No-prep Zirconia Cantilever Resin-Bonded Fixed Dental Prostheses: A Non-Invasive, Simple Approach to Replacing a Single Missing Tooth

Amélie Karine Jacques MAINJOT DDS, MS, PhD

Dental Biomaterials Research Unit (d-BRU), University of Liège (ULiège), Belgium

Department of Fixed Prosthodontics, University Hospital (CHU) of Liège, Belgium

CORRESPONDENCE

Prof. Amélie Mainjot
Dental Biomaterials Research Unit (d-BRU) and Department of Fixed Prosthodontics
Institute of Dentistry
Quai G. Kurth 45
B-4020 Liège
Belgium
Phone : +32 323 30 85
amelie.mainjot@uliege.be

ACKNOWLEDGMENT

The author would like to acknowledge the contributions of Mr Luc and Partick Rutten (Dental Team, Tessenderlo, Belgium) and Mr Jean-Michel Paulus (Liège, Belgium) for their laboratory work; Prof. France Lambert and Prof. Eric Rompen (University of Liège Hospital, Belgium) for performing the mucosal surgeries; and Dr Jean-Claude Bernard and Dr Simon Gigli (University of Liège Hospital) for providing orthodontic treatments.
The author would also like to acknowledge Dr Christelle Sanchez (University of Liège Hospital) for the statistical support and Dr Alexandre Degueldre (University of Liège Hospital) for his help in data collection.
Case #8 was reproduced from Mainjot et al. [11], reprinted by permission of Quintessence publishing.

DISCLOSURE STATEMENTS

Amélie Mainjot is married to the founder of the company MaJEB, which contributes to the development of PICN materials. As the Head of the Dental Biomaterials Research Unit at the University of Liège, she develops research contracts with various dental companies, including Kuraray. This company invites her to present lectures, for which she receives speaker fees.

ABSTRACT

Objectives: To introduce no-prep zirconia cantilever resin-bonded fixed dental prostheses (Z-RBFDPs) as a non-invasive and simple approach to replace individual anterior and posterior teeth.

Clinical Considerations: Sixteen no-prep Z-RBFDPs were placed in 11 patients with a single missing tooth (15 lateral incisors, 1 canine, and 1 premolar); nine exhibited bruxism, and four used a nightguard. Bridges were bonded using a rubber dam and Panavia V5 resin cement after gritblasting zirconia, etching the enamel (n=13) or Vita Enamic palatal veneer (n=3), and applying an MDP-based primer. The survival rate was 100% after a mean follow-up of 3.0 ± 2.6 years (range: 1 month–9.5 years). A Z-RBFDP on an upper canine showed debonding after 2 years and the bonding procedure was successfully repeated. Patient-reported outcomes were positive. Key considerations included restoration design, material selection, bonding procedures, and multidisciplinary soft tissue management. An innovative 3D-printed resin guide was introduced to ensure accurate bridge positioning during the bonding procedure, and the Simple Orthodontic Extrusion technique was used to manage the limited occlusal space.

Conclusion: This case series provides proof-of-principle for no-prep Z-RBFDPs, demonstrating high survival and success rates, even in the presence of known risk factors such as bruxism and unfavorable occlusal relationships.

Clinical Significance: No-prep Z-RBFDPs offer a promising, non-invasive, cost-effective, and straightforward alternative to dental implants for single-tooth replacement. They effectively avoid related complications such as infraposition and peri-implantitis. Further research is required to validate these preliminary findings, particularly for posterior applications. Treatment choices should increasingly align with the patient's preference for non-invasive procedures that prioritize tooth tissue preservation and avoid surgical interventions, as demonstrated in this case series.

Keywords: cantilever bridge, 3Y-TZP, bonding, minimally invasive dentistry, digital dentistry, connective tissue graft, simple orthodontic extrusion

1. INTRODUCTION

Since their introduction in the 1970s, cantilever resin-bonded fixed partial dentures (RBFDPs) have become a popular, minimally invasive treatment option for replacing single missing teeth. In 1973, Rochette et al. described a perforated metal splint designed for periodontally compromised teeth [1]. The application of RBFDPs was later expanded to replace missing anterior teeth in young patients and eventually posterior teeth, with minimal to no tooth preparation [2].

However, the primary issue encountered was the dissolution of cement, which led to the replacement of perforations with alternatives such as electrochemical etching to improve retention [3]. Special attention was also given to specific abutment preparations, including the incorporation of grooves and pinholes, which improved retention and increased success rates, as reported in the late 1990s with the Maryland bridges, with success rates of up to 95% after 10 years [2].

After the 2000s, long-term clinical data on non-metallic RBFDPs made from glass-ceramic or zirconia materials have become available. Ceramic RBFDPs, introduced by Kern et al. in the early 90s, [4] enhanced the esthetic properties of restorations. RBFDPs with a single retainer, also known as cantilevered pontics, have better survival rates than those with double-sided retainers, which can suffer from partial decementation or connector fractures [5]. According to Kern, double-sided retainers can be used in certain cases, such as splinting two adjacent teeth or replacing several incisors in a straight anterior dental arch, without increased mobility [6].

The clinical performance of RBFDPs is comparable to that of conventional fixed partial dentures (FPDs) and implant-supported crowns, with a 5-year success rate of 88% for metal and 84% for non-metal RBFDPs [2]. Specifically, meta-analyses have demonstrated that single-retainer anterior zirconia RBFDPs (Z-RBFDPs) exhibit a 92% 5-year success rate [2], with 3–10-year success rates exceeding 80% (6

studies), where the incidence of debonding or fractures were rare [7]. Additionally, Kern et al. reported 10-year survival and success rates of 98% and 92%, respectively [8].

Data on canine and posterior single-retainer Z- RBFDPs are limited. However, a systematic review of 27 restorations reported 100% survival and 96% success rates (mean observation time: 53 ± 39 months) [9]. Pre-treatment of the restoration surface influences treatment outcomes. A two-step process comprising micromechanical retention using airborne particle abrasion, followed by resin-zirconia adhesion via the application of 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), is recommended [7]. Notably, other materials, such as in-ceram alumina, lithium-based glass-ceramics, and fiber-reinforced composites, have also been successfully used in RBFDPs [2,10]. However, zirconia, particularly 3 mol% yttria-stabilized tetragonal zirconia polycrystal (3Y-TZP), and not the high-translucent zirconia variants, such as 4Y- and 5Y-TZP, exhibits a markedly higher flexural strength and toughness [11]. This allows for a reduction in connector dimensions to enhance esthetics and a thinner retainer wing to promote minimal invasiveness (e.g. 12 mm^2 versus 16 mm^2 connector size and 0.7 mm versus 1 mm occlusal thickness for IPS e. max ZirCAD, 3Y-TZP, and IPS e.max Press, a lithium-based glass-ceramic from Ivoclar-Vivadent, respectively).

Although the popularity of RBFDPs has declined with advancements in implantology. The choice between implants and RBFDPs for replacing a single tooth, particularly an anterior tooth, is now more balanced. This shift is largely due to the advent of non-metallic Z-RBFDPs and the complications associated with dental implants. Recent research indicates that the risk of peri-implantitis exceeds 19% [12], and that of the implant infrastructure reaches 50% [13]. Furthermore, implants are generally more invasive and expensive than RBFDPs. Consequently, RBFDPs are increasingly recognized as viable alternatives to conventional FPDs and implant-supported crowns [2,7]. This is particularly true for the anterior zone, where esthetic demands are higher, the risk of infraposition is more problematic, and the occlusal stress is lower than that in the posterior zone. In the posterior zone, the available clinical literature is limited, and the occlusal

load is higher. Thus, RBFDPs may be recommended in cases of insufficient space width or bone volume for implant placement, angulated roots of adjacent teeth, surgical contraindications, or in younger patients.

According to Kern, the contraindications for RBFDPs include insufficient bonding surface area (< 30 mm² of enamel), inadequate occlusal space (< 0.7 mm), insufficient connector height (< 3 mm), inappropriate occlusal guidance (which should not be on the pontic), and the presence of bruxism without a nightguard [6]. In cases of inadequate occlusal space, some authors have proposed applying the Dahl concept to RBFDPs in both the anterior and posterior sectors [14,15]. This approach involves placing restorations in supraocclusion with the expectation that occlusal relationships will be re-established through the passive eruption of other teeth. However, the authors noted that a minimum of four months is required to restore occlusion, and they report some complications, such as partial occlusal re-establishment and bridge decementation [14]. Recently, we proposed a simple orthodontic extrusion technique as an evolution of Dahl's concept to overcome these drawbacks [16].

Although ceramic RBFDPs are much less invasive than conventional FDPs in terms of preserving tooth tissue, all authors recommend some degree of tooth preparation to enhance the retention of ceramic RBFDPs, with the exception of Sailer et al., who did not advocate for the preparation of glass-ceramic RBFDPs [5]. For anterior teeth, this preparation typically includes a minimal lingual veneer, a central lingual pinhole, and a flat proximal box [6,7]. For the posterior teeth, Yazigi et al. described a minimally invasive preparation of abutment teeth that was limited to the enamel. A retainer wing was prepared on the abutment teeth, partially extending to the proximal ridge and cusps in areas without static occlusal contacts, to serve as an occlusal rest and increase the bonding surface area. All sharp edges and surfaces were carefully smoothed as required for all-ceramic restorations [9]. However, current guidelines in medicine and dentistry strongly advocate for minimally invasive treatments [17,18]. Avoiding tooth tissue preparation could lead to a completely non-invasive treatment, thereby simplifying the procedure.

Therefore, this study aimed to introduce no-prep zirconia cantilever RBFDPs and present a case series to provide a proof of principle.

2. CLINICAL CONSIDERATIONS

1. Analysis of clinical cases

A total of eleven patients, with a mean age of 26.3 years (range: 19.2–63.3 years), sought treatment for the replacement of a missing tooth in either the anterior or posterior region between 2014 and 2023 (Tables 1 and 2). Most patients were referred by dental surgeons or orthodontists because of contraindications for implant placement, including insufficient width or volume of bone, angulated roots of adjacent teeth, and a young age. The most common cases involved agenesis of the upper lateral incisors. A clinical examination was performed to determine the presence of clinical signs of bruxism such as dental attrition, cracks/fractures, masseteric hypertrophy, masticatory muscle pain upon palpation, linea alba, exostoses, and a crenated tongue. The presence of bruxism was recorded if the patient fulfilled at least two criteria: A) tooth grinding/clenching during the night or day and (B) the presence of at least one clinical sign among the following: abnormal attrition wear facets on the teeth, transitory pain or fatigue in jaw muscles on waking, temporal headaches on waking, and jaw locking on waking related to teeth grinding during sleep [19,20].

Images, radiographs, and optical impressions (Primescan camera, Dentsply Sirona, Charlotte, USA) were acquired. In older patients, conventional double-mix impressions using polyvinyl siloxane (PVS) (Imprint 4 heavy and light, 3M, St Paul, USA, or Aquasil Ultra heavy and XLV, Dentsply Sirona, York, USA) were used. A digital smile analysis was performed using the Keynote software, primarily to assess any vertical or horizontal deficiencies in the soft tissue of the alveolar crest at edentulous sites (Case 1, Figures 1 and 2). In some cases, prior restorative treatment was required for other teeth before the Z-RBFDP could be

placed. In these instances, a new impression was obtained. Additionally, some patients required an external bleaching procedure.

2. Soft tissue management

If sufficient quantities of soft tissue were present and the patient was wearing a temporary removable prosthesis, the tissue profile was shaped by relining the prosthesis according to the desired design, if necessary. This was performed on a plaster model, upon which the ideal design created by a dental technician was transferred. For this purpose, a concavity was milled into the model, and the emergence profile was established based on an esthetic analysis. Additionally, an adapted cavity was created within the soft tissue using a diamond bur (Case 2, Figures 3–6).

In the event of soft tissue deficiencies, a connective soft tissue graft may be recommended. For example, the Z-RBFDP was prepared first. Grafting was performed either before bonding (prior approach) (case 3, Figures 7–9) or concurrently with bonding (the same day or within the subsequent week) (immediate approach) (Case 4, Figures 10–14) (Table 1). This immediate approach is currently preferred because it promotes soft tissue healing, driven by the prosthesis design. Regardless, Z-RBFDP was first attempted before the graft, and its shape was optimized based on the results of the esthetic analysis. The try-in prior to the graft helps prevent any interference from the pontic with the soft tissue, which may require slight pressure and complicate this try-in. Additionally, it may encourage the patient to undergo grafting to optimize esthetics.

3. No-prep Z-RBFDP realization

No tooth tissue preparation was performed, and the bonding surface was located on the enamel, except in two patients (three Z-RBFDPs) who had polymer-infiltrated network (PICN) CAD-CAM composite no-prep palatal veneers on the abutment teeth. Sixteen zirconia single retainers and one double retainer was used on the central incisors to replace the two lateral incisors after orthodontic treatment (Figure 15);

subsequently, the RBFDPs were placed. The material used was Prettau 1 ICE Translucent and Prettau 2 Dispersive (ME RBB Milling Machine, Zirkonzahn, Gais BZ, Italy) (3Y-TZP materials) or Zolid gen-x Multilayer (Ceramill Motion 3 milling machine, Amann Girrbach AG, Koblach, Austria) (4Y-TZP material). In the case of anterior single-retainer Z-RBFDPs, the retainer wing was positioned on the adjacent central incisor, except in one case where it was positioned on the canine. For canine and premolar single-retainer Z-RBFDPs, the retainer wing was positioned on the adjacent premolar (case 6, Figures 16 and 17; case 7 Figures 18 and 19). A veneering ceramic (Vita VM9, Vita Zahnfabrik, Bad Säckingen, Germany) or an initial LiSi veneering ceramic (GC Corporation, Tokyo, Japan) was layered on the buccal surface of the pontic, while Zolid gen-X was veneered with IPS e. max Ceram, Ivoclar, Schaan, and Liechtenstein (Figure 4). Notably, the zirconia wings can be very thin (0.3 mm in Case 8, Figures 20–25), whereas the minimum connector height is 3.0 mm.

As shown in Figure 21, the emergence profile of the pontics was ovoid, and the part in contact with the gingiva was not veneered to preserve the biocompatibility of zirconia and promote soft tissue adhesion.

4. <u>No-prep Z-RBFDP bonding</u>

Ten bridges were bonded using an original 3D-printed resin positioning guide designed by the authors (Keystone Industries/KeyPrint/KeyGuide). This guide was (1) rigid for precise positioning; (2) translucent to allow light curing of the composite cement; (3) involved only the occlusal surfaces of adjacent teeth so as to not interfere with the rubber dam; (4) involved the buccal surface of the pontic to hold it in place; (5) had one support on the wing and one on the buccal surface of the abutment tooth, but left all wing borders uncovered to remove excess composite cement (the guide forms an arch at the incisal edge) (Figures 4, 5, 11–14, 16, 22, **Video 1 of Case 4**) [16]. In older patients, either no positioning guide (n=3) or a classic guide in a patterned resin (GC Europe, Leuven, Belgium) was used (n=1), and two zirconia wings were fabricated (one for positioning and one removed after bonding) (n=2).

The correct positioning of the guides and bridges was verified before and after the placement of the rubber dam (Nic Tone, Bucharest, Romania). The bridges were bonded with Panavia V5 (Panavia F in the oldest case) composite cement (Kuraray Europe, Hattersheim, Germany). The wings were gritblasted with 50 µm alumina particles at a pressure of 2.5 bar (Figure 31 D), then ultrasonically cleaned in ethanol and covered with ceramic primer according to the manufacturer's recommendations. The dental tissues were cleaned with a pumice stone, etched with phosphoric acid for 30 s, and covered with tooth primers. After placement of the rubber-dam, No-Prep PICN palatal veneers (Figure 5) were etched with 5% hydrofluoric acid for 60 s (Ultradent, Utah, United States; alternatively, grit-blasting with 50 µm alumina particles can be used) and covered with the ceramic primer. Polymerization was completed after the removal of excess material, and the final light-curing was performed under a glycerin film to avoid the persistence of a polymerization inhibitor layer (**Video 2 of Case 8**).

Occlusal adjustments were made using an Arkansas stone burr, followed by polishing with silicone rubbers specifically designed for zirconia. Occlusal contact with the pontics was not eliminated. If possible, they were lightened only slightly, especially in the distal part of the pontic and connector. If possible, occlusal guidance was eliminated, though this was not the case in the majority of the cases (Figure 19).

5. Managing the lack of occlusal space with simple orthodontic extrusion (SOE) [16]

In Case 8 (Figures 20–24), the occlusal space was insufficient to place the wing retainer. Therefore, metal buttons were bonded (GC Ortho Connect; GC Orthodontics, Tokyo, Japan) from the canines to the molars. 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 (the patient did not have a removable prosthesis to design the soft tissue in advance). Bonding of the restorations resulted in an open bite in the posterior region, and SOE was performed [16]. Intermaxillary elastics were prescribed 24 h/day between quadrants 1 and 4 and between quadrants 2 and 3, except when eating or drinking and brushing the

teeth. Each elastic change was performed twice daily. Posterior occlusion was restored within one week. Subsequently, the buttons were removed.

6. Follow-up

This study was approved by the ethics committee of the University Hospital of Liège (B7072024000038). The mean follow-up period for the restorations was 3.0 ± 2.6 years (range: 1 month–9.5 years). The survival rate of the restorations was 100%. The Z-RBFDP replacing an upper canine showed debonding at the resin/zirconia interface after 2 years. After removing the resin cement from the tooth tissue, the bonding procedure was repeated, and the bridge remained in place for 6.5 years. The patient exhibited bruxism, did not wear a nightguard, and had significant occlusal contact on the pontic (Figures 18 and 19).

All patients expressed high levels of satisfaction with the esthetic and functional outcomes of the procedure, as well as appreciation for its minimally invasive nature. Indeed, the results of a satisfaction questionnaire (n=8 out of 16 restorations, representing 5 patients) demonstrated a mean score of 5 out of 5 for the treatment's esthetic and functional results. Respondents rated the importance of minimally invasive treatment for preserving tooth tissue a 4.5 out of 5. Additionally, the non-invasive nature of the procedure, compared to surgical implantation, was rated 4.25 out of 5.

3. DISCUSSION

The results of this case series on no-prep Z-RBFDPs were highly successful despite disregarding several contraindications. These contraindications included an insufficient bonding surface area (less than 30 mm^2 of enamel), inadequate occlusal space (< 0.7 mm), occlusal guidance on the pontic, and the presence of bruxism without the use of a nightguard [6]. The present findings require further investigation, particularly regarding the canines and posterior teeth. In fact, there was debonding on the canine bridge,

which can be explained by the presence of some of the risk factors mentioned above, especially occlusal guidance, the presence of clinical signs of bruxism, and the lack of a bonding surface (an occlusal rest should have been placed on the premolar wing retainer in an area without occlusal contact) (Figures 18 and 19, Case 7). The bonding procedure was repeated, and the bridge remained in place. Nevertheless, the results were highly promising and introduced a completely non-invasive alternative to dental implants, especially for the replacement of lateral incisors. The short-term clinical performance of no-prep Z-RBFDPs was superior to that of conventional FPDs and implant-supported crowns [2]. Furthermore, the short-term performance of the no-prep Z-RBFDP was comparable to that of the Z-RBFDPs with tooth preparation [2 7 8 9].

Regarding the retainer wing position and design, the abutment tooth was selected to provide the largest possible bonding surface. However, the recommendations of Kern regarding the bonding surface area (min 30 mm^2) were not considered. Consequently, in some instances, the surface area was smaller than the recommended dimensions. Generally, the retainer wing was positioned on the central incisor of the upper anterior teeth. In one case, the retainer wing was positioned on the canine, and the orthodontic retention was placed on the central incisors. In certain instances, partial coverage may be a viable option, contingent on occlusal contact, such as in the presence of a deep bite (Figure 12). The retainer wings were positioned on the palatal surfaces of the premolars and canines. It is recommended that a wide palatal wrap and creation of an occlusal rest in an area without occlusal contact be employed to prevent debonding, as observed in one case. If occlusal contacts were too high, the wing was reduced to < 0.7 mm in certain areas. In cases with a minimal occlusal space limitation, the Dahl technique may serve as a viable option [14,15]. However, for more significant limitations, the SOE technique is effective and avoids certain drawbacks of the Dahl technique [16].

The concept of the no-prep RBFDP has been previously described in the literature, utilizing a lithium-disilicate-reinforced glass-ceramic material, which is a highly bondable ceramic [5]. Zirconia is thought to be less bondable than glass-ceramics, and the existing literature recommends tooth preparation to allow

micromechanical retention of the bridge. Zirconia has several advantages. Its high strength (flexural strength exceeding 1000 MPa) reduces the risk of connection fracture and allows for a reduction in height compared with glass-ceramics, which enhances the esthetic results. Furthermore, the use of zirconia enables the fabrication of thinner retainer wings, which is beneficial for implementing no-prep restorations. Nevertheless, the utilization of 3Y-TZP zirconia is advised because highly translucent zirconia (4Y and 5Y-TZP) exhibits diminished mechanical resistance. In the present study, Zolid Gen-X, a 4Y-TZP, was utilized in one case, although this carried an increased risk.

It is important to note that great care was taken in the selection of the resin cement and pretreatment of zirconia. Current guidelines were followed to optimize bonding, particularly grit-blasting zirconia (2.5 bar) and using a ceramic primer containing functional monomers such as MDP, while the enamel was etched. [7,22]. Additionally, zirconia is the most biocompatible material for soft tissue [23,24], which facilitates its use, particularly on the gingival side of the ovoid pontic. It was recommended that this side remains unveneered. Nevertheless, veneering the buccal surface enables the attainment of a favorable esthetic outcome. As previously stated in the introduction, the background with Z-RBFDPs is highly favorable, and there is a greater quantity of data than with lithium-disilicate-reinforced glass-ceramics.

Buccal (horizontal) tissue discrepancies resulted in compromised pink esthetic and eventual discomfort due to food retention. Minimally invasive connective tissue grafts [16] allow for the restoration of the soft tissue profile and the natural emergence of the pontic. An immediate approach, consisting of bonding the Z-RBFDP within the first week following surgery, was preferred to guide soft tissue healing with the prosthetic component. The utilization of a rubber dam enabled the attainment of optimal bonding conditions.

Finally, a disadvantage of no- RBFDPs was the difficulty in correctly positioning them during bonding. This problem prompted the author to develop an original 3D-printed guide with the aforementioned advantages. This guide proved highly successful, allowing secure positioning in several cases.

The results of this preliminary study promote Z-RBFDP as an excellent alternative to dental implants, not only in young patients. This avoids the disadvantages of implant rehabilitation, particularly the important risks of infrastructure and peri-implantitis [12] [13]. Moreover, this case series underscores a clear patient preference for non-invasive procedures that avoid surgical interventions and preserve the tooth tissue.

4. CONCLUSIONS

The results of this case series provide proof of principle for no-prep Z-RBFDPs, which demonstrated excellent short-term (mean follow-up of 3.0 ± 2.6 years) survival and success rates despite the presence of risk factors for failure, such as bruxism, unfavorable occlusal relationships, or bonding to PICN (hybrid ceramic) palatal veneers. However, further studies are required to confirm these preliminary results, particularly in the posterior region.

Particular attention should be paid to the design of the restoration, especially the design of the posterior retainer wing; the selection of appropriate materials (preferably 3Y-TZP); and the meticulous execution of each step of the bonding procedure, including effective surface pretreatment and the use of a precise positioning guide, such as the 3D-printed resin guide. Finally, multidisciplinary collaboration is essential for effectively managing soft tissue esthetics and occlusal space limitations.

In conclusion, no-prep Z-RBFDPs offer a promising, completely non-invasive, simple, and cost-effective alternative to dental implants for replacing a single missing tooth, while avoiding the risks of infraposition and peri-implantitis. To confirm the present results, long-term clinical studies with larger sample sizes are needed to analyze the different parameters of success rate.

Treatment decisions should increasingly reflect the patient's perspective, and this case series underscores a clear patient preference for non-invasive procedures that prioritize tooth tissue preservation and avoid surgical intervention.

FIGURE LEGENDS

Figure 1: Case #1 – A 19-year-old female patient with agenesis of tooth 12 and a conoid-shaped tooth 22.
A. Frontal view before treatment.
B. Digital smile analysis showing a sufficient amount of soft tissue. Direct composites were applied in an additive manner to adjust the shape of tooth 22 and the incisal edge of tooth 11 (Miris, Coltene, Altstätten, Switzerland).
C. Frontal view after no-prep Z-RBFDP (Prettau 2 Dispersive, Zirkonzahn) bonding.
D. Palatal view showing the retainer wing design on tooth 11.

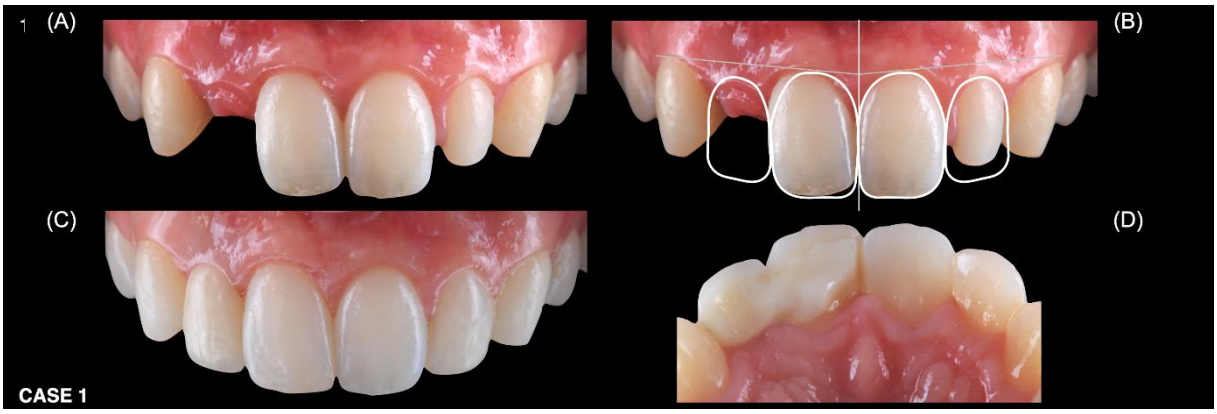

Figure 2: Case #1 – Images after a 9.5-year follow-up period.
A. Frontal view.
B. Palatal view highlighting occlusal contacts in maximum intercuspation (in black) and incisal guidance (in red).

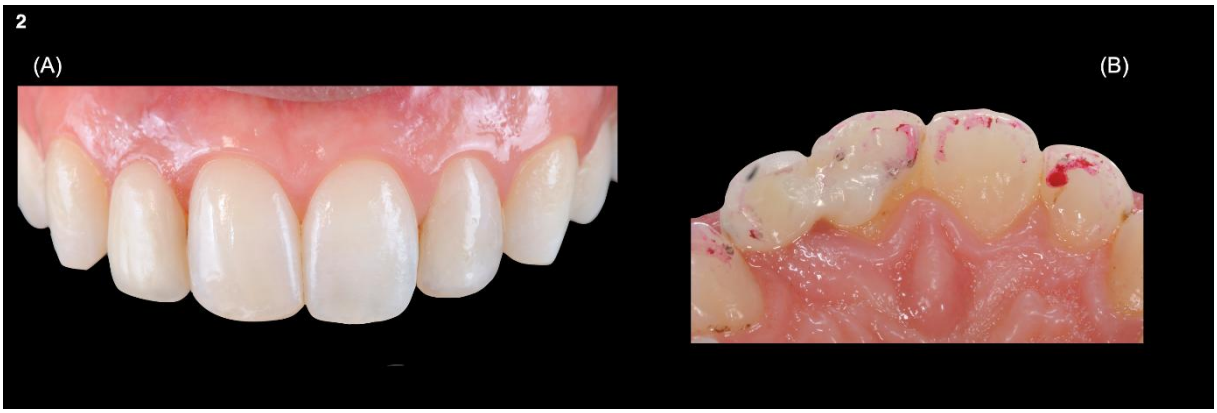

Figure 3: Case #2 – Soft tissue shaping prior to **Z-RBFDP placement in a 36-year-old female patient with agenesis of teeth 12 and 22.**
A. Removable prosthesis on the plaster model: a concavity was milled on the model, and the emergence profile

was idealized following esthetic analysis.
B. Relining of the prosthesis with direct composite on the plaster model.
C and D. An adapted cavity was created within the soft tissue using a diamond bur.
E. Frontal view of the removable prosthesis after relining and soft tissue adjustment.
F. Soft tissue profile three weeks later, on the day of the no-prep Z-RBFDP bonding.

Figure 4: Case #2
A. Design of the 3Y-TZP RBFDP framework (Prettau 2 Dispersive, ME RBB Milling Machine, Zirkonzahn).
B. Layering of a veneering ceramic (Vita VM9, Vita Zahnfabrik) on the buccal surface of the pontic. Dental lab: Luc and Patrick Rutten, Dental Team, Belgium.
C. Ovoid design of the pontic; the surface in contact with the soft tissue remains unveneered to promote biocompatibility.
D. Try-in of the two no-prep Z-RBFDPs using the original 3D-printed resin positioning guide (Keystone Industries/KeyPrint/KeyGuide).
E. Views of the two no-prep Z-RBFDPs positioned within their respective guides.

Figure 5: Case #2
A. Try-in of the positioning guide and the no-prep Z-RBFDPs replacing tooth 22 with the rubber dam in place.
B. Frontal view 1.5 months after no-prep Z-RBFDPs bonding. A soft tissue graft was proposed to the patient for tooth 22, but she declined. However, it would have improved the esthetic result.
C. Occlusal view showing the PICN (hybrid ceramic, Vita Enamic) no-prep palatal veneers on teeth 11 and 21. The no-prep Z-RBFDPs will be bonded to these palatal veneers after hydrofluoric acid etching and application of the ceramic primer.
D. Occlusal view 1.5 months after no-prep Z-RBFDPs bonding.

Figure 6: Case #2 – Result of a no-prep **treatment for both lateral agenesis and severe tooth wear.**
A. Frontal view before treatment, showing agenesis of teeth 12 and 22 as well as severe tooth wear. A restorative procedure using no-prep PICN (hybrid ceramic, Vita Enamic) palatal veneers and some posterior table tops was performed following the One-Step No-Prep technique [25]. Orthodontic treatment was then conducted to restore proper occlusal relationships and create space for teeth 12 and 22. Dental lab for PICN restorations: Jean-Michel Paulus, Liège, Belgium. Orthodontics: Dr Jean-Claude Bernard, University of Liège Hospital, Belgium.
B. Frontal view at the end of treatment.
C. Smile picture before treatment.
D. Smile picture after treatment.

Figure 7: Case #3 – A 17-year-old female patient with agenesis of teeth 12 and 22.
A. Frontal view with her removable prosthesis, highlighting a horizontal soft tissue deficiency.
B. Frontal view without the removable prosthesis.
C. Fabrication of the two no-prep Z-RBFDPs prior to the connective soft tissue graft (Prettau 1 ICE Translucent, ME RBB Milling Machine, Zirkonzahn).

Figure 8: Case #3 – Soft tissue management in the case of deficiency: prior approach.
A. Frontal view of no-prep Z-RBFDPs try-in, highlighting the soft tissue deficiency.
B. Frontal view 1 week after two minimally invasive connective tissue grafts. Surgery by Prof. France Lambert, University of Liège Hospital, Belgium.
C and D. Frontal views 3 months later. Note that a bleaching procedure was carried out.

Figure 9: Case #3
A. Frontal view before treatment.
B. Frontal view after treatment, highlighting the benefits of soft tissue management. Dental lab: Luc and Patrick Rutten, Dental Team, Belgium.

Figure 10: Case #4 – A 56-year-old female patient with several single missing teeth (15, 11, 22, 24) and teeth requiring restoration with lithium silicate-based glass-ceramic partial bonded restorations (PBR) (14, 21, 26).
A. Implants were placed for teeth 15, 11, and 24.
B. Frontal view after PBR bonding and placement of zirconia-based implant restorations.
C and D. Views of the restorations on the plaster model. PBR were realized in GC Initial LiSi press (GC Corporation, Tokyo,Japan) and Initial LiSi block (teeth 14 and 26) . For tooth 11, the implant-based restoration consists of a zirconia abutment and a glass-ceramic veneer (GC Initial LiSi press). Dental lab: Luc and Patrick Rutten, Dental Team, Belgium.

Figure 11: Case #4.
A. Digital design of the restorations. Note that tooth 11 will be restored on the buccal surface with a glass-ceramic veneer and will then receive the retainer wing of the no-prep Z-RBFDP on the palatal surface.
B and C, and **Video 1.** 3D design in Exocad (Exocad Gmbh, Darmstadt, Germany) of the original 3D-printed resin (Keystone Industries, KeyPrint, KeyGuide) positioning guide for the Z-RBFDP on tooth 22. This guide is (1) rigid for precise positioning; (2) translucent to allow light-curing of the composite cement; (3) engages only the occlusal surfaces of adjacent teeth to avoid interference with the rubber dam; (4) includes 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, while leaving all wing borders uncovered to allow for easy 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 12: Case #4.
A and D. Views of the no-prep Z-RBFDP (Prettau 2 Dispersive, Zirkonzahn) for tooth 22 on the plaster model.
B and C. Views with the 3D-printed resin positioning guide. Note the relatively small bonding area of the retainer wing to avoid interference with occlusal relationships. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 13: Case #4.
A to D. Intraoral views of the try-in of the no-prep Z-RBFDP and the positioning guide before bonding under the rubber dam. D shows the specific design of the guide, which allows for easy removal of excess resin cement.

Figure 14: Case #4 – Soft tissue management in the case of deficiency: immediate approach.
A. Frontal view showing the try-in of the no-prep Z-RBFDP and the positioning guide, highlighting the soft tissue deficiency.
B. Frontal view immediately after a minimally invasive connective tissue graft. Surgery by Prof. France Lambert, University of Liège Hospital, Belgium. Note that a frenectomy was also performed.
C. Frontal view immediately after bonding the no-prep Z-RBFDP on the same day as the surgery. Note the suspended suture fixed with fluid composite at the papilla after bonding to pull it along.
D. Frontal view after a two-month follow-up. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 15: Case #5 – A 21-year-old female patient with agenesis of teeth 32 and 42 was treated with a double-retainer no-prep **Z-RBFDP**. The patient underwent orthodontic treatment, and teeth 31 and 41 needed to be joined for retention, with their incisal edges restored using direct composite resin.
A. Frontal view before treatment, showing the absence of teeth 32 and 42 and the direct composite restorations on 31 and 41.
B. View of the double-retainer no-prep Z-RBFDP (Prettau 2 Dispersive, Zirkonzahn).
C and D. Frontal and occlusal views after treatment, demonstrating the final results. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 16: Case #6 – A 19-year-old male patient with agenesis of tooth 24.
A to C. Design of the no-prep Z-RBFDP (Prettau 2 Dispersive, Zirkonzahn), featuring a large enveloping palatal retainer-wing on tooth 25 and an occlusal rest on the distal part of the occlusal surface of tooth 15, which is not in

occlusal contact. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.
D and F. Design of the 3D-printed resin positioning guide.

E. Try-in of the no-prep Z-RBFDP and the positioning guide before bonding, performed under a rubber dam.

Figure 17: Case #6
A and B. Palatal views two weeks after bonding, showing occlusal contacts on the restoration in maximum intercuspation.
C. Buccal view 1.5 years after bonding, demonstrating excellent soft tissue integration. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 18: Case #7 – A 20-year-old male patient with a missing canine.
A and B. Frontal and occlusal views before treatment. Tooth 23 was impacted and subsequently extracted. The patient had undergone guided bone regeneration and a connective tissue graft in the edentulous space. The surgery was performed by Prof. France Lambert, University of Liège Hospital, Belgium.
C. Frontal view 4 years after the no-prep Z-RBFDP bonding (Prettau 1 ICE Translucent, Zirkonzahn). Note that the restoration debonded at the zirconia-resin cement interface at 2 years, and the bonding procedure was successfully repeated.
D. Palatal view 1.5 months after bonding, showing occlusal contacts on the restoration in maximum intercuspation. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 19: Case #7
A to D. Intraoral views at the 4-year follow-up, highlighting significant risk factors in this case, which may explain the debonding failure encountered at 2 years. The patient exhibits clinical signs of bruxism (note the significant attrition facet on tooth 43), does not wear a nightguard, and has substantial occlusal canine guidance on the pontic. Additionally, the retainer-wing design should have been more enveloping, with an occlusal rest on tooth 24.

Figure 20: Case #8 – A 20-year-old male patient with upper lateral agenesis and insufficient occlusal space, treated with the Simple Orthodontic Extrusion Technique [16].
A. Frontal view before treatment, showing a lack of interdental space and soft tissue volume. Due to the patient's young age and limited space, implant placement was contraindicated, and the occlusal contacts on the palatal surfaces of the centrals and canines interfered with the placement of adequately sized RBFDP retainer wings.
B. Digital smile analysis.
C. Post-treatment situation after minimally invasive connective tissue grafts harvested from the palate, endodontic treatment, and internal bleaching of tooth 21. An external bleaching procedure was also performed. Direct composites on teeth 11 and 21 were redone (Inspiro, Edelweiss DR). The diastema was closed with a two-day orthodontic treatment. Surgery was performed by Prof. France Lambert, and orthodontics by Dr. Jean-Claude Bernard and Dr. Simon Gigli, University of Liège Hospital, Belgium.

Figure 21: Case #8
A to C. Design of the no-prep Z-RBFDP with ovoid pontic (Prettau 2 Dispersive, Zirkonzahn). The model was milled to create concavity, and the emergence profile was idealized following esthetic analysis. Note the very thin retainer wings (0.3 mm).
D. During the grit-blasting procedure, a permanent ink marker was used to color the surface to be treated, ensuring precise grit-blasting of the entire retainer wing. Additionally, a small quantity of Teflon was used to protect the pontic.Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Figure 22: Case #8
A. Situation after bonding orthodontic metal buttons from canines to molars to prepare for Simple Orthodontic Extrusion. On the day of bonding, a cavity was created in the soft-tissue graft to accommodate the pontic.
B to D. Correct positioning of the two guides and bridges is checked before and after placing the rubber dam. Note the proper isolation and the absence of bleeding despite the gingival intervention.

Figure 23: Case #8
A and C. Situation just after bonding of the restorations. Intermaxillary elastics were prescribed between quadrants 1 and 4, and between quadrants 2 and 3, to re-establish occlusion through Simple Orthodontic Extrusion. Due to the lack of occlusal space, the restorations are in high occlusion, inducing an open bite in the posterior region.
B. Frontal view before treatment.
D. Frontal view 3 weeks after Z-RBFDPs bonding. Occlusal relationships were re-established after one week.

Figure 24: Case #8
A. Occlusal contacts immediately after bonding of the restorations.
B. Occlusal contacts one week later, showing re-established occlusal relationships. Orthodontics: Dr. Jean-Claude Bernard and Dr. Simon Gigli.

Figure 25: Case #8
A and B. Frontal views at the 18-month recall, showing the natural soft tissue profile and papilla growth. Dental lab: Luc and Patrick Rutten, Tessenderlo, Belgium.

Table 1: Sample description.

Sample description			**N (%)**
Patients			11 (100)
Restorations			16 (100)
	Sex		
		Female	10 (62.5)
		Male	6 (37.5)
	Bruxism		
		Yes	13 (81.3)
		No	3 (18.7)
	Nightguard		
		Yes	4 (25.0)
		No	12 (75.0)
	Missing tooth (n=17)		
		Upper lateral	13 (76.5)
		Lower lateral	2 (11.8)
		Upper canine	1 (5.9)
		Upper premolar	1 (5.9)
	Retainer type		
		Single-retainer	15 (93.8)
		Double-retainer	1 (6.3)
	Retainer wing position (n=17)		
		Upper central	12 (70.6)
		Upper canine	1 (5.9)

	Upper premolar	2 (11.8)
	Lower central	2 (11.8)
Bonding surface (n=17)		
	Enamel	14 (82.4)
	PICN palatal veneer	3 (17.6)
Impression		
	Intraoral scanner	13 (81.3)
	Double-mix impression	3 (18.8)
Soft tissue graft		
	Yes	11 (68.8)
	No	5 (31.2)
	Prior approach	9 (81.8)
	Immediate approach	2 (18.1)
Zirconia material		
	Prettau 1 ICE Translucent Zirkonzahn (3Y-TZP)	5 (31.3)
	Prettau 2 Dispersive, Zirkonzahn (3Y-TZP)	10 (62.5)
	Zolid gen-x Multilayer, Amann Girrbach (4Y-TZP)	1(6.3)
Positioning 3D printed guide		
	Yes	10 (62.5)
	No	6 (37.5)

	Resin cement		
		Panavia V5	15 (93.8)
		Panavia F	1 (6.3)
	Simple Orthodontic Extrusion		
		Yes	1 (6.3)
		No	15 (93.7)

Table 2: Sample description for each restoration.

RBFDP	Patient gender	Patient age (years)	Bruxism clinical signs presence	Nightguard	Pontic tooth number	RBFPD type	Bonding surface	Resin cement	Zirconia material	Follow-up (years)
1	Male	21.9	0	0	12	Single-retainer	Enamel	Panavia V5	Prettau 2 Dispersive	3.1
2	Male	21.9	0	0	22	Single-retainer	Enamel	Panavia V5	Prettau 2 Dispersive	3.1
3	Male	20.3	1	0	23	Single-retainer	Enamel	Panavia V5	Prettau 1 ICE Tanslucent	6.5
4	Male	20.9	0	0	12	Single-retainer	Enamel	Panavia V5	Prettau 2 Dispersive	0.1
5	Female	21.0	0	0	32	Double-retainer	Enamel	Panavia V5	Prettau 2 Dispersive	0.1
6	Female	19.2	0	0	12	Single-retainer	Enamel	Panavia V5	Prettau 2 Dispersive	3.2

7	Male	19.2	0	0	24	Single-retainer	Enamel	Panavia V5	Prettau 2 Dispersive	3.2
8	Male	20.0	1	1	12	Single-retainer	PICN	Panavia V5	Zolid gen-x Multilayer	1.1
9	Female	19.3	1	0	12	Single-retainer	Enamel	Panavia V5	Prettau 1 ICE Tanslucent	3.9
10	Female	19.3	1	0	22	Single-retainer	Enamel	Panavia V5	Prettau 1 ICE Tanslucent	3.9
11	Female	41.6	1	0	12	Single-retainer	PICN	Panavia V5	Prettau 2 Dispersive	1.3
12	Female	41.6	1	0	22	Single-retainer	PICN	Panavia V5	Prettau 2 Dispersive	1.3
13	Female	21.5	1	1	12	Single-retainer	Enamel	Panavia F	Prettau 2 Dispersive	9.5
14	Female	63.3	0	0	22	Single-retainer	Enamel	Panavia V5	Prettau 1 ICE Tanslucent	0.4

15	Female	26.0	1	0	12	Single-retainer	Enamel	Panavia V5	Prettau 1 ICE Tanslucent	6.3
16	Female	24.1	1	1	12	Single-retainer	Enamel	Panavia V5	Prettau 2 Dispersive	0.7

Table 3: Survival, success and Annual Failure Rate probability results up to 9 years (Kaplan–Meier analysis).
AFR: Annual Failure Rate.

Year	N	Survival % (95% CI)	Success % (95% CI)	AFR Success %
1	12	100.0 (100.0-100.0)	100.0 (100.0-100.0)	0.0
2	9	100.0 (100.0-100.0)	100.0 (100.0-100.0)	0.0
3	9	100.0 (100.0-100.0)	88.9 (70.6-100)	3.8
4	3	100.0 (100.0-100.0)	88.9 (70.6-100)	2.9
5	3	100.0 (100.0-100.0)	88.9 (70.6-100)	2.3
6	3	100.0 (100.0-100.0)	88.9 (70.6-100)	1.9
7	1	100.0 (100.0-100.0)	88.9 (70.6-100)	1.7
8	1	100.0 (100.0-100.0)	88.9 (70.6-100)	1.5
9	1	100.0 (100.0-100.0)	88.9 (70.6-100)	1.3

REFERENCES

1. Rochette AL. Attachment of a splint to enamel of lower anterior teeth. *J Prosthet Dent*. Oct 1973;30(4 Pt 1):418-23. doi:10.1016/0022-3913(73)90163-7
2. Alraheam IA, Ngoc CN, Wiesen CA, Donovan TE. Five-year success rate of resin-bonded fixed partial dentures: A systematic review. *J Esthet Restor Dent*. Jan 2019;31(1):40-50. doi:10.1111/jerd.12431
3. Tanaka T, Atsuta M, Uchiyama Y, Kawashima I. Pitting corrosion for retaining acrylic resin facings. *J Prosthet Dent*. Sep 1979;42(3):282-91. doi:10.1016/0022-3913(79)90217-8
4. Kern M, Knode H, Strubb JR. The all-porcelain, resin-bonded bridge. *Quintessence Int*. Apr 1991;22(4):257-62.
5. Sailer I, Bonani T, Brodbeck U, Hämmerle CH. Retrospective clinical study of single-retainer cantilever anterior and posterior glass-ceramic resin-bonded fixed dental prostheses at a mean follow-up of 6 years. *Int J Prosthodont*. 2013;26(5):443-50. doi:10.11607/ijp.3368
6. Kern M. *Resin-Bonded Fixed Dental Prostheses*. 2018.
7. Al-Bermani ASA, Quigley NP, Ha WN. Do zirconia single-retainer resin-bonded fixed dental prostheses present a viable treatment option for the replacement of missing anterior teeth? A systematic review and meta-analysis. *J Prosthet Dent*. Oct 2023;130(4):533-42. doi:10.1016/j.prosdent.2021.10.015
8. Kern M, Passia N, Sasse M, Yazigi C. Ten-year outcome of zirconia ceramic cantilever resin-bonded fixed dental prostheses and the influence of the reasons for missing incisors. *J Dent*. Oct 2017;65:51-55. doi:10.1016/j.jdent.2017.07.003
9. Yazigi C, Kern M. Clinical evaluation of zirconia cantilevered single-retainer resin-bonded fixed dental prostheses replacing missing canines and posterior teeth. *J Dent*. Jan 2022;116:103907. doi:10.1016/j.jdent.2021.103907

10. Mourshed B, Samran A, Alfagih A, Abdulrab S, Kern M. Anterior Cantilever Resin-Bonded Fixed Dental Prostheses: A Review of the Literature. *J Prosthodont*. Mar 2018;27(3):266-75. doi:10.1111/jopr.12555
11. Adabo GL, Longhini D, Baldochi MR, Bergamo ETP, Bonfante EA. Reliability and lifetime of lithium disilicate, 3Y-TZP, and 5Y-TZP zirconia crowns with different occlusal thicknesses. *Clin Oral Investig*. Jul 2023;27(7):3827-38. doi:10.1007/s00784-023-05001-6
12. Diaz P, Gonzalo E, Villagra LJG, Miegimolle B, Suarez MJ. What is the prevalence of peri-implantitis? A systematic review and meta-analysis. *BMC Oral Health*. Oct 19 2022;22(1):449. doi:10.1186/s12903-022-02493-8
13. Papageorgiou SN, Eliades T, Hämmerle CHF. Frequency of infraposition and missing contact points in implant-supported restorations within natural dentitions over time: A systematic review with meta-analysis. *Clin Oral Implants Res*. Oct 2018;29 Suppl 18:309-25. doi:10.1111/clr.13291
14. Lim TW. Creating space for a resin-bonded fixed partial denture retainer by using the Dahl concept. *J Prosthet Dent*. Jun 2024;131(6):1004-7. doi:10.1016/j.prosdent.2022.03.036
15. Ray-Chaudhuri A, Brown T, Ray-Chaudhuri E, et al. When (and when not) to use the Dahl Concept. *Br Dent J*. Feb 2023;234(3):155-64. doi:10.1038/s41415-023-5502-9
16. Mainjot A, Bernard JC, Rutten L, et al. No-prep dentistry using the Simple Orthodontic Extrusion (SOE) technique to create occlusal space. Illustration in tooth wear and resin-bonded bridges. *Int J Esthet Dent*. Aug 02 2024;19(3):228-50.
17. Loomans BAC, Wetselaar P, Opdam NJM. [European statement of consensus regarding the treatment of severe tooth wear]. *Ned Tijdschr Tandheelkd*. Apr 2018;125(4):223-31. Europese consensusverklaring over de behandeling van ernstige gebitsslijtage. doi:10.5177/ntvt.2018.04.17209
18. Eggmann F, Orta AL, Abdulmajeed A, et al. Interdisciplinary Delphi study by PROSEC North America: Recommendations on single indirect restorations made from ceramic and nonmetallic biomaterials for posterior teeth. *J Esthet Restor Dent*. Aug 02 2024;doi:10.1111/jerd.13289
19. Lobbezoo F, Ahlberg J, Raphael KG, et al. International consensus on the assessment of bruxism: Report of a work in progress. *J Oral Rehabil*. Nov 2018;45(11):837-44. doi:10.1111/joor.12663
20. Medicine AAOS. International Classification of Sleep Disorders, 3rd edn. *American Academy of Sleep Medicine*. 2014;Darien (ed), IL ; 2014. Cat 1
21. Collares K, Corrêa MB, Laske M, et al. A practice-based research network on the survival of ceramic inlay/onlay restorations. *Dent Mater*. May 2016;32(5):687-94. doi:10.1016/j.dental.2016.02.006
22. Tzanakakis EG, Tzoutzas IG, Koidis PT. Is there a potential for durable adhesion to zirconia restorations? A systematic review. *J Prosthet Dent*. Jan 2016;115(1):9-19. doi:10.1016/j.prosdent.2015.09.008
23. Grenade C, De Pauw-Gillet MC, Gailly P, Vanheusden A, Mainjot A. Biocompatibility of polymer-infiltrated-ceramic-network (PICN) materials with Human Gingival Fibroblasts (HGFs). *Dent Mater*. Sep 2016;32(9):1152-64. doi:10.1016/j.dental.2016.06.020
24. Grenade C, De Pauw-Gillet MC, Pirard C, et al. Biocompatibility of polymer-infiltrated-ceramic-network (PICN) materials with Human Gingival Keratinocytes (HGKs). *Dent Mater*. Mar 2017;33(3):333-43. doi:10.1016/j.dental.2017.01.001
25. Mainjot AKJ. The One step-No prep technique: A straightforward and minimally invasive approach for full-mouth rehabilitation of worn dentition using polymer-infiltrated ceramic network (PICN) CAD-CAM prostheses. *J Esthet Restor Dent*. Oct 27 2018;doi:10.1111/jerd.12432