinical time.

In rehabilitation with re-establishment of the VDO, transitory restorations take on an additional role. Although there is no consensus in the literature, it is recommended that they be used for a minimum period of 30 days. The implementation of this stage is performed to evaluate the treatment outcome and patient acceptance.[18,19]

The digital impression, determining for the complete digital workflow, has been a significant contributor to transforming the relationship between the professional and the dental laboratory. The possibility of digitally sending a digital impression to the laboratory allows the intraoral scanners to increase efficiency compared with conventional impression materials. On the other hand, there are still limitations, such as the additional cost of purchasing an intraoral scanner and the learning curve for adjusting to the new treatment modality.[20]

Considering these limitations, mainly the economic aspects, and the combined utilization of both the digital and conventional approach seems timely. However, with the increasing availability of scan services by laboratories and radiological clinics, the possibility of applying the complete digital workflow is quite feasible.

Conclusion

The present clinical protocol made possible by the combination of different resources and tools of the CAD/CAM system allows the application of the complete digital workflow as an interesting and high efficiency alternative in the simplification and dynamization of the rehabilitation of dentate patients.

Acknowledgments

None

Conflicts of interest

The author declares no conflicts of interest.

References

1. Abduo J, Lyons K. Clinical considerations for increasing occlusal vertical dimension: a review. *Aust Dent J*. 2012;57(1):2–10.
2. Chander NG, Venkat R. An appraisal on increasing the occlusal vertical dimension in full occlusal rehabilitation and its outcome. *J Indian Prosthodont Soc*. 2011;11(2):77–81.
3. Karlsen AT. Craniofacial characteristics in children with Angle Class II div. 2 malocclusion combined with extreme deep bite. *Angle Orthod*. 1994;64(2):123–130.
4. Morales WCR, Mohl ND. Relationship of occlusal vertical dimension to the health of the masticatory system. *J Prosthet Dent*. 1991;65(4):547–553.
5. Abduo J. Safety of increasing vertical dimension of occlusion: a systematic review. *Quintessence Int*. 2012;43(5):369–380.
6. Ormianer Z, Palty A. Altered vertical dimension of occlusion: a comparative retrospective pilot study of tooth- and implant-supported restorations. *Int J Oral Maxillofac Implants*. 2009;24(3):497–501.
7. Joda T, Gallucci GO. The virtual patient in dental medicine. *Clin Oral Implants Res*. 2015;26(6):725–726.
8. Alghazzawi TF. Advancements in CAD/CAM technology: Options for practical implementation. *J Prosthodont Res*. 2016;60(2):72–84.
9. Papaspyridakos P, Chen YW, Gusmao IG, et al. Complete digital workflow in prosthesis prototype fabrication for complete-arch implant rehabilitation: A technique. *J Prosthet Dent*. 2019;122(3):189–192.
10. Cascon WP, Nunez AP, Diez IC, et al. Laboratory workflow to obtain long-term injected resin composite interim restorations from an additive manufactured esthetic diagnostic template. *J Esthet Restor Dent*. 2019;31(1):13–19.
11. An X, Yang HW, Choi BH. Digital workflow for computer-guided implant surgery in edentulous patients with an intraoral scanner and old complete denture. *J Prosthodont*. 2019;28(6):715–718.
12. Ahmed WM, Verhaeghe TV, McCullagh APG. Maxillary complete-arch implant- supported restoration: A digital scanning and maxillomandibular relationship workflow. *J Prosthet Dent*. 2021;125(2):216–220.
13. Negreiros WM, Jamjoom FZ, Gallucci G, et al. Designing a complete--arch digital trial tooth arrangement for completely edentulous patients by using an open-source CAD software program: A dental technique. *J Prosthet Dent*. 2021;125(3):387–391.
14. Joda T, Brägger U. Time-Efficiency Analysis Comparing Digital and Conventional Workflows for Implant Crowns: A Prospective Clinical Crossover Trial. *Int J Oral Maxillofac Implants*. 2015;30(5):1047–1053.
15. Haim M, Luthardt RG, Rudolph H, et al. Randomized controlled clinical study on the accuracy of two-stage putty-and-wash impression materials. *Int J Prosthodont*. 2009;22(3):296–302.
16. Al-Bakri IA, Hussey D, Al-Omari WM. The dimensional accuracy of four impression techniques with the use of addition silicone impression materials. *J Clin Dent*. 2007;18(2):29–33.

17. Christensen GJ. Impressions are changing: deciding on conventional, digital or digital plus in-office milling. *J Am Dent Assoc*. 2009;140(10):1301–1304.

18. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 1. *Eur J Esthet Dent*. 2008;3(1):30–44.

19. Edelhoff D, Beuer F, Schweiger J, et al. CAD/CAM- generated high--density polymer restorations for the pretreatment of complex cases: a case report. *Quintessence Int*. 2012;43(6):457–467.

20. Papaspyridakos P, Gallucci GO, Chen CJ, et al. Digital versus conventional implant impressions for edentulous patients: accuracy outcomes. *Clin Oral Implants Res*. 2016;27(4):465–472.

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