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Evaluation of Cerec Endocrowns: A Preliminary Cohort Study

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Abstract - *This study aimed to evaluate clinical qualities and evolution on ceramic endocrowns produced with the Cerec 3D (Sirona). Endocrowns were produced in a hospital environment and evaluated according to the FDI criteria on the day of placement and 6 months afterwards. Each item was graded from 1 (good) to 5 (bad). A global score, as well as a score for aesthetics, functioning and biological integration was assessed for each evaluation. During the 6-month evaluation period, the scores were always related to good clinical quality, except for single crown restoration. The scores did not change between the two periods of evaluation.*

KEYWORDS: Cad/Cam, Cerec, Endocrown, FDI criteria

INTRODUCTION

Carious or traumatic lesions sometimes need to be rehabilitated using prosthesis. Various treatment options are available, based on the amount and resistance of residual coronal tissues. Intraradicular anchorage might be necessary when half of the coronal structure is missing[1]. A post is therefore cemented in the main root of the tooth, allowing better crown retention. However, many studies have shown that preparation for post fitting and even the presence of posts can adversely affect the resistance of the root to fracture, instead of strengthening it[2]. Perforations and failure rate are also more common[1,3]. Consequently, enhancing crown retention is the only indication for intraradicular anchorage.

The concept of maximal tissue preservation can be implemented thanks to the development of adhesive techniques[1,4,5]. At present, a post can be eliminated by using these techniques provided that the bonding surface is sufficient, limiting the risk for radicular fracture or failure, thus improving the long-term prognosis[1,3].

Endocrowns comply with these conservative principles. Preparation consists of a circular butt-joint margin and a central retention cavity inside the pulp chamber and does not include intraradicular anchorage. Endocrowns restore the occlusal surface and part of the dental walls: preparation should be supra-gingival to facilitate dental impression and adhesion by using a rubber dam. Retention is therefore increased due to optimal use of the margin located on the enamel to ensure adhesion. As the margins are supra-gingival, using endocrowns allows complete conservation of the sulcus and of the periodontal space in general. Therefore, designing endocrowns eliminates the need for pre-prosthetic periodontal surgery.

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Endocrowns were first proposed by Pissis[6], and were fabricated traditionally with a physical impression after preparation, and intervention by a dental technician with hot-pressed ceramics. Another method using CAD/CAM has emerged more recently. Using Cerec for preparing endocrowns has numerous advantages, in particular the rapidity of treatment: a single session allows sealing of the treated endodontic teeth without using an interim restoration. Some studies have shown that the occlusal surfaces of posterior teeth restored with Cerec were more compatible with occlusal surfaces of teeth before preparation than with those prepared by a dental technician using wax up[7,8]. The main advantage of this technique is that the fabrication process can be managed and controlled. Moreover, the ceramic material used in this technique has many advantages: its hardness and resistance to abrasion are close to those of natural teeth, and its frictional wear rate is similar to that of enamel[9].

To date, only a few studies on clinical reliability have been conducted, perhaps because of the lack of available evaluation tools. Until recently, the most commonly used evaluation criteria, such as the USPHS or Ryge criteria, were incomplete concerning the carious process and the new material used. The USPHS criteria lack sensitivity; for example, the evaluation for the anatomic form criterion is based only on the continuity between the restoration and the tooth. However, this measure is not sufficient to assess the aesthetic and functional items. To avoid this problem, many authors used its own modified Ryge criteria, which created a body of literature extremely difficult to compare. Despite this, numerous studies have been performed using the USPHS criteria and adapted to study objectives[10–12].

But new clinical evaluation criteria, better adapted to current objectives, for direct and indirect restorations have been available since 2007, namely FDI World Dental Federation criteria[13]. These criteria are divided into 3 groups (aesthetic, functional and biological parameters) and permit using a range of selected items for a specific study. Data can then be individualized in order to improve calibration and compare different studies[14]. Differences in restoration

quality can be easier to establish by increasing the number of scores available for each criterion[14]. Moreover, a web-based training and calibration tool *(e-calib)* for FDI criteria is available to investigators, leading to more homogeneous and consistent results[15].

This main objective of this study was to evaluate the quality of endocrowns produced in a hospital setting at the moment of restoration and after 6 months.

MATERIAL AND METHODS

Study Design

This preliminary study was performed on patients visiting the dental hospital and treated with molar or premolar endocrowns. Agreement of the local ethical committee was obtained. The study was performed by four examiners, namely two undergraduate students in their last year of studies and two teachers of the Clermont-Ferrand Dental School (University of Auvergne, France). The evaluations took place on the day of the crown fitting and 6 months afterwards. Students and teachers evaluated each crown separately.

Subjects

The participants in the study were patients visiting the Dental Hospital of Clermont-Ferrand (France) scheduled for molar or premolar prosthetics restorations with at least one endodontically treated tooth.

Inclusion criteria were:

- presence of teeth in opposite arch with normal occlusion,
- absence of para-functional habits
- supra-gingival margin after preparation.

Exclusion criteria were:

- the presence of teeth whose coronal anatomy did not allow use of rubber dam for optimum bonding,
- the lack of cooperation of the patients to perform a postoperative radiograph and use a rubber dam for bonding.

Prosthodontic procedure

Crown preparation: the occlusal preparation consists of a circular butt margin with a reduction of at least 2 mm in the axial direction. The pulp chamber is tapered with a cylindrical-conical diamond bur, in order to make the coronal pulp chamber and the endodontic access cavity continuous[16]. This step is usually quick and simple as the access cavity for endodontic treatment frequently meets these criteria. Walls less than 2 mm thick were automatically removed.

An optical impression (Blue Cam, SIRONA) was performed after tooth preparation. Consequently, design with a virtual model die with possible modifications made by the operator was performed. Then, the following steps were carried out: choice of shade, processing the ceramic blocks, trial fitting, glazing and characterization of the crown. Bonding was performed using a rubber dam and self-adhesive cement (Relyx Unicem 3M Espe), after preparation of the ceramic according to the manufacturer's suggestions and finishing (checking occlusion and contact surfaces). The ceramic blocks used were Vita Mark II.

Experimental procedure

All the examiners had been trained in evaluation by using the e-calib web-based tool according to a standardized procedure[15]. After bonding, each endocrown was evaluated separately the same day and under similar conditions by one student and one teacher (T1). A Bitewing postoperative radiograph was performed. The same procedure was repeated 6 months after restoration (T2).

Endocrown evaluation

An evaluation form based on the FDI (World Dental Federation) clinical evaluation criteria for direct and indirect restorations was designed by the investigators[15]. These 16 criteria were divided into 3 groups: aesthetic properties (surface gloss and roughness, surface staining, colour match and translucency, anatomical form), functional properties (fracture and restorative retention, marginal adaptation, occlusal contour and wear, proximal contact point and food impaction, radiographic examination, patient's view) and biological properties (post-operative hypersensitivity and pulp vitality, recurrence of caries/erosion/abfraction, tooth integrity, effect on the periodontium, adjacent mucosa, general and oral health). The tool was adapted for the evaluation of endocrowns on the basis of their intrinsic properties: post-operative hypersensitivity/pulp vitality and occlusal contour and wear were removed from the list of items. The latter item was removed because evaluating wear is unnecessary during the first phase of the evaluation. Furthermore, using impression and tools like a profilometer was not compatible with an observational study of this nature.

The 14 remaining criteria were conserved and their subdivision maintained. Each item was scored from 1 (clinically very good) to 5 (clinically poor). The score 1 to 3 corresponded to satisfactory. Repair was indicated when an item was scored "4" and the replacement of the endocrown was necessary for a score of "5".

Statistical Analysis

For each endocrown analysed, a mean score was calculated (min =14, max=70). A global score concerning each of the aesthetic items (min=4, max=20), functional items (min=5, max=25) and biological items (min=5, max =25) was also calculated. For each evaluation, differences between the "teachers" and the "students" evaluations were analysed according to a paired Student t-test (α=0 .05). The impact of the type of tooth (molar or premolar) and the location of endocrowns (maxilla or mandible) on each score was calculated with a general linear model. The variation of scores between the 2 evaluation times was analysed with a repeated model procedure.

RESULTS

Endocrowns (11 molars and 5 premolars) from 16 patients (mean age 43±18; 10 women and 6 men) were evaluated. Eight endocrowns were located in the maxilla and 8 in the mandible.

The mean score of FDI criteria was 18.1±2.9 for the juniors and 17.4±3.2 for the seniors, at T1; and 18.3±5.4 for the juniors and 17.2±4.1 for the seniors, at T2. The value for each section is outlined in the Tables 1 and 2. The minimum score was obtained for the biological values (items 11 to 16 of the FDI criteria) and the maximum score for the colour match and translucency (see Table3).

The score did not vary in relation with the location (maxilla or mandible) and the type of tooth (premolar or molar) treated in either evaluation period. Likewise, no difference could be seen between the "students" and "teachers"' evaluations (Figure 1A and 1B). Scores between T1 and T2 did not change except for the biological score evaluated by students ($p<0.05$) (Figure 2A and 2B). At T2 (6 months), only one endocrown scoring above 4 (secondary caries) had to be replaced.

DISCUSSION

The main objective of this study was to evaluate the quality of posterior restorations with Cerec-ceramic endocrowns. Modified FDI criteria were used for evaluations that were conducted on the day of the fitting and 6 months afterwards, by 2 investigators (one student and one teacher).

At 6 months, the clinical results showed that 15 out of the 16 restorations performed were acceptable and therefore demonstrated the value of using Cerec-ceramic endocrowns as a therapeutic procedure. Only one restoration was unacceptable due to the presence of decay under the proximal margin. An enamel demineralization was visible on the radiograph of the first time evaluation and should have been included in the preparation of the endocrown. This error can be explained by the functioning of the hospital dental care unit where the endodontic treatment and the designing of the crown are performed by two different practitioners.

The main advantage of Cerec, compared to the hot pressed technique described by Pissis[6], is the restoration in one visit. However, the hot pressed technique is still in use, like in the case report described by Lander and Dietschi in 2008[1]. For onlay preparations which are similar to endocrowns preparation, there is no difference between the two techniques regarding the marginal adaptation[17]. A clinical study about all ceramic crowns showed the same result.[18] The use of ceramic can be discussed compared to the use of composite. In a study that compared the use of composite versus ceramic for Cerec endocrown, the composite presented a better adaptation[19]. However, a clinical study on direct restoration using composite showed worst results than when using Cerec inlays. Indeed, Lange and Pfeiffer[20] in 2009 stated that the survival rate of inlay restoration was no different from that of posterior restoration with composite material. However, ceramic inlays showed better results after one year for marginal adaptation, anatomical form, marginal staining, and colour stability. Secondary caries and surface aspect were similar for both materials. A recent systematic review shows the same result with a superiority of ceramic inlays[20]. Likewise, no difference was shown between the fracture rate of gold partial crowns (or onlays) and that of ceramic onlays[22]. Similarly, the survival rates of Cerec restorations and gold onlay restorations, also known as "gold standard", remained comparable[23]. The conclusions of this latter study stated that Cerec–ceramic restorations behave better in the long-term (10 year study) than direct restorations and can be considered as a sustainable alternative for direct and laboratory-manufactured restorations. When placed on posterior teeth, glass-ceramic crowns present similar failure rates to those of metal-ceramic crowns[24]. Up to now, Cerec endocrowns have not been evaluated separately from other types of Cerec crowns, but since they are manufactured using the same glass-ceramic blocks, it can be assumed that the results from former studies are transposable. Specific studies are nonetheless required due to the particular characteristics of endocrowns (preparation geometry).

So far, studies describing the aesthetic properties of posterior prostheses have been performed on conventional crowns. In this case, bonded all-ceramic prosthetic restorations provide the most natural aesthetic result compared to porcelain-fused-to-metal crowns, due to the absence of a metal component. This absence of multiple materials (ceramic and metal) allows restorations even in the case of low tooth height[24,25]. Moreover, the problem of gingival staining of surrounding soft tissues is prevented. These results are transposable to endocrowns concerning the absence of gingival staining and the absence of metal component. The maximum value obtained for the colour match and translucency can be explained by the position of the labial limit which is difficult to conceal if distant from the cervical limit. To avoid this phenomenon, also observed in the case of onlays, a specific preparation known as "veneerlay" was proposed[26].

However, the limitations of this study were its small sample size (16 restorations) and the follow-up period, which was too short for the evaluation of the survival rate of prosthetic restorations. In another study, the survival rate of premolar endocrown decrease between 12 and 65 months[27], while the finite element analysis shows that the use of endocrown is possible for premolars[28], and this method of restoration is one that causes the least fracture with an equal longevity[29]. Ideally this present study should be undertaken with a longer follow-up design.

Furthermore, the evaluation of the marginal fit was made using a visual examination completed with an intra-oral radiograph (Bitewings) evaluation. The accuracy and the sensitivity of the combination of these methods were not evaluated and/or compared to a gold standard. The dental probe, used in many studies, was not chosen here because of the FDI criteria definition. Many others methods were described like the use of silicone impressions, but it can only be used during the first evaluation, and does not allow monitoring of the marginal fit[30]. In future studies, the use of the probe could be evaluated and compared to the combination of visual exam and radiograph. The evaluation of the colour match on the day of the bonding is another limit to this study, because of the dehydration of the teeth caused by the use of rubber dam. In future studies, the evaluation of endocrowns will be performed between 24 hours and one week after the bonding.

Table 1. *Specific and global FDI scores obtained at the first studies step for each restoration according clinical aspect (Occlusal scheme and opposing teeth) and type of teeth.*

Restoration	*Occlusal Scheme*	*Opposing teeth*	*Teeth type (premolar or molar)*	*Aesthetic properties*		*Functional properties*		*Biological properties*		*Score FDI*		*Number of non-acceptable criterion*	
				J	S	J	S	J	S	J	S	J	S
1	Group function extended to the affected tooth	All ceramic crown	Premolar	4	5	7	6	5	5	16	16	0	0
2	Group function extended to the affected tooth	Teeth with resin composite restoration	Molar	5	4	6	6	6	5	17	15	0	0
3	Group function no extended to the affected tooth	Teeth with amalgam restoration	Molar	4	4	6	5	5	5	15	14	0	0
4	Group function no extended to the affected tooth	Ceramo-metallic crown	Premolar	4	6	6	5	6	5	16	16	0	0
5	Group function no extended to the affected tooth	Ceramic onlay	Molar	5	5	7	6	5	6	17	17	0	0
6	Canine guidance	All ceramic crown	Premolar	5	5	6	15	5	5	16	25	0	0
7	Canine guidance	Teeth with amalgam restoration	Molar	4	5	6	7	5	5	15	17	0	0
8	Canine guidance	All ceramic crown	Premolar	6	6	12	5	6	5	24	16	0	0
9	Canine guidance	Natural teeth	Molar	5	6	7	5	5	5	17	16	0	0
10	Group function no extended to the affected tooth	Ceramic onlay	Molar	10	10	10	9	5	5	25	24	0	0
11	Group function no extended to the affected tooth	Natural teeth	Premolar	5	7	8	8	5	5	18	20	0	0
12	Group function no extended to the affected tooth	All ceramic crown	Molar	7	5	6	9	6	5	19	19	0	0
13	Canine guidance	All ceramic crown	Molar	6	5	6	6	6	5	18	16	0	0
14	Canine guidance	Teeth with amalgam restoration	Molar	6	4	5	5	6	5	17	14	0	0
15	Canine guidance	Natural teeth	Premolar	4	6	10	7	6	5	20	18	0	0
16	Group function extended to the affected tooth	Natural teeth	Premolar	6	4	8	7	6	5	20	16	0	0
				5.4±1.5	5.4±1.5	7.3±1.9	6.9±2.5	5.5±0.5	5.1±0.3	18.1±2.9	17.4±3.2	0	0

Table 2. *Specific and global FDI scores obtained at the second studies step for each restoration according clinical aspect (Occlusal scheme and opposing teeth) and type of teeth.*

Restoration	*Occlusal Scheme*	*Opposing teeth*	*Teeth type (premolar or molar)*	*Aesthetic properties*		*Functional properties*		*Biological properties*		*Score FDI*		*Number of non-acceptable criterion*	
				J	S	J	S	J	S	J	S	J	S
1	Group function extended to the affected tooth	All ceramic crown	Premolar	4	4	7	7	5	5	16	16	0	0
2	Group function extended to the affected tooth	Teeth with resin composite restoration	Molar	5	8	6	6	5	5	16	19	0	0
3	Group function no extended to the affected tooth	Teeth with amalgam restoration	Molar	5	4	7	5	5	5	17	14	0	0
4	Group function no extended to the affected tooth	Ceramo-metallic crown	Premolar	5	4	7	6	5	5	17	15	0	0
5	Group function no extended to the affected tooth	Ceramic onlay	Molar	4	6	7	7	5	5	16	18	0	0
6	Canine guidance	All ceramic crown	Premolar	8	6	6	16	5	5	19	27	0	0
7	Canine guidance	Teeth with amalgam restoration	Molar	7	4	8	6	8	5	23	15	1	1
8	Canine guidance	All ceramic crown	Premolar	9	6	14	7	8	6	31	19	0	0
9	Canine guidance	Natural teeth	Molar	7	6	6	6	5	5	18	17	0	0
10	Group function no extended to the affected tooth	Ceramic onlay	Molar	10	7	10	9	6	5	26	21	0	0
11	Group function no extended to the affected tooth	Natural teeth	Premolar	7	7	8	9	6	5	21	21	0	0
12	Group function no extended to the affected tooth	All ceramic crown	Molar	6	7	7	5	5	5	18	17	0	0
13	Canine guidance	All ceramic crown	Molar	4	5	5	5	5	5	14	15	0	0
14	Canine guidance	Teeth with amalgam restoration	Molar	6	5	5	5	5	5	16	15	0	0
15	Canine guidance	Natural teeth	Premolar	6	6	9	7	5	5	20	18	0	0
16	Group function extended to the affected tooth	Natural teeth	Premolar	5	7	8	7	5	5	18	19	0	0
				6.1±1.8	5.8±1.3	7.5±2.2	7.1±2.7	5.5±1.0	5.1±2.3	18.3±5.4	17.2±4.1	1	1

Table 3. *FDI scores obtained for each criterion according to different times of study (T1: first evaluation step, day of bonding; T2: six month after) and experience of observers (junior (j) vs. senior (s) practitioners)*

Criterion	*1 Surface luster*	*2 Staining*	*3 Color match and translu-cency*	*4 Esthetic anatomic form*	*5 Fracture of material and reten-tion*	*6 Marginal adaptation*	*7 Occlusal contact and wear*	*8 Approximal anatomical form*	*9 Radiograph-ic exam*	*10 Patient's view*	*11 Postopera-tive (hyper-) sensitivity and tooth vitality*	*12 Reccurence of caries (CAR), ero-sion, abfrac-tion.*	*13 Tooth integ-rity (enamel cracks, tooth fractures)*	*14 Periodontal response (always compared to a reference tooth)*	*15 Adjacent mucosa*	*16 Oral and general health*
T1 (J)	1.3±0.6	1.1±0.3	1.6±0.6	1.4±0.6	1±0	1.6±0.5	Non evaluated	1.8±0.7	1.9±1,4	1±0	Non evaluated	1±0	1±0	1.1±0.3	1.1±0.3	1.3±0.5
T1 (S)	1.2±0.4	1.2±0.4	1.7±0.7	1.4±0.6	1.3±0.9	1.4±0,8	Non evaluated	1.6±0.6	1.2±0.5	1.4±1	Non evaluated	1±0	1±0	1,1±0,3	1±0	1±0
T2 (J)	1.4±0.6	1±0	1.8±0.8	1.9±1	1±0	1.6±0.8	Non evaluated	1.9±1	1.9±1.4	1.1±0.3	Non evaluated	1,2±0.5	1±0	1,2±0.5	1,1±0.3	1±0
T2 (S)	1.3±0.6	1±0	1.9±0.8	1.5±0.6	1.2±0.8	1.3±0.8	Non evaluated	1.7±0.9	1.4±0.8	1.4±1	Non evaluated	1,1±0	1±0.3	1±0	1±0	1.1±0

Figure 1. *(A&B): Total mean score, esthetic, functional and biological scores obtained during the evaluation of endocrowns by both students and teachers at T1 (day of fitting) and T2 (6 months after).*

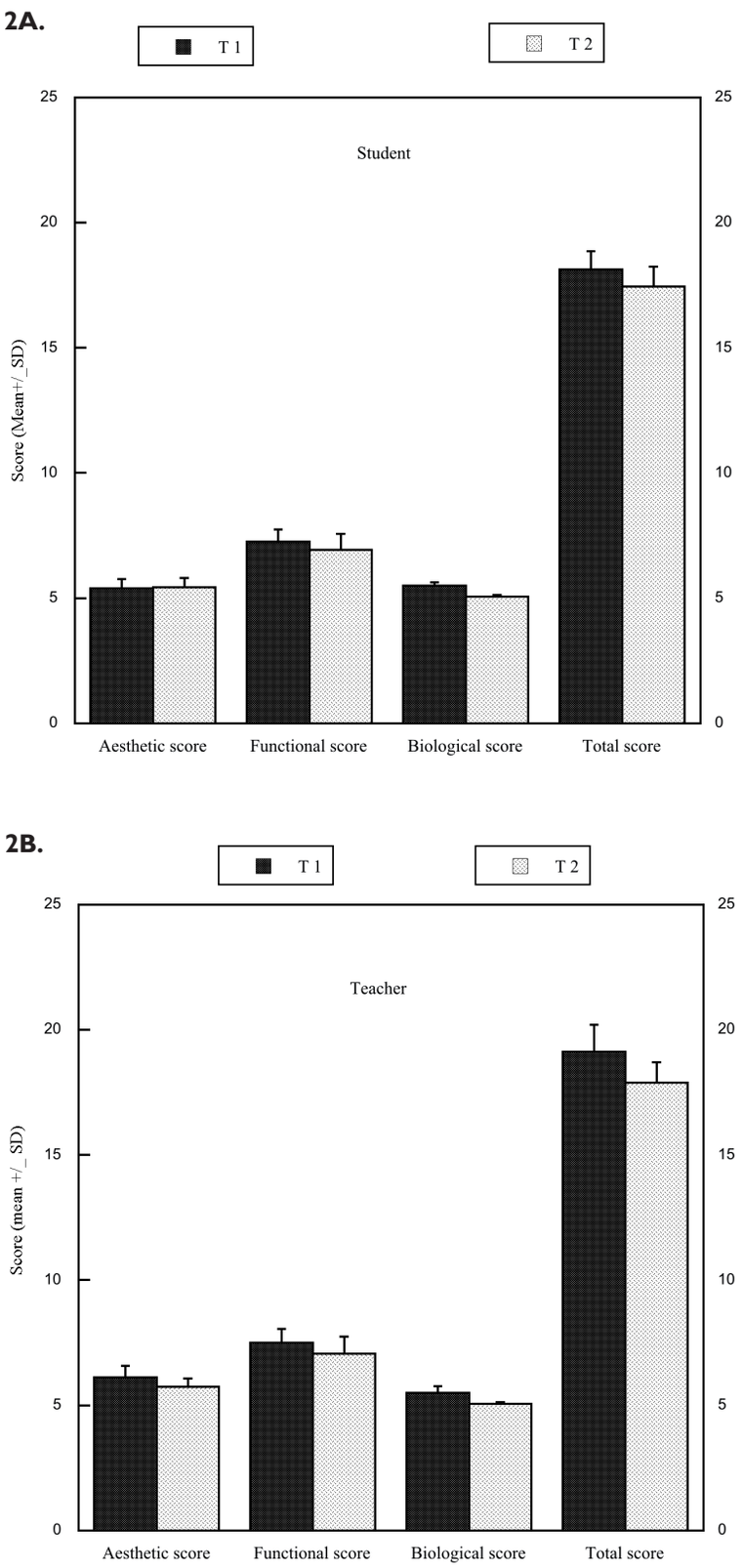

Figure 2. *(A&B):Total mean score, and esthetic, functional and biological scores obtained during the evaluation of endocrowns at T1 (day of fitting) and T2 (6 months after) by both students and teachers. Biological integration score decrease for the student's evaluation (*, p<0.05).*

This study demonstrated the value of Cerec-ceramic endocrowns. However, a study on a larger sample and a longer follow-up period would validate the use of this type of restoration. The FDI criteria for "postoperative hypersensitivity and tooth vitality" should be used to evaluate inlay type posterior restorations on vital teeth, by conventional onlay or V-Prep type, as proposed by Raynal and, later, by Schlichting and colleagues[31,32].

New endocrown preparations, which use the principles of V prep, or ultrathin onlay will eventually reduce the use of conventional crowns and coronal-radicular restorations. Endocrown restoration makes it possible to conserve the maximum surface area of residual tissue and therefore limit the unnecessary removal of healthy tissue during peripheral preparations.

It is proposed that a follow-on study will be undertaken a larger patient cohort and a longer evaluation time. Additionally, conventional endocrowns preparation will be compared either to V-prep endocrowns or the 2 step technique proposed by Rocca and coll, in 2012[33] .

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