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Clinical Report

All-ceramic prosthetic rehabilitation of a worn dentition: Use of a distal cantilever. Two-year follow-up

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ABSTRACT

The rehabilitation of heavily abraded occlusion in patients with parafunctional habits is a restorative challenge to the dentist. Use of all-ceramic systems in such cases is widely considered, but uncertainty over their resistance hinders their broad use. The authors would like to illustrate a possible approach by mixing two all-ceramic systems based on zirconium dioxide and lithium disilicate. A 48-year-old female patient attended with reduced vertical dimension in a full dentition. She suffered from craniomandibular (CMD) pain and desired an esthetic rehabilitation. Prosthodontic treatment was started in a pain-free condition, after correction of the vertical dimension with an occlusal splint, over four months. Determination of the treatment was based on the clinical findings: IPS e.max® ZirCAD frameworks veneered with IPS e.max® Ceram were used for discolored retainers or subgingival finishing lines. All the rest received IPS e.max® Press crowns. A zirconia-based, single-tooth-retained distal cantilever reconstruction was used to replace a missing second molar. No technical or biological complication was observed 24 months after treatment. The patient was highly satisfied and pain-free.

Key Words: Computer-aided design/computer-aided manufacturing, all-ceramic, multilink, relyX Unicem

INTRODUCTION

The development and use of all-ceramic systems in prosthodontics was driven by the need for esthetically improved and more biocompatible materials compared to traditional metal-based prostheses. Nowadays, a large choice of ceramic materials with different mechanical properties and esthetic performance are available. However, there is no evidence supporting the application of one, single ceramic material in every clinical situation.[1] Selection of the most suitable all-ceramic system for a patient, matching intraoral conditions and esthetic requirements, is a highly demanding and challenging procedure.

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All-ceramic systems can be divided based on the presence of a ceramic core.[2,3] Coreless systems are fabricated completely from a specific ceramic material (monolithic), such as, lithium disilicate glass ceramic IPS e.max® Press (Ivoclar Vivadent, Schaan, Liechtenstein).

Core systems use a ceramic framework, characterized by high fracture toughness and veneered with established porcelain, to simulate the esthetics of a natural tooth.[2] Frameworks are mostly fabricated by computer-aided design/computer-aided manufacturing (CAD/CAM) systems from yttrium-stabilized tetragonal zirconia polycrystals (Y-TZP), and in the case of IPS e.max® ZirCAD (Ivoclar Vivadent), covered by hydrothermal veneering ceramic (IPS e.max® Ceram, Ivoclar Vivadent).

Due to translucency, monolithic all-ceramic restorations reproduce the natural appearance of the tooth efficiently.[2,4] At present, a great range of opacities, translucencies, and shadings of silicate ceramic are available. Technicians use paint-techniques (external

color application) for further customization. However, because of its inferior mechanical properties it is only recommended for anterior or posterior single crowns and maximum three-unit, short-span, anterior fixed dental prostheses (FDPs).[5]

High-strength oxide ceramic (core systems) is the preferred material for posterior and/or multiple FDPs.[6,7] According to Sundh *et al*.,[4] Y-TZP ceramics exhibit an excellent mechanical performance and fracture resistance compared to other ceramics. As reported by Studart *et al*.,[7] partially stabilized zirconia can withstand the loads typically applied in the molar region, providing a flexural strength greater than 900 MPa. On account of its high material stability and biocompatibility, zirconia offers a valuable alternative to metal.[8] However, the mostly white and opaque framework carries an esthetic disadvantage.[9] Nevertheless, in case of discolored abutments this can turn into an advantage, too.

The most common clinical complication of these restorations is the veneering porcelain fracture (chipping), with a rate almost 50% higher than that of the porcelain fused to metal (PFM) reconstructions.[10,11] Furthermore, the success of these systems depends on the bond strength between the core and veneer ceramic, while unfavorable shear forces in between can influence their long-term interaction.[12] Another known reason is the missing support of the veneering layers, because of inadequate framework-design.[11,12] Y-TZP frameworks themselves feature a peerless material property: Active crack resistance, known as transformation toughening.[1,4,6,10,12] This Y-TZP transformation effect,[1,6,10,12] providing retarded crack propagation, prevents failure and is a critical factor for clinical success.

However, a drawback of all-ceramic materials is their susceptibility to fatigue mechanisms, which can considerably reduce their initial strength, over time. The mastication forces can reach 250 N, while the forces due to clenching/grinding can reach up to 800 N.[13] Therefore, the rehabilitation of heavily abraded occlusion on patients with parafunctional habits and/or special design features, such as cantilevers and wide spans, is considered to be a contraindication for all-ceramic restorations.[1]

In-vitro studies, as already referred to, support the use of high toughness ceramics as framework materials for posterior all-ceramic FDPs. Potiket, *et al*.[14] suggest that there is no significant difference in the fracture strength between all-ceramic and metal-ceramic restorations. The fracture resistance of ceramic core materials is affected mainly by the connector design. A minimum connector height of 3-5 mm from the interproximal papilla to the marginal ridge is a guideline for most all-ceramic systems. This provides a minimum connection surface of approximately 9 mm^2, which is considered to be appropriate for three-unit FDPs.[5,12,14]

Gabbert *et al*.[9] found acceptable fracture-load values for all-ceramic cantilever FDPs with a Y-TZP framework replacing one premolar, when the end abutment received a full crown. Groten *et al*.[11] already described a successful all-ceramic posterior cantilevered rehabilitation, with a three-year follow-up. With respect to the framework design of the all-ceramic cantilever FDPs, a 16 mm^2 connector cross-section between the abutment and a premolar-sized cantilever is ideally desired.[5]

The following case illustrates the restorative and esthetic potential of two different all-ceramic systems under challenging conditions as alternative to the standard PFM reconstructions. A female patient with reduced vertical dimension, suffering from recurrent mild craniomandibular pain, desired an esthetic, and if possible, a metal-free restoration, due to her mild allergy toward nickel.

Clinical report

A 48-year-old female came to the Prosthodontics Ambulance of the Dental Clinic, at the Tuebingen University Hospital. She suffered from recurrent mild pain on both sides of her mandible. She asked for a complete prosthetic treatment with focus on esthetics and reported to be allergic to acetyl-salicylic-acid and nickel.

Examination

Chewing as well as neck and shoulder muscles were painful on palpation. The temporomandibular joint was pain-free on palpation and movement, without disk derangement. The intraoral examination revealed an Angle's class I, a deficient vertical dimension of occlusion (VDO), bruxo facets on the posterior teeth, and abrasion on the anteriors. The oral hygiene was very good. Physiological probing depths between 2 and 3 mm were detected, except in the upper left second molar, which had a perio-endodontic lesion with probing depths of 6 mm mesial and 9 mm distal [Figure 1]. The third molars were missing. The upper left first premolar and first and second molars were restored

with metal-ceramic crowns, with visible and decayed supragingival margins. The lower right second molar was restored with a metal crown. Other maxillary teeth and the mandibular premolars, second left molar, and the first right molar had composite fillings. Caries and/or secondary caries were detected in the maxillary left central incisors, the right canine, right second premolar, and first molar. On the mandible, the right and left first and the left second molar teeth were also decayed. Only the mandibular anteriors were in a completely healthy condition. Radiographic examination revealed endodontic treatment at the upper left second incisor and the upper left first molar [Figure 2].

Based on the diagnosis, "insufficient prosthetic restoration on a deficient vertical dimension of occlusion (VDO)" and considering the patient's wish for esthetic restoration, the following two-stage treatment was suggested: Preprosthetic conservative treatment, extraction of the maxillary left second molar, and splint therapy for VDO increment. Next, an all-ceramic, full-arch maxillary restoration, with single crowns, was performed. A decision was made to restore the mandibular teeth, except the central and lateral incisors, with all-ceramic single crowns. An alternative treatment possibility (not followed in this case) involved the standard metal-ceramic restoration. The patient gave preference to the first metal-free, more esthetic variant.

Phase 1: Preprosthetic treatment

The conservative preprosthetic treatment included the endodontic retreatment of the maxillary left first molar. The decayed fillings were replaced with Tetric EvoCeram® using the acid-etching technique under relatively dry conditions with the Syntac-Heliobond-System® (Ivoclar Vivadent). A ceramic post was placed (CosmoPost®, Ivoclar Vivadent) in the maxillary left lateral incisor, luted with adhesive resin cement (Multilink® Automix, Ivoclar Vivadent), and built up with a universal nanohybrid composite (Tetric EvoCeram®, Ivoclar Vivadent). The maxillary left second molar was extracted due to infaust prognosis.

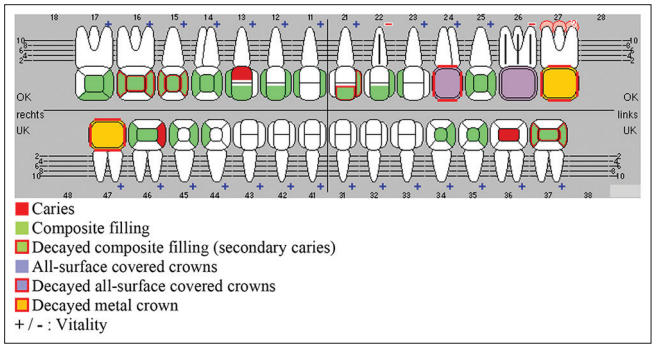

Figure 1: Initial dental status

Irreversible hydrocolloid (Blueprint® Cremix, Dentsply DeTrey, Konstanz, Germany) impressions of both jaws were taken with rim-lock impression trays at the first appointment. Beauty pink (Moyco Union Broach, PA 17402, York, USA) was used for bite-registration. The diagnostic casts were articulated using a face-bow transfer of the Rotofix®-System (Amann Girrbach, Koblach, Austria). Next, the cast-analysis determined the required space for the restoration and consequently the VDO increment. An extra 3 mm from the tips of the incisors was necessary, which was added at the incisal pin of the articulator. In this position a removable mandibular acrylic occlusal splint was made, which was inserted, to test the new VDO position clinically. From our clinical experience the mandibular splints were easier for the patient to accept compared to the maxillary splints. The patient wore this occlusal splint 24/7 (twenty-four hours a day/seven days a week). One month later the patient came for a control. Muscle and temporomandibular joint (TMJ) reaction to the increased VDO were clinically examined. No adverse effects were reported or detected [Figure 3].

As the last part of the preprosthetic phase, the old crowns were carefully removed. Due to the inadequate remaining clinical crown, a titanium post (Unimetric® #210, Dentsply DeTrey) luted with composite (FlexiFlow®, Essential Dental Systems Inc., Hackensack, NJ, USA) was used to restore the maxillary left first molar core. An autopolymerized composite was used for the core build-up of the maxillary left first premolar and molar, and mandibular right second molar (Ti-Core® Natural, Fa Nordenta

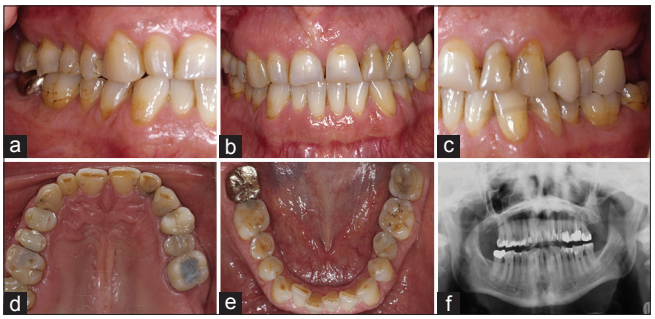

Figure 2: Preoperative situation (a) Right side (b) Frontal view (c) Left side (d) Occlusal view, maxilla after endodontic retreatment of the maxillary left first molar and extraction of the maxillary left second molar (e) Occlusal view of the mandible (f) Radiographic examination

Inc., Mississauga, Canada). The patient remained under regular control for the next three months. The patient's positive feedback from the new vertical dimension as well as the pain-free jaw muscles, allowed the second phase — prosthetic restoration.

Phase 2: Prosthetic treatment

To implement the functional situation of the splint to the final condition, maxillary full arch and mandibular partial arch restoration was necessary.

New diagnostic casts and a new articulation, using face-bow transfer, bite registration, and a diagnostic wax-up were made in the new VDO. This 'backward planning' allowed control of the esthetic results and re-evaluation of the available space for restoration. A combination of IPS e.max® ZirCAD (zirconium oxide for the CAD/CAM technique veneered with IPS e.max® Ceram) and IPS e.max® Press (lithium-disilicate glass ceramic for the press technique) was chosen with regard to the different grades of decay and discoloration. For all the teeth needed to be restored, a full crown design was planned, except partial crowns for the mandibular canines. The maxillary left first molar was planned to be a full crown with a distal cantilever, to avoid elongation of the antagonist. A two-unit, cantilevered FPD was designed, to eliminate the consequences of a potential failure, either because of the doubtful prognosis of the endodontic treated abutment tooth or the all-ceramic cantilever. A possible future abutment loss or connector fracture would not set into risk the whole restoration. IPS e.max® ZirCAD was assigned to the teeth that were discolored or where the subgingival finishing lines were expected, and to the cantilever whose reconstruction had to be supported by a zirconium framework. More specifically, the teeth restored by IPS e.max® ZirCAD were the maxillary right second premolar and molar, left first premolar, first and second molars, and mandibular right second molar.

A 0.8-1 mm chamfer was prepared at the finishing line, wherever possible, paramarginally, for the IPS e.max® Press restorations. An eight- to ten-degree angle of convergence was used for the preparation and all the sharp edges were rounded and smoothed. The occlusal reduction, after VDO increment, was 1.5 mm, to ensure sufficient room for the porcelain. The provisional restoration was made chair-side with the aid of a polyethylene foil (Erkodur-C®, Fa. Erkodent, Pfalzgrafenweiler, Germany). This was made on a duplicated cast from the diagnostic wax-up. Therefore, the maxillomandibular relationship could be adjusted at the final VDO. Bis-GMA-based Protemp® 3 Garant (3M ESPE, Seefeld, Germany) was used as the provisional restoration material. Temporaries were luted with eugenol-free provisional cement (Temp Bond® NE, Fa. Kerr, Salerno, Italy) [Figure 4]. The functional and esthetic parameters were optimized within the provisional phase. Later this situation was transferred to the final restoration.

The single-cord technique (#1 in anterior area and #2 in the posterior area, Retraco®, Fa. Roeko, Langenau, Germany) was used for preparation of the impressions on all teeth, excluding the partial crowns. The cords were imbued with a hemostatic solution and gingival retraction (Racestyptine, Fa. Septodont, Saint-Maur-Des-Fosses, Cedex, France) [Figure 5]. Impressions were taken with polyether (Impregum™, Penta™, and Permadyne™ Garant 2:1, 3M ESPE) using an individualized rimlock tray and a double mixing technique. The impression compound (Kerr, West Collins, Orange, CA, USA) was used for

Figure 3: Mandibular splint on articulator, frontal view

Figure 4: Temporary restorations

bite registration under contralateral support of the temporaries. Face-bow transfer was again done with Rotofix®.

The IPS e.max® Press crowns of high translucency were fabricated by the hot pressing technique. IPS e.max® ZirCAD was available from the manufacturer as zirconium oxide blocks, for the CAD/CAM technique. The IPS e.max® ZirCAD frameworks were veneered with IPS e.max® Ceram (fluorapatite veneering ceramic). Special care was given to the connector design of the single retained cantilever. The cross-section was 16 mm^2, to withstand the later mastication forces. The fitting of the definite crowns were first controlled on the casts and then were tried intraorally, with the aid of a fine probe and Occlu Spray® (Hager and Werken, Duisburg, Germany). The esthetics and occlusion were also controlled. After the final corrections in occlusion, form, and shade, the restorations were glazed.

Adhesive resin cement (Multilink® Automix, Ivoclar Vivadent) was used for adhesive luting of all crowns, according to the manufacturer's instructions. The cantilevered crown, because of the subgingival preparation line, was luted with RelyX® Unicem (resin-modified glass-ionomer luting agent, Unicem Transparent, 3M ESPE) [Figure 6].

After completion of treatment, the patient received a new occlusal splint. The patient came for a 1, 3, 6, 12, and 24-month control. Neither technical nor biological complications were observed 24 months after treatment. The patient was highly satisfied and free from pain [Figure 7].

DISCUSSION

Patients with abraded occlusion and parafunctional habits are a challenge to any dentist. These rehabilitations require time and a multi-stage procedure. The first phase includes VDO re-establishment; a necessity deriving from the need for esthetic improvement of the lower face[15] and the need of the required space for the restoration.

Restorative treatment of patients with inadequate lower facial height is important, because of its effect on the long-term physiological function of the chewing muscles. Starting with a splint therapy, clinicians test the patient's acceptance of the new VDO. Neuromuscular adaptation takes place about three to four weeks after VDO increment.[15] Unproblematic masticatory function, reduced CMD-pain, and the patient's acceptance of this new VDO position are prerequisites for the next treatment-stage-definite restoration. In our case, the patient remained under splint therapy and regular recall for 16 weeks, for greater certainty. Temporary restorations made in this new VDO allowed double-checking of this position.

The treatment plan included single crowns for all abutment teeth, to ensure easy repair abutment of the teeth, with high esthetic value, and slightly supragingival or equigingival margins were restored by lithium disilicate glass ceramic (IPS e.max® Press). The available translucencies and opacities rendered this material ideal for esthetic restorations. Moreover, monolithic lithium disilicate restorations minimized

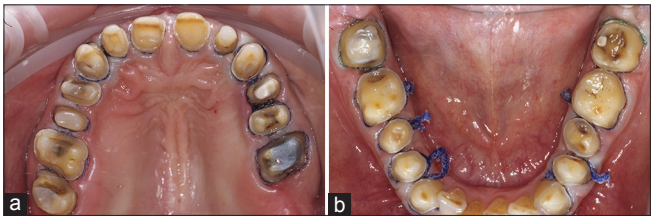

Figure 5: (a and b) Maxilla–mandible preparations

Figure 6: Definitive final restorations (a) Occlusal view of the maxilla (b) Occlusal view of the mandible (c) Right side (d) Frontal view (e) Left side

Figure 7: Two-year follow-up (a) Smile line (b) Frontal view (c) Maxilla-anteriors (d) Radiographic examination

the chipping hazard often observed by veneered zirconia. For discolored abutments the opaque zirconia system was chosen (IPS e.max® ZirCAD). In addition, the zirconia framework was used for the cantilever bridge. Zirconia frameworks showed the best mechanical properties and should be preferred when extreme mechanical load is expected.[4,6,8,11,12,14,16]

The cementation protocol of all-ceramic restorations is essential for success.[6] Clinicians can effectively etch silica-based ceramics for adhesive bonding, which increases the fracture resistance significantly.[3] In contrast, zirconia cannot be etched and bonded in this manner. According to the manufacturer's instructions IPS e.max® ZirCAD and the IPS e.max® Press restorations can be either conventional or adhesively luted. In this case, we used low viscosity composite resin cement (Multilink® Automix, Ivoclar, Vivadent) for all crowns, except for the cantilever-zirconia-based crown at the maxillary left first molar. The subgingival margins of this crown, combined with its posterior topography in the arch, made proper isolation required for adhesive cementation almost impossible. RelyX® Unicem has minimal moisture and contamination tolerance and is furthermore a cement of choice for zirconia all-ceramic restorations.

As concluded by Groten and Huttig,[17] failures of zirconia-based restorations are related to biological events such as bruxism. For prevention of chipping after rehabilitation it is suggested that the patient apply an occlusal splint at night.

CONCLUSION

A combination of the current all-ceramic materials enables the dentist to treat patients with parafunctional habits and abraded occlusion. The selection of the material must be balanced between the esthetic and strength requirements, as well as, mode of cementation. The lithium-disilicate ceramic appears to be a valid alternative for stable superior esthetic results for single-tooth crowns. Zirconia-based solutions must be used for multi-unit and particular restorations, such as distal cantilevers. Nevertheless, more clinical experience is necessary.

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