The One-Step No-Prep Technique for Non-invasive Full-mouth Rehabilitation of Worn Dentition using PICN CAD-CAM Restorations: Up to 9-Year Results from a Prospective and Retrospective Clinical Study

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Abstract

Objectives: To report up to 9-year results of a prospective and retrospective study on non-invasive full-mouth rehabilitation of worn dentition with PICN CAD-CAM restorations using the One-Step No-Prep technique. The secondary objective is to evaluate the influence of restoration thickness on fracture of restorations.

Methods: A total of 580 Vita Enamic restorations (218 anterior and 362 posterior; 260 monoblock (MO) and 320 multiColor (MC)) in 24 patients were clinically evaluated once a year (up 9 months to 9 years) according to FDI criteria. Patient data and prosthetic parameters were registered. The minimum thickness of restorations was measured in 15 patients.

Results: The Kaplan-Meier survival rate of restorations at 9 years was 98.4% (100% for anterior and 96.7% for posterior) and the success rate was 79.7%, while the success rate excluding minor chipping requiring only polishing as failure was 86.7%. Actually, minor chipping was the leading cause of failure and significantly more fractures were observed in the posterior region (9.2 times higher risk), particularly in the first and second molars or when the restoration thickness was less than 0.56 mm. Except for fracture, FDI evaluation showed clinically acceptable results for all restorations, mostly rated as excellent. Results remained consistent over time, including material luster and color, with no staining. MC showed superior esthetics compared to MO. Patient satisfaction was high.

Significance: The One-Step No-Prep technique exhibits successful long-term outcomes, and PICN (hybrid ceramic) is an appropriate material for this non-invasive treatment of tooth wear. Nevertheless, the minimum thickness of posterior restorations should be 0.6 mm, particularly at occlusal contact points**.** MultiColor blocks are recommended for esthetics.

Keywords: tooth wear; CAD-CAM composite; hybrid ceramic, polymer-infiltrated-ceramic-network, thickness; success rate; fracture; fixed prosthodontics; dental materials

Introduction

Tooth wear (TW) is known to have a high and increasing prevalence, especially among young patients. TW is a multifactorial condition influenced by changing lifestyles [1]. Chemical erosion, driven by acidic foods and drinks as well as gastroesophageal reflux (GER), is a major contributing factor [2, 3]. Additionally, mechanical wear is frequently linked to bruxism, which results in attrition (the loss of tooth tissue on the occlusal surface due to friction) and abfraction (the loss of tooth tissue near the gum line due to mechanical stress) [4, 5]. Various methods have been described to rehabilitate patients suffering from severe TW [6]: direct techniques with light-cured composites [7, 8], indirect techniques using different materials such as, CAD-CAM composite or ceramics [9-12]; or a mix of the two techniques.

In 2018 and 2020, Mainjot introduced the One-Step No-Prep technique for the treatment of generalized [13] and localized [14] severe TW, respectively. This technique uses Polymer-Infiltrated Ceramic Network CAD-CAM bonded partial restorations (PICN or "hybrid ceramics", Vita Enamic, Vita Zahnfabrik, Germany) [15] Its main feature is that it does not require any preparation of the tooth tissue ("no-prep" technique) and is performed in a single step, i.e. there is no phase with temporary restorations ("one-step"). This is made possible by the fact that PICN are composite materials that can be milled to a very thin thickness, bonded in a high-performance manner [16] and easily retouched to adjust proximal and occlusal contact points. The material is also easy to repair in the event of failure. In this way, the technique combines the advantages of direct techniques (non-invasive, one-step procedure, easy to repair) and indirect techniques (access to materials that perform better than direct restoration materials, restoration anatomy realization with greater ease and speed). This approach also includes bruxism management by maxillofacial physiotherapist and occlusal analysis for full mouth cases [13]. For localized TW, the technique is associated with simple orthodontic extrusion (orthodontic-assisted One-Step No-Prep technique) [14].

The first three pilot cases of generalized severe TW were realized in 2014 and 2015 [13]. The 2-year results of a prospective study including material wear analysis of 7 additional clinical cases were published in 2020 [10]. All the results were very promising, and our team developed the technique routinely. More recently, 5-year results of the evaluation of intraoral PICN wear in the 7 cases using ex vivo 3D profilometry have been published [17].

The purpose of the present work is to report the up to 9-year results of a prospective and retrospective study of minimally invasive full-mouth rehabilitation of worn dentition with PICN (hybrid ceramic) CAD-CAM restorations using the One-Step No-Prep technique, from the first pilot study conducted at the Department of Fixed Prosthodontics of the University Hospital Center of Liège. The secondary objective is to evaluate the influence of PICN restoration thickness on fracture of restorations.

Materials and methods

1. Study design

This study is a prospective and retrospective clinical study evaluating patients treated with the " One-Step No-Prep " protocol. The patients were treated in the Department of Fixed Prosthodontics of the University Hospital of Liège by four experimented practitioners (AM, JO, CG, AV). The study was approved by the Ethics Committee of the University Hospital of Liège (B707201526682, B707201835507). A total of 24 patients (n=580 PICN restorations) were included in this study and evaluated over a period ranging from 9 months to 9 years. This group included three pilot cases conducted in 2014 and 2015 [13], along with 21 cases performed since 2016. These three pilot cases were studied retrospectively but were routinely followed by the practitioner once a year. The mean age was 44.0 years old (range 26 to 72 years) and 13 patients were men. Table 1 lists the patients and restorations characteristics.

2. Patient selection

Patients presenting generalized severe tooth wear with an esthetic or functional demand were included in the study. Patients were required to have palatine veneers from canine to superior canine, and a minimum of 3 teeth per posterior sextant to be restored with an indirect restoration. The following patients were excluded from the study: patients with untreated periodontal disease and patients with removable prosthesis. Patients with Parkinson disease, or severe arthropathy or spontaneous temporomandibular joint pain associated with mandibular deflection and limited opening (<25 mm) were also excluded.

3. Wear quantification

The Basic Erosive Wear Examination index (BEWE) [18] was calculated for each patient by the same practitioner (JO).

4. Chemical erosion assessment

In addition to a thorough clinical examination to detect the presence of dental erosion surfaces (concave, cuneiform or flat lesions), a questionnaire on dietary habits, general diseases, medications and environmental factors was completed to identify risk factors.

5. Non instrumental approach of bruxism assessment

A clinical examination was performed to register the presence of clinical signs of bruxism, such as dental attrition, cracks/fractures, masseteric hypertrophy, linea alba, exostoses or crenated tongue [19, 20]. The presence of bruxism was recorded if the patient fulfilled at least two criteria: A) reporting of 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 on waking felt in the jaw muscles; temporal headaches on waking; and jaw locking on waking related to teeth grinding during sleep [19] [21, 22]. A complementary clinical examination was performed by an occlusodontist (i.e. a specialist in occlusion and TMDs) to detect the presence of temporomandibular joint (TMJ) disorder. If patients showed symptoms of temporomandibular joint disorders, they were not treated and they were referred to the specialist. Finally, the wearing of an occlusal nightguard before treatment was recorded.

6. Clinical protocol

The patients (n=21) were treated according to the previously described "One-Step No-Prep" protocol [13] (Figure 1). Before treatment, a complete dental examination with carious and periodontal examinations, X-rays and photographs was performed. Double mix impressions with polyvinyl siloxane (PVS) material (Imprint 4 Heavy and XLV, 3M ESPE, Seefeld, Germany) were made, and study models were cast (GC Fujirock EP Super Hard Plaster, GC Europe, Leuven, Belgium). Then an occlusal analysis was performed using a resin jig [23] and a facebow (Quick facebow, Sintec Inc, New Hampshire, USA). The jig was placed for a few minutes to induce muscular relaxation and lower jaw repositioning, and then occlusal relationships were registered with wax (Moyco Beauty Wax, Philadelphia, PA, USA) in double thickness. The dental technician proceeded to a a diagnostic wax-up and started to deposit the wax on the less damaged teeth. He was guided by the residual tissues to restore tooth anatomy, resulting in a very low wax thickness on some posterior teeth. With this "tissue-guided" approach, the estimation of the new VDO was empirical. The wax-up was shown to the patient for approval. Subsequently, the treatment began with the replacement of amalgam fillings and deficient composite restorations with direct composite restorations by the operator (Els composite extra low shrinkage, Saremco Dental, Rebstein, Switzerland or Inspiro, Edelweiss, Zug, Switzerland) or the general dental practitioner (various products were used). Before final impressions, dental tissues were not prepared, but sharp angles were softened. Large direct composite fillings were partially removed to be replaced by indirect restorative material, but the cavity floor was left intact to avoid any sensitivity (in some cases cavities were filled with provisional composite resin, Telio CS Onlay, Ivoclar Vivadent, Schaan, Lichtenstein)). If required, endodontic treatments were performed previously. New double mix impressions (n=23) and occlusal analysis were performed following the same protocol as previously. One case was digitally realized using an optical impression with an intraoral scanner (Primescan, Dentsply Sirona, Charlotte, North-Carolina, USA) and a jaw tracking system for occlusal analysis (Modjaw, Villeurbanne, France). It should be emphasized that the patients did not wear any occlusal splints to test the new VDO before treatment. In some cases, models and full wax-ups were scanned and superimposed using a CAD-CAM system (Ceramill system, Amann Girrbach AG, Koblach, Austria); in more recent cases, digital set-up was performed directly. A CAD-CAM mock-up was realized in wax and tried to validate the restoration design and esthetic result (Ceramill Wax, Amann Girrbach AG, Koblach, Austria). Restorations corresponding to the estimated tissue loss were milled from PICN blocks (Vita Enamic, Vita Zahnfabrik, Germany; Ceramill Motion 2, Amann Girrbach). Depending on the situation, different restoration designs were used. In the anterior region, palatal veneers, buccal veneers, chips or envelope restorations were performed, and in the posterior region, occlusal tabletops, onlays and veneerlays were employed (Table 1). Two types of PICN were used: Vita Enamic Monoblock Translucent or High Translucent (n=10 patients, n=260 restorations) and Vita Enamic multiColor (n=14, n=320 restorations) (Vita Zahnfabrik, Germany). In fact, multiColor blocks were used instead of Monoblock blocks, as they became available on the market. Some restorations were only polished, and some were stained with a light-cured nanofilled composite coating agent (Optiglaze, GC Corporation, Tokyo, Japan or VITA Akzent Plus, Vita Zahnfabrik, Germany). Restorations were tried and then bonded within two consecutive days at two half-day appointments, one for each maxilla (the upper jaw on the first day afternoon, the lower on the second day morning). Restorations were pretreated according to the manufacturer's recommendations, i.e., etching the surface with hydrofluoric acid (HF) for 60 seconds, cleaning it in an ultrasonic bath in ethanol, and then applying a layer of silane (Silane Primer, Kerr, Orange, California, United States or Monobond Plus, SG Ivoclar Vivadent, Schaan, Lichtenstein). A rubber dam was placed. Tooth tissues were cleaned with pumice. A diamond burr at low speed was used to open the tubules of sclerotic dentin and enamel was etched with phosphoric acid. Direct composites were sandblasted and a layer of silane was applied. Then a two-step etch-and-rinse adhesive (Optibond XTR, Kerr, Orange, California, United States) or an universal adhesive (Adhese Universal, Ivoclar Vivadent, Schaan, Lichtenstein) was applicated following manufacturer recommendations and the adhesive layer was polymerized before restoration bonding. The restorations were bonded with a composite resin cement, either Nexus XTR (NX3, Kerr, Orange, California, United States) or Variolink Esthetic DC (Ivoclar Vivadent, Schaan, Lichtenstein). Polymerization was performed after excess removal and final photopolymerization was carried out under a film of glycerin to avoid the persistence of a polymerization inhibition layer. Major occlusal adjustments were made immediately after bonding of the lower restorations with an Arkansas stone burr, followed by polishing with silicon gums and fine adjustments performed within the subsequent weeks. Silicon gums include the Easycomp polishing set (Eve Ernst Vetter GmbH, Germany) and since its introduction, the Vita Enamic polishing set (Vita Enamic, Vita Zahnfabrik, Germany).

In some cases, direct composite was used instead of a PICN restoration on some teeth when tooth wear was very low, most commonly on lower anterior teeth.

A bleaching procedure (home bleaching with a night guard using Illumine 10% tooth gel Kit (Dentsply Sirona, New York, USA) or Opalescence 10% tooth gel (Ultradent Products, South Jordan, UT USA) was also performed (which was not possible when the dentin was still exposed). To mask the junction between the palatal veneer and the buccal face of the upper anterior teeth, direct composite (Inspiro, Edelweiss, Zug, Switzerland) was added on a slight chamfer performed across the junction and where needed to optimize tooth. In some cases (n=3) where TW was more severe on the buccal surface, lithium (di)silicate-reinforced glass-ceramic veneers were used in addition to the palatal veneers ("sandwich technique"). Finally, a nightguard (for the upper maxilla) was provided to all of the patients (Orthocryl, Dentaurum, Ispringen, Germany, n=22). Two patients received a CAD-CAM nightguard using a PMMA blank (Splint Transparent, Zirlux, NY, USA).

7. Registration of patient data

Gender, age, and occlusal relationships were registered (dental class, function, overjet, overbite, crossbite). In 15 of 24 patients, the VDO increase was recorded at the incisal guide pin.

8. Registration of prosthetic parameters

The minimum thickness of each restoration was measured in 384 restorations (for cases evaluated prospectively, i.e. 15 out of 24 patients). Measurement was realized with a metric gauge (Renfert, Hilzingen, Germany). The type of antagonist (enamel, dentin, direct composites, PICN restoration) was also noted for each restoration.

9. Clinical evaluation of restorations

Two independent and calibrated evaluators assessed restorations following the criteria of the World Dental Federation (FDI) [24]. Three dimensions, representing 18 items, were described: esthetic, functional and biological. The functional and esthetic dimension includes patient-reported satisfaction. Each item is assessed on a 5-point Likert scale (1 corresponding to an excellent restoration and 5 corresponding to a restoration that must be replaced). In case of discrepancies, agreement was found between evaluators to determine the final score. Different types of restoration failure were defined: fracture, debonding, caries at restoration margin, as well as endodontic failure and fracture of the tooth supporting the restoration. Restoration fracture was further graded from 0 to 5 according to FDI criteria with (0): no crack, chipping/delamination or material bulk fracture; (1): one hairline crack; (2): two or more or larger hairline cracks and/or material chip. fracture not affecting the marginal integrity or approximal contact (material loss can mainly be corrected by repair if needed) (minor chipping) ; (3): material chip fractures which damage marginal quality or proximal contact (minor chipping); (4): bulk fracture with partial loss (less than half of the restoration, repair is possible) (major chipping); (5): generalized severe deficiencies, e.g., extensive delamination, multiple bulk fractures, or (nearly) completely loose/lost restoration (repair not possible/reasonable) [24].

10. Statistical analysis

Data analysis was carried out in R (version 4.3) using the statistical software jamovi Project 2024 version 2.5.6 (https://www.jamovi.org/). In calculating the success rate, we defined a restoration as "success 1" if it did not require any intervention during the follow-up period, as well as exhibiting no signs of failure. As proposed by other authors, we also calculated a second success rate, "success 2," which included minor chipping (FDI grade 2 and 3) that required only polishing as success. This approach aligns with the definition of success proposed by [25] and [26]. Finally, we defined a restoration that did not require replacement as "survival". Kaplan–Meier curves were applied to illustrate the no-fracture success or survival probability over time and to generate life tables. The log-rank test was used to compare differences between groups (anterior vs posterior, type of PICN, type of restoration, BEWE score). In addition, Bonferroni corrections Cox proportional hazards model was computed to assess the potential influence of several factors on restoration success or survival and find cut-off (age, gender, thickness of the restoration, tooth position 4-5-6-7-8, DVO, anterior vs posterior). Annual failure rates (AFRs) were calculated from life tables according to the formula: $(1 - y)^z = (1 - x)$, in which "y" expresses the mean AFR and "x" the total failure rate at "z" years [27].

Results

1. Clinical data on patients

Sample descriptions in terms of patients, restorations and protocol used are presented in Table 1. Eighteen patients were in class I, 2 in class II.1, 3 in class II.2 and 1 in class III. Regarding the Basic Erosive Wear Examination (BEWE) score, 19 patients had a high-risk level (BEWE score >14), and 5 patients had a moderate risk level (BEWE score =12 or 13). Regarding the etiology of tooth wear, all patients showed clinical signs of both chemical (erosion) and mechanical (bruxism) wear. The mean VDO increase at the incisal guide pin was 5.2 mm ± 0.5 mm (n=15 of 24 patients).

2. Clinical data on restorations

In total, 580 PICN restorations were evaluated up to 9 years (Table 1). Ten patients received PICN restorations on all teeth, and thirteen patients received direct composite restorations for the lower incisors and canines (Inspiro, Edelweiss, Zug, Switzerland (23 patients) or Miris, Coltene, Altstätten, Switzerland (in one patient)). Consequently, 88.04% (n=486) of the restorations were in contact with PICN material and 11.96% (n=66) were in contact with direct composite (in the anterior teeth).

The median minimum thickness of the restorations was 0.86 mm (IQR 0.51-1.22) in the anterior region and 0.53 mm (IQR 0.35-0.70) in the posterior region.

3. Clinical outcomes

3.1. Restoration evaluation

The 9-yr Kaplan-Meier estimated survival rate of restorations was of 98.4 % (95% CI 96.4-100.0). The success rate ("Success 1") was 79.7% (95% CI 74.6-85.1), while the success rate excluding minor chipping requiring only polishing ("Success 2") was 86.70% (95% CI 82.0-91.6) (Table 2). The Annual Failure Rate (AFR) based on survival and success is also shown in Table 3 [27]. Fracture was the first cause of restoration failure (mostly with a marginal chip (Figure 2)) and results have shown a probability of fracture of 16.4% at 9 years based on the total sample. Complications included 51 minor and 3 major chippings, 6 debonding, and 4 caries (Table 4, Figure 3). There was no significant difference in failure rates between the two types of PICN. Patient age, gender or BEWE risk-score didn't significantly influence the survival or the success rates. However, patients with Class II.2 occlusion were 5.63 times more likely to have a major fracture of their restoration than Class I but this trend is not significant ($p=0.226$).

The results did not show an effect of the antagonist, as most contacts were PICN-PICN (88.04%) and we observed very few failures in the anterior region, where contacts with direct composite as the antagonist were involved (Table 5). Figures 4 show the Kaplan-Meier estimated success and survival rates for anterior and posterior restorations, respectively. Significantly more failures were observed in first and second molars than in other teeth (Table 5), but no difference was observed between maxillary and mandibular restorations. The results show that the risk of fracture is 9.16 (3.31-25.39, $p<0.001$) times higher for posterior restorations than for anterior restorations, particularly it was 4.06 times higher for position 6 (1.50-11.02, $p=0.006$) and 5.01 times higher for position 7 (1.88-13.35, $p=0.001$) than position 4 (Table 5, Figure 3). Restorations presenting minor fracture were polished or repaired (Table 4). The following protocol was used: rubber dam placement, sandblasting with the Cojet system, silane application, adhesive and direct composite placement. The debonded restorations were rebonded according to the same procedure as the initial bonding (if resin cement was present in the intaglio, the surface was sandblasted), using the same resin composite cement. Direct composite was used in some cases where the fit was no longer correct.

The FDI evaluation of the restorations 1 month after intervention is shown in Table 6. It shows clinically acceptable results for all restorations from an esthetic, functional and biological perspective, with the majority of restorations rated as excellent, except for some esthetic properties where the majority were rated as good (score 2). However, a difference was observed in the esthetic properties between the two types of PICN: Vita Enamic multiColor showed overall better results in terms of surface gloss, color match and translucency, as well as esthetic anatomical form (Table 7). The FDI results demonstrated remarkable stability over the follow-up period, with 427 restorations evaluated at two years, 264 at four years, and 140 at seven years. Notably, none of the restorations exhibited deterioration in any of the FDI criteria, with the exception of fracture. Patients were shown to be highly satisfied.

3.2. Influence of restoration thickness on fracture failure.

The Cox regression analysis indicated the existence of a fracture risk threshold at a thickness of 0.56 mm. An increase in thickness by 0.1 mm has been demonstrated to reduce the risk of failure by 23% (95% CI 12-33%, p-value <0.001). Figure 5 illustrates the fracture survival curves for restorations with a minimum thickness of 0.56 mm and a thickness below this value. At seven years, the estimated Kaplan-Meier fracture survival rates were 94.0% for restorations with a minimum thickness of 0.56 mm and 73.7% for the rest. The corresponding AFRs are presented in Table 2.

Discussion

The present study provides important and original data on the long-term behavior of restorations in the field of full-mouth rehabilitation of severe tooth wear and generally represents the largest sample of PICN restorations studied to date. It shows excellent long-term estimated survival (98% at 9 years) and success rates (79.7% at 9 years while the success rate excluding minor chipping requiring only polishing was 86.70%) of those restorations under extreme conditions. Indeed, patients suffering from tooth wear have a very high risk of restoration failure due to the very high mechanical and chemical stresses to which biomaterials are subjected. The FDI scores demonstrated excellent results for all properties, with over 90% of restorations receiving a score of excellent or good for all criteria. These results remained stable over time, with the exception of the appearance of fractures. Some observed scores that were clinically sufficient were attributed to the absence of proximal contact points (which is not related to the material), color match and translucency. However, this latter point is not a concern with Vita Enamic multiColor block. Indeed, they are distinguished by a color gradient that imitates the appearance of dentin and enamel and one hypothesis suggests that the manufacturing process of these multilayered blocks may contribute to the observed surface gloss (this could be related to the pressing process which is done layer by layer rather than pressing the whole block at once). It is noteworthy that PICN does not demonstrate any loss of luster, color changes, or staining over time. This is in contrast to direct light-cured composites, which have been observed to degrade as rapidly as 36 months in cases of tooth wear, with a percentage of deterioration of 44% for surface staining, 31% for loss of surface luster, 25% regarding contour and wear and 24% for marginal adaptation [28].

Indeed, both direct and indirect restorations using composite or pure ceramic materials can be considered for severe tooth wear treatment. However, the current lack of scientific studies in the literature means there is no definitive evidence to favor one type of restoration or material over another for tooth wear treatment [6]. Notwithstanding, international guidelines endorse the utilization of minimally invasive or even non-invasive restorations (no-prep) [29], which is facilitated by the use of materials from the composite family due to their capacity for low-thickness manufacturing. PICN, or 'hybrid ceramic', consists of a block of glass-ceramic infiltrated with resin polymerized at high temperature and pressure, unlike other CAD-CAM composites which are all conventional glass fillers mixed with resin. This manufacturing process is patented and Vita Enamic (Vita Zahnfabrik, Germany) is the only PICN material on the market [30]. CAD-CAM composites show a low flexural strength as compared to some other prosthetic materials and are therefore only indicated for single-unit restorations. However, they offer other very important benefits. Indeed, compared to direct composites, PICN offers a high degree of polymerization and high homogeneity with fewer defects [30]. As a result, mechanical properties, wear resistance and chemical stability (water absorption and discoloration resistance) are significantly improved, while toxicity (monomer release) is reduced [31]. In addition, the use of the indirect technique can reduce in-mouth working time and facilitate the realization of proper anatomy as occlusal and proximal contact points [15]. Compared to pure ceramics, PICN offers the ability to be milled to a very thin thickness (allowing no-prep treatment), the ability to deform and absorb occlusal stress in bruxers (its stiffness is similar to tooth tissue, whereas ceramics are too stiff and other composites are too soft), the ease of adjustment of occlusal and proximal contact points (allowing one step treatment), and the ease of repair [10]. In addition, they are less abrasive than glass ceramics based on lithium. The present study's FDI results demonstrated that the esthetic properties of PICN restorations, particularly those made with Vita Enamic multiColor blocks, were clinically excellent or good in terms of luster, color match, and translucency (monocolor blocks exhibiting poorer results). No staining was observed over time. Although the material may not be as glossy as a pure ceramic, the esthetic properties are adequate for patients (particularly when recovered with saliva), as evidenced by the high patient satisfaction scores for esthetics and function.

Finally, PICN has been shown to develop high bond strength with resin composite cement (better than other CAD-CAM composites) [15, 28], and despite the poor macromechanical retention of the restoration and the high occlusal stress, the results of the present study highlight a low debonding rate. Indeed, a recent meta-analysis evaluated the clinical performance of different types of composite and ceramic inlays, onlays and overlays and found a pooled incidence of debonding of 0.9% (95% CI=0.2%-2.1%) according to the 6 studies included [32], which is similar to our study with a probability of debonding of 0.9 % at 5 years and 2% at 9 years. No caries occurred before the 6-year assessment, and this type of failure was observed in the same patient, who drinks soda and suffers from an eating disorder. It is important to acknowledge that the performance of a restoration can be influenced by a number of additional factors, including the type of resin cement used and the choice between polishing and staining agents. Moreover, patient satisfaction with esthetics can be influenced by the presence of ceramic buccal veneers.

While anterior restorations were found to perform extremely well, the most common complication observed in this study was minor chipping of posterior restorations (47 in posterior (8.1%) and 4 (0.7%) in anterior in the total sample during the follow-up), mainly at the thin margins that were in occlusal contact with another PICN restoration. This complication can be explained by the relatively low flexural strength of the material. It was easily managed by polishing or repair. In this regard, the present study highlights an important risk factor, which is the thickness of the restoration, with a cut-off of 0.56 mm, and for every 0.1 mm increase in restoration thickness, the risk of failure was shown to be reduced by 23%. This value is markedly inferior to the manufacturer's recommendations (1 mm in the occlusal area), thereby facilitating the potential for minimally invasive treatment. It is therefore incumbent upon the dental technician to exercise particular vigilance with regard to the thickness value at the occlusal contact points on molars, with particular attention being paid to the first and second molars, which are more susceptible to failure.

The results of this study can be compared with other data relating to direct and indirect treatment of tooth wear. A recent study of 110 dispersed filler CAD-CAM composite (Lava Ultimate, 3M, Saint-Paul, USA) and feldspathic CAD-CAM glass-ceramic (Vitadur, Vita Zahnfabrik, Germany) onlays for full-mouth rehabilitation using the "3-step technique" revealed a 98.2% survival rate and no significant differences between materials and locations of restorations at 6 years [33]. In our study, a similar estimated survival rate of 98.4% was observed at 6 years. Additionally, a study conducted in 2024 evaluated 568 dispersed filler CAD-CAM composite restorations (Lava Ultimate) utilized for full-mouth rehabilitation of patients with severe tooth wear at a 5.5-year follow-up [26]. The posterior survival rate for premolars was 96.8%, while the rate for molars was 100%. In comparison, our study yielded a posterior survival rate of 100% for premolars and 98.1% for molars. The success rate was 87.4% for premolars and 70.7% for molars at 5.5 years [26], while in our study, the success rate was 91.1% for premolars and 71.11% for molars at 6 years. In conclusion, the results of the present study are comparable to those obtained with other indirect materials at medium-term. However, it is noteworthy that the two aforementioned studies did not specify the thickness of the restoration. In contrast, the present study allows for a restoration thickness that may be considerably reduced in order to solely restore the missing tooth tissue without preparation. Furthermore, it would be beneficial to conduct a longer-term evaluation of other materials to facilitate a comprehensive comparison.

The 5-year clinical performance of PICN restorations in the treatment of tooth wear (99.4% estimated survival rate) is shown to be superior to the gold standard in fixed prosthodontics. Indeed, in a meta-analysis, Sailer et al. showed an estimated 5-year survival rate of metal-ceramic of 95.7%. This was similar to the estimated 5-year survival rate of single crowns of leucite or lithium disilicate reinforced glass ceramic (96.6%), glass-infiltrated ceramic, alumina

(94.6%) and densely sintered alumina (96%) and zirconia (91.2%) [34]. In this meta-analysis, ceramic chipping was also reported to be a common problem and occurred similarly in metal-ceramic and all-ceramic crowns. Of the studies included in this meta-analysis, one study reported 5.3 % of minor chipping (smoothened by polishing) at 9 years for lithium disilicate posterior crowns (versus 8.8% in our study), and 2.1% of crown fracture (versus 0.5% in our study) [35]. The recent meta-analysis on the clinical performance of composite and ceramic partial coverage restorations (inlays, onlays, and overlays) demonstrated estimated 10-year survival rates of 75% for composite, 91% for feldspathic glass-ceramic, and 89% for reinforced glass-ceramic [32]. In a retrospective study about all-ceramic inlays and onlays (leucite-reinforced glass-ceramic (IPS Empress)) in posterior teeth, the Kaplan-Meier estimated survival rate of restorations was 92.3% at 10 years (versus 98.4% at 9 years in the present study). The most common clinically unacceptable technical complication was ceramic fracture, with an incidence of 10.6% (versus 0.5% in the present study), and minor chipping, with an incidence of 2.3% (versus 8.8% in the present study). Minor chipping seems to be more common in our study probably due to the very thin thickness of the restorations and, more importantly, the presence of bruxism, which was not the case in the studies cited above. However, PICN appears to be less prone to larger fracture which could be explained by its damping behaviour (lower modulus of elasticity and greater ability to deform, which is attributed to the presence of polymer) and its lower brittleness than ceramics [36]. Data about PICN restorations are still sparse in the literature. In the study of Spitznagel et al., posterior teeth of 47 patients without tooth wear or bruxism were restored with 103 VITA Enamic restorations (45 inlays and 58 partial coverage restoration (PCR)) and their evaluation at 3 years highlighted high survival rates (97.4% for inlays and 95.6% for PCR) [37].

In regard to direct techniques used in the treatment of tooth wear, Mehta et al. demonstrated an annual failure rate of 2.9% for direct composite posterior restorations (5.5-year follow-up study), which is comparable to our findings at the 6-year evaluation (annual failure rate of 2.2%) [7]. The survival rate at 5.5 years was 97.7% (versus 99.4% in our study) while the success rate 1 was 88.6% (refurbishment by polishing included, versus 87.3% in our study) and the success rate 2 was 90.4% (refurbishment by polishing excluded, versus 94% in our study). This study showed that direct composite may be an acceptable medium-term option for the treatment of generalized tooth wear, whereas molar restorations may require more maintenance. In fact, the need for regular intervention (refurbishment and repair) with direct resin composite restorations to treat tooth wear was frequently reported [38, 39]. Moreover, longer-term clinical data are required given that direct composite restorations are known to be susceptible to aging processes, particularly due to the limited effectiveness of light-curing and the resulting low degree of polymerization in comparison to CAD-CAM blocks [15]. Consequently, the primary concerns reported with direct composites are related to significant material wear and discoloration/staining [40, 41], which is not observed at long-term with PICN in the present study. Ultimately, if the cost of PICN restorations exceeds that of direct restorations, the restorative procedure is completed with greater ease and speed.

In conclusion, PICN is a promising material among those available on the market for treating worn dentition in high-risk patients, such as those with bruxism. It effectively combines the advantages of both direct and other indirect composites and pure ceramics, potentially minimizing their associated drawbacks, as previously discussed.

With regard to the specific aspects of the One-Step No-Prep technique, in particular the absence of provisional restorations to test the new VDO, as is always the case with indirect restorations, the present results confirm previous findings [10, 13]. Indeed, despite the one-step significant VDO increase (mean 5.2 mm ± 0.5 mm at the incisal pin), none of the patients reported any problems and they quickly adapted to their new occlusal relationships. This has been confirmed by other authors using Lava Ultimate restorations [26]. This approach is simpler than classical solutions and allows a reduction in costs. In order to further reduce costs, the digital setup is now only performed at the time of realization of the CAD-CAM mockup. Only the intra-oral pictures, a digital smile analysis, and examples of cases are shown to the patient for the purpose of treatment planning acceptance. It should be noted that One-Step No-Prep technique would be very difficult to implement with pure ceramics, which are not easily adaptable to proximal and especially occlusal contact points, and which require a very precise restoration design, facilitated by multi-step procedures. Finally, from the patient's point of view, the results were very satisfactory, both esthetically and functionally.

Future perspectives include, the developpment of fully digital workflow using optical impression and the Modjaw jaw tracking system for occlusal analysis, and the influence of this workflow on occlusal adjustments and related restoration failures. It is also necessary to comply with the minimum thickness of restorations at occlusal contact points on molars, as currently defined.

Conclusion

The One-Step No-Prep technique offers a minimally invasive and straightforward approach for treating severe and generalized tooth wear. This study provides valuable data on the clinical performance of PICN partial bonded restorations, with a 9-year estimated survival rate of 98.4% and a success rate of 79.7%, increasing to 86.7% when excluding minor chipping requiring only polishing, despite the extreme conditions (bruxism and tooth wear chemical risk factors) to which the material was subjected. The findings indicate that PICN restorations can be manufactured in very low thickness; however, minor chipping at thin borders exposed to occlusal stress was the most frequent complication. To reduce chipping, the thickness of posterior restorations should not be less than 0.6 mm, especially at occlusal contact points. Additionally, FDI evaluations showed clinically acceptable results for all restorations, with most being rated as excellent, except in cases of fracture. Results remained consistent over time, including material luster and color, with no staining, while Vita Enamic MultiColor blocks provided better esthetic outcomes than monoblock options.

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During the preparation of this work the authors used DeepL and ChatGPT in order to edit the language. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Tables

Patients (n tot=24)	% (n)
Sex	
Female	45.8% (11)
Male	54.2% (13)
Impression – Occlusal analysis	
Analog	95.8% (23)
Digital	4.2% (1)
Adhesive	
Excite	8.3% (2)
Adhese Universal	62.5% (15)
Optibond XTR	29.2 % (7)
Composite resin cement	
Variolink Esthetic DC	70.8% (17)
Nexus XTR	29.2% (7)

Restorations (n tot=580)	% (n)
Type of restorations	
Anterior	37.6% (218)
Palatal veneers	21.6% (125)
Chips	11.4% (66)
Envelope	3.1% (18)
Buccal veneers	0.5% (9)
Posterior	62.4% (362)
Occlusal tabletop	51.9 % (301)
Onlays	6.0% (35)
Veneerlays	4.5 %(26)
Type of Vita Enamic block	
Monoblock	44.8% (260)
MultiColor	55.2% (320)

Table 1 Sample description in terms of patients and materials used.

Year	n	Survival % (95% CI)	Success 1 % (95% CI)	Success 2 % (95% CI)	Success 1 Anterior % (95% CI)	Success 1 Posterior % (95% CI)	Success 1 Premolars % (95% CI)	Success 1 Molars % (95% CI)	No-fracture Restoration thickness <=0.56mm % (95% CI)	No-fracture Restoration thickness >0.56mm % (95% CI)
1	580	100.0 (100.0-100.0)	99.5 (98.9-100.0)	99.6 (99.1-100.0)	99.5 (98.6-100.0)	99.4 (98.7-100.0)	98.8 (97.3-100.0)	100.0 (100.0-100.0)	99.5 (98.4-100.0)	100.0 (100.0-100.0)
2	486	100.0 (100.0-100.0)	96.5 (94.9-98.1)	98.6 (97.7-99.6)	98.5 (96.9-100.0)	95.2 (92.9-97.6)	96.8 (94.1-99.6)	93.8 (90.1-97.6)	94.2 (90.5-98.0)	98.4 (96.7-100.0)
3	360	99.8 (99.3-100.0)	92.5 (90.1-94.9)	97.2 (95.7-98.7)	98.5 (96.9-100.0)	88.6 (84.9-92.4)	95.9 (92.6-99.2)	81.6 (75.3-88.3)	86.9 (81.5-92.6)	97.9 (95.9-100.0)
4	319	99.4 (98.6-100.0)	91.0 (88.3-93.7)	96.3 (94.4-98.1)	97.8 (95.8-100.0)	86.5 (82.4-90.8)	94.8 (91.0-98.7)	78.4 (71.5-85.9)	84.5 (78.3-91.1)	97.3 (95.0-99.7)
5	319	99.4 (98.6-100.0)	88.0 (84.8-91.4)	95.1 (92.9-97.4)	97.8 (95.8-100.0)	81.6 (76.8-86.9)	91.1 (85.8-96.8)	72.3 (64.4-81.2)	78.0 (70.0-87.0)	96.6 (94.0-99.3)
6	263	99.4 (98.6-100.0)	87.3 (83.9-90.8)	94.0 (91.4-96.6)	96.9 (94.2-99.7)	80.9 (75.8-86.4)	91.1 (85.8-96.8)	71.1 (63.0-80.2)	78.0 (70.0-87.0)	95.1 (91.8-98.5)
7	211	99.4 (98.6-100.0)	83.0 (78.9-87.4)	90.1 (86.6-93.8)	96.9 (94.2-99.7)	73.6 (67.2-80.5)	84.5 (76.8-93.0)	63.0 (53.7-74.0)	73.7 (64.4-84.3)	94.0 (90.2-98.0)
8	17	98.4 (96.4-100.0)	79.7 (74.6-85.1)	86.7 (82.0-91.6)	93.7 (88.8-99.0)	70.0 (62.5-78.4)	81.0 (71.4-91.9)	59.3 (48.6-72.4)		
9	17	98.4 (96.4-100.0)	79.7 (74.6-85.1)	86.7 (82.0-91.6)	93.7 (88.8-99.0)	70.0 (62.5-78.4)	81.0 (71.4-91.9)	59.3 (48.6-72.4)		

Table 2: Results of survival, success and no-fracture probability results up to 9 years (Kaplan-Meier analysis). Success 1: success rate including minor chipping (requiring polishing or repair), caries or debonding. Success 2: success 1 rate excluding minor chipping requiring only polishing. No-fracture: probability of no-fracture, including minor chipping requiring only polishing. Anterior : Tooth position 1-2-3. Posterior: Tooth position 4-5-6-7-8. When several failures occurred at the same restoration, the first one was taken for the time of success (1 restoration concerned on the 580).

Year	n	AFR Survival %	AFR Success 1 %	AFR Success 2 %	AFR Success 1 Anterior %	AFR Success 1 Posterior %	AFR Success 1 Premolars %	AFR Success 1 Molars %	AFR Fracture Restoration thickness <=0.56mm %	AFR Fracture Restoration thickness >0.56mm %
1	580	0.0	0.5	0.4	0.5	0.6	1.2	0.0	0.5	0.0
2	486	0.0	1.8	0.7	0.8	2.4	1.6	3.1	2.9	0.8
3	360	0.1	2.6	0.9	0.5	4.0	1.4	6.6	4.6	0.7
4	319	0.1	2.3	0.9	0.6	3.6	1.3	5.9	4.1	0.7
5	319	0.1	2.5	1.0	0.4	4.0	1.8	6.3	4.8	0.7
6	263	0.1	2.2	1.0	0.5	3.5	1.5	5.5	4.1	0.8
7	211	0.1	2.6	1.5	0.4	4.3	2.4	6.4	4.3	0.9
8	17	0.3	2.8	1.8	0.8	4.4	2.6	6.3		
9	17	0.2	2.5	1.8	0.7	3.9	2.3	5.6		

Table 3: Annual failure rate (AFR) derived from survival, success and no-fracture probability results up to 9 years (Kaplan-Meier analysis). Success 1: success rate including minor chipping (requiring polishing or repair), caries or debonding. Success 2: success 1 rate excluding minor chipping requiring only polishing. Fracture: annual fracture rate, including minor chipping requiring only polishing. Anterior: tooth position 1-2-3. Posterior: tooth position 4-5-6-7-8. When several failures occurred at the same restoration, the first one was taken for the time of success (1 restoration concerned on the 580).

Failure type		1Y	2Y	3Y	4Y	5Y	6Y	7Y	8Y	9Y	Total
No failure	n	571	463	354	312	259	255	204	17	17	517
	%	98.5 %	95.3 %	98.3 %	97.8 %	98.5 %	97.0 %	96.7 %	100.0%	100.0 %	89.1%
Fracture, polished	n	5	16	3	5	0	1	0	0	0	30
	%	0.9 %	3.3 %	0.8 %	1.6 %	0.0 %	0.4 %	0.0 %	0.0%	0.0 %	5.2%
Fracture, repaired	n	1	6	2	1	4	3	4	0	0	21
	%	0.1%	1.2%	0.6%	0.3%	1.5%	1.1%	1.9%	0.0%	0.0%	3.6%
Fracture, restoration lost	n	0	1	0	1	0	0	1	0	0	3
	%	0.0 %	0.2 %	0.0 %	0.3 %	0.0 %	0.0 %	0.5 %	0.0%	0.0 %	0.5%
Tooth fracture	n	0	0	0	0	0	0	0	0	0	0
	%	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0%	0.0 %	0.0%
Restoration debonding	n	3	0	1	0	0	1	1	0	0	6
	%	0.5 %	0.0 %	0.3 %	0.0 %	0.0 %	0.4 %	0.5 %	0.0%	0.0 %	1.0%
Carie	n	0	0	0	0	0	3	1	0	0	4
	%	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	1.1 %	0.5 %	0.0%	0.0 %	0.7%
Endodontic failure	n	0	0	0	0	0	0	0	0	0	0

	%	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0%	0.0 %	0.0%
Total	n	580	486	360	319	263	263	211	17	17	580
	%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0%	100.0 %	100%

Table 4: Failures observed in the study with relative frequency by year of follow-up

Failure type		Tooth position 1	2	3	4	5	6	7	8	Total
No failure	n	70	70	71	86	77	70	63	10	517
	%	97.2 %	97.2 %	95.9 %	93.5 %	88.5 %	**79.6 %***	**74.1 %**/#**	90.9 %	89.1 %
Polished	n	0	0	0	2	3	10	14	1	30
	%	0.0%	0.0%	0.0%	2.1%	3.5%	11.4%	16.5%	9.1%	5.2%
Repaired	n	2	0	2	2	4	6	5	0	21
	%	2.8 %	0.0 %	2.7 %	2.1 %	3.6 %	6.8 %	5.9 %	0.0 %	3.6 %
Restoration lost	n	0	0	0	1	0	1	1	0	3
	%	0.0 %	0.0 %	0.0 %	1.1 %	0.0 %	1.1 %	1.1 %	0.0 %	0.5 %
Tooth fracture	n	0	0	0	0	0	0	0	0	0
	%	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Restoration debonding	n	0	2	1	1	2	0	0	0	6
	%	0.0 %	2.8 %	1.4 %	1.1 %	2.3 %	0.0 %	0.0 %	0.0 %	1.0 %
Carie	n	0	0	0	0	1	1	2	0	4
	%	0.0 %	0.0 %	0.0 %	0.0 %	1.1 %	1.1 %	2.3 %	0.0 %	0.7 %
Endodontic failure	n	0	0	0	0	0	0	0	0	0
	%	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %

Total	n	72	72	74	92	87	88	85	11	580
	%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Table 5: Failure types observed in this study according to the tooth position. Pairwise Comparisons with holm adjustment p-value: * = p<0.05 compared to position 4, ** = p<0.01 compared to position 4 and # = p<0.05 compared to position 5. Note: One tooth in position 5 had one carie at 6 years of follow-up after having a polished fracture at 2 years of follow-up.

	Clinically Excellent % (n)	Clinically Good % (n)	Clinically Sufficient % (n)	Clinically Unsatisfactory % (n)	Clinically Acceptable % (n)	Clinically Unacceptable % (n)
A. Esthetic properties					100(515**)**	
1. Surface luster	38.4 (198)	61.6 (317)				
2. Staining						
a. surface	99.8 (514)	0.2 (1)				
b. margin	99.8 (514)	0.2 (1)				
3. Color match & translucency	36.7 (189)	57.5 (296)	5.8 (30)			
4. Esthetic anatomical form	96.5 (497)	3.5 (18)				
B. Functional properties					100 (515)	
5. Fracture of material/ retention	99.4 (512)		0.6 (3)			
6. Marginal adaptation	62.9 (324)	37.1 (191)				
7. Occlusal contour &wear						
a. Qualitatively	99.4 (512)	0.2 (1)	0.4 (2)			
8. Approximal anatomical form						
a. contact point	89.1 (459)	4.3 (22)	6.6 (34)			
b. contour	98.3 (505)	0.2 (1)	1.6 (8)			
9. Radiographic examination	100 (317)					
10. Patient's view	68.2 (351)	31.8 (164)				
C. Biological properties					100 (515)	
11. Postoperative sensitivity / tooth vitality	98.6 (508)	1.4 (7)				
12. Recurrence of caries, erosion, abfraction	100 (515)					
13. Tooth integrity	100 (515)					
14. Periodontal response	98.8 (509)	1.2 (6)				
15. Adjacent mucosa	100 (515)					
16. Oral and general health	100 (515)					

Table 6: Baseline FDI rating of restorations (1 month after treatment)

Table 7: Baseline esthetic FDI rating of restorations with influence of PICN type (1 month after treatment).

A. Esthetic properties	Vita Enamic monoblock			Vita Enamic multiColor			X^2 p-value
	Clinically Excellent % (n)	Clinically Good % (n)	Clinically Sufficient % (n)	Clinically Excellent % (n)	Clinically Good % (n)	Clinically Sufficient % (n)	
17. Surface luster		100 (192)		46.8 (198)	53.2 (125)		**1.73e-43**
18. Staining							
c. surface	99.5 (191)	0.5 (1)		100 (323)			ns
d. margin	99.5 (191)	0.5 (1)		100 (323)			ns
19. Color match & translucency	14.6 (28)	69.8 (134)	15.6 (30)	40.4 (161)	59.6 (162)		**2.67e-22**
20. Esthetic anatomical form	100 (192)			92.3 (305)	7.7 (18)		**8.69e-4**

Figures

Figure 1: Case of the first patient treated with the One Step - No Prep technique using PICN restorations. Secondary lithium disilicate-reinforced veneers (IPS e.max Press, Ivoclar Vivadent) were fabricated on the buccal surfaces of teeth 13 to 23 (“sandwich technique”). At the 9-year follow-up, minor chipping of the thin margins of the restorations in occlusal contact can be seen on teeth 15, 17 and 35. Two more significant chips can be seen on teeth 44 and 45. Prosthodontics: Prof. A. Mainjot. Dental laboratory for PICN restorations made with the Cerec system (Dentsply Sirona, Charlotte, CN, USA): Renaud Maka, University of Liège. Glass-ceramic veneers: Dental technician: Pieter Ghysens, Brussels, Belgium

a) Frontal view before treatment
b) Occlusal view of the upper maxilla before treatment
c) Occlusal view of the lower maxilla before treatment
d) Frontal view after treatment
e) Occlusal view of the upper maxilla after treatment
f) Occlusal view of the lower maxilla after treatment

g) Frontal view at 9 years after treatment

h) Occlusal view of the upper maxilla at 9 years after treatment

i) Occlusal view of the lower maxilla at 9 years after treatment

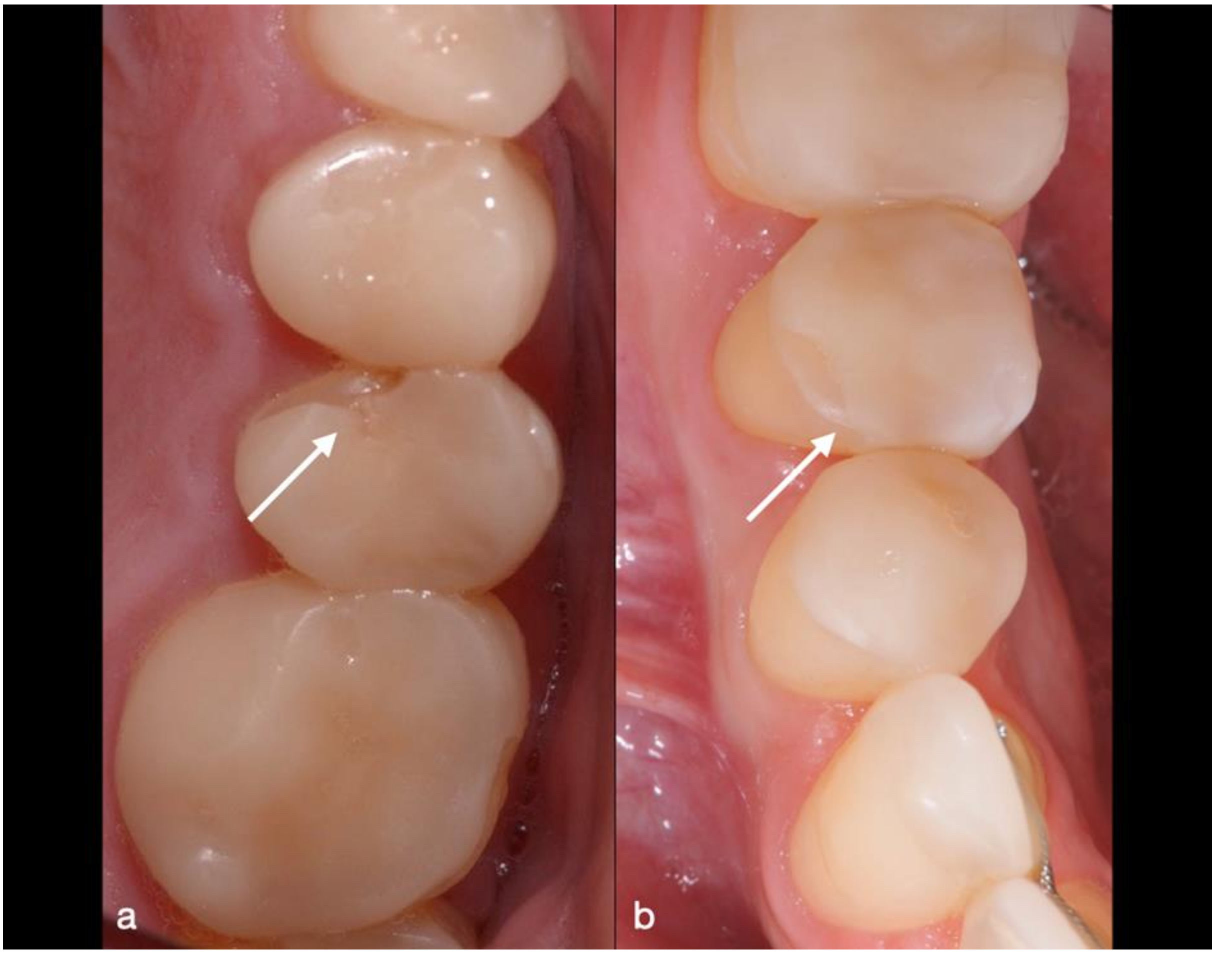

Figure 2: Observed technical complication (Photo courtesy of J. Oudkerk and A. Mainjot)

a) Typical minor chipping of thin restoration borders in occlusal affecting the approximal contact

b) Typical minor chipping of thin restoration borders in occlusal contact affecting the marginal integrity

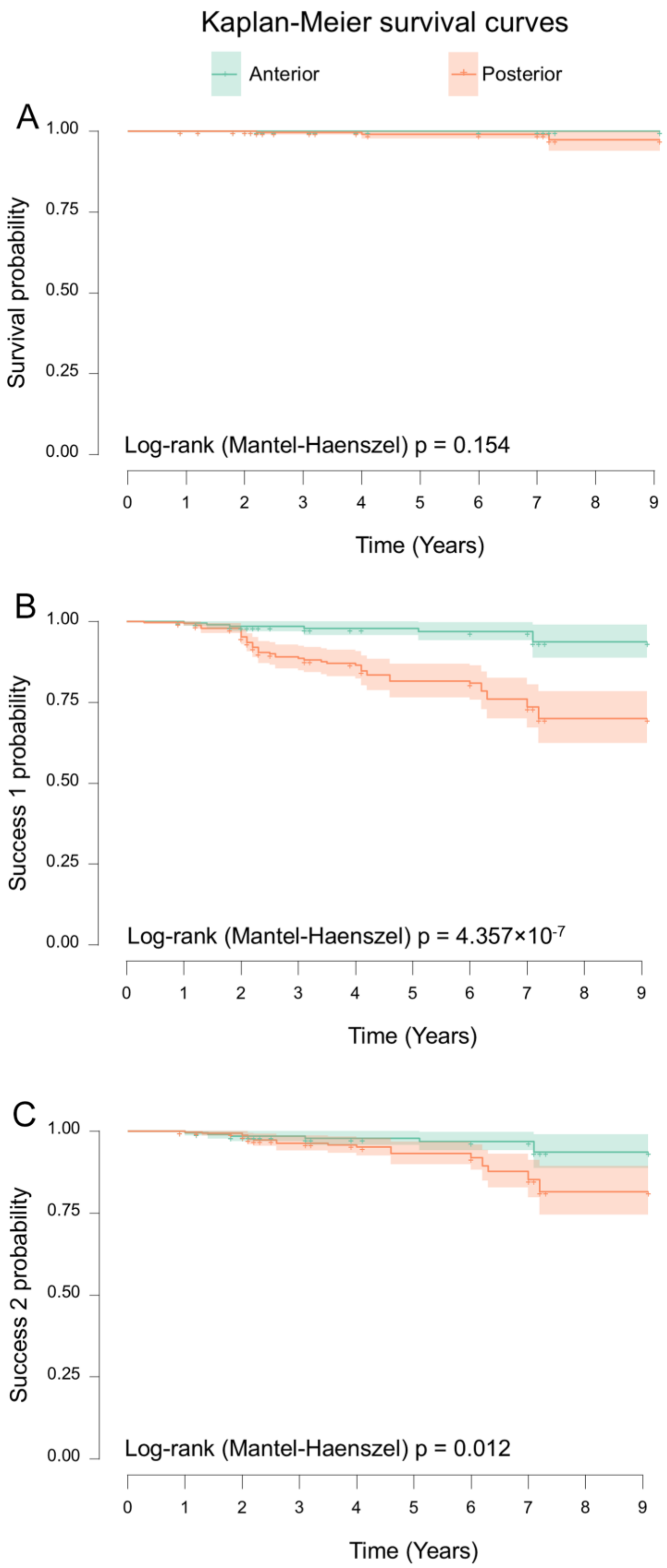

Figure 3: Kaplan-Meier survival and success rate for anterior (in blue) and posterior (in red) restorations. In addition, the success rate excluding minor chips requiring polishing was shown.

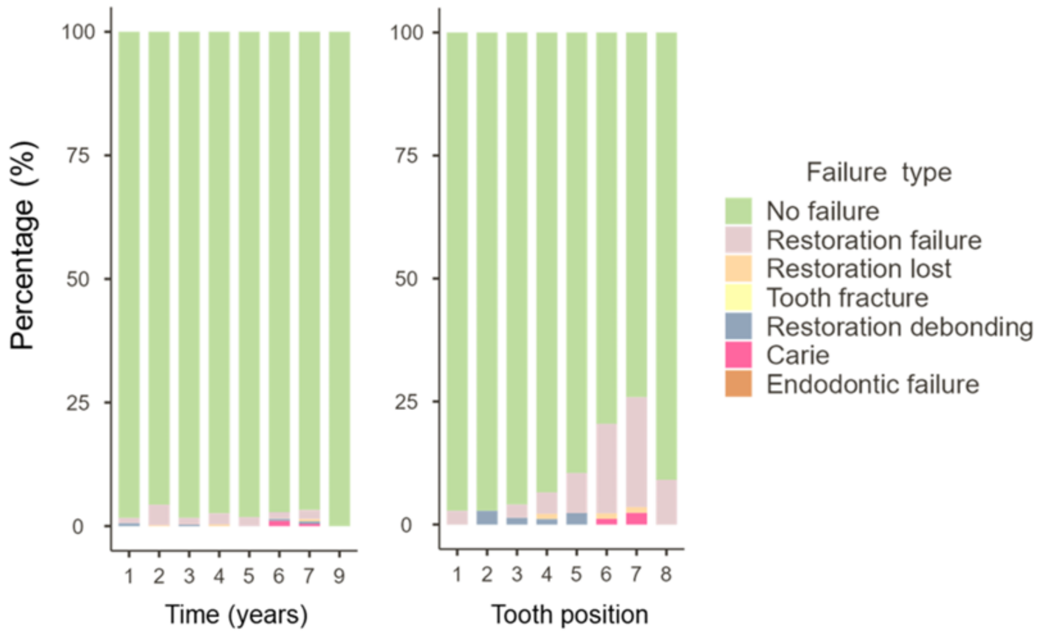

Figure 4: Failures observed in the study with relative frequency by year of follow-up and by influence of tooth position.

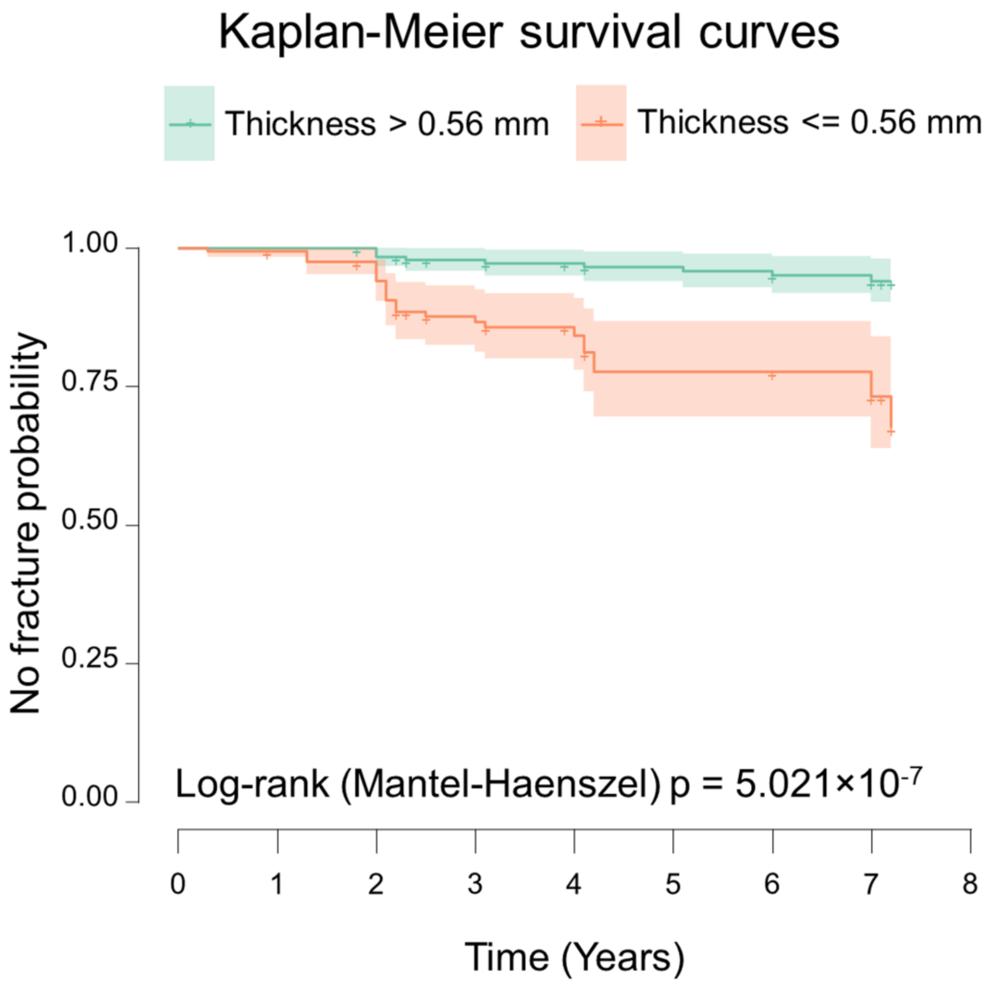

Figure 5: Kaplan-Meier fracture rate for anterior (in blue) and posterior (in red) restorations according to thickness of restorations.