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Operative Dentistry

Adhesive management of anterior tooth wear in combination with the Dahl concept – 27-months observational case-series --Manuscript Draft--

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Abstract:	<p>Localized anterior maxillary tooth wear caused by erosion and attrition with loss of interocclusal space is difficult to manage. This observational case-series study reports six cases with worn anterior dentition, treated with labial ceramic and palatal direct resin composite veneers at an increased vertical dimension of occlusion without restoration of unaffected posterior teeth. 36 palatal direct veneers were made in six patients from a nanohybrid resin composite with the help of a wax-up based template at an increased vertical dimension. After the complete re-establishment of posterior occlusion 40 labial lithium-disilicate ceramic veneers were fabricated with a mock-up guided method. The sandwich veneers were evaluated after a mean service time of 22.7 months according to the USPHS criteria. Re-establishment of posterior contacts as well as subjective patient satisfaction and function were evaluated. The overall success of the labial ceramic veneers was excellent. The quality of the palatal resin composite restorations was found to be good with predominantly 'Alpha' scores. The marginal quality (11.1% and 33.3% of integrity and discoloration, respectively) and surface roughness (16.7%) showed small deteriorations indicated by 'Beta' scores. The resin composite showed, in general, signs of wear facets which resulted in 'Beta' scores in 44.4% of the cases. Posterior contacts re-established firmly within 4 weeks in all cases. Patient satisfaction was high concerning aesthetics and function. The short-term outcome of this non-invasive treatment option is favorable and promising.</p>

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4 **Adhesive management of anterior tooth wear in combination with the Dahl concept – 27-**
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6 **month observational case-series**
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11 **Running title:** Sandwich veneers with Dahl concept of worn teeth
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16 **Clinical relevance statement**
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19 Localized anterior tooth wear can be restored with adhesively bonded labial ceramic and palatal
20 direct resin composite veneers at an increased vertical dimension of occlusion. The separated
21 occlusal contacts re-established within 1 month. The ceramic veneers showed excellent
22 performance and the requirement for maintenance of the palatal veneers was minimal over a period
23 of 22.7 months. This additive technique provides maximal tooth preservation for worn dentition.
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28 **Abstract**
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31 Localized anterior maxillary tooth wear caused by erosion and attrition with loss of interocclusal
32 space is difficult to manage.
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36 This observational case-series study reports six cases with worn anterior dentition, treated with
37 labial ceramic and palatal direct resin composite veneers at an increased vertical dimension of
38 occlusion without restoration of unaffected posterior teeth.
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42 36 palatal direct veneers were made in six patients from a nanohybrid resin composite with the help
43 of a wax-up based template at an increased vertical dimension. After the complete re-establishment
44 of posterior occlusion 40 labial lithium-disilicate ceramic veneers were fabricated with a mock-up
45 guided method. The sandwich veneers were evaluated after a mean service time of 22.7 months
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47 patient satisfaction and function were evaluated. The overall success of the labial ceramic veneers
48 was excellent. The quality of the palatal resin composite restorations was found to be good with
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50 discoloration, respectively) and surface roughness (16.7%) showed small deteriorations indicated
51 by ‘Beta’ scores. The resin composite showed, in general, signs of wear facets which resulted in
52 ‘Beta’ scores in 44.4% of the cases. Posterior contacts re-established firmly within 4 weeks in all
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5 this non-invasive treatment option is favorable and promising.
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10 **INTRODUCTION**

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16 The general term for non-carious tooth loss is tooth wear, describing loss of dental hard tissue
17 generated by different etiological factors such as chemical and mechanical processes.¹ According
18 to Loomans et al., tooth wear is pathological if it is atypical for the age of the patient, causing pain
19 or discomfort, functional problems, or deterioration of aesthetic appearance, which, if it progresses,
20 may give rise to undesirable complications of increasing complexity.² Tooth wear can be identified
21 as erosion, attrition, abrasion and abfraction.³ Clinical observations have demonstrated that wear
22 mechanisms do not act alone but instead, cause loss of tooth surfaces by interacting with each
23 other.⁴ An increased incidence of erosive wear is reported in young populations, thanks to the
24 dietary habits, increased tendency of soft and energy drink consumption and the stressful effect of
25 an accelerated lifestyle.⁵ Irrespective of etiological factors, tooth wear might influence oral health,
26 personal comfort, may result in loss of vertical dimension of occlusion (VDO), tooth sensitivity
27 and pulpal involvement. However, especially for young adult patients, aesthetic complaints are
28 paramount.^{6,7} Depending on the progression, the incisal edges may also show signs of wear and
29 shortening due to loss of enamel support and subsequent chipping. The rate of anterior erosive
30 tooth wear could be severe, even at a young age, if bruxism or other parafunction takes place alone
31 or concurrently with the erosion.⁸
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45 The management of tooth wear may involve complex preventive and restorative care, possibly with
46 full rehabilitation at an increased vertical dimension of occlusion.⁹⁻¹¹ Currently, adhesive dentistry
47 is undergoing considerable progress enabling advanced restoration techniques. In the restorative
48 management of tooth wear there has been a tendency towards minimum-intervention approaches.²
49 According to the minimally invasive treatment concept, partial covering all-ceramic restorations
50 and direct resin based composite (RBC) recently became recommended as preferred therapy.¹²⁻¹⁶
51 Mesko et al. included several papers in their systematic review dealing with the materials and
52 techniques applied to restore teeth with severe tooth wear.¹⁷ They concluded that the absence of
53 randomized clinical trials on the subject appears to be the main limitation of the existing evidence.
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4 However, in line with Ahmed et al., Mesko et al. also found RBC to be a feasible option to restore
5 teeth with severe wear and demonstrated a good performance of this material over short and
6 medium-term follow-up.^{17,18} Unlike the traditional subtractive techniques, with the help of reliable
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adhesion to the tooth, RBCs provide additive treatment solutions while preserving the remaining tooth structure.² Vailati and Belser presented a three-step technique to reconstruct eroded anterior teeth with an additive adhesive approach, providing maximum preservation of tooth structure with predictable aesthetic and functional outcome.¹⁹⁻²¹ The applied sandwich veneers provide palatal guidance and buccal esthetics with the protection of the remaining tooth structure concurrently with the adhesive increase of VDO in the molar region.¹⁹⁻²¹

An ultraconservative and simplified treatment is proposed through the use of the combination of centric relation and Dahl principle in the solution of localized anterior tooth wear and erosion.²² In localized anterior tooth wear compensatory eruption may take place, maintaining the VDO despite the loss of anterior clinical crown height.²³ The resultant loss of interocclusal space presents a challenge for restoration, especially when the posterior teeth are unaffected. The Dahl approach consists of creating interocclusal space through axial tooth movement with an appliance or restorations placed in supra-occlusion, and the subsequent re-establishment of full arch occlusal contacts over a period of time.^{24,25} The original Dahl appliance was based on a metal cobalt-chromium appliance cemented on the palatal surfaces of upper anterior teeth, however, more recently RBC restorations have been used to create the space with good short to medium term survival.²⁵⁻²⁸ Although, the clinical performance seems satisfactory, the limited mechanical and physical properties of RBC restorations demand maintenance.²⁸ To overcome the aesthetic issue which arises from the deterioration of RBC, ceramic veneers can be used on the labial surfaces of anterior teeth in harmony with the perceived needs and concerns of the patient. Meanwhile, the RBC on the palatal surface can wear the increased functional stress at an increased VDO. At the level of case reports, this sandwich approach in combination with the Dahl principle was introduced by Magne et al., however, there is a lack of data about the short-, medium- and long-term performance of this biomechanically favorable treatment option.²²

The aim of this prospective observational case-series study was to assess the short-term clinical performance and patient satisfaction of the sandwich approach used for the treatment of localized anterior tooth wear consisting of palatal resin composite direct build-ups and vestibular lithium-disilicate veneers in combination with the Dahl approach.

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4 **METHODS & MATERIALS**
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8 *Patient selection*
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11 For this prospective observational case-series study a total of six patients (2 males and 4 females)
12 with ages ranging from 22 and 34 years old were selected according to pre-determined inclusion
13 criteria. The inclusion criteria employed comprised of the following: all participants were adults,
14 able to read and sign the informed consent document, physically and psychologically able to
15 tolerate the procedure. Furthermore, patients who were selected for the study had good oral
16 hygiene, full dentition and normal occlusion without periodontal disease, as verified by the clinical
17 and radiographic records. Moreover, patients had remained in continuous clinical follow-up,
18 without attending other dentists. The minimal length of the follow-up time was 20 months. Reasons
19 for placement of direct palatal RBC veneers and labial ceramic veneers were either localized
20 anterior attrition or combination of erosion and attrition with relatively unaffected posterior teeth
21 (Figure 1A, 1B). Tooth wear was determined to be clinically significant when dentin was exposed
22 and when there was a reduction of crown height. Margins placed on enamel with a vital pulp were
23 also requirements which had to be fulfilled in order for the placement of direct and indirect veneers.
24 The study protocol was approved by the Regional Research Ethics Committee of University of
25 Pécs (3410.1/PTE).
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29 The patients were seeking advice for aesthetic reasons and wanted to improve their deteriorated
30 and disadvantageous smile. Before the written informed consent was signed, patients were given a
31 full explanation of the proposed treatment. They were treated at the Operative Dentistry
32 Department of the University of Pécs by one operator. Cause of the localized anterior tooth wear
33 was identified as much as possible based on a careful history and examination. The etiology was
34 primarily attrition (bruxism related occlusal stress) in half of the cases and combined
35 erosion/attrition (confirmed and treated gastroesophageal reflux disease in two cases and high rate
36 of soft drink/energy drink consumption in one case with concurrent bruxism related wear) in the
37 other half (Table 1).
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Bruxism related occlusal stress was identified by self-report and clinical examination. **The etiology of bruxism related to anxiety, insomnia and lifestyle-related stress. The elimination of the etiological factors was already ongoing or started to treat.**

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4 History taking was performed by a questionnaire survey according to Pintado et al. which focused
5 on night or awake grinding, jaw fatigue or temporal headache on awakening.²⁹ The clinical
6 examination consisted of the assessment of tooth wear, chipping or abfraction, masticatory muscle
7 hypertrophy or discomfort, teeth mobility, hypersensitivity, clicking of the temporomandibular
8 joint and tongue or cheek indentation.³⁰ Before starting the treatment, a consultation with an expert
9 in temporomandibular disorder was provided. **Diagnostic Criteria for Temporomandibular
10 Disorders (DC/TMD) were clinically applied to determine the presence or absence of any
11 temporomandibular disorder.**^{31,32} The erosive status of the maxillary anterior teeth was evaluated
12 with the help of the Anterior Clinical Erosive Classification (ACE).³³ According to the clinical
13 examinations, localized anterior loss of tooth structure, including dentin with minimum wear of
14 mandibular incisors, relatively intact posterior occlusal surfaces and absence of
15 temporomandibular disorder were diagnosed. According to self-reports and clinical signs, all the
16 patients suffered from bruxism related occlusal stress. Table 1 shows the patient related factors,
17 like age and gender and provides information about the etiology of tooth wear with its
18 classification.

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32 The suggested therapy, approved by the patients, was the sandwich veneer approach in combination
33 with the Dahl's concept. Patients received a total of 36 direct palatal RBC veneers on their vital
34 maxillary anterior teeth (Table 1). This method can replace the eroded tooth structure with the
35 additive approach at an increased VDO. The residual posterior interocclusal space is progressively
36 eliminated by the passive eruption of the posterior teeth and slight intrusion of the anterior teeth
37 reestablishing the occlusal contacts. A total of 42 lithium disilicate-reinforced pressed ceramic
38 veneers were used on the labial surfaces to improve the aesthetic appearance and to preserve
39 maximally the remaining tooth substance while simultaneously balancing the functional stresses
40 on the anterior dentition (Table 1).

41 42 43 44 45 46 47 48 49 *Restorative procedure*

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53 Upper and lower one-stage sandwich vinyl polysiloxane impressions (Variotime Easy Putty and
54 Light Flow, Kulzer, Hanau, Germany) were taken. This was followed by bite registration
55 (Variotime Bite, Kulzer, Hanau, Germany) recorded in centric relation obtained by a leaf gauge.
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59 The difference between maximal intercuspation and centric relation was also determined. A
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4 facebow was used to transfer the relation between the jaws and temporomandibular joint. The study
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6 casts were then mounted on an articulator in centric relation. A wax-up was carried out on the
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8 palatal, incisal and labial surfaces of the upper six anterior teeth and additionally on the labial
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10 surfaces of those premolars which were affected by the erosive effect. The wax-up was the basis
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12 for creating an intraoral mock-up (Structur 2 SC, VOCO, Cuxhaven, Germany), which was used
13
14 as a visual aid to show the proposed treatment outcome and analyze the aesthetic and functional
15 (anterior and canine guidance) changes. A silicone (Registrado Clear, VOCO, Cuxhaven, Germany
16 or Variotime Easy Putty, Kulzer, Hanau, Germany) copyplast from the diagnostic wax-up was used
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18 as a trimmed palatal/incisal stent for the direct RBC build-ups to provide a desirable form for the
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20 palatal surface. Before the build-up procedure the teeth were isolated with a rubber dam and the
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22 palatal surfaces of the anterior teeth were air abraded with 29 μm Al_2O_3 powder with copious
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24 irrigation at 1 mm distance for 15 s (AquaCare Twin, Velopex, London, UK). Only sharp enamel
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26 edges were removed with diamond bur (No.890LF, Meisinger, Neuss, Germany). To prevent
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28 bonding to adjacent teeth, every second teeth were restored at the same time. Teeth were separated
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30 with slight interproximal stripping (Sof-Lex Finishing strips, 3M, St. Paul, MN, USA) and isolated
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32 interproximally by a teflon tape. Regarding the adhesive technique, a two-step etch-and-rinse
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34 system (Adper Single Bond, 3M, St. Paul, MN, USA) was used for each restoration. Every second
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36 tooth was conditioned with the total-etch technique by applying 37% phosphoric acid for 20 s
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38 (Ultra-etch, Ultradent, South Jordan, UT, USA), followed by 20 s rinsing and careful drying. The
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40 one step enamel-dentin adhesive was applied by rubbing the exposed dentin and enamel with a
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42 micro-brush soaked in the resin. In order to evaporate the solvent, gentle, 10 s air-drying was
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44 carried out, followed by 10 s polymerization with a light emitting diode (LED) curing unit (LED.D,
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46 Woodpecker, Guilin, China; $\lambda = 420\text{--}480$ nm) in standard mode, at an average tip irradiance of
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48 1450 mW/cm^2 with an 8 mm diameter fiberglass light guide. Nanohybrid RBC (Enamel Plus HRi
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50 Bio Function, Micerium S.p.A., Avegno, Italy; BF2 shade) was applied to the matrix in alternating
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52 order then the matrix was seated on the teeth and the excess material was removed from the labio-
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54 incisal aspect maintaining the planned new length as seen with the help of the stent (Figure 1C).
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56 The RBC was light-cured for 40 s from an incisal direction. After removal of the stent, the palatal
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58 surface was directly light cured for a further 40 s to provide a high rate of polymerization.
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60 Interproximal excess was removed carefully – without causing bleeding - with a metal
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62 interproximal strip (Kerr perforated fine diamond finishing strip, Kerr, Bioggio, Switzerland). The
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4 restorative procedure was repeated for the remaining teeth. Once all the teeth have been bonded to
5 the palatal aspect the labio-incisal surface was covered with one more layer of RBC to complete
6 provisionally the anterior restoration at the desired length until the posterior contacts are re-
7 established. The provisional increase of the length with direct RBC could provide a functional test
8 for the re-established anterior and canine guidance. Patients were informed about the possible
9 inconvenience caused by the posterior disclusion and color mismatch of the lengthened incisal edge
10 before the final facial veneer fabrication. The finishing-polishing procedure was performed with
11 football, needle shape red fine-grit diamond burs (No.330F and No.890LF, Meisinger, Neuss,
12 Germany) followed by Enhance/PoGo system (Dentsply Sirona, York, PA, USA) and with
13 aluminum oxide strips (Sof-Lex Finishing strips, 3M, St. Paul, MN, USA). Then the occlusion was
14 refined according to the following principles to ensure even stable contacts on all anterior teeth of
15 equal intensity in centric relation (static occlusion) and guidance provided by the incisors and
16 canines (dynamic occlusion) (Figure 1D). The restored palatal surface and the increased incisal
17 length must be in harmony with the envelope of function and should provide unobstructed
18 movement. The palatal cingulum and slightly flat occlusal stop provide stable contact and centric
19 freedom for the lower incisors. This smooth surface will help minimize future wear of the opposing
20 lower incisors and directs forces down the long axis of the tooth, thereby reducing the possible
21 labial tooth movement. During lateral excursion the canine guidance should provide incisal
22 disclusion which is crucial to avoid the future fracture of the restored incisal edges. After the
23 occlusal adjustment, final finishing, and polishing were performed by the Enhance/PoGo system
24 and the surface gloss was enhanced by goat hair brush, felt disk/wheel and polishing pastes (Enamel
25 Plus HFO Shiny Finishing Kit, Micerium S.p.A., Avegno, Italy). Posterior disclusion was
26 measured from a wax record taken postoperatively between the first molar teeth (Table 1). **The
27 increase of VDO by the additional palatal layer is ranged between 1.0 to 2.0 mm.**

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29 Few days (~ 2-3) after the palatal restorative procedure, patients were scheduled for an anterior
30 occlusal check-up to control the stable contacts and anterior guidance. It was also important to
31 assess patient comfort and to test the phonetic implications of the extensive rehabilitation of the
32 maxillary incisors. For a phonetic test, the 's' sound is appropriate since it can be influenced by
33 horizontal or vertical volume alterations on the anterior teeth.

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35 Progression of the posterior tooth eruption was assessed weekly with an 8 µm Shim Stock foil
36 (Arti-Fol, Bausch, Köln, Germany) (Figure 2A-D). After the detection of firm contacts on all

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4 posterior teeth (four weeks after palatal build-up for all patients) the procedure for labial ceramic
5 veneer fabrication was started. The first step was the mock-up preparation according to the initial
6 diagnostic wax-up. As the new position of the occlusal plane and the increased VDO may be
7 slightly different from what was initially planned, the length of the maxillary anterior teeth should
8 be reconfirmed during this second mock-up session. Once the patient's consensus on the final shape
9 of the maxillary anterior teeth was obtained, the mock-up guided preparation with the help of a
10 depth marker diamond cylinder bur (No.834, size 016, cutting depth 0.3 mm; size 021, cutting
11 depth 0.5 mm; Komet, Besigheim, Germany) was performed (Figure 3A). Three shallow
12 orientation grooves were cut through the mock-up RBC or/and enamel on the labial surface. Then
13 the mock-up was removed and the orientation groove which left a mark on the enamel was
14 highlighted with a water-resistant pen (1513 Multimark F permanent, Faber-Castell, Stein,
15 Germany). Round ended tapered diamond (No.868 and 8868, Komet, Besigheim, Germany) was
16 used to remove enamel between the marked grooves and to create definitive contouring and
17 finishing. The color marking was not removed completely to ensure no more than the desired
18 enamel was prepared. Supra/paragingival chamfer-like finishing line was prepared in a depth of
19 0.3 mm, which was extended interproximally as an elbow, involving the labial half of the contact
20 area without breaking the contact. Butt-joint incisal preparation was performed, completely
21 removing the length added by the provisional RBC build-up, leaving only the original length of the
22 tooth (Figure 3B). The ceramic veneer would later re-establish the final length. The margin was
23 placed in the volume of the palatal RBC (Figure 3B and Figure 4A-C). The prepared surface was
24 polished with abrasive discs (Sof-Lex disks, 3M, St. Paul, MN, USA) and a gingival retraction cord
25 (Size 0, UltraPak, Ultradent, South Jordan, UT, USA) was placed in the sulcus. Upper two-stage
26 and lower one-stage sandwich vinyl polysiloxane impressions (Variotime Easy Putty and Light
27 Flow, Kulzer, Hanau, Germany) were taken. This was followed by bite registration (Variotime
28 Bite, Kulzer, Hanau, Germany) recorded in maximum intercuspation. The shade of the prepared
29 teeth and also the desired shade were selected with the patient's consensus. Provisionals were made
30 with the help of the impression which was fabricated to perform the mock-up. At the next
31 appointment the pressed lithium disilicate-reinforced glass ceramic laminate veneers (GC Initial
32 LiSi Press, GC, Leuven, Belgium) were tried in the mouth to check the fit and try-in paste (NX3
33 Nexus Third Generation, Kerr, Bioggio, Switzerland) was used to select the proper shade of the
34 adhesive luting cement (Figure 3C). To achieve durable bond-strength the internal surfaces of the
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4 cleaned (Ivoclean, Ivoclar Vivadent, Schaan, Liechtenstein) veneers were etched with 9,5%
5 hydrofluoric acid (Porcelain Etch, Ultradent, South Jordan, UT, USA) for 20 s, followed by
6 washing, drying and silane (Silane, Ultradent, South Jordan, UT, USA) application which was left
7 to dry. The luting procedure started from both cleaned central incisors and progressed bilaterally.
8 The above described total-etch adhesive procedure was performed on the isolated teeth. To provide
9 accurate fit of the veneer prior to light-curing the adhesive layer was thinned with air-drying for
10 minimum 20 s and the removal of excess was helped by the vacuum of the high-volume evacuator's
11 tip. A clean microbrush was used to remove the gathered excess at the marginal bevel if the air-
12 stream and the evacuator's effect had to be completed. The light-curable adhesive resin cement
13 (NX3 Nexus Third Generation, Kerr, Bioggio, Switzerland) was applied to the veneers, which were
14 then gently seated with finger pressure. Excess cement was removed with a microbrush and a thin
15 modelling brush. The above-mentioned LED curing unit was used to polymerize the cement for
16 4x20 s from labial, mesial, distal and incisal aspects with 5 s break to avoid heat damage of the
17 pulp. The final restorative phase was completed by polishing the marginal areas with a silicone
18 rubber point (PoGo system, Dentsply Sirona, York, PA, USA), after removal of excess set cement
19 with a No.12 surgical scalpel (Figure 3D). Restorations were carefully checked for any occlusal
20 interference (static and dynamic). After the one-week follow-up of the labial veneers, maintenance
21 was provided in each half year.
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39 *Clinical evaluation*

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42 From the palatal build-up session, the progression of the compensatory eruption was recorded
43 weekly by the evaluation of the opposing teeth contacts until maximum intercuspation was
44 achieved between each posterior tooth. During the five-week follow-up appointment, the patient's
45 opinion on the aesthetic result, post-operative pain or discomfort and bruxism or TMD related
46 symptoms were evaluated (Table 2).
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51 In January of 2020, the anterior palatal direct RBC veneers and labial ceramic veneers were
52 evaluated by two examiners independently using a dental mirror and explorer in accordance with
53 modified United States Public Health Service (USPHS)²⁷ criteria (Table 3). Particular attention was
54 paid to the interface between the palatal direct veneer and the labial indirect veneer in terms of
55 marginal integrity. The time and type of any intervention applied during the maintenance was
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4 recorded. Besides the evaluation of the restoration, patients were questioned again about the
5 aesthetic satisfaction, discomfort and bruxism or TMD related symptoms.
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7 Data collection and statistical analysis were performed using SPSS for Windows 23.0 (SPSS,
8 Chicago, IL, USA). Because of the low case number, only a descriptive statistical analysis was
9 indicated and only percentages of the respective scores of the USPHS evaluation are given.
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14 15 **RESULTS** 16

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19 In the present observational case-series study a total of 36 direct RBC palatal veneers and 42 labial
20 ceramic veneers were evaluated in 6 adult patients (mean age: 26.67 at the time of restoration
21 placement) with the diagnosis of localized anterior tooth wear. The follow-up time varied from 20
22 to 27 months for palatal veneers and 18 to 25 months for labial veneers with a mean observation
23 time of 23.7 and 21.7 months, respectively. The investigators were trained and calibrated before
24 the evaluation. Cohen's kappa statistic showed excellent intraobserver (kappa values of 0.82 and
25 0.80) and interobserver (a kappa value of 0.79) agreement. **Figure 5** shows the evaluation of
26 patients' satisfaction with the aesthetic result, discomfort, re-establishment of posterior contacts
27 and bruxism or TMD related symptoms at the five-week follow-up appointment (from the palatal
28 build-ups to one week after the labial veneers are cemented). According to one participant's report,
29 discomfort was only present in the first few days, right after the palatal build-up. Phonetic
30 implications - **pronouncing the 's' sound** - occurred for all patients, but after a short conversation
31 (**five to ten minute adaptation**), it was no longer perceptible. The progression time and order
32 showed almost the same pattern for all participating patients which is visualized in Figure 2C. All
33 patients had accepted the new VDO well, without showing symptoms of TMD. However, bruxism
34 was still present in two patients (detected by self-report), although it had not intensified. To
35 decrease the risk of bruxism-related failure, a supplemental protection with a night-guard
36 (Michigan-type occlusal appliance) was fabricated for the above-mentioned patients at the five-
37 week check-up (**Figure 6**). During the subsequent observation period there was no change in
38 aesthetic satisfaction and the stabilized occlusion was reported to be comfortable. Based on the
39 self-reports and clinical examinations of the other four patients there were no obvious signs of
40 bruxism, despite being present at the start of treatment. The evaluation of the palatal direct RBC
41 and labial ceramic restorations according to the USPHS criteria is presented in **Figure 7** which
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4 involved also the assessment of the marginal adaptation and discoloration of the palatal-labial
5 veneer interface. During the observation period all the involved teeth were caries-free and remained
6 vital. Of the overall 78 restorations none of them were considered unacceptable, the restorations
7 were scored as ‘alpha’ or ‘bravo’ for all items evaluated according to the USPHS criteria. The
8 survival during this short-term observation period for both types of restoration was 100%. Palatal
9 direct restorations had higher rates of small deteriorations for almost every evaluated criteria
10 (Figure 8A), except for anatomic form and color match. Slight wear on the palatal restoration was
11 found to be the most frequent issue (44.4%), followed by slight marginal discoloration (33.3%).
12 Pitted surface roughness was found on all six palatal RBC (16.6%) in one patient, whereas the
13 texture of all other palatal veneers showed a silky gloss appearance. Slight marginal deterioration
14 was detected at only four palatal veneers (11.1%), which were managed with re-polishing. The
15 labial-palatal veneer interface showed mild deterioration in marginal adaptation (16.7%) and
16 marginal discoloration (22.2%). The labial ceramic veneers showed excellent performance, with
17 slight marginal discoloration detected at only one veneer (Figure 8B).

31 DISCUSSION

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35 In this prospective observational case-series study the short-term survival of anterior sandwich
36 veneers as Dahl-restorations were evaluated in six patients who suffered from localized anterior
37 erosion or attrition. Furthermore, patient’s satisfaction, discomfort, progression of posterior teeth
38 eruption and bruxism related occlusal stress were also analyzed. Acceptable to excellent clinical
39 performance was observed for the sandwich veneers - which consisted of direct palatal RBC and
40 indirect labial ceramic restorations - after a mean observation period of 23.7 and 21.7 months,
41 respectively. However, results and survival analysis should be interpreted with care because on one
42 hand the case number is very limited, and on the other, no long-term data are available regarding
43 this sandwich veneer approach. Our primary purpose was not only to describe the outcome of the
44 sandwich approach after a short observation period, but also to generate hypotheses regarding the
45 survival of this treatment method that subsequently can be tested in studies of greater
46 methodological rigor.

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4 composite palatal veneers followed by the restoration of the labial aspect with ceramic veneers.¹⁹⁻
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6 ²¹ This adhesive technique allows preservation of the remaining tooth structure, especially with
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8 respect to the intact proximal surface. Subsequent work of the authors demonstrated, in a 6-year
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10 follow-up study, no major detectable failure of sandwich restorations.³⁴ The adhesively bonded
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12 ceramic veneers with well-determined surface-treatment and cementation protocol represent a
13
14 highly reliable and long-term treatment option regarding the esthetic and functional aspects, and is
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16 supported by several other researches.³⁵⁻³⁸ Due to the low number of cases, our results cannot be
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18 supported by statistical analysis, but in line with the findings of other studies, for each of the
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20 examined parameters, the labial ceramic veneers performed excellently during the short
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22 observation period. The original three-step adhesive rehabilitation technique restores the posterior
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24 region with overlays at an increased VDO, however our treatment combined the sandwich approach
25
26 with the Dahl concept and used palatal veneers as anterior deprogrammers followed by a
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28 compensatory eruption for the relatively unaffected posterior teeth to reconstruct the functional
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30 occlusion. This combined method of adhesive techniques and the Dahl principle was introduced
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32 by Magne et al.²² The Dahl concept allows maximal tooth structure preservation, without the need
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34 for posterior overlay restorations, with special respect to the healthy molars and premolars. Poyser
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36 et al. collected the clinically relevant studies related to the Dahl concept, and found that the majority
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38 of the available literature originated from the United Kingdom.²⁴ Although, case-reports are
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40 available, there is lack of international uptake of this technique.^{22,24} On the other hand, the quality
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42 of the level of evidence from these studies is medium to low, thus, randomized controlled clinical
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44 trials are necessary to provide evidence-based data.²⁴ The original Dahl appliance is a removable
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46 localized palatal bite-raising metal device which can create the necessary space for the further full-
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48 coverage restorations of destructed anterior teeth.²⁵ To overcome the problem, induced by
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50 excessive tooth preparation for full coverage crown, adhesive double-veneer (palatal metal and
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52 labial ceramic) was introduced by Bishop et al.³⁹ The improvements and continuous development
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54 of adhesive dental materials ensure durable, ultraconservative solutions. The treatment of anterior
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56 tooth wear with direct RBC restoration, placed in supra-occlusion at an increased VDO, was
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58 described first by Darbar and Hemmings.⁴⁰ Direct RBC replaces the eroded tooth structure with an
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60 additive approach and additionally can be used as an anterior deprogrammer to reposition the
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62 mandible in centric relation.^{8,22} Hemmings et al. reported 89.4% success rate of direct resin
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64 composite palatal veneers in the treatment of localized anterior tooth wear after 30-months follow-
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4 up and the posterior occlusion satisfactorily restored after a mean duration of 4.6 months with good
5 patient's satisfaction.²⁶ Redman et al., in their short to medium term study, confirmed that RBC
6 restorations placed at an increased VDO are viable first-line options to treat anterior tooth wear,
7 however, the authors concluded, that the probability of failures is increased after five years.²⁷
8 Gulamali et al. concluded in their medium-term survival study, that more than 90% of the
9 investigated direct and indirect RBC restorations exhibited minor or major failure over the
10 preceding ten years and required intervention and maintenance.²⁸ Mechanical limitations of RBCs
11 can lead to marginal fracture and staining, meanwhile, failures such as bulk fracture, surface
12 roughness and discoloration are uncommon.²⁷ Regarding most deteriorations a similar tendency
13 was detectable in our study also. However, survival of palatal restorations was found to be 100%.
14 Few restorations had minor defects after the short observation time, such as surface roughness,
15 marginal discoloration, marginal adaptation and consequent gingival inflammation. In line with
16 Redman et al., surface roughness took the form of pitting in one patient, suspected to be due to the
17 exposure of tiny voids as the palatal RBC wore and erosive effects softened the external layer.²⁷ In
18 our cases, a nanohybrid RBC was applied directly to the silicon matrix and pressed to the palatal
19 surface of the tooth. Probably, the absence of an intensive condensation phase is the reason for the
20 voids and subsequent surface roughness. Although, a clinical study found, that the indirectly made
21 palatal veneer had surprisingly higher incidence of roughness.²⁷ Despite the short observation
22 period, marked small wear facets appeared frequently (USPHS 'Bravo' score is 44.4%) on the
23 palatal veneers, especially on the static occlusal contacts. All the six patients suffered from night
24 or awake grinding before the initiation of the treatment, however only two patients reported
25 continuing bruxism after the palatal build-up. They received night-guard splints to prevent fracture
26 of the veneers. Though, based on the detected wear facets, it is assumed that some degree of
27 occlusal stress was still present in all patients, the newly constructed anatomic palatal shape and
28 designed guidance limited the parafunctional movements which was consequently less noticeable
29 to the patients. **Although only two of our participants needed night-guard splint, it is important to
30 emphases, that regular check-ups and maintenance is suggested to detect in time the signs of
31 increased activity of bruxism. As an alternative solution to decrease the risk of restoration's failure
32 a fabrication of a night-guard splint routinely could be beneficial at the end of the restorative
33 treatment.** It is considered advantageous to use RBC restorations opposite worn teeth, since RBCs
34 have lower wear resistance than the opposing teeth, thus the wear rate of the antagonist could be

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4 decreased.^{41,42} Further advantages of RBC as a Dahl restoration, are the maintainability, time- and
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6 cost-saving ability and preservation of healthy tooth structures.⁴³ Moreover, it can protect exposed
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8 dentin from further wear and the reversible nature of this approach may allow repair and an
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10 alternative restoration in the future. This technique offers good patient compliance, and
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12 satisfaction, even when repair is needed. Our patients tolerated the increased VDO and posterior
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14 disclusion very well. They were maximally adapted within a short time, as it was reported in other
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16 studies as well.^{26,27}

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18 The palatal RBC restorations provided a deliberate occlusal plane and axial loading of the
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20 antagonist teeth, therefore no adverse tooth movements were detected on the anterior teeth. The
21
22 fundamental importance of the reconstructed canine guidance lies in preventing the fracture of the
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24 labial veneer by separating the upper and lower incisors during lateral movements. Already in the
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26 design or mock-up phase, it is necessary to determine the future length of the incisors and align
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28 them with the available inter-incisal space provided by the planned canine guidance. Furthermore,
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30 it is assumed, that the stable anterior occlusion and guidance facilitate posterior teeth eruption by
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32 neuromuscular regulation. Post-eruptive tooth movement maintains the position in occlusion by
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34 compensation for occlusal tooth wear. Although, the proper mechanism of compensatory eruption
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36 is unclear, it is supposed that coordinated forces of the oro-facial muscles, under the influence of
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38 the central nervous system, are responsible for tooth eruption.⁴⁴ Lund described that the control of
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40 mastication depends on sensory feedback which serves to regulate the muscle activity through all
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42 stages of mastication.⁴⁵ Individual chewing cycle is divided into three stages: opening, fast-closing
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44 and slow-closing. Latter is associated with increased forces required for grinding the bolus. It is
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46 speculated, that when the posterior region is discluded, as in the case of only anterior contacts and
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48 guidance, the slow-closing phase and resultant increased elevator muscle activity is absent thus the
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50 food mastication function is confused. The central nervous system receives several feedbacks from
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52 muscles, periodontal receptors and touch receptors of the mucosa and consequently induce bone
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54 remodeling with consequent tooth eruption to maintain the physiologic function of the masticatory
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56 system. In our study, all the subjects had re-established posterior contacts within four weeks.
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58 Redman et al. found in 31 patients 61% to have complete and 39% to have partial re-establishment
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60 of posterior occlusion within 2 to 18 months, with a mean of 7 months.²⁷ It is likely that mandibular
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62 repositioning and the young age of our patients contributed to the rapid result.
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4 Within the limitations of this observational case-series, it is concluded, that the adhesively
5 bonded labial ceramic and palatal direct RBC veneer – namely sandwich veneer - with the
6 combination of the Dahl concept is a promising method to treat localized anterior tooth wear. The
7 minimally invasive additive approach and the compensatory eruption of posterior teeth reconstruct
8 the aesthetics and function with maximal preservation of the remaining tooth structure. Although,
9 mechanical limitations of the direct RBC can lead to wear, marginal breakdown, marginal
10 discoloration and surface roughness, the maintenance of these palatal restorations is
11 straightforward with refinishing or with localized repair. There is a high degree of patient
12 satisfaction associated with sandwich restorations. The temporary posterior disclusion is well-
13 tolerated and contacts are re-established within a very short period of time.
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34 **Legend to the figures**

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38 **Figure 1.** Initial situation of a localized anterior tooth wear from labial (A) and palatal (B) aspects.
39 The process of the palatal direct resin composite veneer fabrication by silicon matrix technique (C)
40 providing static and dynamic contacts on the anterior teeth (D).
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44 **Figure 2.** The initially discluded posterior teeth (A) showed a general progression of eruption (B)
45 resulting in firm re-established posterior contacts (C, D).
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48 **Figure 3.** Indirect ceramic veneer fabrication with mock-up guided preparation (A) with butt-joint
49 incisal finishing line (B). Try-in paste helps to select the favorable shade of the adhesive cement
50 (C) to provide a natural appearance for the veneers (D).
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54 **Figure 4.** Butt joint incisal preparation is well seen on the veneer in-surface (arrows) (A), which is
55 seated onto the plane-cut incisal edge including the palatal direct resin composite veneer (B)
56 leading to a palatal-labial veneer interface located on the palatal veneer margin (arrows) (C).
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Figure 5. Evaluation of patient satisfaction and the function.

Figure 6. Michigan-type occlusal night-guard splint is fabricated in hard transparent thermoplastic polymer (A) that covers all the maxillary teeth (B) and has flat, simultaneous occlusal centric stops for mandibular teeth. The sloping canine guide plane (C – black arrows) of 1 to 2 mm permits only minimal lateral or protrusive movements under full occlusal contact (D – blue marks) of the lateral splint surface before disocclusion occurs. Anterior and canine guidance (D – red marks) provides posterior disocclusion. Thin layer of pattern resin was chair-side used to correct the canine guidance on the left side (D – black arrow).

Figure 7. Evaluation of palatal resin based composite (RBC) and labial ceramic restorations according to the USPHS criteria.

Figure 8. Slight discoloration of the margins and pitted surface roughness of the palatal veneers is detectable (A), however the labial ceramic veneers serve excellent (B) at the 23 months' follow-up appointment.

Table 1 - Patient related factors, etiology of tooth wear and distribution of sandwich veneers

Patients Age (year) /Gender	Etiology of tooth wear	Number of palatal RBDC veneers (Involved teeth) / increased VDO (mm)	Number of labial ceramic veneers (Involved teeth)	Duration of follow-up (month) PV LV
22 / f	Erosion(sd)-Attrition/ACE Class IV.	6 (6-11) / 1.5	8 (5-12)	22 20
26 / f	Erosion(GERD)-Attrition/ACE Class IV.	6 (6-11) / 1	10 (4-13)	27 25
34 / f	Erosion(GERD)-Attrition/ACE Class IV.	6 (6-11) / 2.0	6 (6-11)	24 22
26 / f	Attrition (>2mm incisal loss)	6 (6-11) / 1.5	6 (6-11)	26 24
25 / m	Attrition (>2mm incisal loss)	6 (6-11) / 1.5	6 (6-11)	23 21
27 / m	Attrition (>2mm incisal loss)	6 (6-11) / 1.5	6 (6-11)	20 18
Total number of veneers:		36	42	23.7 21.7

Abbreviations: m - male; f - female; sd - soft drink; GERD - gastroesophageal reflux disease; ACE - Anterior Clinical Erosive Classification; ACE Class IV. - fractured incisal edges (>2mm), exposed palatal dentin; RBDC - resin based direct composite; VDO - vertical dimension of occlusion (measured between the upper and lower first molars); PV - palatal veneer; LV - labial veneer

Table 2 - Criteria used to evaluate the treatment outcome related to the satisfaction and function

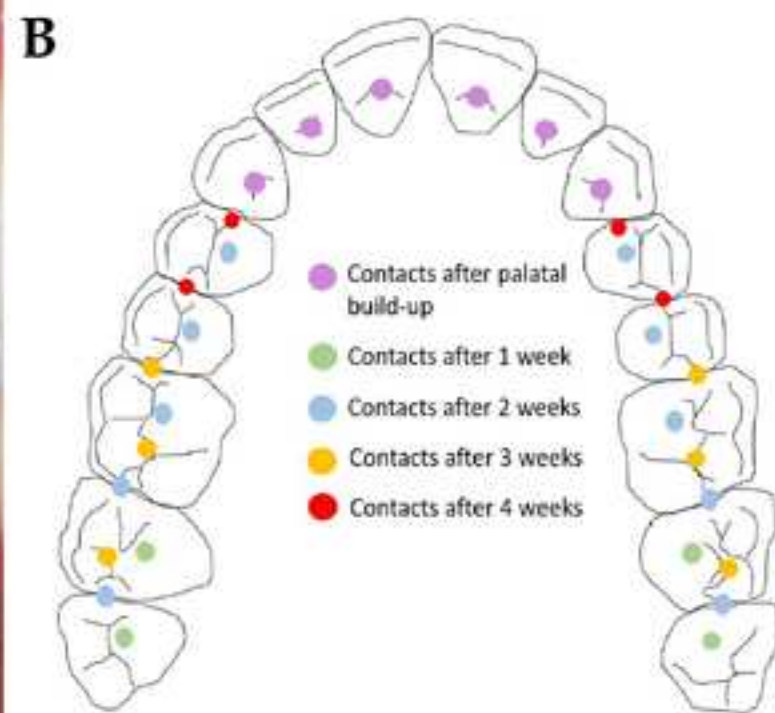
Aesthetic result	A	Subject has no complaint and is pleased with the result.
	B	Subject has some remark but accepts the result.
	C	Subject unhappy about the result and requests intervention.
Re-establishment of posterior occlusion	A	Multiple, firm Shim Stock holds between all pairs of opposing posterior teeth.
	B	Some Shim Stock holds between most but not all pairs of opposing posterior teeth.
	C	No contact between any of the posterior teeth.
Post-operative pain or discomfort	A	None.
	B	Mild; not requiring intervention.
	C	Moderate to severe requiring operative retreatment or other clinical intervention.
Bruxism or TMD related symptoms	A	Subject has no bruxism/TMD related symptoms / gone compared to the condition before treatment.
	B	Bruxism/TMD related symptoms persist without change.
	C	Bruxism/TMD related symptoms occurred / intensified compared to the condition before treatment.

Abbreviation: TMD, temporomandibular disorder

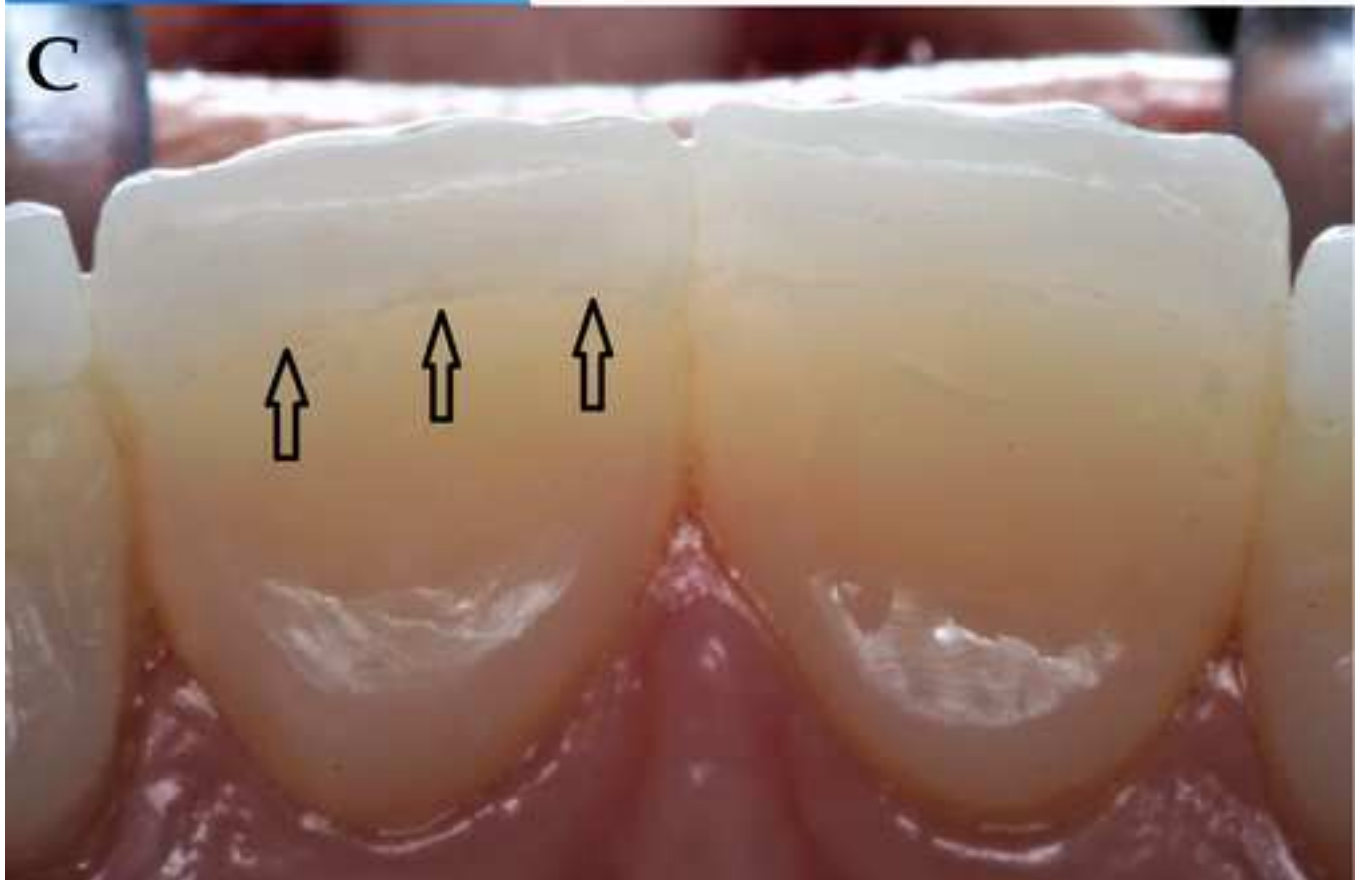
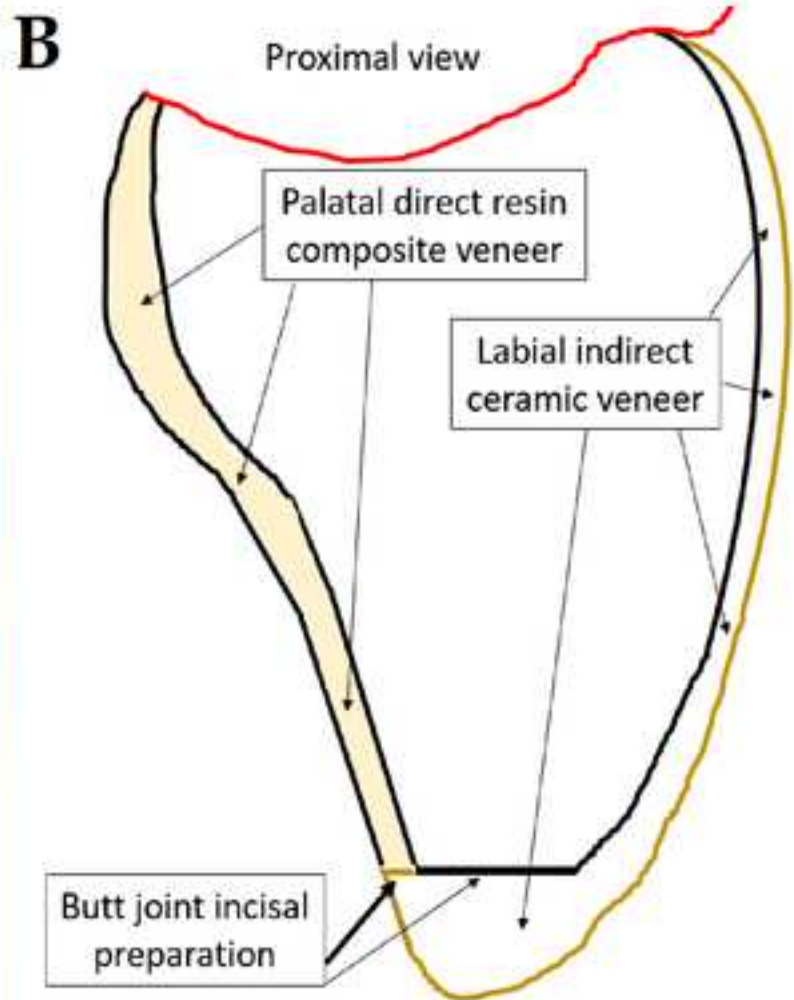
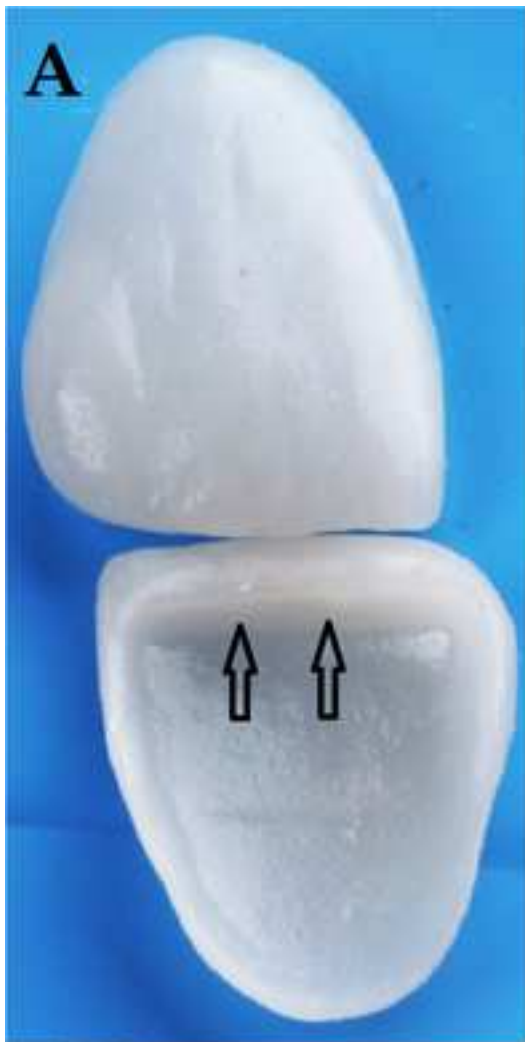
Table 3 - Clinical assessment criteria (USPHS) used to evaluate the restorations

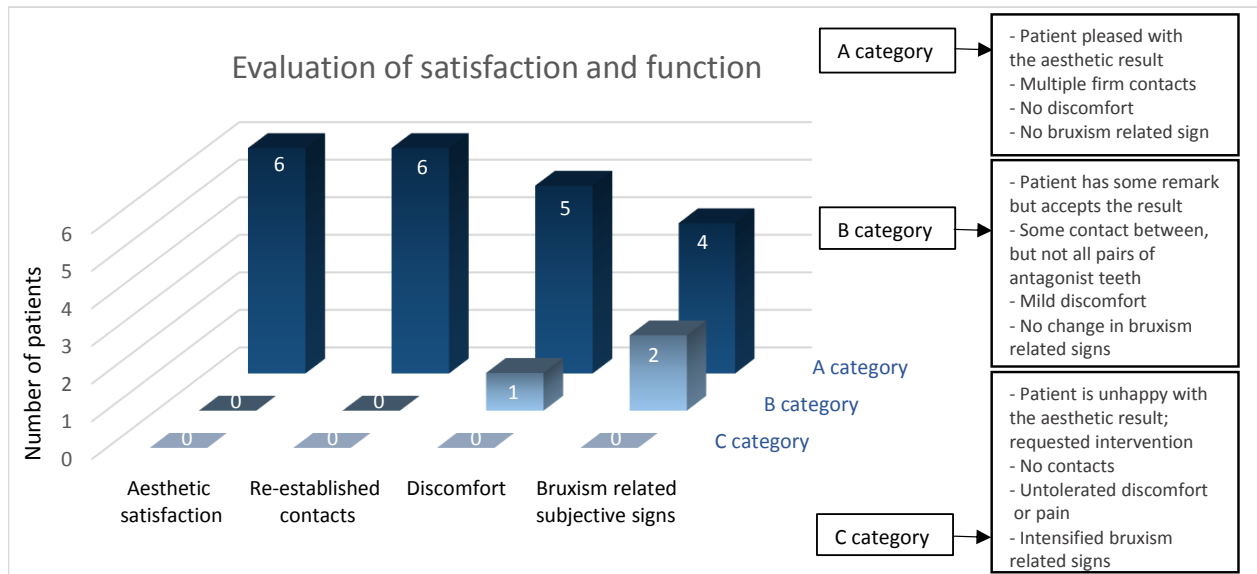
Anatomic form	A	The restoration is of desirable form.
	B	The restoration is not of desirable form due to bulk fracture and requires monitoring, refinishing or repair.
	C	Sufficient material has been lost due to fracture or debonding that replacement is necessary.
Marginal adaptation	A	The restoration appears to adapt closely to the tooth along the periphery of the restoration. An explorer does not catch when drawn across the margins, or, if it does catch it will only catch in one direction and no crevice is visible.
	B	The explorer catches and there is visible evidence of a crevice into which the explorer will penetrate.
	C	The explorer penetrates into a crevice that is of such depth that replacement of the restoration is required.
Wear	A	There is no visible evidence of wear.
	B	There is visible faceting indicative of wear.
	C	There is gross wear resulting in exposure of tooth substance.
Surface roughness	A	Surface of the restoration is smooth.
	B	Surface of the restoration is slightly rough or pitted; can be monitored, refinished or repaired.
	C	Surface of the restoration is deeply pitted or has irregular grooves or defects not related to anatomy; can not be refinished.
Marginal discoloration	A	No visual evidence of marginal discoloration.
	B	Marginal discoloration of a superficial nature which can be monitored or removed with minimal refinishing.
	C	More severe marginal discoloration which can not be removed with further refinishing and necessitates replacement.
Colour match	A	The restoration matches in colour and blends well with the adjacent tooth structure.
	B	The mismatch in colour is within an acceptable range.
	C	The mismatch in colour is outside an acceptable range.
Gingival health	A	There is no clinical evidence of gingival inflammation adjacent to the restoration.
	B	There is some evidence of mild gingival erythema adjacent to the restoration but no bleeding on probing.
	C	There are obvious signs of gingival inflammation adjacent to the restoration including bleeding on probing.
Caries	A	No evidence of caries along the margin of the restoration.
	B	Caries is evident along the margin.

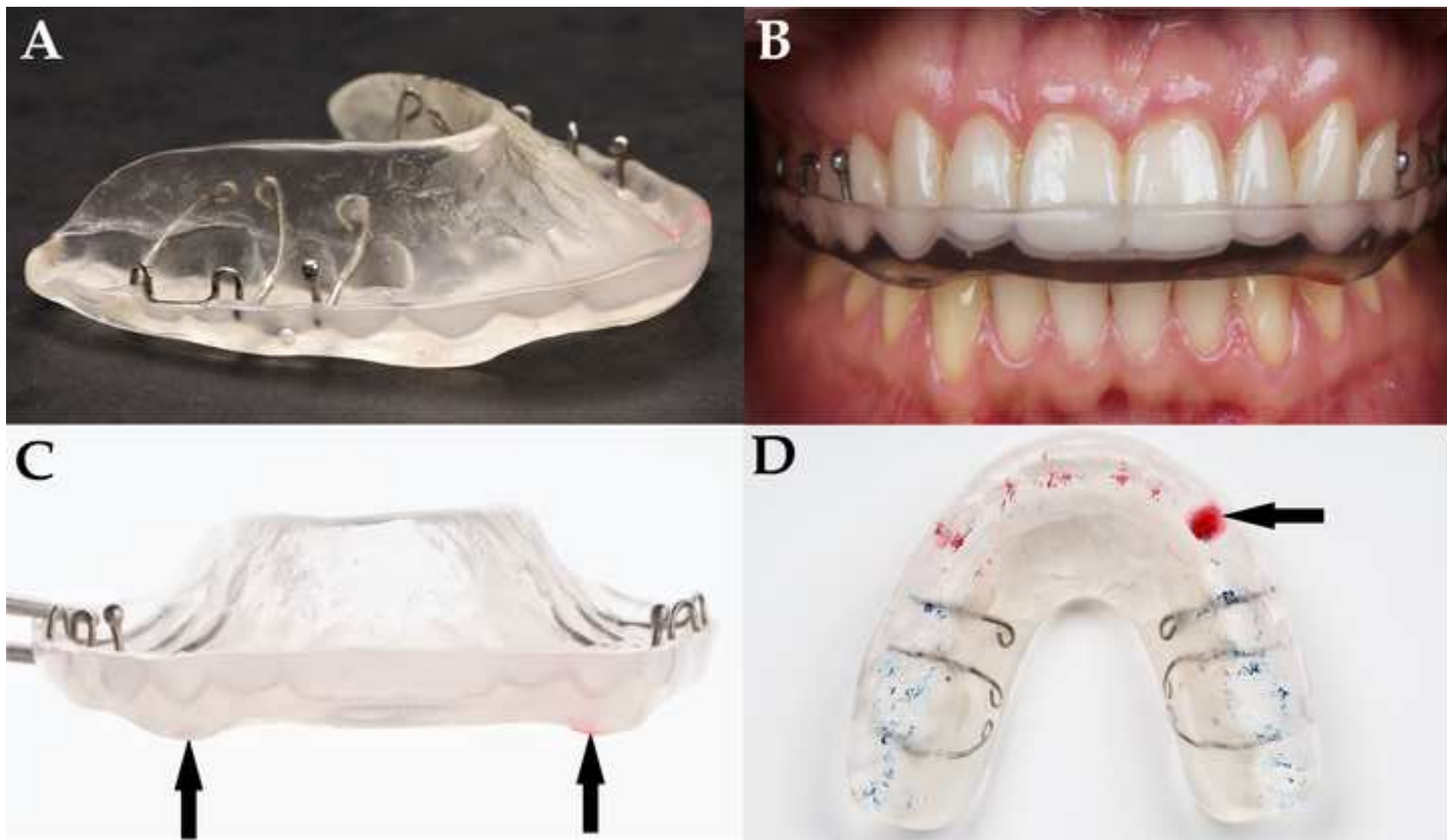




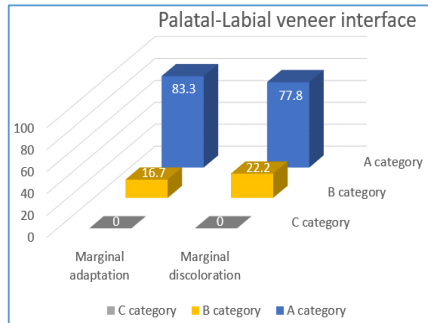
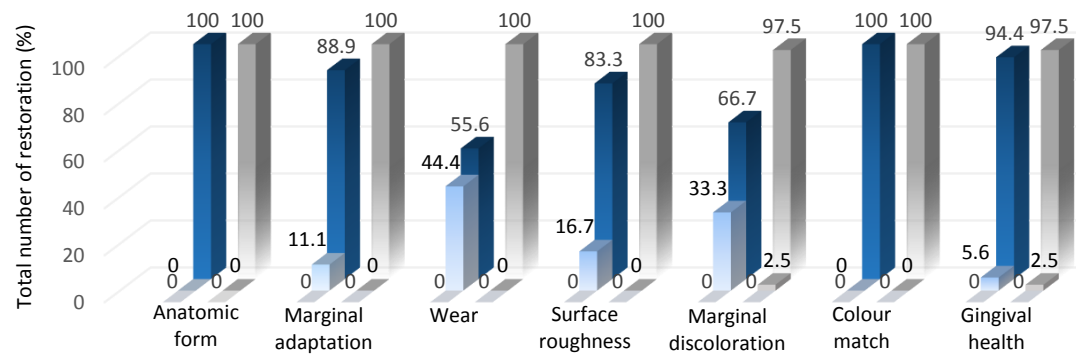








EVALUATION OF PALATAL RESIN BASED COMPOSITE (RBC) AND LABIAL CERAMIC RESTORATIONS ACCORDING TO THE USPHS CRITERIA





Sandwich veneers with Dahl concept of worn teeth

ACKNOWLEDGEMENT

This work was supported by the Bolyai János Research Scholarship (BO/713/20/5); the ÚNKP-20-5 New National Excellence Program of the Ministry for Innovation and Technology from the Source of the National Research, Development and Innovation Fund (ÚNKP-20-5-PTE-615) and PTE-ÁOK-KA-2020/24. The authors would like to thank the laboratory master technicians (Lajos Olasz and Mónika Takács) for their integral support in completing these complex cases. Special thanks to Isván Somoskövi, DMD (Department of Oral Diagnostics, Specialist Orthodontist and leader of management team for comprehensive TMD rehabilitation of Dental Clinic of University of Pécs) for the consultations and the help in the TMD examinations of the patients involved in the study. Further thanks to Sarolta Gyulai dentistry student.

Detailed answers and reactions to Reviewer's comments.

Every modification according to the reviewer's kind instructions was marked with red in the article text and also copy in the answers with red.

Reviewer #1

The submission provided was a prospective observational case-series study of six patients. Perhaps a larger "N" could have been useful in determining the validity of the method used.

Dear Reviewer,

With the ongoing study, the authors try to increase the case number to provide statistically supported data and the uninterrupted follow-up of the presented (and more) patients may provide longer term results.

Answers and reflections to the Reviewer's questions:

1. In line number 21, the manuscript mentions consultation with an "expert in temporomandibular disorder" prior to providing treatment. Perhaps a description of the expert's credentials and the method(s) used to determine the absence of any temporomandibular symptoms or disorder would prove helpful to the reader.

According to the reviewer's kind advise the description of the expert's credentials is given in the Acknowledgements part:

“Special thanks to Isván Somoskövi, DMD (Department of Oral Diagnostics of University of Pécs, Specialist Orthodontist and leader of management team for comprehensive TMD rehabilitation of Dental Clinic of University of Pécs) for the consultations and the help in the TMD examinations of the patients involved in the study.”

István Somoskövi is the responsible person for the translation of the **Diagnostic Criteria for Temporomandibular Disorders** to Hungarian language and he applied the DC/TMD during the examinations of our patients.

Somoskövi I, Radácsi A, Nagy Á, Radnai M (2018) Developing the Hungarian version of the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). *Fogorvosi Sz* **111(2)** 44-51. <https://ojs.mtak.hu/index.php/fogorv-szemle/article/view/4889>

The manuscript is also complemented with the description of the method (DC/TMD and its references) used to determine the presence/absence of any temporomandibular symptoms or disorder:

“Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) were clinically applied to determine the presence or absence of any temporomandibular disorder.”

References:

31. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP et al. (2014) International RDC/TMD Consortium Network, International Association for Dental Research; Orofacial Pain Special Interest Group, International Association for the Study of Pain. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for clinical and research applications: recommendations of the International DC/TMD Consortium Network and Orofacial Pain Special Interest Group. *J Oral Facial Pain Headache* **28(1)** 6–27.

32. Somoskövi I, Radácsi A, Nagy Á, Radnai M (2018) Developing the Hungarian version of the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). *Fogorvosi Sz* **111(2)** 44-51. (Article in Hungarian).

2. Additionally, on line number 30, the subjects self-reported incidences of bruxism related occlusal stress. Were the etiologies of the reported cases of bruxism investigated in order to prevent relapse upon completion of the study?

Thank you for the question, which is an important warning that the etiology of bruxism has been omitted from the manuscript, even though it is very important information.

Yes, the etiology of bruxism was investigated and we found 3 patients with anxiety: one of these patients lost her son 5 years ago and thank to the psychotherapy, she almost recovered and her bruxism activity much more decreased according to the self-report, meanwhile the signs of past bruxism and parallel gastroesophageal reflux disease (it has now been treated) were present on the

teeth. Two other anxious patients (one suffers from panic disease – psychotherapy-treated) reported further bruxism after the treatment and night-guard splint was fabricated as it was described in the manuscript. One other patient suffers from sleep disorder (insomnia) which is suspected to be the etiology of his bruxism. The insomnia is treated by medications recommended by his physician. Two patients (medical students) reported increased activity of bruxism during the exam periods, which subsides after this stressful period. One of these patients suffered from GERD, but now it has been treated; the other patient consumes lot of cola, but she tries to decrease the amount of it.

According to the reviewer’s kind comment, the text is supplemented with the following sentence:
“The etiology of bruxism was related to anxiety, insomnia and lifestyle-related stress. The elimination of the etiological factors was already ongoing or started to treat.”

3. On line 48 it states that a Michigan-type occlusal appliance night-guard was provided to two of the participants who still reported that they were experiencing bruxism. Would it not have been beneficial to provide such an appliance to each participant to help maintain and protect the new resulting occlusion achieved?

Thank you for the reflection and question.

During the follow-up period it was found, that the increased VDO and the newly built-up anterior guidance can be used as an anterior deprogrammer to reposition the mandible in centric relation. It was detected, that the newly constructed anatomic palatal shape and designed guidance limited the parafunctional movements and the protection of the ceramic veneers against fracture is provided by the canine guidance which separates the upper and lower incisors during lateral movements.

However, the changed vertical dimension which also changes the muscle activity is supposed to be only temporary change, since the muscles get used to the increased VDO after a while. The relapse is supposed to be strongly dependent on the cause/etiology of the bruxism. In case of unknown or untreated etiology of bruxism the splint fabrication is beneficial and recommended.

Our study is ongoing and with increased case number and long-term follow-up we try to collect data about the unchanged or changed bruxism activity related with this technique.

Based on the reviewer's important suggestion, the Discussion part was supplemented with the following sentence:

“Although only two of our participants needed night-guard splint, it is important to emphasize, that regular check-ups and maintenance is suggested to detect in time the signs of increased activity of bruxism. As an alternative solution to decrease the risk of restoration's failure a fabrication of a night-guard splint routinely could be beneficial at the end of the restorative treatment. “

4.Line numbers 38 and 39 describe that phonetic implications occurred but became no longer perceptible after a short conversation. Was this the extent of any phonetic changes/issues?

The participants perceived short-term change in pronouncing the 's' sound, which is influenced by horizontal or vertical volume alterations on the anterior teeth, but it was no more detectable after five to ten minute adaptation.

The text was complemented with this additional information:

“Phonetic implications - pronouncing the 's' sound - occurred for all patients, but after a short conversation (five to ten minute adaptation), it was no longer perceptible.”

Reviewer #3

Thank you for this nice case series documentation and submission. Impressive results were obtained. Would be interested to see longer term follow up of these cases. I would request additional commentary on the following questions below:

Dear Reviewer, thank you for the kind reflection regarding the case series documentation. The authors try to increase the case number to provide statistically supported data and the uninterrupted follow-up of the presented (and more) patients may provide longer term results.

The follow-up time of our observational study is indicated in the title to be informative to readers.

“Adhesive management of anterior tooth wear in combination with the Dahl concept – 27-month observational case-series”

Answers and reflections to the Reviewer's questions:

1. For the ceramic veneer bonding protocol, was the dentin bonding agent light cured prior to bonding of the ceramic veneer? It mentioned that the protocol was followed as above, meaning the palatal RBC, so I assume it was light cured. How did you ensure full seating of the veneers and was there any issues with veneers not seating completely due to cured bonding agent?

The ceramic veneer bonding protocol was the same applied in case of direct resin composite veneers, however an exceptional moment is the air-blowing prior light curing. To provide a very thin layer of bonding agent it was air-dried for 20 s and the removal of excess was helped by a negative pressure of a suction device. In a few cases a clean bonding microbrush was used to remove the gathered excess at the marginal bevel if the air-blowing and the suction seemed to be not fully effective. Then the adhesive layer was light cured for 20 s.

According to the reviewer's kind comment, this part of the text is corrected with this additional information:

“To provide accurate fit of the veneer prior to light-curing the adhesive layer was thinned with air-drying for minimum 20 s and the removal of excess was helped by the vacuum of the high-volume evacuator's tip. A clean microbrush was also used to remove the gathered excess at the marginal bevel if the air-stream and the evacuator's effect had to be completed.”

There were no fitting problems of the veneers after the bonding procedure.

2. How much was the VDO increased in each case in mm?

The extent of increased VDO for each case is given in Table 1. (Patient related factors, etiology of tooth wear and distribution of sandwich veneers). The text has also been supplemented with this sentence: *“The increase of VDO by the additional palatal layer is ranged between 1.0 to 2.0 mm.”*

Table 1 - Patient related factors, etiology of tooth wear and distribution of sandwich veneers						
Patients	Age (year) /Gender	Etiology of tooth wear	Number of palatal RBDC veneers (Involved teeth) / increased VDO (mm)	Number of labial ceramic veneers (Involved teeth)	Duration of follow-up (month)	
					PV	LV
1	22 / f	Erosion(sd)-Attrition/ACE Class IV.	6 (6-11) / 1.5	8 (5-12)	22	20
2	26 / f	Erosion(GERD)-Attrition/ACE Class IV.	6 (6-11) / 1.0	10 (4-13)	27	25
3	34 / f	Erosion(GERD)-Attrition/ACE Class IV.	6 (6-11) / 2.0	6 (6-11)	24	22
4	26 / f	Attrition (>2mm incisal loss)	6 (6-11) / 1.5	6 (6-11)	26	24
5	25 / m	Attrition (>2mm incisal loss)	6 (6-11) / 1.5	6 (6-11)	23	21
6	27 / m	Attrition (>2mm incisal loss)	6 (6-11) / 1.5	6 (6-11)	20	18
Total number of veneers:			36	42	23.7	21.7

Abbreviations: m - male; f - female; sd - soft drink; GERD - gastroesophageal reflux disease; ACE - Anterior Clinical Erosive Classification; ACE Class IV. - fractured incisal edges (>2mm), exposed palatal dentin; RBDC - resin based direct composite; VDO - vertical dimension of occlusion (measured between the upper and lower first molars); PV - palatal veneer; LV - labial veneer

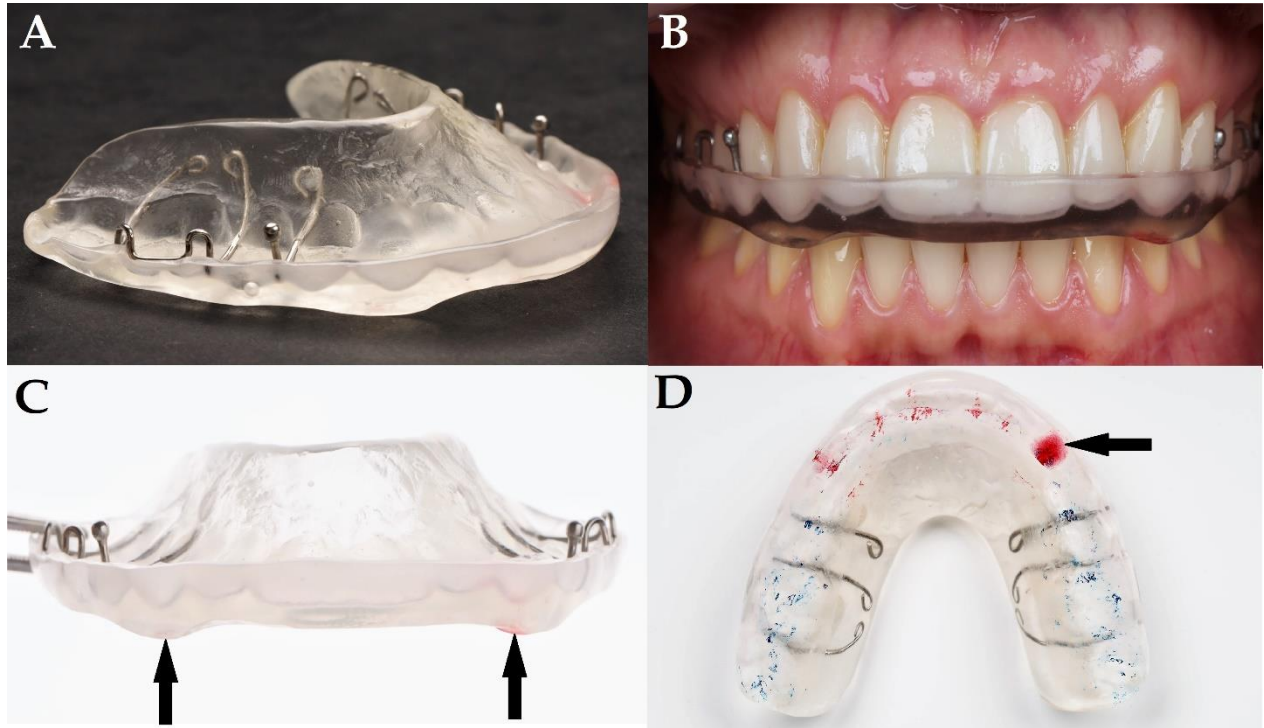
3. Was any occlusal adjustment of the posteriors completed during the follow up appointments?

This is a very good and relevant question. We examined and followed the occlusal contacts with a particular attention. However, according to our observation and findings, no occlusal adjustment was necessary. We believe this was due to the initial normocclusion (correct sagittal maxilla-mandibular positions i.e. Angle class I cases) of our cases.

4. Can you provide an image of the Michigan type occlusal splint utilized after treatment, or describe it in greater detail for the readers that may be unfamiliar with it?

According to the reviewer’s kind request, an image of the Michigan-splint is provided as Figure 6. The detailed description of the splint is included in the figure caption:

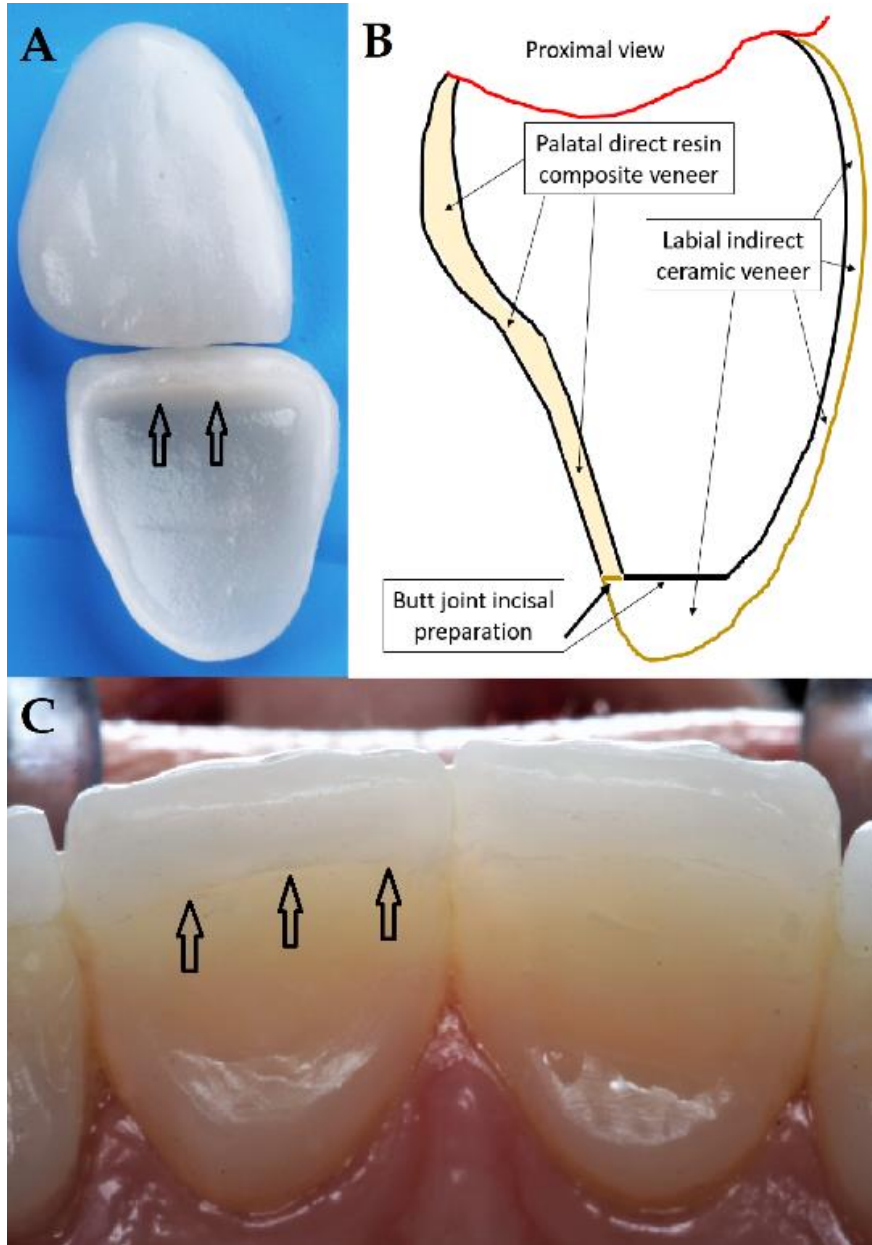
“Figure 6. Michigan-type occlusal night-guard splint is fabricated in hard transparent thermoplastic polymer (A) that covers all the maxillary teeth (B) and has flat, simultaneous occlusal centric stops for mandibular teeth. The sloping canine guide plane (C – black arrows) of 1 to 2 mm permits only minimal lateral or protrusive movements under full occlusal contact (D – blue marks) of the lateral splint surface before disocclusion occurs. Anterior and canine guidance (D – red marks) provides posterior disocclusion. Thin layer of pattern resin was chair-side used to correct the canine guidance on the left side (D – black arrow).”



5. An image of the labial/ceramic veneer preparations would be beneficial so that the reader can see the margins ending on composite and/or tooth structure.

According to the reviewer's kind recommendation a new figure was constructed to present the butt joint incisal preparation which involves the tooth structure and the palatal resin composite veneer simultaneously.

Figure 3B also shows an image from the incisal view of the preparation, thus it is not included in the new figure.



“Figure 4. Butt joint incisal preparation is well seen on the veneer in-surface (arrows) (A), which is seated onto the plane-cut incisal edge including the palatal direct resin composite veneer (B) leading to a palatal-labial veneer interface located on the palatal veneer margin (arrows) (C).”