No-Prep dentistry using the SOE technique (Simple Orthodontic Extrusion) to create occlusal space: illustration in no prep localised tooth wear treatment and resin-bonded bridges

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ABSTRACT

In restorative dentistry, the lack of occlusal space may lead to healthy tissue mutilation to provide sufficient space for the restorative material. No-prep dentistry can be achieved by placing high-bite restorations, followed by simple orthodontic extrusion (SOE) of other teeth to close the created open-bite. This rapid, partial orthodontic treatment is well-accepted by patients as it can be easily performed using simple buttons and takes just a few weeks to re-establish occlusal contacts. The SOE technique is a further development of the Dahl concept, and has the advantages without the disadvantages. Two applications of this technique are presented in this article: the treatment of severe wear of anterior teeth with no-prep palatal veneers made of polymer-infiltrated ceramic network (PICN, hybrid ceramics) material and the realization of no-prep resin-bonded zirconia bridges to replace missing lateral incisors. An original 3D-printed resin guide for correctly positioning resin-bonded bridges and facilitating the removal of excess composite cement is also presented. This work highlights the considerable advantages of multidisciplinary collaboration in the field of minimally invasive dentistry.

Keywords: occlusion, orthodontics, minimally invasive dentistry, PICN, hybrid ceramic, zirconia, tooth wear, resin-bonded bridges

1. INTRODUCTION

Current guidelines in restorative dentistry emphasize the importance of developing minimally invasive treatment strategies that preserve tooth tissues as much as possible, which is nowadays made possible thanks to the development of adhesive dentistry, for example, in the case of tooth wear. However, in the management of severe localized tooth wear, limited to some anterior and/or sometimes posterior teeth, the lack of occlusal space due to compensatory tooth eruption remains a common challenge. It can lead to the mutilation of healthy tissue to provide sufficient space for the restorative material, or to overtreatment by performing restorations on intact posterior teeth to increase the vertical dimension of the occlusion. For example, some authors have recently proposed monolithic zirconia crowns for patients with severe tooth wear in the esthetic zone [1]. This type of procedure is invasive for the remaining dental tissues and has shown certain technical complications, such as fractures, despite the high mechanical properties of zirconia. On the other hand, resin-bonded bridges (RBBs) are popular minimally invasive treatment options for replacing missing teeth. However, preparation of tooth tissue is often necessary, especially if the occlusal space is limited.

In 1975, Dahl et al. [2 3] proposed a remarkably interesting and conservative approach to create an anterior interocclusal space. In the original concept, which is a two-step procedure, a removable supraoccluding metallic appliance system is supposed to induce both extrusion of posterior teeth and intrusion of worn anterior teeth to facilitate the placement of anterior restorations by creating interocclusal space (at that time, porcelain-fused to metal crowns were used as restorations since adhesive dentistry was not yet developed) [4] (Figure 1A and 1B). Due to poor compliance with this removable appliance [2 5], fixed Dahl appliances were developed, and subsequently a one-step Dahl concept was proposed, which uses final anterior direct composite restorations to increase the VDO[6 7 8 9]. However, full occlusal contact re-establishment is reported to be an issue [5 6 7 8]. Poyser et al. reported that the occlusion re-establishes after an average period of 6 months, which can be prolonged to up to 18-24 months [4]. However,-Aljawad

et al. [10] showed that a mean period of 25.4 months (range 6 to 60 months) is required to recreate the posterior occlusion. Moreover, the predictability of the extrusion of the posterior teeth was shown to be imprecise, and some authors reported obtention of partial contacts in about one third of cases and no occlusion re-establishment in 17% of patients [6 8]. Current approaches using direct composites describe a risk restoration failure (such as wear and margin degradation) [6 7]. Finally, symptoms of transient temporomandibular joint dysfunction [11 5] and difficulties in chewing and speaking were shown [3 6].

Dahl's concept has been described in the frame of resin-bonded bridges (RBBs) in the anterior and posterior sectors. However, the authors state that a minimum of 4 months is required to restore occlusion, and report some complications, such as partial occlusal re-establishment and bridge decementation [12].

Recently, Mainjot & Charavet [13] introduced the orthodontic-assisted one-step no-prep technique, which is a straightforward and minimally invasive approach for the treatment of localized tooth wear. It involves the use of no-prep Polymer-Infiltrated Ceramic Network (PICN or “hybrid ceramic”, Vita Enamic, Vita Zahnfabrik, Germany) CAD-CAM palatal veneers and simple orthodontic extrusion (SOE) to ensure rapid, correct, and predictable extrusion of the posterior teeth.

This article presents two cases of minimally-invasive dentistry using the SOE technique to create an occlusal space for treatment of localized severe tooth wear and RBB, respectively.

2. CASE #1: NO PREP LOCALIZED TOOTH WEAR TREATMENT

1. Clinical case analysis

A 21-year-old woman presented in 2018. She was unhappy with her smile: the esthetic appearance and restoration of the tooth tissue were the main complaints. She had mechanical wear of the maxillary anterior teeth due to bruxism. The tooth wear was severe in this sextant (BEWE score = 3, i.e., tooth dentin exposure with loss of hard tissue ≥ 50% of the surface area and loss of the clinical crown ≥50%) [14], while the mandibular incisors showed very slight tooth wear, which did not require treatment, and the

posterior teeth were intact (Figure 2). No temporomandibular joint disorder and no mandibular mispositioning (such as mandibular protrusion) was detected. The patient was referred to a maxillofacial physiotherapist (a physical therapist specialized in temporomandibular disorders) for the treatment of symptoms associated with bruxism, such as muscle pain. The physiotherapist massages the muscles and teaches the patient exercises to do at home to relax the masticatory muscles. The physiotherapist also educates the patient about her bruxism behavior.

Pictures, radiographs, and optical impressions (Omnicam camera, Sirona, Salzburg, Austria) were obtained.

2. No-prep PICN restorations realization

No preparation of tooth tissues was performed, so the optical impressions were used directly to fabricate the restorations. First, a digital smile analysis was realized using the Keynote software (Apple Inc., Cupertino, CA, USA) and sent to the dental lab (Figure 2 c). Then, a digital setup (Ceramill Motion 2 System, Amann Girrbach) was designed on the basis of the estimated amount of tooth tissue loss, the digital smile analysis, and the reconstruction of harmonious incisor proportions. Occlusal relationships were not taken into account when designing the restorations. The technique resulted in an empirical estimate of the new VDO and in restorations in supraocclusion.

Two different CAD-CAM mock-ups were performed in wax (Ceramill wax, Amann Girrbach) and tried in to validate the esthetic result, particularly with respect to the diastema (Figure 2 f-h). In fact, in one of the mock-ups, the diastema was closed by extension of the palatal veneers (partial-coverage restoration intended to restore the surfaces of the palatal and incisal teeth) to the buccal surface of the central incisors, providing the restoration an original design that the authors called the 'envelope' design (no-prep partial-coverage restoration, recovering the palatal and buccal faces of an anterior tooth, without recovering the proximal faces). On this basis, the patient decided to close the diastema.

Afterward, four palatal veneers (maxillary lateral incisors and canines) and two 'envelope' restorations (maxillary central incisors) were milled out PICN blocks (Vita Enamic) were milled (Ceramill Motion 2

System, Amann Girrbach) (Figure 2 j-l). They were stained with a light-cured nanofilled composite coating agent (Optiglaze, GC Corporation, Tokyo, Japan), tested (to validate the restoration design and the new VDO) and then bonded in one appointment ("One-step No-prep" technique) [13]. Restorations were pretreated according to the manufacturer's recommendations, which involved etching the surface with hydrofluoric acid for 60 s, then cleaning them in an ultrasonic bath in ethanol, and finally applying a layer of silane (Monobond S, Ivoclar Vivadent, Schaan, Liechtenstein). The rubber dam was placed. Tooth tissues were cleaned with pumice and then treated with a two-step etch-and-rinse adhesive (Adhese, Ivoclar Vivadent). The adhesive application was preceded by the pretreatment of sclerotic dentin, in which the surface was depolished with a diamond bur at low speed to open tubules [15,16]. Restorations were bonded with a composite resin cement (Variolink Esthetic DC, Ivoclar Vivadent), polymerization was conducted after excess removal, and final photopolymerization was performed under a film of glycerin to prevent the persistence of a polymerization inhibition layer. Occlusal adjustments were performed with an Arkansas stone bur, followed by polishing with silicon gums. The occlusal adjustments only consisted of equilibration of occlusal contacts on the anterior maxillary restorations. Orthodontic blue posterior bites (OptiBand, Ormco, CA, USA) were placed on the first molars to provide posterior occlusal contact and improve the comfort of the patient while waiting for the appointment with the orthodontist, scheduled for the week after restoration bonding. (Figure 3 a-c). Indeed, bonding of restorations resulted in a significant open bite in the posterior region.

3. Simple Orthodontic Extrusion (SOE)

The orthodontic blue posterior bites (Figure 3 a-b) were removed. After the bonding procedure was completed according to the manufacturer's instructions (Transbond Self Etching Primer, 3M, Maplewood, MN), direct composite buttons were designed (Venus Flow, Kulzer, Hanau, Germany) from the first premolar to the second molar. Intermaxillary elastics (IntraOral Elastics, Medium Pull, 1,3 N, ∅ 3.2 mm / 1/8 inch, Dentaurum, Ispringen, Germany) were prescribed between all brackets 24 h/day, except when

eating or drinking and brushing the teeth, to close the posterior space (Figure 3 c). Each elastic was changed twice daily. A debonding occurred 6 days after placement, which was immediately repaired. Re-establishment of the posterior occlusion was restored in 34 days, according to excellent patient compliance. Subsequently, intermaxillary elastics were prescribed for ≥30 days (16 h/day) during the retention phase; then, the composite buttons were removed. Therefore, the overall orthodontic treatment time was 64 days (34 and 30 days for the active and retention phases, respectively) with a final equilibrated occlusion obtained (Figure 3 n).

4. Esthetic finishing

A bleaching procedure was performed (which was not done when dentin was still exposed to decrease the risk of sensitivity [17]. To mask the labial finish line of the palatal veneers of the maxillary anterior teeth, a direct composite (Inspiro, EdelweissDR, Zug, Switzerland) was added to a slight chamfer made across the finish line and where needed to optimize the shape of the tooth (Figure 3 g-o). Finally, an acrylic occlusal splint (for the maxillary anterior teeth) was made. Final views are presented in Figure 4 a-f.

5. Follow-up

In recall, the patient was highly satisfied with the esthetic and functional results of the treatment, the absence of provisional restorations, the comfort and esthetics of the PICN material. Regarding the orthodontic treatment, the patient was also very satisfied with respect to its duration, related functional and esthetic handicap, respectively. Finally, the patient appreciated the minimally invasive aspect of her treatment, as reported in a previous publication related to the orthodontic-assisted one-step no-prep technique [18] [19].

After a follow-up period of 5 years, the success rate of palatal veneers and envelope restorations was of 100%. However, some signs of wear of the stains on 'envelope' veneers were observed after 3 years. Consequently, stains were removed using an Arkansas bur and the buccal surfaces were polished with

specific gums for the material (Vita ENAMIC polishing kit) to obtain a result equivalent to the glazing but more durable. This result is promoted by the use of a multicolored PICN block (Vita ENAMIC multiColor). After 5 years, the palatal view of the restorations did not show a significant wear process (Figure 4 g). A new bleaching procedure and maintenance of the buccal margin with a small amount of direct flowable composite (Inspiro) were carried out on 12 to maintain a highly satisfactory esthetic result (removal of the stained marginal composite with Arkansas bur, sandblasting, silane application, then adhesive and flowable composite) (Figure 4 h-j).

3. CASE #2: NO-PREP ZIRCONIA RESIN-BONDED BRIDGES (RBB) TO REPLACE MISSING LATERALS

1. Clinical case analysis

A 20-year-old man presented in 2020 with upper lateral agenesis and trauma history in 2010. He underwent several years of orthodontic treatment, starting with a functional removable appliance followed by a fixed orthodontic appliance, aimed at correcting a dento-skeletal class II malocclusion (mandibular retrognathia) and managing agenesis (e.g. middle inter-incisal alignment on the sagittal median line), which left a very narrow space for the lateral incisors (Figure 5). He presented an orthodontic relapse, particularly in the posterior sectors: the orthodontic treatment was completed over 5 years before and the compliance with wearing the removable retainer was not excellent. Two class 4 direct composites were present mesially on 11 and 21. Tooth 21 had an apical lesion and was slightly discolored. No temporomandibular joint disorder was detected. A cross-bite was present on the 26 and edge-to-edge on 16 but the patient did not want to correct them. In fact, the patient wanted a fast, simple treatment to replace his lateral incisors and he didn't want to undergo orthodontic treatment again.

Pictures, radiographs, and optical impressions (Primescan camera, Dentsply Sirona, Charlotte, USA) were obtained. A digital smile analysis was performed using Keynote software and sent to the dental lab (Figure 5 e). A digital setup was designed on the basis of this analysis, which highlighted the need to

close the diastema between 11 and 21 to save space for the laterals (Figure 5 e-g). The analysis also showed a horizontal tissue defect (concavity) of the alveolar crest at the level of the edentulous spaces. The young age of the patient and the lack of space contraindicated implant placement, while occlusal contacts on the palatal surfaces on the centrals and canines interfered with the placement of large enough RBB wings.

2. Clinical case preparation

Endodontic treatment and internal bleaching (Opalescence endo, Ultradent, South Jordan U, USA) were performed on 21. An external bleaching procedure (Opalescence, Ultradent) was also performed, while direct composites on 11 and 21 were redone (Inspiro, EdelweissDR (Figure 6 a-b). After the bonding procedure was completed according to the manufacturer's instructions (phosphoric acid 15 seconds), direct composite buttons were designed (GC Ortho Connect Flow, GC Orthodontics, Tokyo, Japan) on the two central incisors. An elastic chain was placed on the two direct composite buttons and the interincisal diastema was closed within two days. To stabilize the results obtained, a metal ligature was then placed on the 2 composite buttons (Figure 6 b).

3. No-prep zirconia RBB realization

Two 3Y-TZP (Prettau 2 Dispersive, Zirkonzahn M2 RBB Milling Machine with a single wing on the central incisors (incisors are chosen for their greater bonding surface compared to canines) were realized on the basis of an optical impression. No tooth tissue preparation was performed. The bridges try-in highlights the soft tissue deficiency and convinced the patient to undergo grafting to optimize the esthetic result (Figure 6 c). After some adjustments in the design of the prostheses (Figure 6 c), minimally invasive connective tissue grafts were made to optimize buccal tissue defects and, therefore, pink esthetics. Through a mini trapezoidal flap, buccal split pouches were performed using a micro-blade. Connective tissue grafts were harvested from the palate, inserted into pouches, and single interreupted sutures were

performed with 6/0 resorbable thread (Figure 6 d-f). Figure 7 shows that the emergence profile of the pontics is ovoid and the part in contact with the gingiva is not veneered to preserve the biocompatibility properties of zirconia. In that objective, a concavity was milled on the model and the emergence profile level was idealized following the esthetic analysis. Note that the zirconia wings are very thin (0.3 mm), while the minimal connector height is 3.0 mm (Figure 7 a-f).

4. No-prep RBB bonding with 3D-printed resin guide

The bridges were bonded three weeks after soft-tissue grafting, using a new original 3D-printed resin guide designed by the author (AM) (Keystone Industries /KeyPrint /KeyGuide). This guide is (1) rigid for precise positioning; (2) translucent to allow light-curing of the composite cement; (3) involves only the occlusal surfaces of adjacent teeth to not interfere with the rubber dam ; (4) involves the buccal surface of the pontic to hold it in place; 5) has one support on the wing and one on the buccal surface of the abutment tooth, but leaves all wing borders uncovered to allow removal of excess composite cement (the guide forms an arch at the incisal edge) (Figures 7-8 and **video 1**).

Before the bridge bonding, the orthodontic phase was initiated. After the bonding procedure was completed according to the manufacturer's instructions (phosphoric acid 15 seconds), metal buttons were bonded (GC Ortho Connect, GC Orthodontics, Tokyo, Japan) from canines to molars (Figure 8 f-g).

On the day of bonding, a cavity was created to accommodate the pontic in the soft-tissue graft using a coarse-grained diamond ball bur under anesthesia (because the graft induces an excess of tissue relative to the desired profile of emergence, making it impossible to place the bridge) (Figure 8 h-k). The correct positioning of the two guides and bridges is checked before and after the rubber dam is placed (Nic Tone, Bucharest, Romania) (Figure 8 h-m). The bridges were bonded with Panavia V5 composite cement (Kuraray Europe, Hattersheim, Deutschland). The wings were sandblasted with 50 micron alumina particles at a pressure of 2.5 bar, then ultrasonically cleaned in ethanol, and covered with ceramic primer according to the manufacturer's recommendations. Dental tissues were cleaned with a pumice stone,

etched for 30 seconds with phosphoric acid and covered with the dental primer. Polymerization was carried out after excess removal, and final light-curing was performed under a glycerine film to avoid the persistence of a polymerization inhibitor layer (**video 2**). Occlusal adjustments were made using an Arkansas stone burr, followed by polishing with silicon gums. They consisted only of equilibration of occlusal contacts in maxillary anterior restorations. Indeed, as in the first case description, bonding of restorations resulted in an open bite in the posterior region (Figure 9 a-c).

5. Simple Orthodontic Extrusion (SOE)

Intermaxillary elastics (IntraOral Elastics, Medium Pull, 1,3 N (128 g), ∅ 4,8 mm / 3/16 inch, Dentaurum, Ispringen, Germany) were prescribed between quadrants 1 and 4 and between quadrants 2 and 3, 24 hours/day, except when eating or drinking and brushing the teeth. Each elastic was changed twice a day. To provide additional extrusive movement to the right maxillary canine, the button was rebonded more cervically. The reestablishment of posterior occlusion was restored in one week, according to excellent patient compliance (Figure 9 c-d). The composite buttons were then removed.

6. Follow-up

At the three-week recall (Figure 9 f-h), the patient was very satisfied with the esthetic and functional results of the treatment, the duration of SOE, the associated functional handicap, and the associated esthetic handicap, respectively. Finally, the patient greatly appreciated the minimally invasive nature of this treatment.

After 18 months of follow-up (Figure 10), the soft tissue anatomy appeared naturally convex and healthy, and the papillae grew on each side of the pontics, allowing a well-integrated emergence profile.

4. DISCUSSION

The SOE technique constitutes an evolution of the Dahl concept with the use of simple orthodontic systems to ensure rapid, correct, and predictable extrusion of the posterior teeth. This technique has the advantage of being more readily accepted by patients than conventional orthodontic treatment and allows for minimally invasive dentistry.

Prosthodontic phase

1. No-prep Localized tooth wear treatment

In cases of anterior localized tooth wear, definitive no-prep restorations are placed before orthodontic treatment, if the teeth and/or gingival levels are well-aligned. If not, global orthodontic treatment is required before anterior restoration placement (see clinical cases presented in ref Mainjot et Charavet)[13]. Sometimes, some posterior teeth are also affected by tooth wear and in this case they are restored at the same time as the anterior teeth [13]. PICN materials (hybrid ceramics) exhibit several advantages compared to ceramics and other indirect or direct composite materials, as follows: (1) the ability to be milled to an extremely low thickness with less edge chipping than ceramics[20] [21], which allowed for a "no-prep" approach and restoration design corresponding only to estimated tissue loss; (2) ease of in-mouth adjustments, in which the management of occlusal relationships required meticulous adjustments, and from this point of view, PICNs were shown to be more adaptable than ceramics; (3) biomechanical properties, with an elasticity modulus value being intermediary between those of dentin and enamel, while ceramics are brittle and too stiff, and other composite (including CAD-CAM) materials are too soft [22]; (4) high degree of conversion of monomers, which improves mechanical resistance and chemical stability and reduces free monomer release compared to light-cured composites [22]; (5) bonding properties, which were shown to be higher than other CAD-CAM composites and as good as glass ceramics when the material is etched [23] [24].

Moreover, the use of CAD-CAM indirect restorations facilitates tooth anatomy design with a reduced chairtime compared to direct composites. However, it must be noted that, in case of slight wear and small

amount of tissue loss, direct composites remain indicated, the technique principle being to restore tissues in an additive way. The presented technique was shown to yield successful short-term clinical results [13]. Anterior PICN restorations did not experience any failure, while Aljawad and Rees [10] reported a 88.8% success rate and a 95.6% survival rate (25-month follow-up) of direct anterior composites used with the Dahl concept, and Milosevic and Burnside revealed an estimated failure rate of 5.4% in the first year [25]. Gulamali et al. highlighted the need for maintenance with direct composites [26].

From the esthetic point of view, the result with palatal veneers and addition of direct composite on the buccal surfaces of the anterior teeth was highly satisfactory and presented the advantage of avoiding tooth preparation and cost related to ceramic veneers, which can always be performed later if needed. Although the author was reluctant at the beginning of the treatment, the 'envelope' design restorations were shown to provide successful results from the esthetic point of view. It was proposed to the patient to perform ceramic buccal veneers in a second time if they were not satisfied; however, she was extremely happy with the results. The use of a CAD-CAM mock-up is particularly interesting since it validates the design of the restoration, test the new VDO, and obtain the patient's approval. It is also easier and much faster for the dentist than the in-mouth realization of a composite mock-up. Furthermore, the CAD-CAM mock-up facilitates the dental technician's work, as it constitutes a real draft of the final restoration: it reduces the risk of changes after the prosthesis is milled.

From a functional point of view, the one-step and empirical VDO increase did not result in any inconveniences. These results confirm previous findings of the one-step no-prep technique for generalized tooth wear, in which PICN restorations are bonded on all teeth, without testing the VDO with provisional restorations[18] [19]. The determination of VDO is always an inaccurate and empirical process [27]; generally, it is based on dental restorative needs, and with the one-step no-prep approach, the principle is simply to recreate missing tissues based on the anatomy of the remaining tooth, since PICN materials do not require important thickness. Although it is rarely used with indirect restoration techniques, the one-step approach of VDO increase is already successfully used with direct techniques in tooth wear treatment

[28] [11], and a 5-mm increase in the incisal pin was previously reported to not cause any undesirable effects on the temporomandibular joints and associated muscles [27] [29].

2. Zirconia RBB to replace missing laterals incisors

All ceramic RBB are now proven to constitute a reliable, esthetic and minimally invasive treatment option in case of missing anterior tooth. In fact, a systematic review reported a 5-year success rate of 92.5% for zirconia RBB [30], while Kern et al. reported 10-year survival and success rates of 98% and 92% in a study including 108 zirconia RBB [31]. The high strength of zirconia reduces the risk of connection fracture and also allows its height to be reduced compared to that of glass-ceramics. From the point of view of the authors, RBB is the treatment of choice to replace missing lateral incisors, particularly in young patients, in order to avoid the disadvantages of implant rehabilitation in terms of the occurrence of infra position, which was shown to affect 50% of cases [32]. Agenesis of lateral incisors is often associated with buccal (horizontal) tissues discrepancy compromising the pink esthetic and eventually incomfort because of food retention. The minimally invasive mucosal surgery allowed to restore the soft tissue profile and natural emergence of the pontic. In this particular case, the prostheses were bonded after 3 weeks and a reintervention was necessary to create the ovoid space for the pontic. An immediate approach might have been considered to guide the soft tissue healing with the prothetic component.

To the authors' knowledge, there are no clinical data available on zirconia RBBs made without tooth tissue preparation [33]. Indeed, zirconia is reputed to be less bondable than glass-ceramic, and tooth preparation allows micromechanical retention of the bridge. The author is accustomed to performing no-prep RBBs. However, great care is taken in the choice of composite cement and the pretreatment of zirconia. Current guidelines are applied to optimize bonding, in particular, sandblasting zirconia at 2.5 bar and using a ceramic primer containing functional monomers such as MDP [34], while enamel is etched.

The disadvantage of no prep RBBs is the difficulty encountered in positioning them correctly during bonding. This problem led the author to develop the original 3D-printed guide with the advantages

presented above, a guide that has proved very successful and enables secure positioning in several cases.

Orthodontic phase

The SOE technique appears to guarantee rapid and predictable restoration of the posterior occlusion, which was described as problematic in Dahl's concept [6 8]. As shown in cases #1 and #2, no delay was necessary between the prosthetic and orthodontic phases, and restoration of the occlusion took only 13 (case #1) and 7 (case #2) days, respectively. The speed of treatment represents a significant advantage, while the technique is based on a very simple, inexpensive, and esthetic orthodontic method. Indeed, a period of 25.4 months (range, 6-60 months)[10] has been reported for restoration of posterior occlusion with the Dahl concept, leading to transient difficulties in terms of mastication and speech[2 6] and possibly causing tongue dysfunction or myofunctional problems. Finally, the SOE technique can be customized according to the initial clinical situation: for example, in cases of significant posterior open bite or the presence of a crossbite, buttons can be replaced by a localized bracket system to ensure greater predictability of posterior tooth movement, as described in a previous publication[13]. In addition, the technique can also be easily adapted/modified, depending on reevaluation during treatment. In case #2, the button on 13 was re-bonded more cervically to achieve greater extrusion movement. The SOE technique can therefore be adapted to a variety of clinical situations, but it is important to have it performed by an orthodontist in order to properly manage occlusal variations. Finally, the SOE technique has been shown to be associated with a high level of acceptance and satisfaction, regardless of the system used[13], and patient compliance with wearing elastics 24 hours a day for a very short period of time has always been excellent.

5. CONCLUSIONS

Ortho-pros collaboration offers the possibility of making treatments simpler and non-invasive for tooth tissues. Compared to the Dahl concept, the SOE technique is more efficient and predictable in terms of treatment time. It accelerates the extrusion of posterior teeth and also allows correct occlusal contacts to be managed. The technique is particularly well accepted by patients and should be offered more often, with explanations of its simplicity, speed of application and absence of esthetic disadvantages compared to conventional orthodontic treatment, which is more difficult for patients to accept.

New materials such as PICN (hybrid ceramics) for the treatment of localized wear or zirconia for RBB, play an important role in the success of these minimally invasive treatments, since it is due to their development and respective properties that these treatments are possible. Additionally, 3D printing technologies are easy-to-use processes for designing custom-made guides.

Finally, the cases presented here illustrate once again the importance of the multidisciplinary approach and teamwork in the field of minimally invasive and esthetic dentistry.

Future perspectives include the need of long-term studies on the reproducibility and prognosis of the technique, as well as the clinical behavior of restorative materials.

FIGURE LEGENDS

Figure 1: Schematic illustration of the Dahl concept and the orthodontic-assisted one-step no-prep technique, respectively. A. Severe tooth wear of the maxillary anterior teeth (incisors and canines) with passive eruption. B. The original Dahl appliance (removable metal bite platform made with cobalt-chromium: fixed appliances were later developed) creates interocclusal space. Over time, the anterior space is created by a combination of intrusion of the anterior teeth, which are in contact with the appliance and in supraocclusion and of passive eruption of the posterior teeth, which permits re-establishment of the posterior occlusion. The anterior space obtained after removing of the appliance allows reconstruction of anterior teeth. More recently, the appliance was replaced by the placement of direct composites on the anterior teeth, those composites being placed in supraocclusion during the time of posterior teeth eruption. C. The orthodontic-assisted one-step no-prep approach, in which definitive PICN palatal veneers are placed in supraocclusion to restore the anterior teeth and the extrusion of the posterior teeth is accelerated and controlled by partial orthodontic treatment.

Figure 2: **Case #1**, a 21-year-old female patient. A. Frontal view before treatment: in this case only the maxillary anterior teeth show severe tissue wear, while a very slight tooth wear was observed on the mandibular incisors, which did not require treatment. C. Digital smile analysis highlighting tissue loss. B and D. Lateral views showing the absence of interocclusal space to place restorations. E. Occlusal view of the anterior teeth showing palatal tissue loss. F. A CAD-CAM anterior mock-up in wax on a printed model of the maxilla (Omnicam camera). G. Try-in using Vaseline of the first mock-up. It consists of palatal veneers, which do not close the diastema. H. Try-in of the second mock-up. Here, the diastema was closed, extending the palatal veneers to the buccal surface of the central incisors, providing the restoration with an “envelope” design. On this basis, the patient decided to close the diastema. I. Occlusal view of the maxillary anterior teeth before restoration placement: no tooth tissue preparation was performed (no prep, only sclerotic dentin is depolished with a diamond bur). J. PICN “envelope” restoration for the central incisor. K and L. PICN (Vita Enamic) palatal veneers (on laterals and canines) and “envelope” restorations (on centrals) on printed model after staining with Optiglaze. Dental lab: Jean-Michel Paulus, Liège, Belgium.

Figure 3: **Case #1**. A. Occlusal view after restorations bonding: occlusal contact is only present on restorations. Consequently, posterior orthodontic bites were placed on the first molars to improve patient comfort. B. Lateral view showing the posterior open bite. C. Lateral orthodontic system, which is composed of direct composite buttons bonded on buccal surfaces and linked with intermaxillary elastics. After only 13 days, the open bite was already closed. D. A. Frontal view after restorations bonding and with lateral orthodontic system. Note that the shade of the restorations was lighter since a bleaching procedure will be later performed (which is not possible when the dentin is still exposed). E and F. Lateral views before and after restorations bonding and orthodontic treatment, respectively. G and H. Procedure to mask the junction between the palatal veneer and buccal surface of the lateral incisors and canines. After the rubber dam is placed, a slight chamfer is performed across the junction. I. PICN sandblasting at 2.5 bar with alumina particles. J. After rinsing with water, enamel etching with phosphoric acid. K. After rinsing with water, silane (Monobond S) application on PICN. L. Bonding application (Clearfil SE Bond, Kuraray Dental, Ijmuiden, Holland), which will be followed by high-value direct composite (Inspiro, EdelweissDR, Zug, Switzerland) layering. M. Frontal view after bleaching and masking of the junction between the buccal surfaces and the palatal veneers with direct composite. N. Lateral view at the end of the treatment. O. Occlusal view at the end of treatment, showing proper occlusal contacts everywhere.

Figure 4: **Case #1**. A and C. Frontal view and smile pictures before treatment. B and D. Frontal view and smile pictures 9 months after restoration bonding. E and F. Face pictures before and after treatment highlighting the improvement in smile esthetics. G. Palatal view at the 5-year follow-up. H, I and J. Clinical views at the 5-year follow-up, after a new bleaching procedure and 12 buccal margin maintenance with some flowable direct composite (Inspiro). Orthodontics: Prof. Carole Charavet. Prosthodontics: Prof. Amélie Mainjot.

Figure 5: **Case #2**, a 20-year-old male patient with upper laterals agenesis replaced by a removable prosthesis. A and B. Frontal views before treatment. C. Occlusal view and, D. Lateral view, showing a lack of interdental space and soft tissue volume. The patient's young age and the lack of space contraindicated implant placement while the occlusal contacts on the palatal surfaces on centrals and canines interfered with the placement of large enough RBB wings. E. Digital smile analysis. F and G. Digital setup. Diastema between 11 and 21 needs to be closed to save space for the laterals.

Figure 6: **Case #2.** A. Situation after endodontic treatment and internal bleaching of 21. An external bleaching procedure was also performed. Direct composites on 11 and 21 were redone (Inspiro, EdelweissDR). B. Situation

after diastema closure with a two-days orthodontic treatment. C. The RBB try-in highlights the soft tissue deficiency and reveals the adjusments to be performed in prosthesis design, particularly in the emergence profile. D. Minimally connective tissue grafts harvested from the palate. E. After insertion of the connective tissue grafts the split thickness pouches were secured with a 6/0 resorbable suture. F. Healing after 1 week.

Figure 7: **Case #2**. A and C. RBB design with pontic ovoid. B and D. A concavity was milled on the model and the emergence profile level was idealized following the esthetic analysis. E and F. Zirconia RBB design. Note that the wings are very thin (0.3 mm). G and video 1. 3D design in Exocad of an original 3D-printed resin guide (Exocad Gmbh, Darmstadt, Germany). H and I. 3D-printed resin guide for #12 and #22 respectively (Keystone industries, Keyprint, Keyguide). This guide is (1) rigid for precise positioning; (2) translucent to allow light-curing of the composite cement; (3) involves only the occlusal surfaces of adjacent teeth so as not to interfere with the rubber dam ; (4) involves the buccal surface of the pontic to hold it in place; 5) has one support on the wing and one on the buccal surface of the abutment tooth, but leaves all wing borders uncovered to allow removal of excess composite cement (the guide forms an arch at the incisal edge). Guide design: Prof. Amélie Mainjot. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 8: **Case #2**. A to E. Original 3D-printed resin guides. Views on models. F. Situation after metal buttons bonding from canines to molars. F and H. On the day of bonding, a cavity to accommodate the pontic was created in the soft-tissue graft. I and K. The correct positioning of the two guides and bridges is checked before the rubber dam is placed. L.The rubber dam in place. M. Correct positioning of the guide and bridge is also checked after placing the rubber dam. Note the correct isolation and the absence of bleeding despite the intervention on the gingiva. Guide design: Prof. Amélie Mainjot. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 9: **Case #2**. A. Situation just after bonding of the restorations and intermaxillary elastics (IntraOral Elastics, Medium Pull, 1,3 N (128 g), ∅ 4,8 mm / 3/16 inch, Dentaurum, Ispringen, Germany) were prescribed between quadrant 1 and 4 and between quadrant 2 and 3 to re-establish the occlusion. B. Restorations are in high occlusion and induce an open bite in the posterior region. C. Occlusal contacts just after bonding of the restorations. D. Occlusal contacts one week later: occlusal relationships are already reestablished. E. Frontal view before treatment. F. Frontal view 3 weeks after RBB bonding. G and H**.** Face pictures before and after treatment highlighting the improvement in smile esthetics.

Figure 10: **Case #2.** A and B. Smile pictures before treatment and at the 18-month recall. C. Frontal view at the 18-month recall. Note the natural soft tissue profile and papilla growth. D and E. Frontal view before treatment and at the 18-month recall. F and G. Papilla integration at the 18-month recall. Orthodontics: Prof. Carole Charavet following by Dr Jean-Claude Bernard and Dr. Simon Gigli. Muco-gingival surgery: Prof. France Lambert. Prosthodontics: Prof. Amélie Mainjot.

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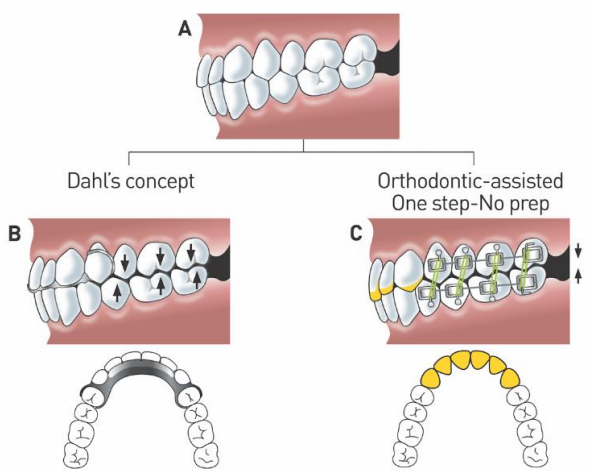
538 Figure 1



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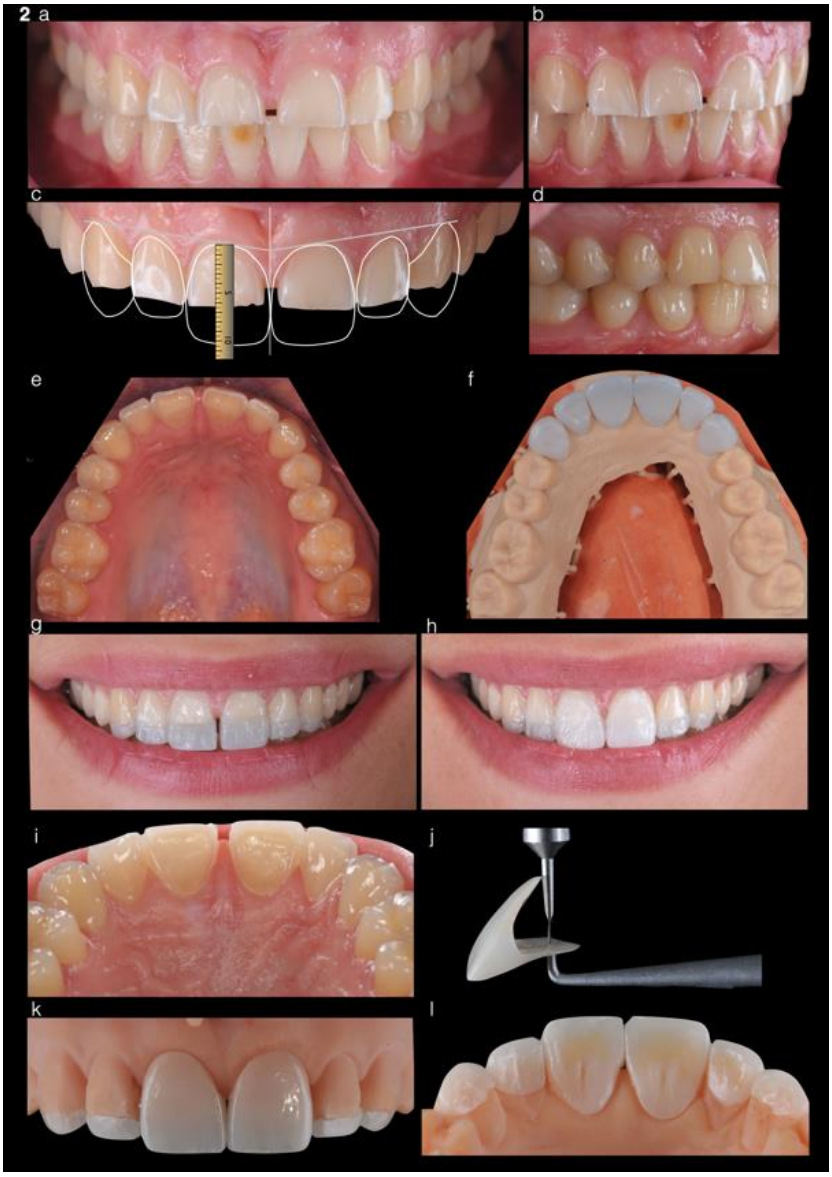

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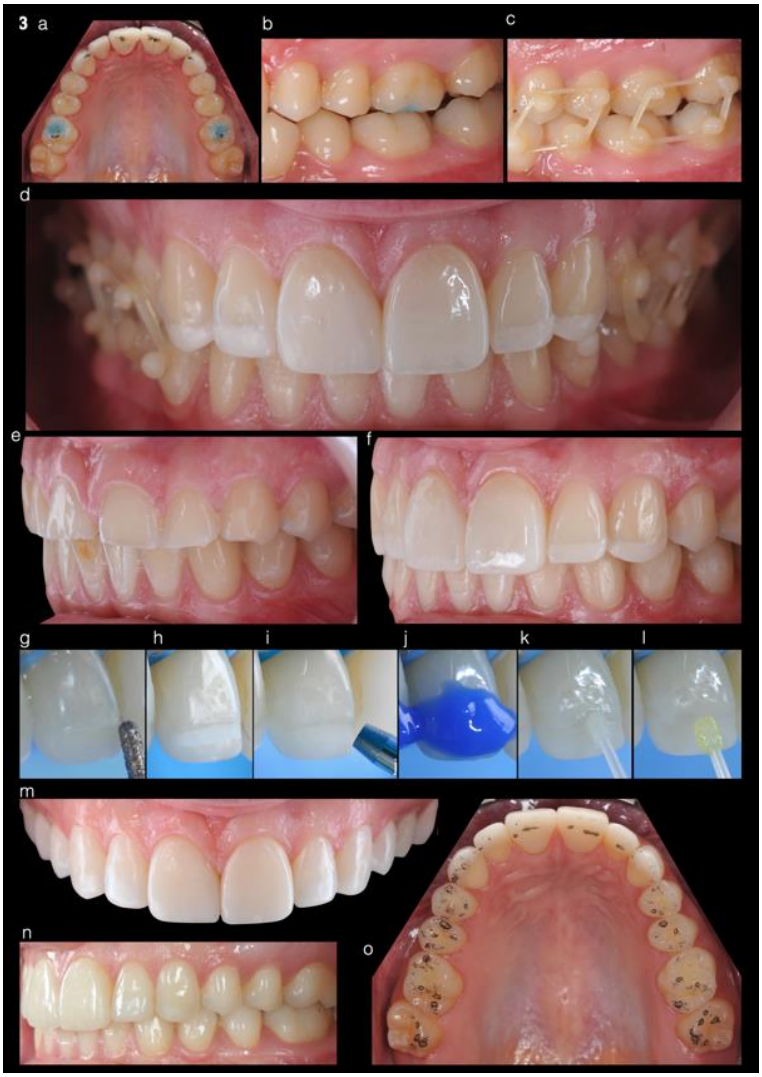

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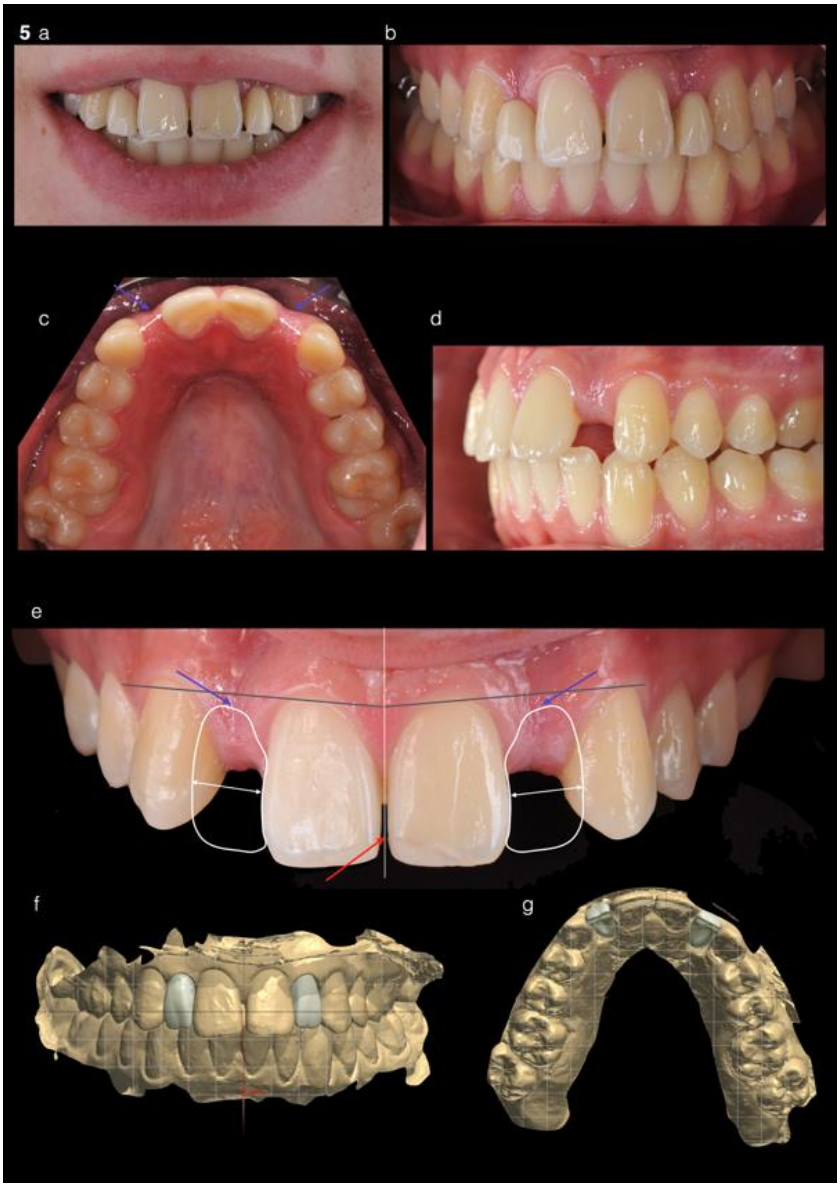

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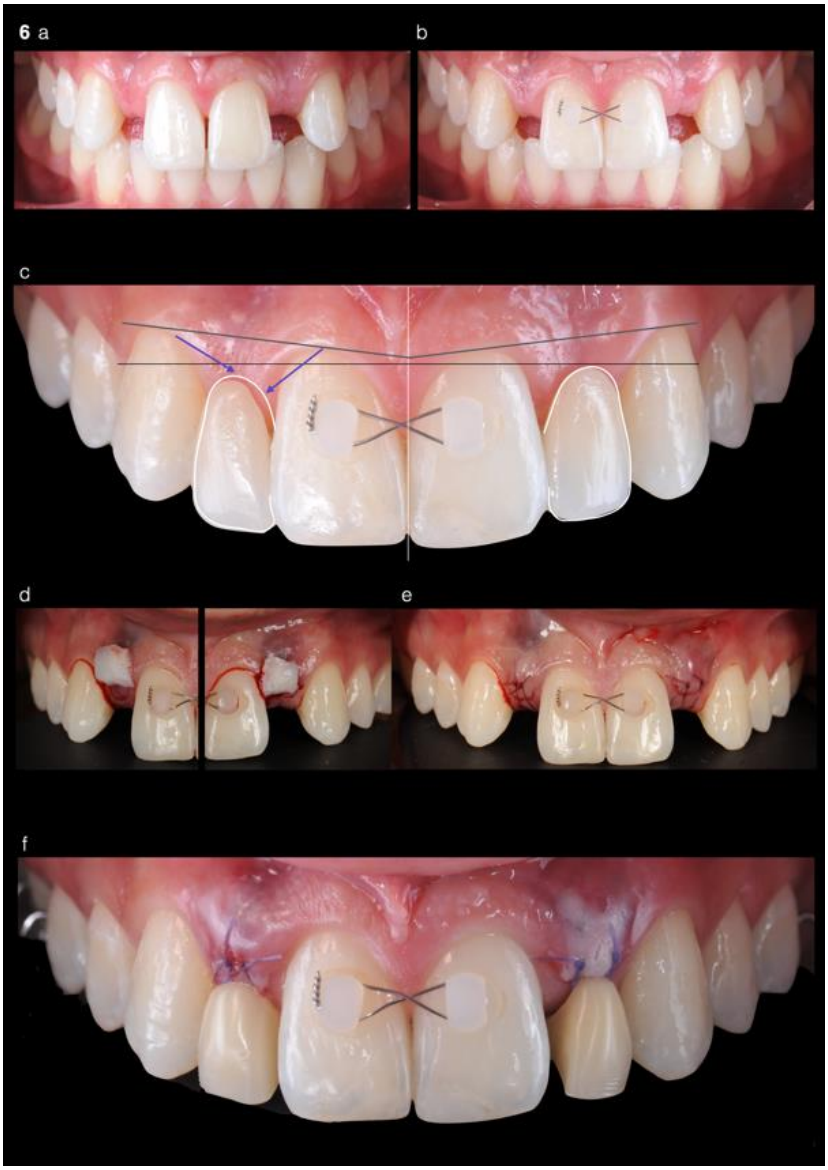

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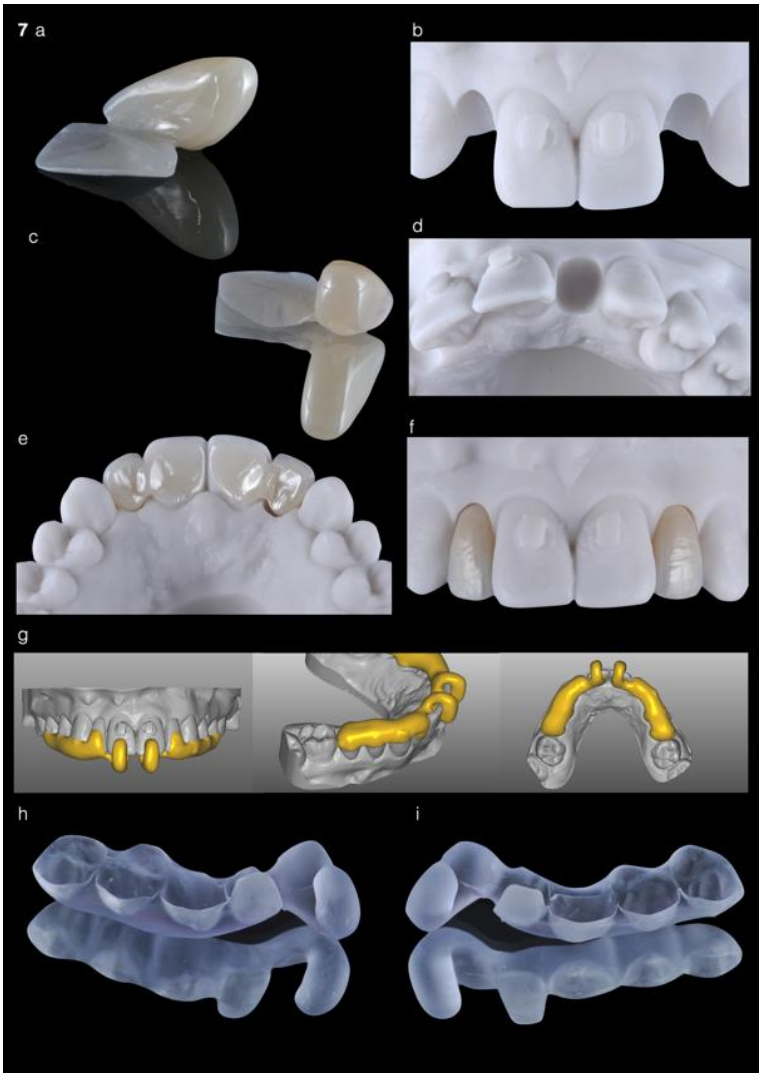

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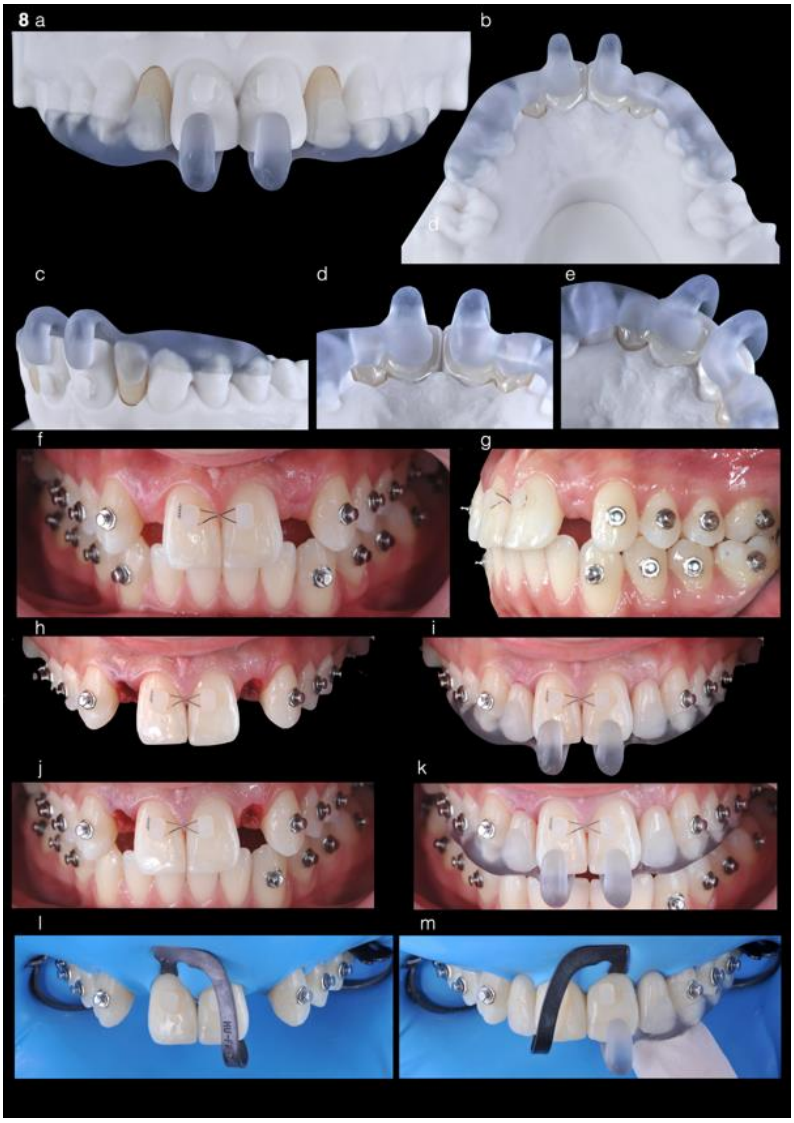

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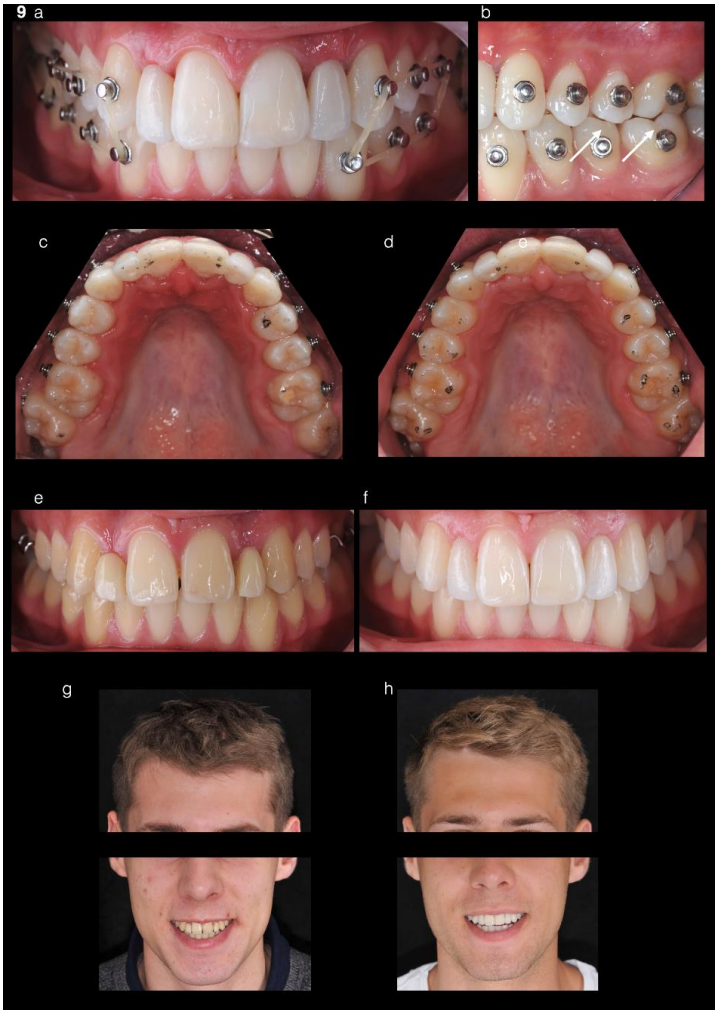

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