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Aesthetic Functional Area Protection (AFAP): a new concept for prevention of ceramic chipping with zirconia frameworks

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ABSTRACT

Chipping of the ceramic veneer is reported as a common event when using copings made with zirconium-oxide based for fixed dental prostheses (FDPs). Inadequate support of the veneering ceramic by the zirconia substructure IS considered one of the possible causes of this complication. In this article, a new technical method for prevention of ceramic chipping with zirconia frameworks, the Aesthetic Functional Area Protection (AFAP), IS presented.

KEYWORDS Ceramic chipping; Zirconia structures; Zirconium-oxide FDPs.

INTRODUCTION

Metal-free fixed prosthodontic solutions HAVE became increasingly popular (1-7): they offer improved aesthetics with biological and mechanical results similar to those accomplished by metal-ceramic FDPs (8-11). Zirconia, a polycrystalline material partly stabilized by yttrium oxide (approximately 3 mol%) and without a glassy matrix, became a popular option (1) since FDPs with zirconia frameworks exhibited excellent technical and biologic outcomes. Moreover, it appearS that, despite a reported 13% incidence of chipping of the ceramic veneer (12), such prostheses show evidence of a survival rate similar to that of metal-ceramic FDPs after few years of function (13-16).

To avoid chipping of the veneering ceramic, new materials have been introduced. They allowed the construction of monolithic zirconia crowns that could support greater functional stresses (17). However, coloration techniques of these monolithic zirconia crowns did not fully guarantee the aesthetic standards which were previously achieved with veneering ceramic techniques. It should be noted that by means of ceramic stratification it was possible to imitate not only the color of the tooth, but also its natural optical physical characteristics.

In a previous article (18) early clinical observations from patients treated with 96 zirconium-oxide based ceramic single and multiple unit FDPs on natural teeth and on implants were presented. All these FDPs were fabricated according to the Aesthetic Functional Area Protection (AFAP) concept of framework design for prevention of veneering ceramic chipping. Ninety-six zirconium-oxide based ceramic FDPs (205 units) were observed in follow-up appointments for at least 12 months, 34 FDPs (101 units) for over 18 months. In this relatively short observation period, only one single unit FDP cemented on an implant abutment displayed minor chipping after 14 months of function: the problem was satisfactorily solved with polishing of the chipped ceramic area.

The aim of this article was to present the laboratory steps of the AFAP concept which could permit the use of ceramic stratification techniques on zirconia structures and also to take advantage of the mechanical characteristics of monolithic zirconia crowns.

TECHNIQUE DESCRIPTION

The design of zirconia structures has been changed following the AFAP concept: the shape no longer acted as a simple support of the veneering ceramic, but also provids protection of the ceramic itself (Fig. 1, 2). This was possible as a result of the mechanical evolution

FIG. 1 Vertical occlusal load in the area of a marginal crest and relative AFAP concept design of the zirconia support structure which counteracts these forces.

FIG. 3

FIG. 5

FIG. 6 Light transmission through the zirconia structure.

FIG. 8 View under reflected light.

FIG. 2 Horizontal occlusal load on triangular crests and relative AFAP concept design of the zirconia support structure which counteracts these forces.

FIG. 4

FIG. 3-5 Hands-on demonstration of AFAP concept design for posterior zirconia crowns. The tapered shape of the zirconia structure is similar to that of a natural tooth.

FIG. 7 A very thin layer of veneering ceramic allows excellent results with regard to hue, chroma, fluorescence and value, thanks to the irregular surface of the prosthetic structure.

FIG. 9 Definitive zirconia crown.

FIG. 10 Esthetic result under incident light.

and of the improvement of translucency characteristics of more recent zirconia materials. These innovative zirconia structures were designed both for lateral-posterior teeth and for anterior teeth, thus reinforcing the resistance of each element. All these different forms depended on the occlusal relationships of teeth and therefore on the function of each tooth. These functions included mastication of the lateral-posterior teeth; phonetics, swallowing and aesthetics of the anterior teeth; and distribution of occlusal stress management of all teeth (lateral-posterior and anterior). The zirconia substructures were designed to fully support the veneering ceramic on the cusps of lateral-posterior teeth and on the incisal edges of anterior teeth.

Lateral-posterior teeth: following the AFAP concept in lateral-posterior sectors, the zirconia structure (presintered Prettau Zirconia, Zirkograph, Zirkonzahn S.r.l., Gais, Italy) of the cuspid was extended; as a result, the zirconia structure contained the occlusal veneering ceramic (Ice Zirkon Keramik, Zirkonzahn S.r.l.) and consequently protected it. Therefore, the veneering ceramic could work only under pure compressive forces; in fact the occlusal forces in maximum intercuspation were applied inside the occlusal fossa toward the external sides of it. The veneering ceramic which covered these zirconia structures could present reduced thickness by means of a specific stratification technique (Fig. 3-10).

Anterior teeth: the most interesting application of the AFAP concept was the realisation of a protective structure in the maxillary incisal edges areas where veneering ceramic chipping is more frequent (Fig. 11). It should be noted that the forces applied in this area were exclusively traction forces and therefore were extremely dangerous. The zirconia structure (presintered Prettau Zirconia, Zirkograph, Zirkonzahn S.r.l.) was designed to be placed in alignment with the incisal margin: from the chromatic point of view, the zirconia was aligned with the halo effect of adjacent natural teeth. This halo effect was always semi-opaque in nature, and the zirconia was able to imitate it. It therefore became an integral part of the general chromatic complex (Fig. 12-

FIG. 11 Veneering ceramic chipping can be often seen at the maxillary incisal edge areas where occlusal forces work in traction.

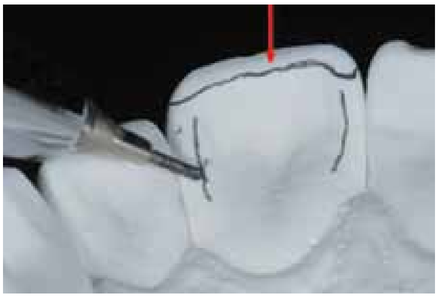

FIG. 12 The AFAP goal is to realise a zirconia incisor margin.

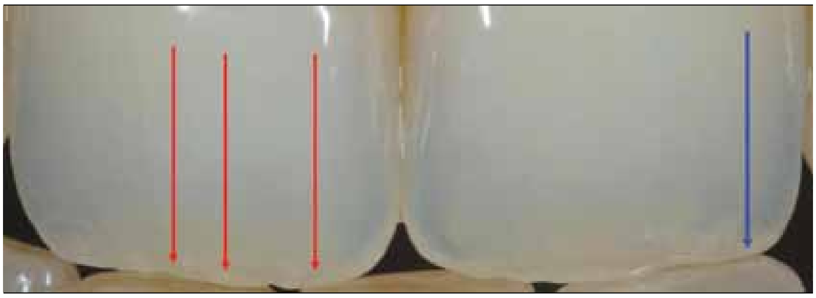

FIG. 13 Zirconia connectors are connected in alignment with the semi-opaque areas of the dental mamelons.

FIG. 14 Presintered zirconia structure following the AFAP concept design.

FIG. 15 Connectors present maximum thickness in the palatal-facial surfaces.

FIG. 16-18 Facial and palatal view of the zirconia structure after sintering.

FIG. 19 Excellent optical characteristics with light reflected from the zirconia structure.

FIG. 20, 21 After ceramic veneering the incisal zirconia margin excellently reproduces the halo effect of a natural tooth.

FIG. 22 View under reflected light.

22). Realisation of the incisal edges areas with zirconia material allowed a greater exploitation of the extremely low abrasive characteristics of the polished zirconia (19-20): as a result, this safeguarded the integrity of the opposite teeth. The goal was to create an incisor margin in zirconia which was not, however, made by a complete palatal wall in zirconia: indeed, this would compromise the aesthetics of the incisal area by partially blocking the passage of light and would alter the transparency and the effects of opalescence in this area. Under the zirconia structure an empty space was created where the veneering ceramic (Ice Zirkon Keramik, Zirkonzahn S.r.l.) could be stratified, thus allowing the passage of light in a natural way. The zirconia structure should therefore be made with thin vertical connectors that presented maximum thickness in the palatal-facial surfaces and create the essential empty space. These connectors should be placed in alignment to the semi-opaque

FIG. 23 Ciinical situation: tooth 21 presents an incisal area characterised by intense translucency and opalescence.

FIG. 24 Zirconia structure following the AFAP concept design: the zirconia connectors are placed strategically.

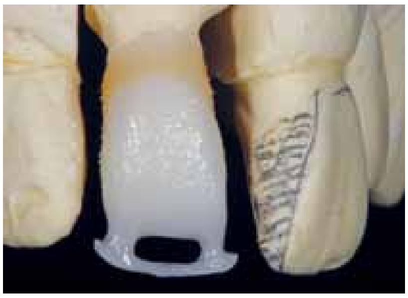

FIG. 25 Dynamic dentin layered in the incisal area to lower the luminosity of the crown.

FIG. 26 After the first ceramic bake an excellent chromatic integration of the zirconia structure is achieved.

FIG. 27 Second bake.

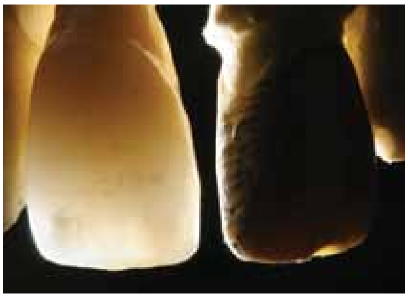

FIG. 28 The aesthetic result under reflected light.

FIG. 29 The crown after polishing.

structures of the dental mamelons which were planned by following a precise chromatic analysis. These zirconia protectors were then covered by the veneering ceramic, in both the facial and palatal areas, thus becoming an integral part of the chromatic complex (Fig.23-30).
The individual needs of application of the AFAP concept should be stressed. Zirconia was used in the areas of maximum functional stress, leaving an almost exclusive aesthetic and filling function to the veneering ceramic (Fig. 31-33).

DISCUSSION AND CONCLUSION

When zirconium-oxide based ceramic FDPs are used, it is extremely important to reduce the risk of chipping of the veneering ceramic. Chipping has been attributed to different reasons: coefficient of thermal expansion (CTE) mismatch with the veneering ceramic, incorrect heating and cooling rates, incorrect surface treatment of the zirconia prior to the application of the ceramic, and inadequate support of the veneering ceramic (14). The AFAP concept presented in this article allowed to develop a zirconia framework design that could support and protect the weaker veneering ceramic, while not compromising the aesthetic outcome. A similar concept was suggested for traditional metal-ceramic FDPs by Shoher and Whiteman in 1983 (21). However metal frameworks should be adequately opacized and, as a result, cut back from the surface enough to apply a sufficiently thick layer of ceramic to provide a natural appearance to the FDP. On the other side zirconia's light

FIG. 30 Clinical view of the definitive zirconia crown.

FIG. 31

FIG. 31-33 These figures highlight a rahabilitatoin using the technique described.


FIG. 32


FIG. 33

color allowed the technician to bring it to the surface as limited islands of material in specific areas; that is, at the incisal edges of anterior teeth and at the cusp tips of lateral-posterior teeth. In these areas, the oblique tensional forces were believed to determine a higher risk of ceramic chipping. The supportive zirconia areas presumably converted the oblique tensional forces applied on the aesthetic ceramic to compressive forces which were better withstood by the veneering ceramic material.

Our clinical experience, based on a synergic approach between the prosthodontist, who had to locate and register the real and individual function of the patient's teeth, and the dental technician, who had to cope with these indications with materials and forms, appeared to give excellent results without compromising either function or aesthetics.

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