

THE ONE STEP-NO PREP TECHNIQUE: A STRAIGHTFORWARD AND MINIMALLY INVASIVE APPROACH FOR FULL-MOUTH REHABILITATION OF WORN DENTITION USING POLYMER-INFILTRATED CERAMIC NETWORK (PICN) CAD-CAM PROSTHESES

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ABSTRACT

Objectives

To introduce a novel approach for full-mouth rehabilitation of severely worn dentition using polymer-infiltrated ceramic network (PICN) computer-aided-design and manufacturing (CAD-CAM) restorations, without tooth tissue preparation and provisional phase.

Clinical considerations

Three patients with generalized tooth wear, suffering from dental pain, masticatory dysfunction, bruxism and neck and back pain, were selected and treated in collaboration with physiotherapists. Occlusal analyses were performed and full-mouth diagnostic wax-ups were designed on the basis of estimated tissue loss. Deficient direct restorations were replaced and low-thickness PICN (Vita Enamic) restorations (up to 0.2 mm) were CAD-CAM designed from wax-ups, milled, tried-in and then bonded within two consecutive days. To mask palatal veneers, either buccal direct composites or glass-ceramic veneers were later performed. An occlusal splint was realized. Clinical results were shown to be successful after a follow-up of 22, 18, and 13 months, respectively. The absence of provisional phase did not engender any inconveniences. Patient reported outcomes were very positive, showing a reduction in neck and back pain and a well-being increase.

Conclusion

The proposed protocol is particularly minimally invasive and straightforward compared to classical techniques. PICNs exhibit several advantages compared to other materials. Preliminary results of this multidisciplinary approach are promising but deserve further clinical research.

Clinical significance

The development of CAD-CAM technologies offers the possibility of improving treatment of severe worn dentition, reducing chairtime and need of tooth tissue preparation, and introducing a new class of composite materials (hybrid ceramics), which exhibit interesting properties for this indication. The influence of the proposed multidisciplinary approach, particularly the collaboration

with physiotherapists, needs to be further explored with respect to treatment of associated symptoms, such as masticatory muscles hypertrophy and neck pain.

KEYWORDS: CAD/CAM ; composites ; dental materials ; polymer-infiltrated network ; wear

1. INTRODUCTION

Tooth wear is reported to have a high and increasing prevalence, particularly in young patients.¹⁻⁴ Causes of tooth wear can be mechanical (attrition, abrasion, and abfraction) and/or chemical (erosion), in which bruxism and consumption of acidic drinks and food being often pointed out as important risk factors.^{3,4} In generalized severe tooth-wear cases, patients can suffer from not only dental pain but also from masticatory dysfunction, temporo-mandibular joint disorders, masticatory muscles and orofacial pain, and psycho-social handicap because of impaired esthetics.⁵ Restoring functional occlusal relationships and esthetics requires a full-mouth rehabilitation with an increase in the vertical dimension of occlusion (VDO), which constitutes a complex and multisteps treatment. Current guidelines include the need to develop minimally invasive treatment strategies, which do not involve, as much as possible, the removal of more tooth tissue.⁵ Different options have been proposed in the literature: direct techniques with light-cured composites, indirect techniques with ceramic or composite partial-bonded restorations, or a mix of the two techniques. Direct composites constitute the most frequent option reported⁷: this additive technique (using silicon molds resulting from a wax-up) is particularly minimally invasive but it is time-consuming. Moreover, it can result in a need for maintenance care (eg, repair of fractures), particularly in the presence of bruxism.⁵ In indirect minimally invasive techniques, composite palatal veneers, eventually associated with ceramic buccal veneers, are usually performed to restore upper incisors and canines ("sandwich technique"),⁸ whereas ceramic or composite occlusal onlays are realized on premolars and molars. In the "three-step" technique introduced by Vailati in 2008,⁹⁻¹¹ a resin composite mock up is performed first on the buccal faces of anterior teeth and then on the occlusal faces of posterior teeth. The definitive prostheses are realized in successive steps: palatal veneers followed by buccal veneers and then posterior onlays by quadrant. The provisional restorations are intended to test the new VDO (which is arbitrary determined), to validate the esthetic result, and to guide the tooth tissue preparation for indirect restorations. Recently, Vailati and Carcofio introduced a simplified version of the three-step technique for cases with moderate erosion (<2 mm loss of original length of upper incisors).¹² In this version, definitive computer-aided-design and manufacturing (CAD-CAM) composite posterior restorations (Lava Ultimate, 3 M ESPE, St Paul, MN) are directly performed on one arch, whereas direct composite semiprovisional restorations are performed on the other, anterior teeth being restored with palatal veneers in a second step. Finally, the current tendency in tooth wear treatment is to avoid any tooth tissue preparation ("No prep") using very low thickness prostheses (a few tenths of a millimeter), but this approach is challenging regarding material resistance and management of the provisional restorations.

Currently, there is no evidence regarding the best technique (direct or indirect) or material (composite or ceramic) to be used to restore severe worn dentition.^{5, 7} New high-performance CAD-CAM composites, particularly polymer-infiltrated ceramic network materials (PICNs) (hybrid ceramics), could constitute interesting materials for indirect approaches.¹³

Therefore, the aim of this technical procedure is to describe a novel technique (One step-No prep) for full-mouth rehabilitation of worn dentition using PICN indirect restorations. The proposed multidisciplinary approach, which includes the collaboration with physiotherapists for associated symptoms, is characterized by the absence of tooth tissue preparation and of provisional phase.

2. CLINICAL CONSIDERATIONS

Three clinical cases of generalized severe tooth wear, two men (41 and 71 years old; cases #1 and #2, respectively) and one woman (53 years old, case #3), were selected to present the One step-No prep treatment protocol (Figures 1-4). All patients suffered from bruxism and gastric acidity. Case #1 also reported an important consumption of soda. Their complaints were related to dental pain, masticatory dysfunction, and neck and back pain. Cases #1 and #2 also complained about their esthetic appearance. Cases #2 and #3 did not want to change the existing crowns and bridges for economical purposes. All cases were referred to an occlusodontist and no temporo-mandibular joint disorder was detected. They were also referred to a maxillo-facial physiotherapist and a physiotherapist specialized in muscular chains and global posture for diagnostic and treatment. Case #1 had four implants placed by a specialist. First of all, pictures, radiographs and double mix impressions with polyvinyl siloxane (PVS) material (Aquasil Ultra heavy and xlv, Dentsply Sirona, York or Imprint 4 heavy and light, 3 M, St Paul, MN) were taken and an occlusal analysis was performed using a resin jig and a facebow (Quick facebow, Sintec Inc, NH) (Figures 5 and 6). The jig, which had one occlusal contact point located on the middle of the anterior region, was put in place during 5 minutes to induce muscular relaxation and lower jaw repositioning, and then occlusal relationships were registered with a double layer of wax (Moyco Beauty Wax, PA, USA). This analysis was performed after a visit to the physiotherapist specialized in posture, which was intended to equilibrate the posture and muscular chains before occlusal analysis. It has to be underlined that patients did not wear any occlusal splint before treatment. A full wax-up was designed on the basis of the registered occlusal relationships and on the basis of the estimated amount of tooth tissue loss (Figure 7). The dental technician started to deposit the wax on the less damaged teeth and was guided by the residual tissues to restore tooth anatomy, which resulted in very low wax thickness on some posterior teeth. In the present cases, he began with cusps of canines and premolars, and those reconstituted teeth served as a reference for the new VDO determination. With this “tissue-guided” approach, the estimation of the new VDO was empirical (3.5 and 5.5 mm at the incisal guide pin for cases #2 and #3, respectively, not measured for case #1). The full wax-up was shown to the patient for approval. Afterward, the treatment started with the replacement of amalgam fillings and deficient composite restorations with direct composite restorations (Els composite extra low shrinkage, Saremco Dental, Rebstein, Switzerland). If required, endodontic treatments were

performed previously. No preparation of tooth tissues was performed, except for the tooth #25 of case #3, which was prepared for an endocrown. After new impressions with PVS, the models and the full wax-ups were scanned and superimposed using a CAD-CAM system (Omnicam camera and Cerec 4 software, Sirona, Salzburg, Austria for case #1; Ceramill system, Amann Girrbach AG, Koblach, Austria for cases #2 and #3) (Figure 8). Then, restorations corresponding to the estimated tissue loss (palatal veneer, posterior occlusal table tops and veneerlays; $n = 16, 27$ and 27 for cases #1, #2, and #3, respectively) were milled from PICN blocks (Vita Enamic HT, Vita Zahnfabrik, Germany; Cerec MCXL machine for case #1 and Ceramill Motion 2, Amann Girrbach for cases #2 and #3) (Figures 9-11). In case #1, it was planned to restore lower anterior teeth with direct composites, as for the tooth #43 of case #3. For case #1, restorations were just polished, while for cases #2 and #3 they were stained with a light-cured nanofilled composite coating agent (Optiglaze, GC Corporation, Tokyo, Japan). The restoration thickness reached 0.2 mm on some posterior occlusal faces (Figure 9). Restorations were tried-in and then bonded within two consecutive days, in two half-day appointments, one for each maxilla (the upper jaw on the first day afternoon, the lower on the second day morning). Restorations were pretreated following the manufacturer's recommendations, etching the surface with hydrofluoric acid (HF) for 60 seconds, cleaning it in an ultrasonic bath in ethanol and then applying a layer of silane (Monobond S, Ivoclar Vivadent, Schaan, Lichtenstein). The rubber dam was placed for posterior teeth but not for anterior. Tooth tissues were cleaned with pumice, and then treated with a two-step etch-and-rinse adhesive (Adhese, Ivoclar Vivadent) (Figure 12). The adhesive application was preceded by the pre-treatment of sclerotic dentin, depolishing the surface with a diamond bur at low speed to open tubuli, and of the feldspathic ceramic of crowns and bridges, etching the surface with HF followed by silane application. Restorations were bonded with a composite resin cement (Variolink Esthetic DC, Excite DSC bonding agent for case #1 and #3, Adhese universal bonding agent for case #2, Ivoclar Vivadent), polymerization was carried out after excess removal and a final photopolymerization was performed under a film of glycerin to avoid the persistence of a polymerization inhibition layer. Major occlusal adjustments were realized just after bonding of lower restorations with an Arkansas stone bur followed by polishing with silicon gums, fine adjustments being performed within the following weeks and after a visit to the physiotherapist (occlusal relationships resulting from the wax-ups were canine guided for case #2 and group guided for case #1 and #3). A bleaching procedure was also performed (which was not possible when dentin was still exposed). To mask the junction between the palatal veneer and the buccal face of upper anterior teeth, two options were envisaged in function of patient request and budget. In all cases, direct composite was added on a slight chamfer performed across the junction and where needed to optimize tooth shape (Figure 13A-C). Furthermore, in case #1, lithium disilicate glass-ceramic buccal veneers were performed following classical procedure, that is, tooth reduction being realized in function of a wax-up (Figure 13D-F). Accessorily in this patient, PICN screw-retained restorations on implants were also placed for teeth #24, #36, #47. Finally, an acrylic occlusal splint (for the upper maxilla) was performed for all patients. After treatment, patients were asked to fill a patient-centered outcomes form, using a 10-level Likert-type scale.



Fig. 1. Smile pictures before and after treatment, for each case, respectively. For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³



Fig. 2. Frontal views before and after treatment, for each case, respectively. For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³



Fig. 3. Occlusal views of the upper maxilla before and after treatment, for each case, respectively. For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³

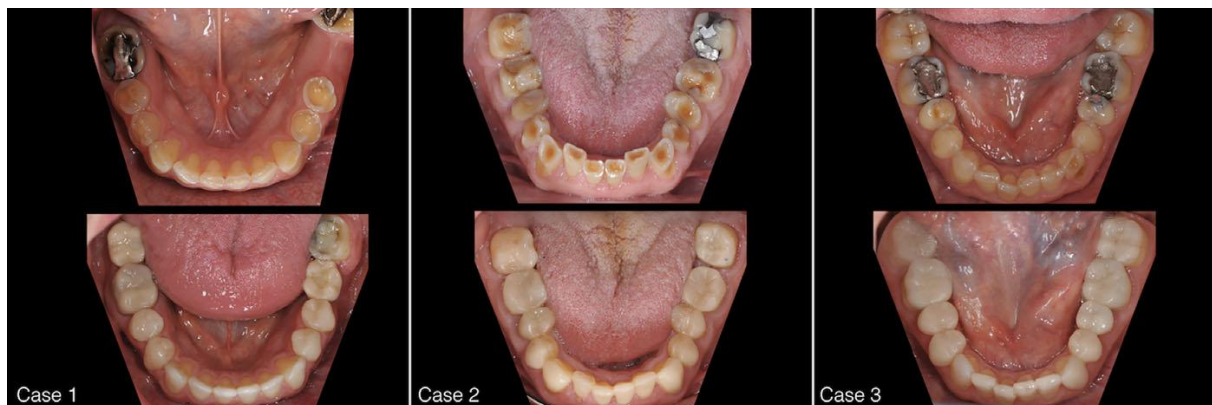


Fig. 4. Occlusal views of the lower maxilla before and after treatment, for each case, respectively. For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³



Fig. 5. Panoramic radiography before treatment and at recall, for each case, respectively. Note in case#1, the absence of the PICN screw-retained crown on tooth #47, which debonded from the ti-base and had to be sent to the dental lab for repair. For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³

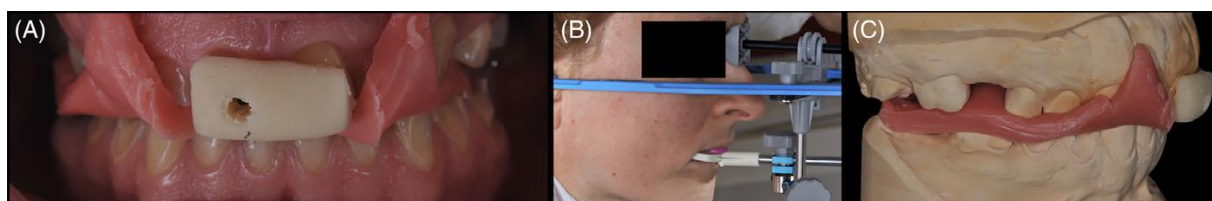


Fig. 6. Occlusal analysis: A, occlusal relationships registering using a resin jig and a double layer of wax (Moyco beauty wax); B, Facebow (Quick facebow); C, paster models placed in the articulator. A and C pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³



Fig. 7. “Tissue-guided” full-mouth wax-up, for each case respectively. For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³

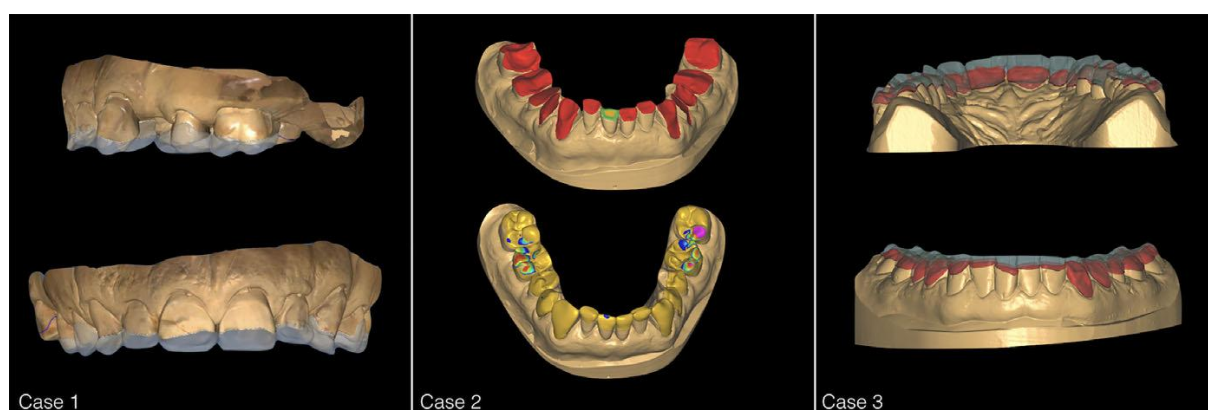


Fig. 8. Superimposition of the scans of the models and the wax-up, for each case respectively. (Omnica camera and Cerec 4 software for case #1; Ceramill system for cases #2 and #3). For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³



Fig. 9. A-C: A 0.2 mm-thick PICN posterior occlusal table top just after milling (Vita Enamic). Pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³



Fig. 10. Occlusal views of final PICN restorations on plaster models after polishing (case #1) and staining with Optiglaze (cases #2 and #3). For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³



Fig. 11. Views of final PICN restorations on plaster models. Note the buccal “half-veneers” on the lower incisors of cases #2 and #3 (for case #1, direct composite restorations were performed). Dental technician: Renaud Maka, University of Liège for case #1 and Jean-Michel Paulus, Liège, Belgium for cases #2 and #3. For case #1, pictures were reprinted by permission of SAGE Publications Inc from Mainjot et al.¹³

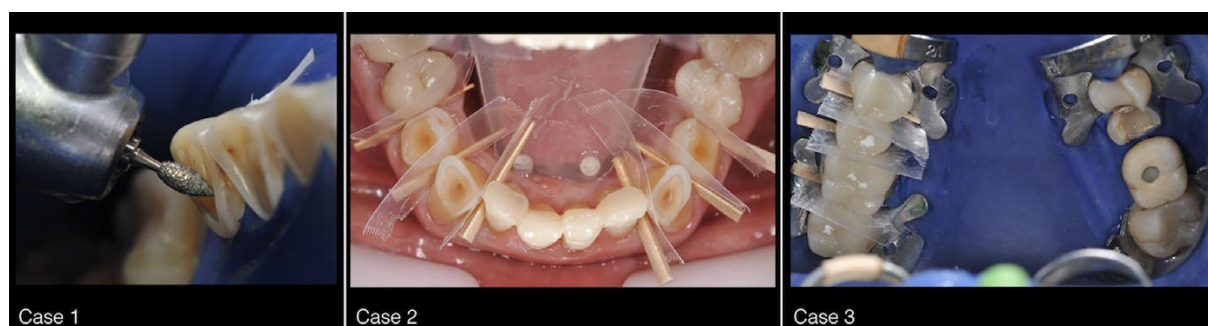


Fig. 12. Clinical views of the bonding procedure. Case #1: Depolishing of the sclerotic dentin with a diamond bur. Case #2: Bonding of buccal anterior restorations using an orthodontic Nola dry field system and not the rubber dam, to avoid errors in restoration placement due to the position of the restoration border. Case #3: Bonding of posterior restorations using the rubber dam. Note that a restoration was bonded on a PFM screw-retained crown on implant (tooth #26), while an endocrown was performed on tooth #25

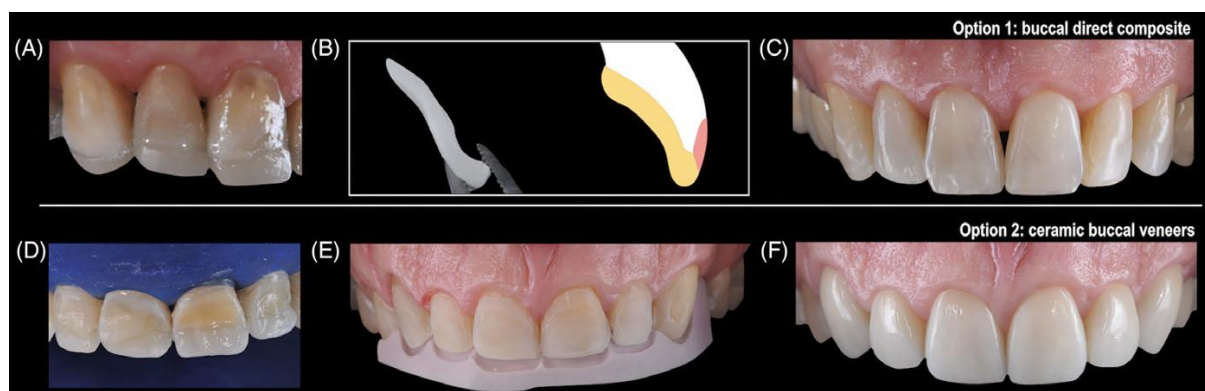


Fig. 13. Illustration of the two options used to restore the buccal faces of upper incisors. A-C, Direct composite (Miris 2, Coltene-Whaledent AG, Altstätten, Switzerland, for case #2; Inspiro, Edelweiss DR AG, Zug, Switzerland, for case #3) was added on a slight chamfer performed across the junction between the tooth and the palatal veneer, it was also added where needed to optimize tooth shape (Figure 13A-C from case #2). D-F, In case #1 lithium disilicate glass-ceramic buccal veneers (e.max Press, Ivoclar Vivadent) were secondarily performed Dental technician: Pieter Ghysens, Brussels, Belgium

After a follow-up of 22, 18, and 13 months, respectively, for cases #1, #2 and #3, 2 PICN partial-bonded restorations out of 70 had to be replaced (Figure 14). Indeed, in case #2, a palatal veneer on tooth #23 had to be replaced because the restoration length was too short and the direct composite, which was added to lengthen the tooth, fractured (Figure 15A). The other failure, which was in the same patient, was related to the weakness of the proximal contact point between two lower molars, which implied the replacement of one restoration. Technical complications included minor chipping of thin borders of occlusal table tops, one in case #1 and two in case #2 (Figure 15B): they were polished. Moreover, in case #1, one implant crown debonded from the ti-base and had to be bonded again (manufacturer's recommendations were initially not followed for the bonding procedure), and two chippings were observed on direct composite restorations performed on the lower anterior teeth.

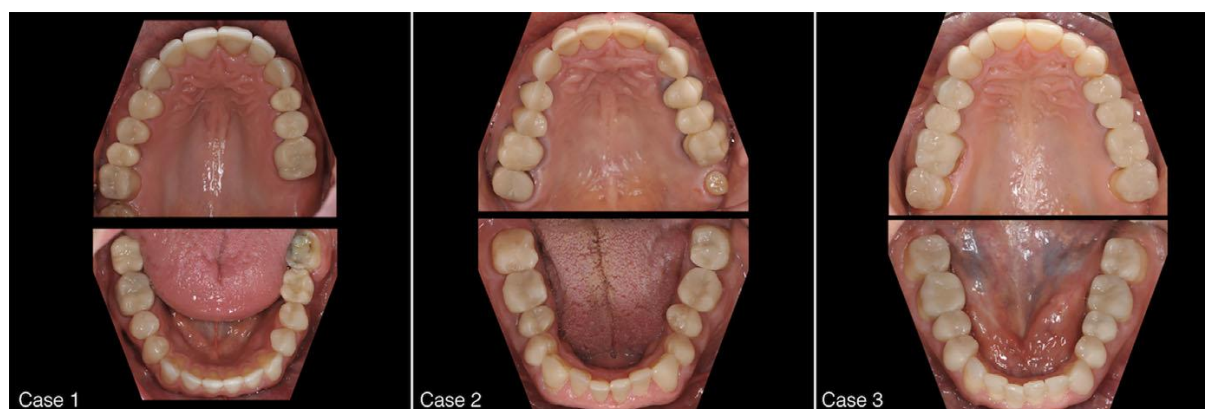


Fig. 14. Occlusal views of the two maxilla at recall, for each patient, respectively (follow-up: 22 months for case #1, 18 months for case #2 and 13 months for case #3)

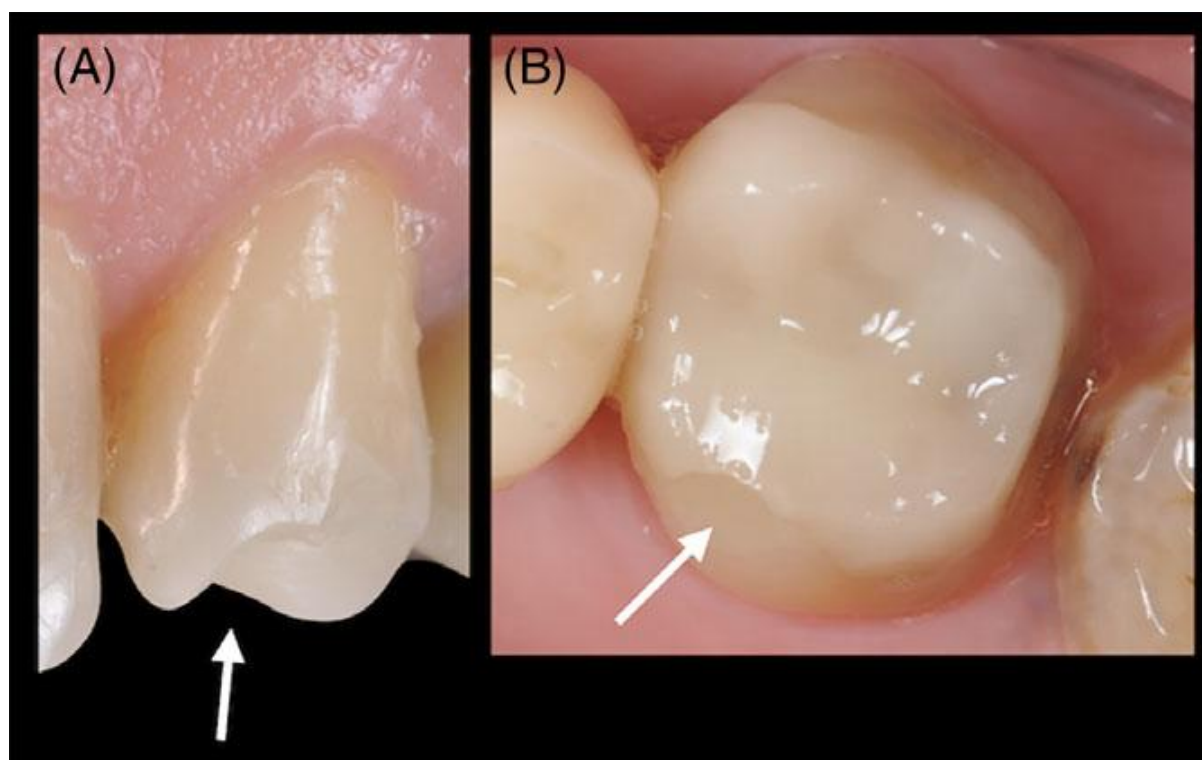


Fig. 15. Observed technical complications. A, In case #2, a palatal veneer on tooth #23 had to be replaced because the restoration height was too short and the direct composite, which was added to lengthen the tooth, fractured; B, In case #1, minor chipping of the thin palatal border of the occlusal top on tooth #26, which was further polished. For case #1, pictures were reprinted by permission of SAGE Publications Inc

Patient self-reporting through the satisfaction form was very positive. A mean score of 7.3 of 10 was obtained regarding the intervention course and the two consecutive half-day appointments, and 8.3 regarding the esthetic and functional results. The comfort of the PICN material gave a mean score of 8 while the absence of provisional restorations gave a mean score of 9, no temporo-mandibular disorder increase being observed. On the contrary, patients #1 and #2 described a significant reduction in neck and back pain associated with the treatment, while patient #3 described a slight reduction, neck pain having been previously attributed to professional activities. Patients #1 and #2 also described an important increase in well-being regarding the esthetic result. All patients did not complain anymore about dental pain after treatment.

3. DISCUSSION

The main difference of the proposed approach with conventional indirect methods is related to the absence of new VDO testing phase and provisional restorations use (One step), definitive indirect restorations being all bonded within two consecutive days, which reduces visit number, chairtime, cost and treatment complexity. The procedure is also characterized by the material approach, with the use of PICN materials (hybrid ceramics), which exhibit several advantages compared to ceramics and other composite materials, such as (1) the ability to be milled to a very low thickness with less

edge chipping than ceramics^{14, 15} which allowed for a “No prep” approach and a restoration design corresponding to the estimated tissue loss; (2) the ease of in-mouth adjustments: the management of occlusal relationships required meticulous adjustments and from that point of view, PICNs were shown to be more adapted than ceramics; (3) the biomechanical properties, ceramics being brittle and stiff, while direct light-cured composites exhibit a reduced strength and a too low elasticity modulus compared to tooth tissues¹⁶; (4) the high degree of conversion of monomers, which improves chemical stability and reduces free monomer release compared to light-cured composites¹⁶; (5) the bonding properties, which were shown to be as good as glass-ceramics when the material is etched.¹⁷ The use of CAD-CAM indirect restorations facilitates tooth anatomy and occlusion management with a reduced chairtime compared to direct composites. Finally, the presented protocol focuses on temporo-mandibular disorders, with the realization of an occlusal analysis and the collaboration with physiotherapists to treat associated symptoms, such as muscular hypertrophy and pain.

In the presented pilot cases, this novel approach was shown to give successful short-term clinical results. A palatal veneer had to be replaced because the restoration length was too short and the direct composite, which was added to lengthen the tooth, fractured (Figure 15A). To avoid this kind of failure, palatal veneers can be designed with a restoration length, which is slightly too long and then in-mouth adjusted. The other failure was related to the weakness of the proximal contact point between two inferior molars and then not specific of the described approach. Minor chippings were related to borders of very thin table tops, which were submitted to occlusal contact, while no major fracture of restorations was observed, despite high occlusal stress. The esthetic result, with the addition of direct composite on the buccal faces of anterior teeth, was satisfactory and presented the advantage of avoiding tooth preparation and cost related to ceramic veneers. However, stains were shown to wear out on occlusal faces. From the practitioner's point of view, the One step-No prep approach was shown to be particularly straightforward compared to all classical indirect and direct techniques. The absence of provisional restorations to test the VDO increase, like in direct techniques, did not engender any inconveniences. Indeed, it was previously reported that an increase in VDO, of a maximum of 5 mm at the incisal guide pin, is well tolerated by patients and that there is no need to test its effects and acceptance.¹⁸⁻²⁰ In fact, the one-step approach was proposed because the realization of provisional restorations can be problematic when performing restorations as thin as 0.2 mm-thick table tops, notably because of the fracture risk. Conversely, overestimating the VDO or preparing tooth tissues to increase material thickness and then resistance do not constitute ideal solutions. Moreover, the realization of direct composite provisional restorations is time-consuming and composite is not easy to remove. Finally, patients described a reduction in neck and back pain after full-mouth rehabilitation. The treatment influence on this type of pain, which can be attributed to the multidisciplinary approach with physiotherapy, needs to be further explored. Indeed, neck and back pain are reported to be important causes of the world global burden of disease.²¹ Patient centered outcomes were very positive from an esthetic and functional point of view, explaining well-being increase.

Future perspectives include the development of well-conducted clinical research to confirm the results of the presented pilot cases. They also include the study of experimental PICN materials, with even higher mechanical properties.²²

4. CONCLUSION

The development of CAD-CAM technologies offers the possibility of improving treatment of severe worn dentition, reducing the chairtime and need of tooth tissue preparation, and introducing a new class of composite materials (PICNs) (hybrid ceramics), which exhibits interesting properties for this indication compared to ceramics and other composite materials. The proposed approach was shown to give successful short-term clinical results in three pilot cases and to be particularly straightforward, minimally invasive and cost-effective. The absence of provisional restorations to test the VDO increase did not engender any inconveniences. The influence of the proposed multidisciplinary approach, particularly the collaboration with physiotherapists, needs to be further explored with respect to treatment of associated symptoms, such as masticatory muscles hypertrophy and neck pain. Patient centered outcomes were very positive. Future perspectives include the development of clinical research and the study of future generations of experimental PICN materials.

DISCLOSURE STATEMENT

The author does not have any financial interest in any of the companies or products used in this study.

REFERENCES

1. Kitasako Y, Sasaki Y, Takagaki T, Sadr A, Tagami J. Age-specific prevalence of erosive tooth wear by acidic diet and gastroesophageal reflux in Japan. *J Dent*. 2015; 43(4): 418-423.
2. Mulic A, Fredriksen O, Jacobsen ID, Tveit AB, Espelid I, Crossner CG. Dental erosion: prevalence and severity among 16-year-old adolescents in Troms, Norway. *Eur J Paediatr Dent*. 2016; 17(3): 197-201.
3. Tschammler C, Muller-Pflanz C, Attin T, et al. Prevalence and risk factors of erosive tooth wear in 3-6 year old German kindergarten children-a comparison between 2004/05 and 2014/15. *J Dent*. 2016; 52: 45-49.
4. Wetselaar P, Vermaire JH, Visscher CM, Lobbezoo F, Schuller AA The prevalence of tooth Wear in the Dutch adult population. *Caries Res* 2016; 50(6): 543-50. PubMed PMID: 27694757.

5. Loomans B, Opdam N, Attin T, et al. Severe tooth Wear: European consensus statement on management guidelines. *J Adhes Dent*. 2017; 19(2): 111-119.
6. Gillborg S, Akerman S, Lundegren N, Ekberg EC. Temporomandibular disorder pain and related factors in an adult population: a cross-sectional study in southern Sweden. *J Oral Facial Pain Headache*. 2017; 31(1): 37-45.
7. Mesko ME, Sarkis-Onofre R, Cenci MS, Opdam NJ, Loomans B, Pereira-Cenci T. Rehabilitation of severely worn teeth: a systematic review. *J Dent*. 2016 May; 48: 9-15.
8. Vailati F, Gruetter L, Belser UC. Adhesively restored anterior maxillary dentitions affected by severe erosion: up to 6-year results of a prospective clinical study. *Eur J Esthet Dent*. 2013; 8(4): 506-530.
9. 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.
10. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 2. *Eur J Esthet Dent*. 2008; 3(2): 128-146.
11. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 3. *Eur J Esthet Dent*. 2008; 3(3): 236-257.
12. Vailati F, Carciofo S. CAD/CAM monolithic restorations and full-mouth adhesive rehabilitation to restore a patient with a past history of bulimia: the modified three-step technique. *Int J Esthet Dent*. 2016; 11(1): 36-56.
13. Mainjot AK, Dupont NM, Oudkerk JC, Dewael TY, Sadoun MJ. From artisanal to CAD-CAM blocks: state of the art of indirect composites. *J Dent Res*. 2016; 95(5): 487-495.
14. Lebon N, Tapie L, Vennat E, Mawussi B. Influence of CAD/CAM tool and material on tool wear and roughness of dental prostheses after milling. *J Prosthet Dent*. 2015; 114(2): 236-247.
15. Awada A, Nathanson D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. *J Prosthet Dent*. 2015; 114(4): 587-593.
16. Mainjot A. Recent advances in composite CAD/CAM blocks. *Int J Esthet Dent*. 2016; 11(2): 275-280.
17. Eldafrawy M, Ebroin MG, Gailly PA, Nguyen JF, Sadoun MJ, Mainjot AK. Bonding to CAD-CAM composites: an interfacial fracture toughness approach. *J Dent Res*. 2018; 97(1): 60-67.
18. Attin T, Filli T, Imfeld C, Schmidlin PR. Composite vertical bite reconstructions in eroded dentitions after 5.5 years: a case series. *J Oral Rehabil*. 2012; 39(1): 73-79.
19. Orthlieb J-DE. Occlusal vertical dimension: myths and limits. *Réalités Cliniques*. 2013; 24(2): 99-104.
20. Moreno IO. Dysfunction of the masticatory system and OVD: review of the literature. *Réalités Cliniques*. 2013; 24(2): 93-98.

21. Disease GBD, Injury I, Prevalence C. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the global burden of disease study 2016. *Lancet*. 2017; 390(10100): 1211-1259.
22. Nguyen JF, Ruse D, Phan AC, Sadoun MJ. High-temperature-pressure polymerized resin-infiltrated ceramic networks. *J Dent Res*. 2014; 93(1): 62-67.