The One-step No-prep Approach for Full-mouth Rehabilitation of Worn Dentition using PICN CAD-CAM Restorations: 2-yr Results of a Prospective Clinical Study

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Short title: The One-step No-prep Approach for Full-mouth Rehabilitation of Worn Dentition.

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Keywords: tooth wear; minimally invasive treatment; CAD-CAM composite; fixed prosthodontics; dental materials.

Abstract

Objectives: To prospectively evaluate the One-step No-prep treatment of full mouth-worn dentition, a minimally invasive and multidisciplinary approach using PICN CAD-CAM composite restorations without provisional phase.

Methods : Seven patients (n=192 restorations) with severe tooth wear were included. Patient data were recorded, and an occlusal analysis and a tissue-guided wax-up were realized. After replacement of old fillings, no-prep Vita Enamic restorations (posterior restorations and palatal veneers) were bonded within 24 hours. Direct composites were performed to mask the buccal joint on anterior teeth. Maxillo-facial physiotherapy was performed. Restorations were evaluated following World Dental Federation criteria. Treatment influence on Oral-Health-Impact-Profile-49 (OHIP-49) score was assessed.

Results: Tooth wear etiology was related to soft drink consumption and bruxism. Mean VDO increase was 5.09±0.85 mm on the incisal pin. The mean restoration thickness on molars was 0.55±0.21mm, and the lowest was 0.11 mm. 2-year survival rate of restorations was 100% and success rate was 93.5%, with 11 minor chippings and one debonding. A significant improvement of the global OHIP-49 score was observed.

Conclusions: In this clinical study on high risk patients, PICN restorations, applied in a minimally invasive way, showed high survival and success rates after two years, while minor chipping of very thin occlusal borders constituted the most frequent complication. Moreover, the patient acceptance was good according to OHIP-49 in this multidisciplinary approach.

Clinical significance: The use of PICNs allows the development of no prep and simple treatment protocols of worn dentition. The absence of provisionals did not engender any problem, on the basis of the realization of an occlusal analysis, the support of a maxillo-facial physiotherapist, and the use of an easy-to-adjust restorative material.

Keywords: tooth wear; minimally invasive treatment; CAD-CAM composite; fixed prosthodontics; dental materials.

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Introduction

In recent years, a significant increase in the prevalence of tooth wear has been observed, especially in young patients [1] [2] [3]. These problems are promoted by changing lifestyles, particularly chemical erosion favored by acidic food/drink and gastro-esophageal reflux, while mechanical wear is often related to the presence of bruxism, which engenders attrition and abfraction [4, 5]. Severe dental tissue wear can engender dental pain due to exposure of dentinal tubules [6, 7] and a decrease in the masticatory function. Moreover, severe tooth wear leads to an unsightly appearance in most patients, who report a real social handicap [8] [9]. In addition to preventive approaches in the absence of symptoms and patient demand [10], current recommendations emphasize the need to develop minimally invasive treatment strategies that preserve as much as possible remaining tooth tissues [9], with the current tendency being to avoid any tooth tissue preparation ("No prep"). However, restoring functional occlusal relationships and aesthetics requires a full-mouth rehabilitation with an increase in the vertical dimension of occlusion (VDO), constituting a complex treatment. Various techniques have been described: direct techniques with light-cured composites, which constitute the most commonly reported treatment [8], indirect techniques; or a mix of the two techniques. The direct technique can involve the estimation of the new VDO in the articulator before light-cured composites placement using silicone bite-stops in the posterior zone (DSO-technique) [11] [12], or the realization of a global wax-up with an arbitrarily determined increase of the VDO, followed by the placement of light-cured composites using a transparent silicon key [13, 14]. Additionally, some authors have performed the wax-up on the basis of an analysis of occlusal

relationships (e.g., using facial bow and a jig) [13], and others have used provisional restorations to test the new VDO before final direct composite realization [15]. The direct technique is particularly minimally invasive and reversible, restorations being easy to repare, while the treatment cost is reported to be reduced [16, 17]. However, the technique can result in the need for maintenance care (for example polishing and repair), especially in the presence of bruxism [9] since the prognosis of restorations is patient dependent [18]. Conversely, with indirect, minimally invasive strategies, composite palatal veneers, eventually associated with ceramic buccal veneers, are usually performed to restore the upper incisors and canines ("sandwich technique"), while ceramic or composite occlusal onlays are realized on the premolars and molars [19] [20] [21]. These treatments gave multiple steps and require several appointments, involving the realization of mock ups and provisional restorations, which are intended to test the new VDO, to validate the aesthetic results and to guide tooth tissue preparation for indirect restoration [22]. If indirect techniques allow for the use of materials that are more performant than light-cured composites, the restorations are more expensive [18]. However, there is no evidence regarding the best technique (direct or indirect) or material (composite or ceramic) to be used to restore severely worn dentition [8, 9], and to the authors' knowledge, there have been no clinical studies examining the performance of indirect restorations used for full-mouth rehabilitation of worn dentition. Recently, a novel technique (One-step No-prep) for full-mouth rehabilitation of worn dentition using CAD-CAM composite restorations was introduced [23]. It is characterized by the absence of tooth tissue preparation and a provisional phase, the use of Polymer-Infiltrated Ceramic Network (PICN) materials, the realization of an occlusal analysis and the collaboration with physiotherapists to treat associated symptoms, such as muscular hypertrophy and pain.

In this "one step" treatment, definitive indirect restorations are bonded within two consecutive days, reducing visit numbers in comparison with other indirect techniques and treatment

complexity (particularly regarding very thin provisional restorations management). PICN materials (hybrid ceramics, Vita Enamic, Vita Zahnfabrik, Bad Säckingen, Germany) were shown to exhibit several advantages compared to ceramics for this indication, such as the ability to be milled to a very low thickness and ease of in-mouth adjustments [24]. Furthermore, they have also shown good mechanical [25] and bonding properties [26]. The One-step No-prep approach was shown to yield successful short-term clinical results in three pilot cases and to be particularly straightforward and minimally invasive. The absence of provisional restorations to test the VDO increase did not engender any inconvenience and the patients' perceptions were very positive. However, those preliminary results must be confirmed with an in-depth analysis of the different facets of this protocol. Moreover, there is a lack of data about the clinical behavior of PICN partial coverage restorations [27] [28] [29]. Consequently, the objective of the present study was to prospectively evaluate the "One Step - No Prep" protocol for full-mouth rehabilitation of worn dentition, studying the clinical behavior of PICN restorations and treatment influence on patients' Oral-Health-Related-Quality of Life (OHRQoL) using the Oral-Health-Impact-Profile-49 questionnaire (OHIP-49).

Materials and methods

1. *Study design*

This study was a prospective clinical study evaluating patients treated with the "One-step No-prep" protocol. The patients were treated in the Department of Fixed Prosthodontics of the University Hospital of Liège by four experimented practitioners. They were informed about the objectives of the study, and their consent was obtained before treatment. The study was approved by the Ethics Committee of the University Hospital of Liège (B707201526682).

2. *Patient record registrations*

Specific data were collected regarding the following parameters: sex, age, and occlusal relationships were registered (dental class, function, overjet, overbite, crossbite).

3. Patient selection

Seven patients presenting generalized severe tooth wear with an aesthetic or functional demand were included in the study. The patients were required to have a minimum of 28 teeth, palatine veneers of the canine to canine superior teeth and a minimum of 3 teeth per posterior sextant to restore with an indirect restoration (Figure 1a, Figure 2a, Figure 2b). The following patients were excluded from the study: smokers and patients with poor oral hygiene, those with periodontal disease or severe osteoarthritis, and patients with crowns, bridges, or implants. Patients with Parkinson disease or spontaneous temporomandibular joint pain associated with a mandibular deflection and an opening limitation (<25 mm) were also excluded.

4. Wear quantification

To quantify dental wear, the Basic Erosive Wear Examination index (BEWE) [30] was calculated for each patient by the same practitioner.

5. Chemical erosion assessment

In addition to a thorough clinical examination to detect the presence of dental erosion surfaces (concave, cuneiform or flat lesions), an accurate medical history was recorded including questions about nutrition habits, general diseases, medications, and environmental factors.

6. Non instrumental approach of bruxism assessment

A clinical examination was performed to register the presence of clinical signs of bruxism, such as dental attrition, cracks/fractures, masseteric hypertrophy, linea alba, exostoses or crenated tongue [31] [32]. The presence of bruxism was recorded if the patient fulfilled at least two

criteria: A) reporting of tooth grinding during the night or day; or B) the presence of at least one clinical sign among the following: abnormal attrition wear facets on the teeth; transitory pain or fatigue on waking felt in the jaw muscles; temporal headaches on waking; and jaw locking on waking related to teeth grinding during sleep [31] [33]. A complementary clinical examination was performed by an occlusodontist (i.e. a specialist in occlusion and TMDs) to detect the presence of temporomandibular joint (TMJ) disorder. If patients had symptoms of TMJ disorder, they were sent to a maxillofacial physiotherapist before treatment. Finally, the wearing of an occlusal nightguard before treatment was recorded.

7. Clinical protocol

The patients were treated according to the previously described "One-step No-prep" protocol [23]. Before including patients in the study, a complete dental check-up with carious and periodontal examinations, X-rays and photographs was performed. Double mix impressions with polyvinyl siloxane (PVS) material (Imprint 4 Heavy and XLV, 3M ESPE, Seefeld, Germany) were realized, and study models were cast (GC Fujirock EP Super Hard Plaster, GC Europe, Leuven, Belgium). Then, an occlusal analysis was performed using a resin jig [34] (Figure 1b) and a facebow (Figure 1c) (Quick facebow, Sintec Inc, New Hampshire, USA). The jig was placed for a few minutes to induce muscular relaxation and lower jaw repositioning, and then occlusal relationships were registered with wax (Moyco Beauty Wax, Philadelphia, PA, USA) in double thickness (Figure 1d). The dental technician started to deposit the wax on the less damaged teeth and was guided by the residual tissues to restore tooth anatomy, resulting in very low wax thickness on some posterior teeth (Figure 1e). With this "tissue-guided" approach, the estimation of the new VDO was empirical. The full wax-up was shown to the patient for approval. Subsequently, 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). Before impressions, dental

tissues were not prepared, but sharp angles were softened and large direct composite fillings, presenting large proximal boxes, were partly removed to be replaced by the indirect restorative material, with cavities filled with provisional composite resin (Telio CS Onlay, Ivoclar Vivadent, Schaan, Lichtenstein). If required, endodontic treatments were performed previously. New double mix impressions and occlusal analysis following the same protocol as previously were performed after a visit to the physiotherapist, which was intended to equilibrate the posture and muscular chains before final occlusal analysis. It should be emphasized that the patients did not wear any occlusal splints to test the new VDO before treatment. A resin posterior key was realized to validate the occlusal relationships in the articulator. The models and the full wax-ups were scanned and superimposed using a CAD-CAM system (Ceramill system, Amann Girrbach AG, Koblach, Austria) (Figure 1f). A CAD-CAM mock-up was performed in wax and tried to validate the restoration design and aesthetic result (Figure 1g). Restorations corresponding to the estimated tissue loss (palatal veneer, posterior occlusal tabletops and veneerlays) were milled from PICN blocks (Vita Enamic HT, Vita Zahnfabrik, Germany; Ceramill Motion 2, Amann Girrbach) (Figure 1h, Figure 1i). Some restorations were only polished or stained with a light-cured nanofilled composite coating agent (Optiglaze, GC Corporation, Tokyo, Japan). The restorations were tried and then bonded within two consecutive days at two half-day appointments, one for each maxilla (the upper jaw on the first day afternoon, the lower on the second day morning). The restorations were pretreated following the manufacturer's recommendations, i.e., 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 (Silane Primer, Kerr, Orange, California, United States). A rubber dam was placed for the posterior teeth but not the anterior teeth. Tooth tissues were cleaned with pumice. A diamond burr at low speed was used to open the tubules of sclerotic dentin and enamel was etched with phosphoric acid. Direct composites were sandblasted with the Cojet system (3M,

Saint-Paul, USA) and a silane (Silane Primer, Kerr, Orange, California, United States) was applicated. Then a two-step etch-and-rinse adhesive (Optibond XTR, Kerr, Orange, California, United States) was applicated following manufacturer recommendations and the adhesive layer was polymerized before restoration bonding. The restorations were bonded with a composite resin cement with the Nexus XTR system (NX3, Kerr, Orange, California, United States), polymerization was performed after excess removal, and final photopolymerization was performed under a film of glycerin to avoid the persistence of a polymerization inhibition layer. Major occlusal adjustments were realized immediately after bonding of the lower restorations with an Arkansas stone burr, followed by polishing with silicon gums and fine adjustments performed within the subsequent weeks and after a visit to a maxillofacial physiotherapist. A bleaching procedure (home bleaching with a night guard using Illumine 10% tooth gel Kit, Dentsply Sirona, New York, USA) was also performed (which was not possible when the dentin was still exposed). To mask the junction between the palatal veneer and the buccal face of the upper anterior teeth, direct composite (Inspiro, Edelweiss, Zug, Switzerland) was added on a slight chamfer performed across the junction and where needed to optimize tooth shape (Figure 1j, Figure 1k, Figure 1l, Figure 1m, Figure 2c, Figure 2d). Finally, an acrylic nightguard (for the upper maxilla) (Orthocryl, Dentaurum, Ispringen, Germany) was provided to all of the patients.

8. Prosthetic parameter analysis

For each restoration, the nature of the antagonist (enamel, dentin, direct composites, PICN restoration) was registered. The lowest thickness of each restoration was measured, and the VDO increase at the incisal guide pin was registered.

9. Clinical evaluation of restorations

Two independent and calibrated evaluators assessed restorations following the criteria of the World Dental Federation (FDI) after one month, six months, 1 year and 2 years [35]. Three dimensions, representing 18 items, were described: aesthetic, functional and biological. The functional and aesthetic dimension includes patient-reported satisfaction. Each item is assessed on a 5-point Likert scale (1 corresponding to an excellent restoration and 5 corresponding to a restoration that must be replaced). In case of discrepancies, agreement was found between evaluators to determine the final score.

10. Patient Reported Outcome Measures (PROMs)

The Oral-Health-Impact-Profile-49 [36] questionnaire (OHIP-49, OHRQoL for Oral-Health-Related-Quality of Life) was filled out before treatment and at each evaluation time. The OHIP questionnaire includes 49 statements divided into seven areas, namely functional limitations, physical pain, psychological discomfort, physical disability, psychological disability, social disability and disability. For each question, a score between 1 and 5 is given, from never to very often. A high global score identifies poor quality of life related to oral health. In the present study, it was decided to present the global OHIP score [37] and the overall score for each of the seven areas, respectively.

11. Statistical analysis

Data analysis was carried out using GraphPad Prism (GraphPad Software, San Diego, CA). The data collected were expressed in terms of the prevalence or the mean ± standard deviation (Mean ± SD). The prevalence was defined as the proportion (%) of people with a given condition relative to the total population studied. The annual failure rate (AFR) of restorations was calculated on the basis of survival and success, respectively (https://link.springer.com/content/pdf/bbm%3A978-3-540-34582-4%2F1.pdf). An analysis of the normal distribution of data was systematically performed with the Shapiro-Wilk test. In

order to compare the mean scores of OHIP-49 variables, not normally distributed, before and after the intervention (1 month and 2 years), the Mann–Whitney U test and the Wilcoxon signed-rank test were used. In all tests, variations were considered statistically significant when p-value < 0.05.

Results

1. *Clinical data about the patients*

Seven patients (n=192 PICN restorations) were included in this study. Among them, 6 were men. The mean age was 37.7 ± 12.8 years old. Six patients were in class I, and one patient was in class II.2. Of the patients 57.2% (n=2) showed a group function, 14.3% (n=1) had a canine function, and 28.5% (n=2) had both types of function. Regarding the Basic Erosive Wear Examination (BEWE), 6 patients had a high risk level (BEWE score >14), and one patient had a medium risk level (BEWE score =13). Regarding the etiology of wear, all of the patients showed both chemical (erosion) and mechanical wear (bruxism) signs. Most of the patients (71.4%, n=5) reported drinking 1 to 2 liters of soda every day, and 28.6% (n=2) had gastro-esophageal reflux. All of the patient reported grinding or clenching habits during the night or day, with a minimum score of 4 out of 10. Finally, 85.7% (n=6) of patients described being stressed and anxious in their daily lives.

2. *Clinical data about PICN restorations*

In total, 192 PICN restorations were evaluated at 2 years. Six patients received PICN restorations on all of their teeth, and one patient received direct restorations for the lower incisors and canines (Inspiro, Edelweiss). Consequently, 96.36% (n=185) of restorations were in contact with PICN material and 3.64% (n=7) with direct composite. The mean thickness registered at the thinnest point of restorations was 1.2 ± 0.4 mm for upper incisors (n=28), 1.1

± 0.5 mm for lower incisors (n=24), 1.0 ± 0.5 mm for canines (n=26), 0.7 ± 0.3 mm for premolars (n=56) and 0.5 ± 0.2 mm for molars (n=58). The lowest thickness measured was 0,11 mm on a molar. The mean VDO increase as measured at the incisal pin was 5.09 ± 0.85 mm, and the greatest VDO increase registered was 6.00 mm (n=2).

3. Clinical evaluation of restorations

After periods of 1 and 2 years, the survival rates of PICN restorations (n=192) were 100% and 100%, respectively, and the success rates were 100% and 93.75%. The annual failure rate (AFR) on the basis of survival and success was 0% and 3.1%, respectively. FDI rating of restorations at 2 years is presented in Table 1. One hundred percent of restorations were scored as clinically acceptable for all properties at 2 years. The results showed 11 cases of minor chipping and one case of debonding (the weak link was the interface between the resin cement and the sclerotic dentin) (Figure 3). Restorations presenting minor chipping were polished or repaired following this protocol: rubber dam placement, sandblasting with Cojet, silane application (Silane primer, Kerr), adhesive (Optibond XTR, Kerr) and direct composite placement (Els composite extra low shrinkage, Saremco Dental, Rebstein, Switzerland). The debonded restoration was rebonded following this procedure: elimination of the sclerotic dentin layer and of the surface layer of the composite resin cement in the restoration intaglio with a diamond burr, sandblasting of the resin cement and silane application, application of a three-step etch-and-rinse adhesive on tooth tissues following manufacturer recommendations (Optidbonf FL, Kerr) and bonding of the restoration with Inspiro direct composite (adaptation was not perfect anymore and direct composite was used to increase the mechanical resistance and esthetics of the marginal joint). Those failures affected the success but not the survival rate of the restorations.

4. Patient Reported Outcome Measures (PROMs)

The OHIP-49 results before treatment, at 1 month and 2 years, are presented in Table 2.

Discussion

Tooth wear is a multifactorial phenomenon, and in the present study, all of the patients showed both mechanical and chemical risk factors related to bruxism and soft drink consumption, highlighting the importance of early diagnosis and information in the prevention of this pathology [9]. The BEWE index was used for wear quantitative evaluation because of its common utilization and ease of use [30]. The high scores obtained (>13) and the presence of patients' aesthetic and functional complaints, particularly tooth pain, constitute indications for treatment, as recommended in recent European guidelines [9].

Despite its high risk regarding the one-step significant VDO increase (mean of 5.08±0.84 mm at the incisal pin), *i.e.*, without using provisional restorations or nightguards to test the new VDO as often recommended [22], the results of the One-step No-prep approach confirmed results obtained with the three pilot cases [23]. The global OHIP score was, as shown in a previous study related to severe tooth wear treatment with direct composites [38], significantly improved already one month after treatment and still after two years, while all sub-scores, except the one for social disability, were significantly improved after two years (Table 2). Detailed analysis of the sub-scores showed that, from a function and pain point of view, the patient's quality of life improves with time. In fact, patients quickly adapted to their new occlusal relationships, and only pronunciation troubles were present at one month but not later. The VDO determination is always an inaccurate and empirical process, and with the One-step No-prep approach, the principle is simply to recreate missing tissues on the basis of the remaining tooth anatomy. Although reported to be risky and not recommended for indirect restoration techniques, the one-step approach of VDO increase is already successfully used with direct techniques [16] [12] , and it was previously reported that a 5 mm increase at the incisal

pin did not engender any undesirable effects on the temporomandibular joints and associated muscles [39, 40]. In this limited clinical study, none of the patients reported any problems with the one-step VDO increase.

PICNs were confirmed to be well-adapted to the technique in terms of the ability to be milled in very low thickness (up to 0.11 mm on molars) and ease of in-mouth adjustment, particularly regarding occlusal contact points. Indeed, ceramic restorations cannot be easily adjusted and repolished after placement, with PICNs and other composite materials being more adapted to a one-step approach. PICNs also exhibit an elasticity modulus, which is comprised between the enamel and dentin, while ceramics are too stiff, and other composites are too flexible, and their damping behavior is particularly interesting in cases of bruxism and high occlusal stress [41]. Other advantages of PICNs are the bonding properties: in the present study, despite the presence of bruxism and the non-retentive prosthesis design, only one debonding was registered among 192 restorations. It was related to a severely damaged upper incisor, with sclerotic dentin and a small amount of enamel, and the fracture occurred at the interface with tooth tissues and not in the material (Figure 2). Regarding mechanical strength, 5.73% of minor chipping was observed after two years, most often on thin restoration edges, which were in occlusal contacts. Indeed, restorations were very thin and submitted to extreme conditions, particularly due to high occlusal stress. From this point of view, the new generation of PICNs should perform better due to their high flexural strength and flexural load energy [41]. Despite this fact, the survival rate and success rate of restorations were 100% and 93.75%, at two years, which were higher than recently reported survival and success rates at three years for partial coverage posterior restorations in PICN (95.6% and 82.4%, respectively, for 44 restorations) [27] and in lithium disilicate glass-ceramic (98.3% and 85%, respectively, for 60 restorations) [42]. However, to the authors' knowledge, there have been no clinical studies reporting the performance of partial indirect restorations for full-mouth rehabilitation of severe worn dentition. Several studies were

published about treatment of those cases with direct composites showing various results [14, 16] [43] [12]. Loomans et al. reported, for 1256 restorations, an overall success rate of 94.8% at 3.5 years, and a survival rate of 99.3% [12], which is similar to the present study, while Sundaram & Bartlett concluded that the use of direct (as artisanal indirect) composite resin for restoring worn posterior teeth is contraindicated [14] . Those contradictory results could be explained by the operator-dependent effect of direct techniques, or the difference between the applied composite resins (microfilled versus highly filled hybrid composite resin) [16] . The inconvenience of direct composites is, from a material point of view and compared to PICNs and other CAD-CAM composites, the degree of conversion of monomers, which is lower due to the polymerization mode (light curing compared to high temperature and high pressure for PICNs) [44]. In fact, this parameter influences all material properties, such as mechanical properties, biological properties (monomer release), chemical stability and aging [24, 25]. Moreover, CAD-CAM blocks are more homogeneous with fewer flaws, also promoting mechanical behavior. Finally, with respect to the rapid evolution of digital dentistry and chairside systems, occlusion and tooth anatomy will be easier to design with computer help, promoting the use of CAD-CAM restorations, particularly in composite materials, which are well-adapted to those manufacturing processes.

Regarding the restorations' color matching and translucency, the FDI criteria yielded high scores for evaluators and patients after two years. Furthermore, OHIP results showed significant better psychological comfort after treatment (Table 2).

Future perspectives include the study of new PICN materials, particularly the recently introduced biomimetic PICN, which exhibits a gradient in mechanical and optical properties to mimic tooth tissues. Its hardness is similar to enamel on the surface and dentin in the depths, and its high flexural strength and flexural load energy are promising in terms of wear behavior, chipping resistance and damping effect.

Conclusion

The One-step No-prep technique is a minimally invasive and straightforward approach for the treatment of severe and generalized tooth wear. The treatment protocol was shown to yield successful clinical results from the functional and aesthetic points of view, the one-step approach of VDO increase was well tolerated and the global OHIP score, as 6 sub-scores on 7, were significantly improved. The present study provided significant data about the clinical performance of PICN partial restorations with respect to the existing literature, constituting the largest sample of restorations examined until now. The observed survival (100%) and success (93.75%) rates of restorations at two years were high, despite the extreme conditions to which the material was submitted. Minor chipping of very thin borders submitted to occlusal stress was the most frequent complication encountered. Finally, with respect to the rapid evolution of digital dentistry and the development of chairside systems, occlusion and tooth anatomy will be easier to design with computer help, which promotes the use of indirect CAD-CAM composite restorations for the treatment of severe worn dentition.

Future perspectives could include the development of clinical research to confirm the present results and the performance of future generations of PICN materials, particularly biomimetic PICN.

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Captions

Table 1: 2-year FDI rating of restorations. In bold, failures considered for the success rate calculation.

	Clinically Excellent % (n)	Clinically Good % (n)	Clinically Sufficient % (n)	Clinically Unsatisfactory % (n)	Acceptable (%)	Unacceptable (%)
A. Esthetic properties					100(192)	
1. Surface luster		100 (192)				
2. Staining						
a. surface	100 (192)					
b. margin	90.6 (174)	9.4 (18)				
3. Color match & translucency	16.7 (32)	67.7 (130)	15.6 (30)			
4. Esthetic anatomical form	97.4 (187)	1.6 (3)	1.0 (2)			
B. Functional properties					100 (192)	
5. Fracture of material/ retention	94.3 (181)	3.6 (7)	2.1 (4)			
6. Marginal adaptation		100 (192)				
7. Occlusal contour &wear	100 (192)					
a. Qualitatively	100 (192)					
b. Quantitatively						
8. Approximal anatomical form	93.2 (179)	1 (2)	5,8 (11)			
a. contact point	99.5 (191)	0.5 (1)				
b. contour						
9. Radiographie examination	100 (192)					
10. Patient's view	100 (192)					
C. Biological properties					100 (192)	
11. Postoperative sensitivity / tooth vitality	96.9 (186)	3.1 (6)				
12. Recurrence of caries, erosion, abfraction	100 (192)					
13. Tooth integrity	100 (192)					
14. Periodontal response	94.3 (181)	5.7 (11)				

15. Adjacent mucosa	100 (192)
16. Oral and general health	100 (192)

Table 2: Comparison of global OHIP score and sub-scores before treatment and one month after treatment, and before treatment and two years after treatment, respectively (1 being the best score and 5 the worst).

	Before Treatment (Mean±SD)	1month (Mean±SD)	p value (Before treatment-1 month	2 years (Mean±SD)	p value (Before treatment-2 years)
Global Score	**1.88±1.26**	**1.54±0.92**	**0.0010*** **	**1.36±0.92**	**<0.0001*** **
Functional limitation	2.02±1.34	1.79±1.03	0.5235 ns	1.56±1.09	0.02*
Physical pain	2.56±1.41	1.84±1.06	0.0035**	1.70±1.21	0.0003***
Psychological discomfort	2.49±1.36	1.71±1.15	0.0006***	1.49±1.7	≤0.0001***
Physical disability	1.66±1.15	1.52±0.89	0.7753 ns	1.17±0.52	0.0055**
Psychological disability	1.79±1.12	1.38±0.73	0.0462*	1.33±0.93	≤0.0002***
Social disability	1.09±0.37	1.09±0.28	1 ns	1.09±0.37	1 ns
Handicap	1.34±0.94	1.14±0.47	0.4345 ns	1.02±0.15	0.0431*

SD : Standard deviation, * Significant ($p \leq 0.05$), ** Significant ($p \leq 0.01$), *** Significant ($p \leq 0.001$), ns Insignificant.

Figure 1: Case 1

a) Occlusal views before treatment.

b) Occlusal relationships registered using a resin jig and a double layer of wax (Moyco Beauty Wax).

c) Facebow (Quick facebow).

d) Plaster models placed in the articulator.

e) "Tissue-guided" full-mouth wax-up.

f) Superimposition of the scans of the models and the wax-up with the Ceramill system.

g) Wax CAD-CAM mock-up.

h) Occlusal views of final PICN restorations on plaster models after polishing (in this case, restorations were not stained).

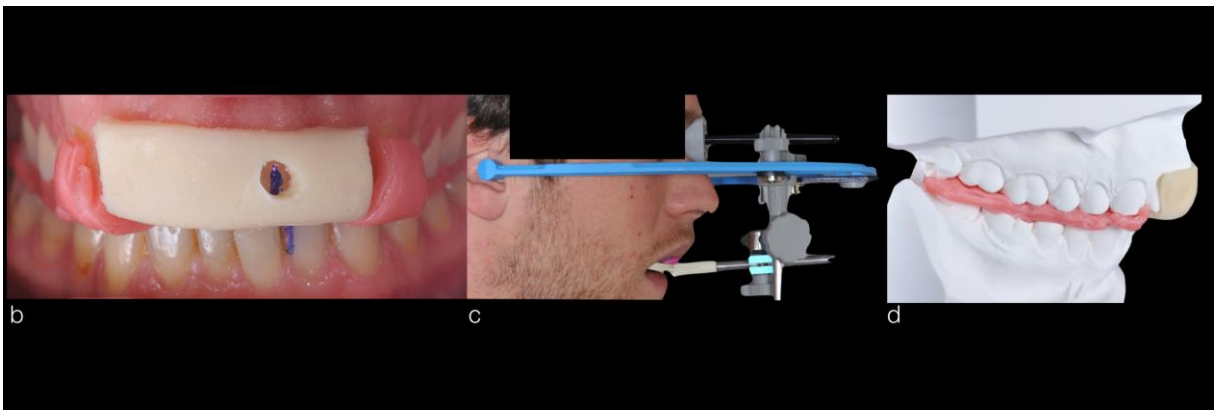
~~i)~~ A 0.11 mm-thick PICN (Vita Enamic) posterior occlusal table top immediately after milling.

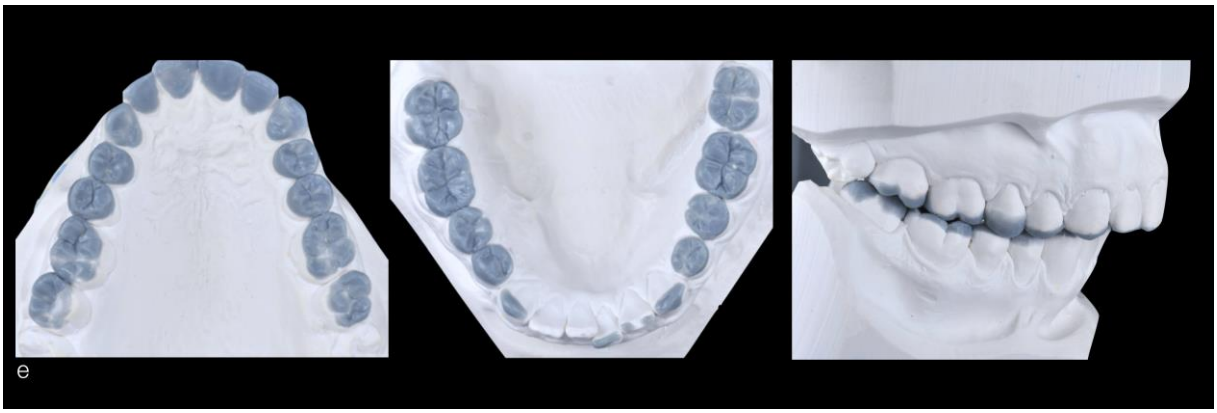
j) Direct composite was added on a slight chamfer performed across the junction between the tooth and the palatal veneer to mask the joint between the palatal veneer and the buccal face of the upper anterior teeth. In this case, the chamfer comprised two buccal grooves to fill with incisal direct composite to promote the aesthetic result. Direct composite was also added where needed to optimize tooth shape. This option is a minimally invasive alternative to ceramic buccal veneer, which can be performed a second time if the patient is not satisfied with the result or if the direct restoration is aging too quickly.

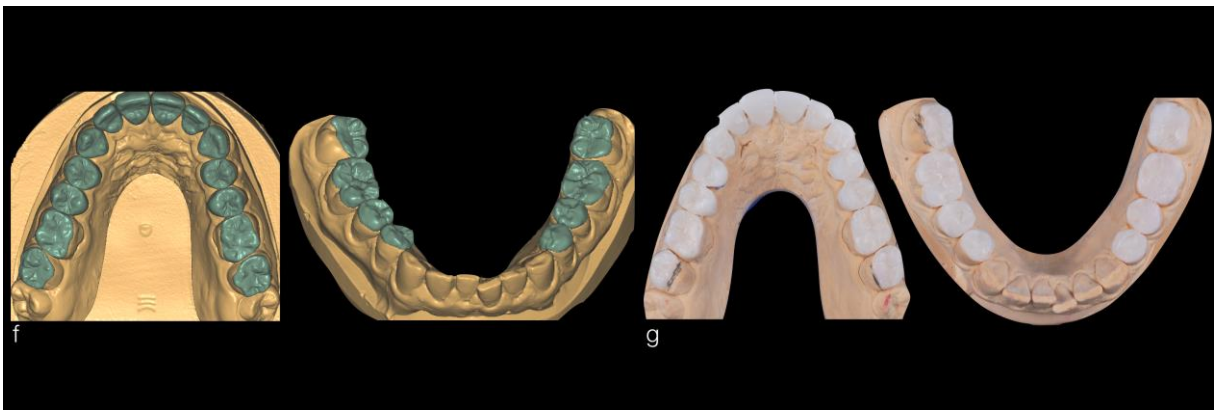
k) Buccal views of upper anterior teeth before treatment, after palatal veneer bonding and after buccal joint masking with direct composite, respectively. Palatal veneers should be performed a bit longer than needed regarding the position of the incisal edge to be able to perfectly adapt this edge to the horizontal plane after bonding. Direct composite should not be present on the incisal edge for mechanical resistance issues.

l) Occlusal views after treatment.

m) Smile pictures before and after treatment.





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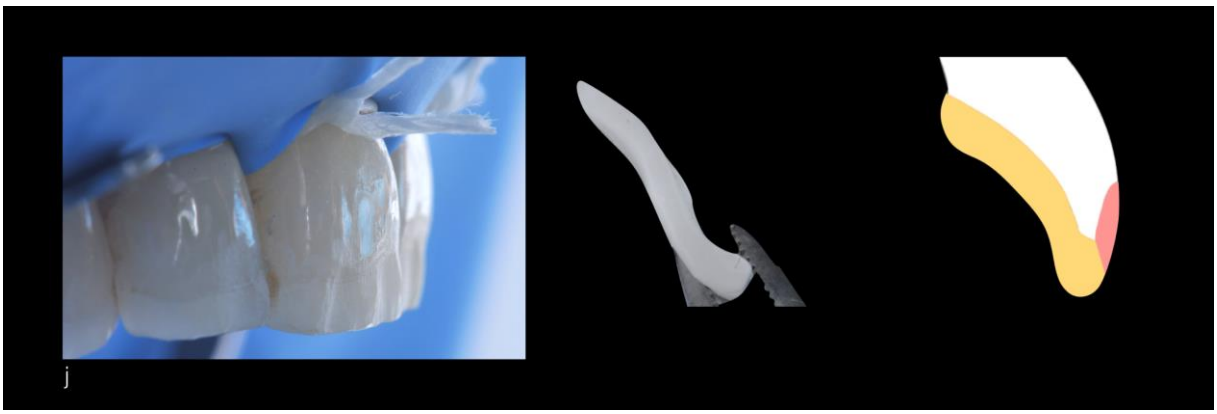
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Figure 2: Case 2, severe tooth wear in a patient suffering from anorexia and bruxism.

a) Occlusal views before treatment.

b) Frontal view before treatment

c) Frontal view after treatment. The patient was sent to a specialist to consider soft tissue grafts for gingival recessions.

d) Occlusal views after treatment.

Figure 3: Observed technical complications.

a) In case 2, loss of the restoration on tooth #22, which was severely damaged, after a 19-mth follow-up. The weak link was the interface between the resin cement and the sclerotic dentin. The restoration was successfully rebonded after eliminating the sclerotic layer with a diamond burr.

b) Typical minor chipping of thin restoration borders in occlusal contact.