Int. J. Odontostomat.,
7(1):151-159, 2013.

Aesthetic All-ceramic Restorations. CAD-CAM System

Restauraciones Estéticas de Porcelana Pura. Sistemas de CAD-CAM

Enrique Fernández Bodereau*; Laura Bessone & Gabriela Cabanillas****

FERNÁNDEZ BODEREAU, E.; BESSONE, L. M. & CABANILLAS, G. Aesthetic all-ceramic restorations. CAD-CAM System. ***Int. J. Odontostomat., 7(1)***:151-159, 2013.

ABSTRACT: Aesthetic dentistry is dedicated to imitate nature by maintaining the size, shape, color and symmetry. Technology has developed metal-free ceramic materials so capable of reproducing a natural appearance, that traditional materials have been replaced by them. The yttrium partially-stabilized zirconium oxide does not only have the advantage of being extremely resistant, but it is also highly translucent. It has a translucency that allows about 50% of the incident light to pass through, a characteristic that is vital for providing a more natural appearance to restorations. The duration of scanning and milling procedures will depend on the size of the object, the number of objects processed and the steps selected (CAM or CAD/CAM). The framework of the densely sintered zirconium oxide with its precise fit is veneered with the veneering ceramic developed especially for this purpose. Almost in all cases, there are several treatment alternatives for the same diagnosis. The success of these restorations will be predicted as long as it is founded on sustaining biological principles. The aim of this paper is to concisely present the sequences for a clinical treatment in a schematic and illustrative manner.

KEY WORDS: aesthetic restorations, all-ceramic crowns, CAD/CAM prosthesis, cercon system.

INTRODUCTION

Restorations requirements are resistant, lasting, precise, functional and aesthetic. All-ceramic has been developed for more than a century and has several possibilities for the elaboration of metal free restorations of maximum aesthetic. First all-ceramic restorations emerged in 1903, and contained a high percentage of feldspat (60%), silica (25%) and fluxes (Land, 1886, 1903). Later, in 1965, their reinforced ceramics with alumina appeared (McLean & Hughes, 1965; McLean, 1974-1976) where the glass matrix of the porcelain is spread with crystals to improve resistance but, actually, aesthetics is affected due to opacity increase. Therefore, to reconcile the aesthetic requirements and the resistance, a thin alumina coping, similar to a metal core, over which a veneering ceramic is put, began to be used (Chiche & Pinalt, 1994).

The strengthening of the porcelain can be done by four methods: i) Metal strengthening (Brukl & Ocampo, 1987); ii) Strengthening by high resistance ceramic crystals spread and vitreous matrix elasticity; iii) Ceramic strengthening by low glass fusion and iv) Strengthening by glass crystallization (Castellani, 1990).

All-ceramic restorations in general show: ideal esthetic, matching opacity with translucency, the color is inalterable throughout time, show a good biologic response, compatible with soft tissues in subgingival margins, they do not suffer from corrosion or wear.

Some systems have "Grababilidad" which favors its adherence and, allows a more conservative vestibular reduction. The thermal conductivity of the ceramic is lower than the metal one which turns it in an insulating element and protecting a pulp dentin complex. Some significant inconveniency is the resistance module that is generally lower regarding the metal ceramic restoration; all systems require a careful manipulation and careful preparation to give support to the porcelain (Fradeani & Aquilano, 1997). They can be classified in: i) Complete cover restorations: crowns and ii) Partial covering restoration: a) Veneers, b) Inlays and onlays.

* Professor and Chair, Department of Clinical Prosthodontics, Dental School, National University of Córdoba, Córdoba, Argentina.
** Assistant Professor, Department of Clinical Prosthodontics, Dental School, National University of Cordoba, Córdoba, Argentina.

All-ceramic crowns are indicated in cases of (McLean; Shillingburg *et al*., 1981): i). Abrasive wears of the opposing teeth, ii). Anterior upper area of the oral cavity with great esthetic demands, iii). When pieces cannot be restored by more conservative methods, iv). When the abutment has enough support, and v). When the laboratory has experience in the system's selection; And its contraindications are: i) When there is a para-functional habit; ii) Inadequate support for the dental preparation; iii) It is not advisable as abutment bridge, unless it is placed on the anterior area and iv) When there is a pronounced overbite in the anterior area.

The ceramic systems are classified according to their method of production.

Molding and Sintering System. Optec HSP/(Pentron-Jeneric), Duceram LFC(Degussa), In-ceram (Vivadent, Baldwin Park. Calif), Allceram (Formerly Cerestore Innotek Dental Corp).

Injection and pressure system. Empress (Ivoclar, Lichtenstein), IPS Empress 2 (Ivoclar, Lichtenstein), Optec OPC, SISTEMA IPS, E MAX(lithium disilicate) Ivoclar, Lichtenstein.

The importance relies on: the combination of a high flexural strength (400 MPa) in two opacity levels, that is to say, it improves the aesthetic. For this reason it can be indicated for anterior and posterior individual structures, 3 unit structures up to the 2nd premolar as implant abutment substructures (i.e. individual crowns and 3 unit bridges).

CAD CAM Systems

Cerec 3. Vita CEREC Mark II. (Vita Zahnfabrik) lDicor MGC. (Dentsply, L. D. Caulk División) Procera AllCeram. (Nobel Biocare, Goteborg, Sweden), Celay (Mikrona,Spreitenbach, Switzerland). The ones mostly used at present are: CEREC SYSTEM 3 (Sirona), LAVA SYSTEM (3 M), PROCERA SYSTEM (Nobel Biocare), EVEREST SYSTEM (KAVO). Cercon system (Degudent, Densply International Company), hereafter described, was used for the resolution of the clinical cases here exposed.

Cercon System. The Cercon system has offered new restorative possibilities for the clinic. This system capitalizes exceptional fracture resistance (between 900 and 1200 MPa) and aesthetic, it has the capacity to build up free metal bridges having long periods of duration as well as individual crowns. The Cercon art addition (veneering ceramic) with adequate adjustments has reduced some tensions associated with the manufacturing and forms for the dental prosthesis, and the dentist can securely offer an aesthetic product with restorative foreseeable results (Poss, 2007).

Components: a) Cercon eye: Eye scan; b) Cercon brain: milling unit and c) Cercon heat: Sintering furnace.

The system (Filser *et al.*, 1997) is based on the development done by Swiss investigators from the Federal Institute of Technology Zurich, in coordination with the Dental School of Zurich. The procedure was described many times in literature with the name DCM (direct ceramic machining). Finally, with Deugent collaboration it was improved and brought out to market. The zirconium oxide or Y-TZP (Luthardt *et al.*, 2000) (yttria stabilized polycrystalline tetragonal zirconium) has been successfully used since 1969 in orthopedics for artificial hips. This material has predominantly been used in odontology, for pre-manufactured posts in root canals, orthodontic brackets or trans epithelial abutment implants.

At present they are used for:

- Anterior or posterior individual crowns.

- All-ceramic— Bridges with terminal abutments up to 47 mm anatomic length in anterior and posterior areas. The number of pontics must be limited to two molars per bridge space.

- Inlay bridges for the substitution of individual teeth with a maximum thickness of the pontic of 10 mm.

The general contraindications are bruxism and the treatment resistant para-functions.

The Cercon system process (McLaren & White, 2000) begins with the eye scan with a crown ceramic laser model. Through a software procedure, they are milled from a Y-TZP block pre-synthesized which will later be sintered. These two processes, scanning and cutting are done in the Cercon brain unit. The cutting has two stages, while the rough area is incised in an initial process of pre-milling, the second step is adjusting it to the precise structure.

The milled object is sinterized in the Cercon heat unit in a thermal process reaching a final temperature of 1350°C. The sintering process takes six hours to be completed since it is associated to the volumetric contraction of the milled element. The cut out of the block shows a 30% expansion, which also doubles in the unit Cercon brain through a computing calculation after being scanned. This is possible due to the CERCON base contraction; the zirconia block can be precisely determined during manufacture thus being predictable. The crown is finished with the corresponding veneering ceramic (Cercon) that has the same thermal expansion coefficient than the core to avoid mismatches at this level.

High tolerance towards gingival tissues, maximum duration, optimal aesthetic work, does not need online exportation, allows milling zirconia, cobalt chromium and polyamide but of all materials used, zirconia obtains the best finished work, time of work as the traditional prosthesis and the software updates itself without cost. The inconveniencies are: it does not allow either bridges of more than 7 elements nor hybrid prosthesis on implants.

CLINICAL CASES

In the first clinic case, All-ceramic veneers were done; using the Injection and pressure system (E-max, Ivoclair, Liechtenstein): thus achieving the goals: aesthetics, function and predictability of restoration (Figs. 1 to 3).

At the second clinic case, a Central Incisor was rehabilitated with a complete ceramic crown, Zirconia structure and CERCON system were used (Figs. 4 to 6). The sequence of the clinical treatment is described with the images.

DISCUSSION

Three important factors were analyzed in the literature and they supported the use of CERCON system in the cases exposed: aesthetic, fracture resistance and marginal adaptation.

Regarding aesthetic, several authors performed researches; we are going to mention only some of them, such as Lou *et al.* (2004), who evaluated the results of this new system regarding its technical and clinical aspects. Cercon system was clinically applied in ceramic crowns and bridges, all cases were followed up in periods of 1, 3, 6 and 12 months after restorations cementing. The Cercon system showed a natural and aesthetic appearance. There were no changes in color or fractures. That is, the proved reliability of the ceramic crowns and Cercon system bridges was due

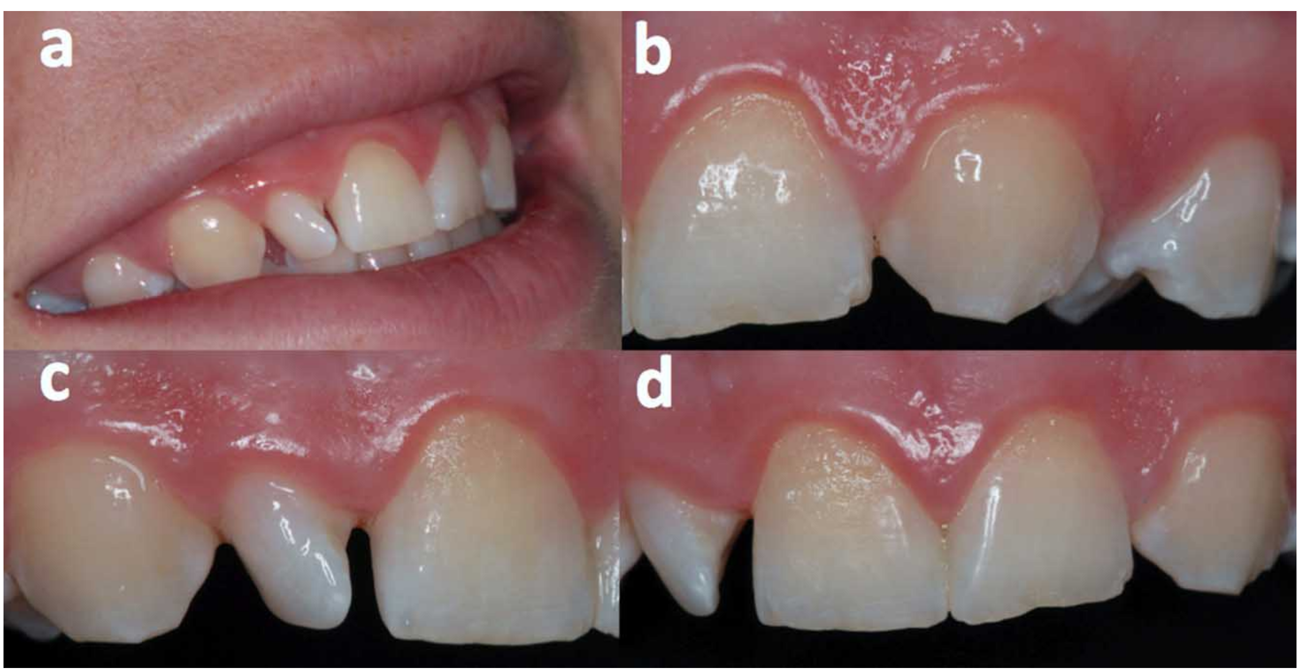

Fig. 1. (a-d). At the clinical exam, see that some teeth had deficient aesthetic due to morphologic alterations.

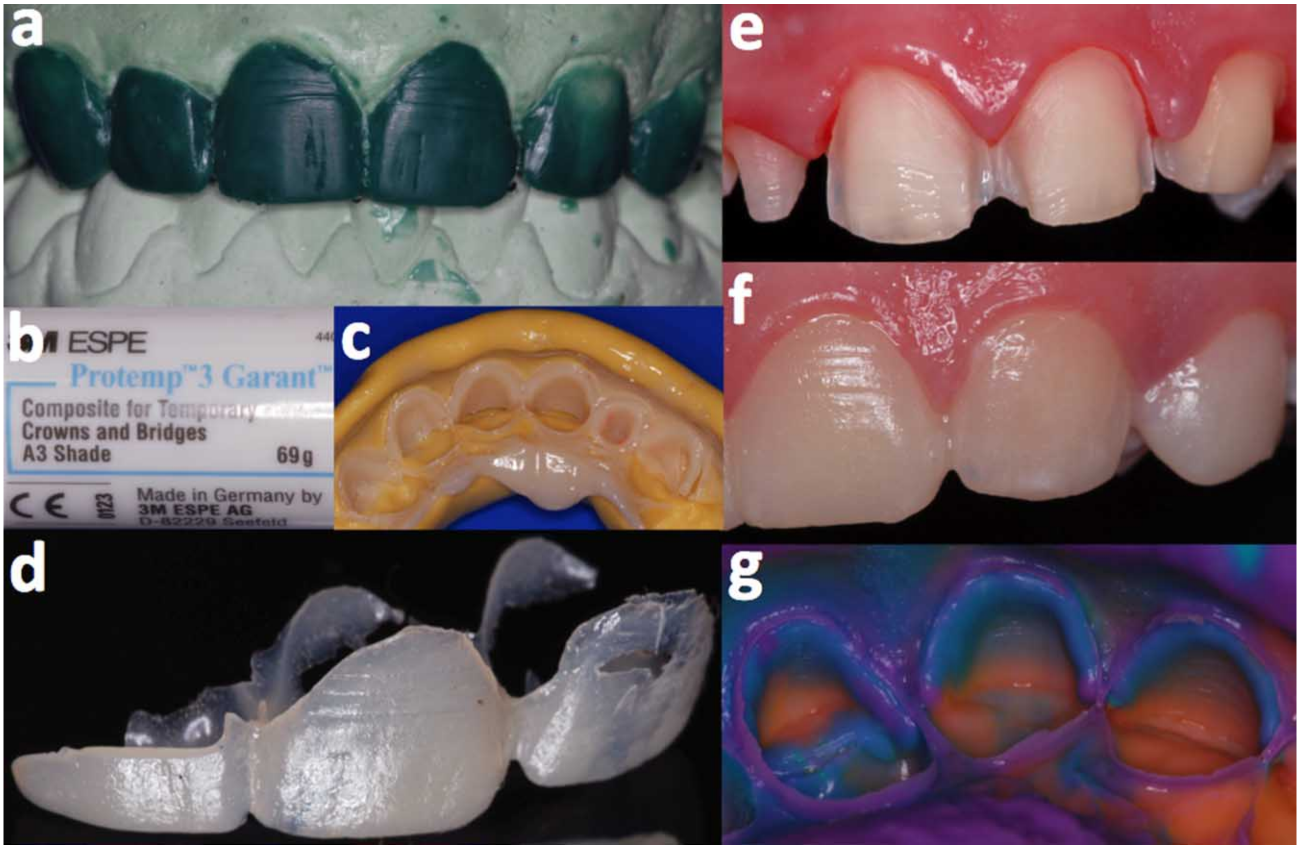

Fig. 2. (a). The treatment plan consisted of E-MAX (IVOCLAR) veneers elaboration with Injection system. See the mockup. (c-d). The provisionals must to have an adequate emergency profile, having into account not only the tissues biology but also the patient's aesthetic expectative. We have done with this material Protemp 3 Garant, Composite for temporary crown and bridges (3M,ESPE, Germany). (e). See the teeth preparation, with minimal invassive tissue. (f). The provisional restorations are on the teeth preparation, observe the adaptation of these provionals and see the harmony of hard and soft tissues. (g). The reproduction of teeth preparation, see the margins of restorations.

Fig. 3. (a). Laboratory trial of the E-MAX structure. See the margins adaptation. (b). The veneers finished and placed in the mouth, observe the great aesthetic and (c) the emergency profile that we obtained with the veneering ceramic.

Fig. 4. (a, b). In the second case we restored a Central Incisor with a color alteration, with endodontic treatment due to traumatism, that was resistant to bleaching process (a, b).

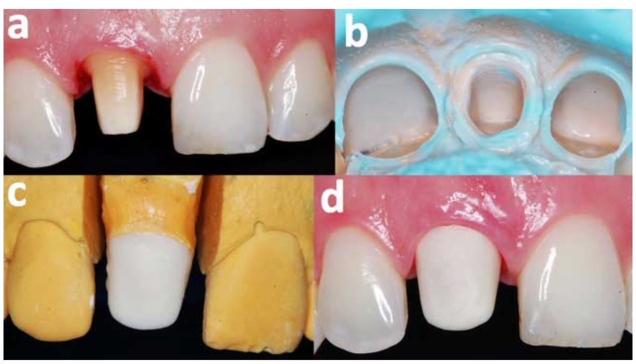

Fig. 5. (a). See the tooth preparation, with adequate and uniform thick and margins. (b). The reproduction of teeth preparation, see the margins of restorations. (c). Laboratory trial of the CERCON structure. See the perfect marginal adaptation. (d). Observe the CERCON structure on the tooth preparation that adapted correctly.

to the strengthening effects of the zirconia veneers and this system indication can be extended to posterior bridges achieving a longer duration. Besides, being aesthetically compared to other all-ceramic techniques turns it as the ideal system for all-ceramic crowns and bridges.

On the other hand, regarding color stability and predictability of aesthetic result, research was performed (Sailer *et al*., 2007) in which 3 ceramics of

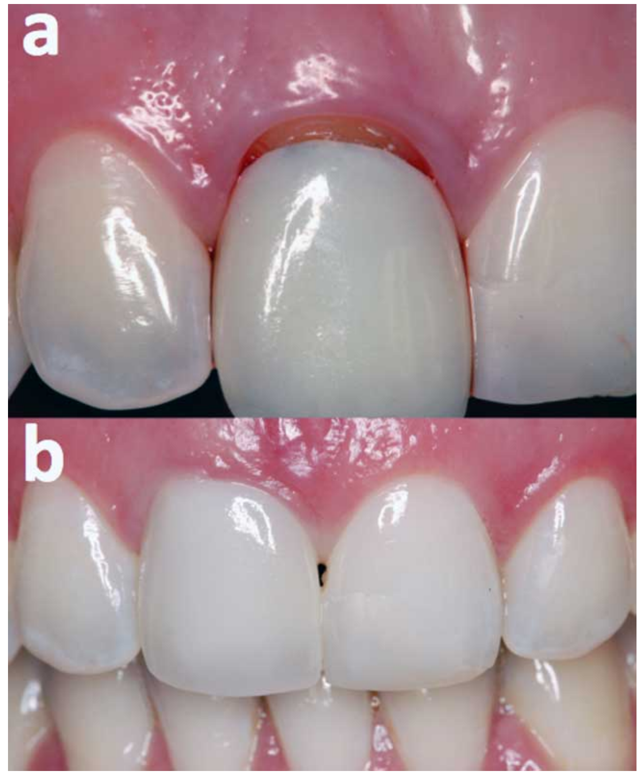

Fig. 6. (a, b) Then, see the finished CERCON crown, with this type of restoration we obtained, not only, an excellent aesthetic but also great fracture resistance.

veneering zirconia core were compared. The veneering ceramics used were: Ceramics A (initial, GC), Ceramic B (Triceram, Esprident) and C, ceramic (Cercon Ceram S, DeguDent). The reference crown and teeth colors were captured through spectrophotometric (SpectroShade), and color difference (deltae) was observed through this objective method. Besides, the reference crowns and teeth were subjectively compared by 11 blind observers. These authors concluded that the three ceramics complied with the demanding aesthetics only in a limited way. Ceramics B (Triceram, Esprident) had the most predictable results in terms of color stability, surpassing Ceramics C (Cercon Ceram).

Regarding crowns marginal adaptations, there are some studies among which a research will be mentioned (Cehreli *et al*., 2009) where slip cast glass infiltrated Alumina/Zirconia and CAD/CAM Zirconia all ceramic crowns were compared. They used INCERAM Cercon® Zirconia crowns fabricated and cemented with a glass ionomer cement. They used a special system (CDA) to evaluate the restorations quality in the termination marginal line, plaque formation and the results of the gingival index in 6 months, 1 year and 2 follow up appointments per year were used to control the periodontal results of the treatments.

No signs of marginal discoloration, persistent pain and secondary cavities were detected in any of the restorations. According to CDA criteria, the marginal integrity was qualified as excellent for INCERAM Zirconia (73%) and (80%) Zirconia Cercon restorations, respectively. Lack of color coincidence was higher in Zirconia INCERAM restorations (66%) than Zirconia Cercon (26%). Plaque and gingival index results were mostly zero and almost constant with the time.

The changes depending on the plaque time and the gingival index results within and among the groups were statistically similar (p>0,05). This clinical research showed that the unique INCERAM Zirconia restorations and Cercon crowns are comparable in terms of clinic results, as well as in treatment modalities.

The clinical literature examined by a review (Kelly, 2007) the evidence that supports the use of CAD/CAM and the reconstruction with materials strengthened with fiber. Possible tests were identified through the database (PuBMed, EMABSE medication and pharmacology; Center for review and dissemination of New York University, Cochrane Library, manual searching of non- indexed literature, secondary reference searching, and personal contacts with clinical researches as PI). Searching terms included: dental CAM restorations of CAD/CAM, Cerec, Lava, Cercon, Procera, onlay incrustation, dental prosthesis, and fiber reinforced composite (FRC). A total of 76 documents were analyzed in this research. They reach to the conclusion that a great number of independent cohorts support the use of CAD/CAM incrustations of ceramic/onlay restorations and crowns, but there are some complications that inhibit the application of the exam. Perhaps, except for the fiber-based endodontic abutments, the FRC clinic literature seems not to be enough for the experts review. Besides, they agree that in vitro studies nowadays cannot be evidence for the clinical practice, except in limited cases of simple function. Another study (Romeo et al., 2009) concerned with the marginal adjustment of covering crowns asserts that it is an important requirement for success of the long term of this sort of restoration. The study proposal was to verify the marginal adaptation of the assisted design by computer (CAD)/ assisted manufacturing equipment (CAM), the crowns of the prepared teeth. Four kinds of materials: Zirconia veneering ceramics (DCZircon, DCS Dental, Allschwill, CH/S Cercon, Degussa, DeguDent GmbH, Hanau, Germany), copings reinforced with fiber composites (DC-Tell, DCS Dental/ Gradia, GC Europe, Leuven, Belgium), titanium-ceramic coping (DC Titan, DCS Dental/Tikrom, Orotig, Verona, Italy) and veneering titanium composites. Marginal difference values were measured in four points (0 degrees, 90 degrees, 180 degrees and 270 degrees from the center of the vestibular surface) around the termination line, on the prepared teeth. The digital pictures were taken at each point of reference and software was used to measure the quantity of marginal discrepancy in microns.

The results showed that all materials under trial, except for the composites reinforced with fiber, reflect a marginal adaptation within ADA (25-40 mm) specified limits. Among the limits of this study, it was concluded that CAD/CAM marginal adjustment is the restoration within the limits considered clinically acceptable for ADA #8 specifications.

Other investigations (Kohorst *et al.,* 2009) in vitro assessed the marginal adjustment of four Zirconia bridges manufactured by 4 different systems of manufacturing assisted by computer (CAM). Three systems (inLab, Everest, Cercon) are presintered and had to be sintered to the final density after the milling, while with a system (Digident) the restorations were directly done with a material completely sintered.

After the manufacturing, the horizontal and vertical marginal discrepancies were determined by a replica technique. Within these study limitations, it can be concluded that the marginal adjustment depends significantly on the used CAD/CAM system; a more precise adjustment was seen with the restorations done of Zirconia completely sinterized. In order to evaluate the configuration influence of the restoration core in the marginal adaptation in unique previous restorations, Komine *et al.* (2007) used three different CAD/CAM systems: Cercon Smart Ceramic (CE Group), Vita YZ/Cerec In-Lab (YZ/CL group), and Xawex (XA group). Cores of two different configurations (straight and curved) were manufactured for each group. Their marginal adaptation was measured in 60 different points within the complete circumferential margin by a stereomicroscope. The marginal discrepancy values were compared between the two core designs and among the three groups by the t-test.

The general level of statistical significance was 5% after correcting the p values with Bonferroni-Holm method. Among these study limitations, it could be proved that the core marginal configuration influences in the crowns marginal adaptation manufactured with sintered ZrO2 partially independent of the CAD/CAM system used. The present study assessed the marginal and internal adaptation of the Zirconia dioxide veneering ceramic (ZrO2) with three different designs of crowns of the termination line (Aboushelib et al., 2007). In vitro crowns of the upper central incisors were analyzed with the following final line: the straight shoulder (S), rounded shoulder (RS) and chamfer (C). ZrO2 veneering ceramic made with a CAD/CAM (Cercon Smart Ceramic) system, and the crowns were finished with a feldspathic veneering ceramic. The measures for the marginal and internal adaptations were done in two steps. It was shown that the determination line design seems not to influence on the marginal adaptation of the copings and unique crowns of ZrO2.

This study in a way contrasts the previous ones. The aim of other investigations was (Aboushelib et al.,) assessing the Fracture resistance to the impacts of the ceramic systems and proving whether load velocity affects the fracture mechanism. The absorbed energy by Empress and Cercon-Ceram S (IPS) crowns in a trial of fracture resistance was compared by the absorbed energy in a trial of impact resistance. Fractography principles were used to identify the origin of the fracture and to calculate the failure tension. Finite Element Analysis (FEA) system was used to rationalize the results. In spite of the high resistance of the zirconium cores, there was no significant difference in the absorbed energy between the two systems in the trial of impact resistance.

The dominant way of fracture of all the ceramic restoration layers under occlusal load is cone of cracks in the covering ceramics. It was concluded that the covering ceramic resistance has to be improved, to develop the high resistance of the zirconium cores. Some authors studied (Coelho *et al.,* 2009) the fatigue stress behavior of crowns with two zirconium ceramic systems. The mean measures of the crown of a first inferior molar, imported in the CAD software, a tooth preparation was modeled by the proximal walls reduction of 1.5 mm and the oclusal surface of 2.0 mm. The tooth preparation, based on CAD was done with YTZP cores (LAVA system + 3M/ESPE LAVA ceramic, and Vita covering + CERCON frame, Dentsply). All mechanic tests were done by sliding of a WC penetrator of 6.2 mm in diameter 0.7 Weibull and the feasibility of the missions of 50.000 load cycles of 200 N were calculated (Alta Pro 7, ReliaSoft). The only fractured loads were through the zirconium core. The feasibility of a load of a cycle of 200 N x 50K was not significantly different among the systems. LAVA and CERCON showed similar fatigue patterns, the fatigue load of the two systems produces the similar failing ways. Other investigators proposal (Yilmaz *et al*., 2007) was evaluating and comparing the mechanical properties of ceramic base materials as the biaxial flexural strength and resistance fracture tests. Samples were made of ceramic materials (Finesse, Cergo, IPS Empress, In-Ceram Alumina, In-Ceram Zirconio, and Zirconium Cercon) manufactured with 15 mm diameter and a width of 1.2±0.2 mm. Significant differences in the power and values of the hardness of the materials evaluated were found. Cercon (zirconium core material) showed high resistant values to the biaxial flexure and the fracture resistance in comparison to other studied ceramics. Rossenttrit *et al*. (2009), compared resistance to fracture in vitro of elaborated crowns with CAD/CAM systems and crowns in alignment with zirconium. The following materials were analyzed: an electrophoretic deposition of alumina ceramics (Wolceram) and 4 of the systems based in Zirconia (Cercon, DeguDent; Digizon, Amann Girrbach and Lava, 3M ESPE). There were applied 1.200.000 mechanical loads of 50 N; 3.000 thermal cycles with distilled water between 5°C and 55°C (2 minutes per cycle) to evaluate fracture resistance, fracture patterns and defect sizes were determined. It was shown that the fracture strength varied between 1.111 and 2.038 N for the conventional cementing and between 1.181 and 2.295 N for the adhesives.

No significant differences were found between the adhesive and the conventional cementing. Fracture patterns were presented mainly as a spalling of the coating. Besides, it was concluded that the crown material and the cementing do not have any significant influence in the fracture strength. Thus, for these authors, the adhesive cements are not necessary for the high resistance ceramic application (Komine *et al*., 2010: Trushkowsky, 2011; Belli *et al*., 2012; Beier *et al*., 2012).

CONCLUSIONS

The all-ceramic systems used allow at present the restoration confections through varied production methods as modeling and sintering, injection, pressure, gluing, and turning (CAD/CAM), that is, from sintering of a refractory stump to its elaboration with software support.

Its selection will depend on multiple factors, but in our opinion the most important so as to avoid failures, is to gather the necessary knowledge in the use of materials and techniques base on the scientific evidence.

In our experience, marginal adaptation to these restorations is in general exact, even more when they are combined with cementing adhesive techniques that warranty a margin hermetic closing.

Ceramic development is in its boom, constantly improving, and incorporating new technologies for modeling the restorations to become more resistant, precise and for simplifying manufacturing and usage.

FERNÁNDEZ BODEREAU, E.; BESSONE, L. M. & CABANILLAS, G. Restauraciones estéticas de Porcelana Pura. Sistemas de CAD-CAM. ***Int. J. Odontostomat., 7(1)***:151-159, 2013.

RESUMEN: La estética en odontología está orientada a imitar la naturaleza, a tratar de conservar las proporciones, las formas, el color, la simetría. La tecnología ha desarrollado materiales cerámicos libres de metal que han reemplazado a los materiales tradicionales, capaces de imitar mejor a la naturaleza. El óxido de circonio parcialmente estabilizado con itrio, no solo es extremadamente resistente, sino que posee la ventaja de ser altamente translucido. Su translucidez de aproximadamente el 50% de la luz incidente, permite la elaboración de restauraciones con apariencia natural. La duración del proceso de escaneado y fresado dependerá del tamaño del objeto, del número de objetos procesados y de los pasos seleccionados (CAM o CAD/CAM). La estructura de óxido de circonio densamente sinterizado con su preciso ajuste, se cubre con la cerámica de recubrimiento que ha sido especialmente desarrollada para este propósito. En casi todos los casos que se nos plantean hay un solo diagnóstico, pero distintas alternativas de plantear el tratamiento. El éxito de estas restauraciones será predecible siempre que sefundamente en el conocimiento de los principios biológicos que la sustentan. El objetivo de este artículo es exponer de manera concisa las bases teóricas a modo esquemático y las imágenes de la secuencia del tratamiento clínico.

PALABRAS CLAVE: restauraciones estéticas, coronas de porcelana pura, prótesis de CAD-CAM, sistema Cercon.

REFERENCES

Aboushelib, M. N.; de Jager, N.; Kleverlaan, C. J. & Feilzer, A. J. Effect of loading method on the fracture mechanics of two layered all-ceramic restorative systems. *Dent. Mater., 23(8)*:952-9, 2007.

Beier, U. S.; Kapferer, I. & Dumfahrt, H. Clinical long-term evaluation and failure characteristics of 1,335 all-ceramic restorations. *Int. J. Prosthodont., 25(1)*:70-8, 2012.

Belli, R.; Monteiro, S. Jr.; Baratieri, L. N.; Katte, H.; Petschelt, A. & Lohbauer, U. A photoelastic assessment of residual stresses in zirconia-veneer crowns. *J. Dent. Res., 91(3)*:316-20, 2012.

Brukl, C. E. & Ocampo, R. R. Compressive strengths of a new foil and porcelain-fused-to-metal crowns. *J. Prosthet. Dent., 57(4)*:404-10,1987.

Castellani, D. Differential treatment planning for the single anterior crown. *Int. J. Periodontics Restorative Dent.,10(3)*:230-41,1990.

Cehreli, M. C.; Kökat, A. M. & Akca, K. CAD/CAM Zirconia vs. slip-cast glass-infiltrated Alumina/Zirconia all-ceramic crowns: 2-year results of a randomized controlled clinical trial. *J. Appl. Oral Sci., 17(1)*:49-55, 2009.

Chiche, G. & Pinalt, A. *Esthetics of anterior fixed prosthodontics.* Chicago, Quintessence Publishing Co., 1994.

Coelho, P. G.; Silva, N. R.; Bonfante, E. A.; Guess, P. C.; Rekow, E. D. & Thompson, V. P. Fatigue testing of two porcelain-zirconia all-ceramic crown systems. *Dent. Mater., 25(9)*:1122-7, 2009.

Fradeani, M. & Aquilano, A. Clinical experience with Empress Crowns. *Int. J. Prosthodont., 10(3)*:241-7,1997.

Filser, F.; Lüthy, H.; Schärer, P. & Gauckler, L. All-ceramic dental Bridges by direct machining. *Bioceram. Proc. In. Symp. Ceram. Med., 10*:371-6, 1997.

Kelly, J. R. Developing meaningful systematic review of CAD/CAM reconstructions and fiberreinforced composites. *Clin. Oral Implants Res., 18 Suppl 3*:205-17, 2007.

Kohorst, P.; Brinkmann, H.; Li, J.; Borchers, L. & Stiesch, M.

Marginal accuracy of four-unit zirconia fixed dental prostheses fabricated using different computer-aided design/computer-aided manufacturing systems. *Eur. J. Oral Sci., 117(3)*:319-25, 2009.

Komine, F.; Blatz, M. B. & Matsumura, H. Current status of zirconia-based fixed restorations. *J. Oral Sci., 52(4)*:531-9, 2010.

Komine, F.; Iwai, T.; Kobayashi, K. & Matsumura, H. Marginal and internal adaptation of zirconium dioxide ceramic copings and crowns with different finish line designs. *Dent. Mater. J., 26(5)*:659-64, 2007.

Land, C. H. A new system of restoring badly decayed teeth by means of an enameled metallic coating. *Independent Pract.;7*:407-9,1886.

Land, C. H. Porcelain dental art. *Dent. Cosmos, 45*:437-44,1903.

Lou, B. Y.; Chao, Q. Y.; Wang, M.; Lu, Z. & Chao, Y. L. Shortterm follow-up study of Cercon all-ceramic crowns and Bridges. *Hua Xi Kou Qiang Yi Xue Za Zhi, 22(5)*:402-3, 2004.

Luthardt, R.; Sandkuhl, O. & Reitz, B. Zirconia-TZP and alumina--advanced technologies for the manufacturing of single crowns. *Eur. J. Prosthodont. Restor. Dent., 7(4)*:113-9, 2000.

McLean, J. W. *The Science and art of dental ceramics: a collection of monographs*. New Orleans, Louisiana State University, School of Dentistry, Continuing Education Program, 1974-1976.

McLean, J. W. & Hughes, T. H. The reinforcement of dental porcelain with ceramic oxide. *Br. Dent. J., 119(6)*:251-67,1965.

McLaren, E. A. & White, S. N. Survival of inceram crowns in a private practice: a prospective clinical trial. *J. Prosthet. Dent., 83(2)*:216-22, 2000.

Poss, S. CAD/CAM restorations: aesthetic all-ceramics, predictable fit. *Dent. Today, 26(2)*:86, 88, 2007.

Romeo, E.; Iorio, M.; Storelli, S.; Camandona, M. & Abati, S. Marginal adaptation of full-coverage CAD/CAM restorations: in vitro study using a non-destructive method. *Minerva Stomatol., 58(3)*:61-72, 2009.

Rosentritt, M.; Behr, M.; Thaller, C.; Rudolph, H. & Feilzer, A. Fracture performance of computeraided manufactured zirconia and alloy crowns. *Quintessence Int., 40(8)*:655-62, 2009.

Sailer, I.; Holderegger, C.; Jung, R. E.; Suter, A.; Thiévent, B.; Pietrobon, N.; *et al.* Clinical study of the color stability of veneering ceramics for zirconia frameworks. *Int. J. Prosthodont. 20(3)*:263-9, 2007.

Shillingburg, H. T.; Hobo, S. & Whitsett, L. *Fundamentos de Prostodoncia Fija*. Chicago, Editorial Quintessence Publishing Co. Inc., 1981.

Trushkowsky, R. D. Esthetic and functional consideration in restoring endodontically treated teeth. *Dent. Clin. North Am., 55(2)*:403-10, 2011.

Yilmaz, H.; Aydin, C. & Gul, B. E. Flexural strength and fracture toughness of dental core ceramics. *J. Prosthet. Dent., 98(2)*:120-8, 2007.

Correspondece to:
Dr. Enrique Fernández Bodereau
Professor and Chair
Department of Clinical Prosthodontics
Dental School
National University of Córdoba
Ituzaingó 1035
Córdoba
ARGENTINA

Phone: 03514606019

Email bodereau@uolsinectis.com.ar
laurabessone@hotmail.com

Received: 08-08-2012
Accepted: 02-01-2013