Endocrowns: A retrospective patient series study, in an 8-to-19-year period

Borgia Botto, Ernesto*, Barón, Rosario**, Borgia Botto, José Luis***

Abstract

**Purpose.** The aim of this paper is to present the retrospective clinical performance of 11 endocrowns, placed in a single private practice in an 8-to-19-year period. **Materials and Methods.** Inclusion and exclusion criteria for the sample and the restorations were established. One hundred and thirty patients were selected at random. Eleven endocrowns had been placed in 11 patients. Three restorative materials and three resin cements were used. Cohen's Kappa coefficient, on the quality analysis of the restorations, ranged from 0.78 to 1. Due to the small sample, inferential statistical methods could not be used. Therefore, statistical descriptive methods were applied. **Results.** At the moment of the clinical examination, 10 (90.9%) endocrowns were in function and 1 failed (9.1%). **Conclusions.** Endocrown is a conservative and aesthetic technique-sensitive procedure used to restore posterior endodontically treated teeth, mainly molars, with a very good biomechanical and functional performance, and very acceptable longevity.

**Keywords:** Endodontically treated teeth, bonded onlays, restoration without post, aesthetic, adhesion.

Disclosure

The authors declare no conflicts of interest related with this study.

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Introduction
The rehabilitation of posterior endodontically treated teeth (PETT) always poses a challenge to dentists. Biological factors (periodontal and/or endodontic prognosis, assessment of the individual caries risk, root anatomy and coronal remnant tissues) and functional factors (gender, parafunctional habits, location of the tooth in the dental arch and the role of the tooth in the whole treatment), must be considered before making a treatment decision. Therefore, in some clinical situations, the restorative procedure arises from a multidisciplinary and/or interdisciplinary approach. Moreover, clinical studies have shown no statistically significant differences in the success rate of endodontically treated teeth (ETT) restored with or without posts (1-4). One of the options to restore a PETT without posts is the restorative procedure introduced by Pissis in 1995 (5), described as the “mono-block porcelain technique”, later known as Endocrown (EC). Pressed lithium-disilicate ceramic, CAD-CAM feldspathic ceramic, CAD-CAM lithium-disilicate ceramic and CAD-CAM resin nanoceramic are the materials and techniques more widely used for ECs nowadays (6). Nevertheless, clinical studies are scarce and there is not enough scientific-based evidence. There are some reports of one or two clinical cases (7-9) and a few longitudinal clinical studies that do not extend beyond twelve years (10-13). Therefore, it might be interesting to discuss the clinical results of a small but well-documented group of patients with ECs. The aim of this paper is to present the retrospective clinical performance of 11 ECs, placed in a single private practice, in an 8-to-19-year period.

Materials and Methods
This work has been approved by the Ethics Committee, School of Dentistry, Universidad de la República. Montevideo, Uruguay. In April 2013, the first author decided to conduct a retrospective longitudinal clinical study of several restorative procedures performed by himself in his private office, for approximately 44 years. Therefore, a comprehensive database was required, which could only be obtained from the personal records and the clinical examination of current patients that had been treated at the office for an extended period of time. The inclusion criteria for the sample were: the patients must have been treated and evaluated in the first author’s office for at least 7 years and still in the practice up to 2013, with complete dental arches and a normal occluding relation. The patients with Removal Dental Prosthesis, disabilities, who had moved or passed away were excluded. Of 2552 registered patients, 210 met the inclusion criteria. A sample of 140 patients was considered adequate by the authors and they were selected at random by a dental assistant unaware of the aim of the selection. These 140 patients were invited to participate in a clinical examination, between November 2013 and April 2014: 130 agreed to participate, whereas 10 declined for personal reasons. A written informed consent form was signed prior to the examination. The EC must have been in function for at least five years to be included in the study. Failure criteria: loosening, removal of the restoration, endodontic or periodontal pathologies or tooth loss. Data from clinical history and examination were collected on each patient and registered on specially designed spreadsheets. The co-authors participated as independent evaluators and the calibration between the
authors had been done previously on 120 restorative procedures outside the sample. The clinical examination was performed with a mirror and a sharp explorer. An x-ray was taken in each PETT. The assessment of the restorations was blind between the authors. Cohen’s Kappa Coefficient (14) on the quality of the restorations and the radiographic examination ranged from 0.78 to 1 [(excellent according to Fleiss guidelines (15)]. In cases of disagreement regarding quality assessment of the restorations, the lowest rating was recorded.

<table>
<thead>
<tr>
<th>MARGINAL ADAPTATION</th>
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<tr>
<td>Alpha: No lack of continuity along the margin as observed with the explorer.</td>
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<tr>
<td>Bravo: Evidence of a crevice along the margin, but the explorer cannot penetrate.</td>
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<tr>
<td>Charlie: Evidence of a crevice along the margin, into which an explorer can penetrate. Requires control, repair or retreatment.</td>
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<th>MARGINAL DISCOLORATION</th>
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<tr>
<td>Alpha: No pigmentation anywhere on the margin.</td>
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<tr>
<td>Bravo: Pigmentation present but does not penetrate along the margin toward the pulp.</td>
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<tr>
<td>Charlie: Severe pigmentation. The restoration must be removed.</td>
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<th>SURFACE</th>
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<td>Alpha: The surface of the restoration is unaltered.</td>
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<tr>
<td>Bravo: The surface of the restoration shows wear, and must be controlled.</td>
</tr>
<tr>
<td>Charlie: The surface of the restoration shows perforations, fractures or significant tear. It must be polished, repaired or retreated.</td>
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Table 1 Modified Ryge criteria

Out of 270 PETT studied, 26 (9.6%) were restored without posts. Of these, 11 were rehabilitated with an EC (4.1% of the total sample) in 11 patients. Ten patients were called back in September 2015 for a new clinical control, of whom nine attended. As the other patient was out abroad, this patient was contacted by telephone and reported no problem related to the EC in tooth #26. The patient was included in the study with the previous data.

Marginal Adaptation, Marginal Discoloration and Surface were the variables studied to establish the quality of the restorations, following Ryge criteria (16) as modified by the authors (Table 1). The Success Criteria were defined by the authors according modified Ryge criteria and the statements of Anusavice (17) and grouped as follow:

- **Excellent (Ex):** When restorations are rated “Alpha” on Marginal Adaptation, Marginal Discoloration and Surface.
- **Good (G):** When restorations are rated “Bravo” on Marginal Adaptation and/or Marginal Discoloration and/or Surface.
- **Functional Survival (FS):** When restorations are rated “Charlie” on Marginal Adaptation and/or Marginal Discoloration and/or Surface.
- When considered jointly, Excellent and Good were rated as Clinical Success.

From the beginning of the attention, the caries risk was assessed in each patient, they were enrolled in a comprehensive prevention plan and advised to undergo periodical maintenance therapy.

Tooth preparation is considered by the operator as the most important factor in the clinical success of restorative treatment. It must be based on a conservative approach, according to the extension of the carious lesion, remnant tooth structure, location of occlusal contacts, crown height, occlusal plane, habits of the patient, biomechanical properties of the restorative materials and aesthetic considerations.

According to the authors of this paper, *Endocrown can be defined as the partial or total coronal restoration of a PETT, with a material manufactured indirectly, anchored in the pulp chamber, always covering the entire occlusal surface and bonded to the remaining tooth.*
Three restorative materials and three resin cements were used (Table 2). Ruber dam isolation is mandatory for luting EC. It must follow the manufacturer’s instructions on handling the resin cement. After placed, excess cement was removed with dental floss and/or disposable brushes. The EC should be kept in place until the end of polymerization. Light-polymerization was alternatively applied for 40-60 seconds from the buccal, lingual, occlusal and mesial and distal interproximal surfaces. The margins of the restorations were covered with glycerin gel to prevent an oxygeninhibited layer. A quartz-tungsten-halogen light-curing unit was used until 2002, and later a light-emitting diode (LED) was used. Before completing the procedure, a thorough functional control of occlusion was performed.

The variables evaluated were: age, gender, period of clinical attendance, tooth preparation, restorative material, type of cement, quality and longevity of restorations, parafunctional habits, distribution in the dental arches, secondary caries and maintenance therapy.

Given the small sample, inferential statistical methods could not be used; therefore, statistical descriptive methods were applied.

Results

The sample consisted of 9 women and 2 men, yielding a ratio of 4.5 women/men. The mean age was 52 years and 8 months in women (range: 27 to 75) and 67 years in men (range: 65 to 69). The lifespan over which the patients were treated in the practice varied between 7 and 43 years. The average was 18 years and 1 month. At the time of the examination, 10 (90.9%) ECs were in function in 10 patients. One EC had been lost after 12 years and 9 months due to periodontal disease in tooth #26. No restoration had loosened. Neither secondary caries nor radiographic failures were observed in the 10 PETT in function (Figs. 1a,1d; 2c; 3c,3d; 4c).

Fig. 1a Initial state in tooth #26. Buccal-Distal root must be resected.

Fig. 1b Tooth preparation for EC in #26.

Fig. 1c EC after 9 years (Gradia, GC Corp., Japan)), (SC = Ex).
Fig. 1d X-ray control after 9 years.

Fig. 2a Preparation for EC in tooth #34.

Fig. 2b EC in #34 after 19 years (IPS-Empress, Ivoclar, Vivadent, Liechtenstein). The glass-ionomer in gingival had a survival time of 23 years and needed to be repaired, (SC = G).

Fig. 2c X-ray control after 19 years.

Fig. 3a Preparation for EC in tooth #46. A chamfer was performed on buccal wall.
Fig. 3b EC after 18 years (IPS-Empress, Ivoclar, Vivadent, Schaan, Liechtenstein). Note the parafunctional wear facets, the gingival recession and the non-caries cervical lesion. This patient refused to wear nocturnal stabilization splint, (SC = G).

Fig. 3c Final control of endodontic treatment.

Fig. 3d X-ray control after 18 years.

Fig. 4a Preparation for EC in tooth #26. A chamfer was performed on buccal, distal and palatal walls.

Fig. 4b EC after 10 years (IPS-Empress) (SC = Ex).

Fig. 4c X-ray control after 10 years (a=years).

Three ECs in function were placed in maxillary molars, 5 in mandibular molars and 2 in mandibular premolars, yielding a ratio of 4.0 molars/premolars (Table 2).
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Tooth Restoration Material Cement Marginal adaptation Marginal discoloration Surface Date of place Survival time
34 ON/DO IPS-Empress Dual Cement BRAVO ALPHA ALPHA 9/1996 19y
46 ON/MOD IPS-Empress Relyx ARC ALPHA ALPHA BRAVO 7/1997 18y 2m
44 ON/MOD Isosit-IO Relyx ARC BRAVO BRAVO ALPHA 9/2001 14y
16 ON/MODP Gold Alloy Panavia ALPHA ALPHA ALPHA 12/2001 13y 9m
26 ON/MO Isosit-IO Dual Cement FAILED FAILED FAILED 10/95 12y 9m
38 ON/MO IPS-Empress Relyx ARC ALPHA ALPHA CHARLIE 9/2003 12y
26 ON/MODBP IPS-Empress Relyx ARC ALPHA ALPHA ALPHA 9/2003 10y 2m
46 ON/DO IPS-Empress Relyx ARC ALPHA ALPHA ALPHA 5/2006 9y 4m
26 ON/MO Gradia Relyx ARC ALPHA ALPHA BRAVO 9/2006 9y
48 ON/MODB IPS-Empress Relyx ARC ALPHA ALPHA ALPHA 3/2007 8y 6m
46 ON/MOD IPS-Empress Relyx ARC ALPHA ALPHA ALPHA 4/2007 8y 5m

Table 2. Endocrowns: tooth location, tooth preparation, restorative material, type of cement, quality of the restorations, mean survival. (ON=onlay; MO=mesial-occlusal; DO=distal-occlusal; MODB=mesial-occlusal-distal-buccal; MODP=mesial-occlusal-distal-palatal; y=years; m=months).

The observed mean survival time of 10 PETT still in function was 12 years and 3 months. The pattern standard deviation was 3 years and 11 months (95% CI, 2 years and 10 months - 6 years and 5 months).

Two small “chippings” in occlusal surfaces were polished. However, the Success Criteria on the quality of the restorations was rated as follows: Excellent 5 (50%), Good 4 (40%) and Functional Survival 1 (10%) (Table 2). Furthermore, at the clinical examination, 2 asymptomatic patients had parafunctional wear facets (the activity was not assessed) and 5 were using nocturnal stabilization splints. If these 2 groups of patients were considered together, 7 (70%) of the 10 patients in the observed period had or had had a history of parafunction.

Five patients (50%) underwent maintenance therapy at least once a year.

Discussion

There is not enough scientific-based evidence on the clinical performance of EC. In fact, longitudinal clinical studies are scarce. Lander and Dietschi (7) presented 2 successful cases in a 3 year-period; Biacchi et al (8) one case in a 3 year-period and Fages and Bennasar (9) one case without a follow-up. After one year, Otto (10) found that Bravo increased from 30% to 55% on Marginal Adaptation in 10 EC. Meanwhile, Bernhart et al (11) in 20 ECs, had a success rate of 90% in two years.

In this paper, 90.9% (10) of ECs remained in function, with an observed mean survival time of 12 years and 3 months. Considering the quality of the restorations in function, 90% of Clinical Success was observed. This is better than the result reported in four articles reviewed (7-10) and could be similar or better than Bernhart et al (11) if we consider the high percentage of failures observed in only two years.
On the other hand, Otto and Mörmann (12) in 25 ECs had a success rate of 90.5% in molars and 76% in premolars up to 12 years, and Bindl et al (13) in a 7-year-long prospective study of 86 ECs (70 molars and 16 premolars), the success rate was 80% in molars and 68.8% in premolars. These authors concluded that ECs appeared inadequate for premolars.

Considering the ratio molar/premolar in this work, it was similar to Otto and Mörmann (12) and Bindl et al (13). The location in the dental arches didn’t influence the clinical outcome in this study. Moreover, the percentage of ECs in function was similar to that observed by Otto and Mörmann (12) and higher than the results in Bindl et al (13). Besides, 14 ECs were loosening in Bindl et al (13) and none in this paper.

Therefore, the clinical results in this paper were better or similar than the results reported in the articles reviewed (7-13). In spite of this, differences in sample sizes between this study and two articles abovementioned (12, 13) could restrict the comparisons made.

On the other hand, several clinical studies concluded that the coronal remnant was the most important factor in the clinical success of ETT (18-21). Therefore, a conservative approach is essential in tooth preparation for EC. According to the above definition, the entire occlusal surface must be covered by the restoration. Onlays mainly transmit compressive forces on the tooth-restoration adhesive interface, improving biomechanical behavior (22-4). A 3 mm of occlusal reduction was suggested (25); a higher fracture resistance was found when increasing occlusal thickness (26). Furthermore, if the buccal and/or palatal/lingual walls have a thickness greater than 2.0 mm, a 1.2 mm chamfer in the occlusal wall could have a ferrule effect, improving the fracture resistance of the teeth and the retention of the restoration (Figs. 3a, 4a).

The inner walls of the coronal portion and the pulp chamber must have an occlusal divergence greater than 6°. Retentions or undercuts must be locked with glass-ionomer cement and a layer of this cement was dispensed in the floor of the pulp chamber. In this study, four preparations had three coronal walls (Figs. 1b, 2a), four had two walls (Fig. 3a) and two covered at least four surfaces. Besides, extending the preparation to the buccal surface is only considered for aesthetic reasons or given reduced dimensions of the wall. In the latter situation, 1.2 mm of axial reduction in the buccal wall with a chamfer finish line was performed (Fig. 4a).

These criteria are not in accordance with the total coronal reduction proposed by Fages and Benassar (9).

Meanwhile, when proximal boxes must be performed, they must follow the established protocols for bonded ceramic inlays/onlays (27,28). The authors disagree with Rocca and Krejci (29), who partially restore these surfaces with direct light-activated composite resin, increasing the number of interfaces and reducing the surface for bonding the EC. Therefore, the above discussed criteria in teeth preparations and the presence and preservation of coronal teeth structure could have improved the clinical results in this study.

Furthermore, recent laboratory studies have shown: 1) teeth restored with ECs were potentially more resistant to failure than those with FRC posts (30, 31) or had similar fracture resistance (32-36); 2) by eliminating the use of a post and filling core, the number of adhesive bond interfaces is reduced, thus making the restoration less susceptible to the adverse effects of degradation of the hybrid layer (8), and 3) using resin nanoceramic blocks for the manufacture of
ECs may result in better fracture resistance and a more favorable fracture mode than other investigated ceramic blocks, but more microleakage might be expected with this material (37).

Meanwhile, dual and chemical curing resin cements, performed better than light or self-etching curing resin cements, in laboratory and clinical research (38-44). Nevertheless, increasing the exposure time through different thickness of ceramic materials and using high power light-emitting diode (LED) curing units, recent laboratory studies have found a greater degree of conversion and after 24 hours, greater microhardness values in light and dual-polymerization resin cement (45, 46). Therefore, the clinical procedures and the types of cements used, could have influenced the good Clinical Success (90%), (Figs. 1c, 2b, 3b, 4b).

In a recent publication, bruxism was statistically found as the highest factor risk of fractures in ETT (47). In the present paper, 7 patients (70%) had or had had history of parafunction, which is in relative accordance with epidemiological studies of bruxism and TMD (48, 49). Moreover, when considering gender as a variable, men develop stronger forces than women (50). In this paper, gender could have improved the clinical outcome (ratio: 4.5 women/men). However, in the work of Bindl et al (13), the patients with a history of TMD were excluded from the sample. Therefore, this criterion might have improved their clinical results.

Besides, there were no secondary caries in this study. This outcome might be due to the fact that individual caries risk was assessed, the patients were enrolled in a comprehensive prevention plan and ongoing periodical maintenance therapy. Still, only 50% of the patients attended the clinic at least once a year.

The variables age, restorative material and maintenance therapy, cannot be studied in this work, due to the small sample and only one restoration failed.

Therefore, EC can be indicated in almost all cases of PETT, mainly molars, especially in short crowns, calcified root canals and very slender roots. It is contraindicated when the thickness of the wall at the cervical margin is less than 2mm.

Moreover, longevity of posterior restorations depends on factors related to the material, the patient and the operator (51, 52). In the present study, all restorations were performed by an experienced operator, which might have improved the clinical results.

Conclusions

According the high clinical success rates and within the limitations of this study, we could conclude that Endocrown is a conservative and aesthetic procedure to restore PETT, mainly molars, which is technique-sensitive, with very good biomechanical and functional performance, and very acceptable longevity. Furthermore, despite the small sample, our results highlight several factors that must be considered to achieve an excellent clinical outcome.

Further clinical investigations should be conducted to determine the long-term success of larger samples of endocrowns, performed with different materials.

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