Success Rates of Endocrown and Crown Restorations for Endodontically Treated Posterior Teeth: A 46-month Retrospective Study

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Research Article

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Abstract

Background

The objective of the present study was to compare the success rates of endocrown and crown restorations for endodontically treated posterior teeth over a 46-month period.

Methods

The 174 restorations (85 endocrowns; 89 crowns) in a total of 168 patients were manufactured between 2016 and 2017 using chairside CAD/CAM method. Root canal treatment and tooth preparation of each tooth was done by one and the same endodontist. Data were descriptively analyzed and success rates were calculated using Kaplan-Meier statistics.

Results

The average time to recall was 45.5 ± 3.9 months. 21.2% patients had the habit of drinking and 40.2% patients had parafunctional habits. The success rates of endocrowns and crowns were 87.1% and 86.5% respectively ($p=0.89$). For premolars, only 73.7% of endocrowns were acceptable compared to 89.5% of crowns ($p=0.123$) and nearly all failures happened in the first year. But the situation is totally reversed for molars ($p=0.276$). And all the differences were not significant. The main failure reason was restoration debonding.

Conclusions

The success rate of endocrown restorations was comparable to that of crowns restorations for endodontically treated posterior teeth in the 46-month study.

Trial registration

The retrospective study was approved by the Ethics Committee of Stomatological Hospital of Wuhan University ([2020] Lun Shen Zi (B61)).

1 Background

Timely restoration to closely sealing root canal system after root canal treatment has a significant influence on the long-term success rate of the treated tooth. The prevalence of teeth with inadequate coronal restorations (54.3%) is significantly higher than that of teeth with adequate coronal restorations (34.7%) [1]. Either direct or indirect restoration is chosen based on the severity of the defect.

Traditionally, when the defect areas of the teeth are large, indirect restorations, crowns would be selected to restore the tooth. Now, more choices were presented, such as endocrown. In 1999, the term “endocrown” appeared, which was formally proposed by Bindl [2]. Endocrown is a monoblock ceramic crown consisting of a circle of butt edges and a retainer located in the pulp chamber. In recent years, with the development of materials and bonding technology, endocrowns, which preserve more dental tissue, have been gradually accepted by dentists and widely used in the restoration of endodontically treated molars and premolars. The use of endocrowns takes advantage of adhesive cementation and the retainer stretching into the pulp chamber to obtain retention. With the application of computer aided design / computer aided manufacturing

(CAD/CAM) and the improved bonding system to reduce lateral force, the stress distribution of the endocrown become more reasonable. The minimally invasive approach is time-saving and easy to master compared to crowns especially for endodontists who are familiar with tooth structure, but had less experienced at tooth preparation [3].

By review the literature about endocrowns, we found that many in vitro and finite element analysis studies were published, but clinical studies were lacking and none of them were from China, where the concept of tooth crown and root as an integration was widely accepted and promoted. Two in vitro studies [4, 5] showed that there was no statistically significant difference in the tooth resistance of destroyed molars repaired with the endocrown or post-core crown. Lin et al [6] demonstrated that the stress distribution of the endocrown in the dentin and the cement layer was better than that of the crown, and its anti-fracture strength and failure probability after restoration were similar to those of the crown. A systematic review of seven clinical studies [7] that were conducted between 1995 and 2018 and had follow-up durations ranging from 6 months to 10 years concluded that there was no significant difference in the success rate of endocrown and crown restoration for the molar. Although endocrowns have been widely used in clinical practice, there is still a need for more reliable retrospective studies or high-quality prospective studies to ensure the clinical efficacy of endocrowns in the restoration of endodontically treated posterior teeth.

Therefore, the aim of this retrospective study was to compare the success rates of endocrowns and crowns for endodontically treated posterior teeth operated on by endodontists to guide the restoration of posterior teeth in clinical practice, especially in China.

2 Methods

1.1 Study Design

This is a retrospective study by collecting medical records and implementing intraoral examination. The study had got approval from the Ethics Committee of Stomatological Hospital. The objects of this study are endocrowns and crowns manufactured in the Department of Cariology and Endodontics of Stomatological Hospital of Wuhan University for posterior endodontically treated teeth from April 2016 to February 2017. By review their original medical records, patients were selected on the basis of the following inclusion criteria and exclusion criteria.

Inclusion criteria:

1. Patients aging from 20 to 70;
2. Posterior tooth;
3. Endodontically treated tooth;
4. Tooth with more than two surface defects;

Exclusion criteria:

1. Uncooperative patients;
2. Undergoing orthodontic treatment;
3. Lost more than two posterior teeth;
4. Teeth with cracked crown,
5. Vertical root fracture or periodontal problems;
6. Teeth without natural antagonistic teeth or adjacent teeth.

By 2020, 168 patients (174 teeth) were recalled. They understood the purposes of the study and signed consents before examinations.

1.2 Root Canal Treatment and Restoration

All root canal treatments were operated by endodontists working in the Department of Cariology and Endodontics. The same doctor finished tooth preparation and bonding process. Intraoral scanning and restoration design were done by a

technician using CEREC AC Omnicam Chair side System (Dentsply, Germany). The restoration materials were An IPS e.max CAD Porcelain pieces (Ivoclar, Martyr Dunstan).

1.3 Clinical Measurement

Basic information of patients and teeth was collected. Two independent evaluators learned the FDI criteria systematically through a web-based training and calibration tool (www.e-calib.info). After that, they evaluated restorations following the modified World Dental Federation (FDI) criteria to compare 4-year clinical efficacy. If there were differences in the evaluation results between the two evaluators, a consensus would be reached through discussion. As long as one of the subcategories is evaluated as “Clinically Unsatisfactory” or “Clinically Poor”, we regard the restoration as a failure. When one of the subcategories is assessed as “Clinically Poor”, we consider that the restoration does not survived.

1.4 Data Analysis

Statistical analyses were performed using the Stata software (SPSS 25, IBM, Armonk, New York) with a 5% significance level. Cox multiple factors analysis was applied to analyze the relationship between baseline characteristics of endodontically treated teeth and the success of restorations. Chi-square test and Nonparametric rank sum test were used to analyze baseline characteristics. Success curves were generated by the Kaplan–Meier estimator and success rate differences were calculated by the Log-Rank test.

3 Results

A total of 174 teeth (85 teeth in the endocrown group and 89 teeth in the crown group) were included for analysis. The average time to recall was 45.5 ± 3.9 month. Regarding basic characteristics (age, gender, dental arch, drinking habits and parafunctional habits), no significant differences were found between the two groups (Table 1). A total of 21.2% of patients had a drinking habit(frequent intake of beverages, coffee or tea), and 40.2% of patients had parafunctional habits, such as bruxism and unilateral mastication. Cox multiple factors analysis found no correction of baseline characteristics (age, gender, dental arch, drinking habits and Parafunctional habits) of endodontically treated teeth with the success of restorations.

Table 1
Baseline characteristics of endodontically treated teeth

	Endocrown	Crown	P value
Age (year)	40.2	43.7	0.063
Gender			0.827
Male (n)	32	36	
Female (n)	53	53	
Dental arch			0.677
Maxillary (n)	38	37	
molar	26	12	
premolar	12	25	
Mandible (n)	47	52	
Molar	40	39	
Premolar	7	13	
Drinking habits (n)	16	21	0.064
Parafunctional habits (n)	31	39	0.408

The overall success rate and survival rate of the restorations were 86.8% and 97.7%. The success curves of the endocrown and crown for posterior teeth are showed in Fig. 1, and nearly no failure occurred in the third year. In the endocrown group, 83 teeth survived the whole follow-up period, with a success rate of 87.1% (Table 2). The most common reason for failure was endocrown debonding (9 teeth), followed by recurrence of caries (3 teeth), unsatisfactory marginal adaptation (1 tooth), unsatisfactory approximal anatomical form (1 tooth) and staining (1 tooth, Fig. 2). In the crown group, 87 teeth survived with a success rate of 86.5% and 12 teeth failed because of crown debonding (10 teeth), periodontal response (3 teeth), approximal anatomical form (2 teeth) (Table 3). No significant difference was found between the two groups. Premolars and molars were also analyzed respectively, and the success curves are showed in Fig. 3 and Fig. 4.

Table 2
Success rate of endodontically treated teeth

Group	Endocrown	Crown	P value
Premolar % (n)	73.7 (14)	89.5 (34)	0.123
Molar % (n)	90.9 (60)	84.3 (43)	0.276
Total % (n)	87.1 (74)	86.5 (77)	0.888

Table 3
Modified FDI rating of endocrowns

	Clinically Excellent% (n)	Clinically Good% (n)	Clinically Sufficient% (n)	Clinically Unsatisfactory% (n)	Clinically poor% (n)	Acceptable%	Unacceptable%
A. Esthetic properties						98.8	1.2
Surface luster	95.3 (81)	2.4 (2)	2.4 (2)				
Staining	96.5 (82)	2.4 (2)		1.2 (1)			
B. Functional properties						87.1	12.9
Fracture of material and retention	85.9 (73)	1.2 (1)	2.4 (2)	10.6 (9)			
Marginal adaptation	91.8 (78)	3.5 (3)	3.5 (3)	1.2 (1)			
Approximal anatomical form	76.5(65)	11.8 (10)	12.9 (11)	1.2 (1)			
Patient's view	69.4 (59)	5.9 (5)	15.3 (13)	7.1 (6)	2.4 (2)		
C. Biological properties						96.5	3.5
Recurrence of caries	91.8 (78)	3.5(3)	1.2 (1)	1.2 (1)	2.4 (2)		
Tooth integrity	97.6 (83)	1.2 (1)	1.2 (1)				
Periodontal response	88.4 (77)	5 (6)	2.4 (2)				
Adjacent mucosa	84.7 (72)	14.1 (12)	1.2 (1)				

For premolars, only 73.7% of endocrowns were acceptable compared to 89.5% of crowns. Nearly all failures happened in the first year. However, the situation is totally reversed for molars. For molars, the success rate of the endocrowns was higher than that of crowns, although no difference was found (Table 2). It is worth noting that in the approximal anatomical form subcategory, 14.1% of teeth in the endocrown group and 12.4% in the crown group were defined as “Clinically Sufficient” or “Clinically poor” (Table 3 and Table 4).

Table 4
Modified FDI rating of crowns

	Clinically Excellent% (n)	Clinically Good% (n)	Clinically Sufficient% (n)	Clinically Unsatisfactory% (n)	Clinically poor% (n)	Acceptable%	Unacceptable%
A. Esthetic properties						100	0
Surface luster	86.5 (77)	13.4 (12)					
Staining	94.4 (84)	3.4 (3)	2.4 (2)				
B. Functional properties						87.6	12.4
Fracture of material and retention	88.8 (79)	3.4 (3)	1.2 (1)	11.2 (10)			
Marginal adaptation	97.8 (87)	1.2 (1)	1.2 (1)				
Approximal anatomical form	78.7 (70)	9.0 (8)	10.1 (9)	2.2 (2)			
Patient's view	67.4 (60)	6.7 (6)	15.7 (14)	7.9 (7)	2.2 (2)		
C. Biological properties						96.6	3.4
Recurrence of caries	97.8 (87)	2.2 (2)					
Tooth integrity	98.9 (88)	1.1 (1)					
Periodontal response	83.1 (74)	10.1 (9)	3.4 (3)	1.2 (1)	2.4 (2)		
Adjacent mucosa	83.1 (74)	14.6 (13)	2.4 (2)				

4 Discussion

In this study, the 46-month success rates of endocrowns and crowns were calculated and analyzed by applying the modified FDI criteria. The success rates and survival rates of posterior teeth restorations in our study was consistent with those of the other studies [8, 9]. We concluded that the success rate of endocrowns was comparable to that of crowns made by the CAD/CAM method, which indicates that the endocrown can be used as a substitution for the crown while restoring an endodontically treated posterior tooth. Overall, the quality of restorations completed by endodontists was reliable. These findings agreed with many previous in vitro or vivo studies [6, 10, 11].

In 2007, the FDI World Dental Federation first developed clinical criteria for the evaluation of direct and indirect restorations. [12–14]. The criteria are sensitive with 18 subcategories and related to the width of marginal gaps, the tightness of

approximal contact points and the amount of clinical wear given quantitative values. In our study, we chose the FDI criteria as the evaluation criteria, with some of the subcategories deleted due to difficulty in evaluating them or patient disapproval.

Teeth with mesial and distal subgingival margins are common for endodontically treated posterior teeth due to the high prevalence rate of proximal caries. A study concluded that proximal caries comprised 6 ~ 11% percent of the total caries experience [15]. These teeth with large defect are usually in need of crown or endocrown restorations. In our study, we found that for endocrowns, 62.4% restorations had subgingival margins. 13.2% of restorations with subgingival margins debonded, which doubled compared to that of restorations when the margins were flush with or above the gingivae. So, we concluded that the phenomenon of debonding was related to subgingival margin. When the margin is 1 mm below the gingiva, an accurate margin would be hard to achieve [16]. subgingival margins can also damage gingivae. In addition, moisture control would be a problem, leading to debonding. By review the medical histories, we found that only a few cases used rubber dams or deep margin elevation technique. Rubber dam could prevent the tooth from water in the bonding process. Deep margin elevation technique is a good method for teeth with subgingival margins to elevate the margins with glass ionomer to the cemento-enamel junction. It could increase bonding strength, decrease ceramic fracture and make polishing convenient [17–20]. Rubber dams, deep margin elevation technique and other methods good for bonding should be promoted in the preparation and bonding process.

Some studies [21, 22] revealed that one of the main failure reasons of indirect restorations was restoration fracture, which was not found in our study, likely due to the reasonable distribution of masticatory force and short period of our investigation. Debonding occurred before the occurrence of fracture, which usually happened several years later [3, 23, 24]. Fortunately, debonding is a repairable failure if the patients return in time.

For premolars, more failure occurred when restored with endocrowns, although no statistically significant difference was found. This could due to the narrower pulp chambers of premolars. The narrow pulp chamber reduces the surface area for adhesive retention of the endocrown and impedes the transmission of masticatory force to the root [25]. The result is consistent with a systematic review. In the study, the success rates of endocrown and crown for premolars were 68% ~ 75% and 94% ~ 95%, respectively [7].

All endocrown restorations and 75% of crown restorations for premolars that did not survived located in the maxillae. This may be related to the special loading feature of maxillary premolar: bearing a more complex burden of axial and shear load [2, 26]. The existing evidences suggest that the endocrown restoration for endodontically treated premolar should be more cautious. When restoring maxillary premolars, more attention should be paid to characteristics of the tooth, such as surface area of pulp chamber and occlusal relationship [27].

The study provides valuable evidence for the application of endocrown restoration to endodontically treated posterior teeth. The restoration totally operated on by endodontists, which is a tendency with the development of chair-side CAD/CAM technology. However, as a retrospective research, it was hard to make strict inclusion criteria for endocrown or crown restoration, which made it impossible to discuss the indications of endocrown and crown. To obtain higher-quality evidence and analyze the reasons for various failures, a prospective study with a well-designed research plan should be carried out.

5 Conclusions

No difference was found between the crown and the endocrown when restoring endodontically treated posterior teeth in the 46-month study. The restoration finished by endodontists was reliable. Follow-up should occur more frequently in the first year to fix repairable failure. While restoring premolars, the use of endocrowns should be more cautious due to the limited evidence. To provide more scientific evidence for clinical practice, more well-designed studies with sufficient sample sizes are required.

Abbreviations

CAD/CAM

computer aided design / computer aided manufacturing

FDI

the modified World Dental Federation

Declarations

Ethics approval and consent to participate

All procedures performed in studies involving human participants were reviewed and approved by the institutional review board and in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Ethics Committee of Stomatological Hospital of Wuhan University approved this study ([2020] Lun Shen Zi (B61)). All patients understood the purposes of the study and signed consents before examinations.

Consent for publication

All authors have seen the manuscript and approved the attached manuscript. All authors affirm that the paper has been submitted solely to *BMC Oral Health*.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no conflict of interest.

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Authors' contributions

All authors contributed to the study conception, design. Chen F, Duan H and Hu Q contributed to oral examination. Chen Z and Zhang L contributed to restoration evaluation, data analysis, and result interpretation. The first draft of the manuscript were performed by Chen F. All authors commented on the final versions of the manuscript.

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Figures

Figure 1

Kaplan-Meier success curve of endocrowns and crowns for posterior teeth

Figure 2

An endocrown clinical case on tooth #36 was evaluated as “clinically good” by the modified FDI criteria, documented with CAD/CAM data and photos highlighting the residual tooth tissue amount, restoration design and restoration appearance in the follow-up. The prepared tooth had a defective distal wall, and a normal occlusion relationship with a dispersed bite force was obtained after computer-aided design (a–d). The immediate restoration appearance after bonding was perfect (d and f). Clinical pictures at 46-month period showed little margin staining (g and h)

Figure 3

Kaplan-Meier success curve of endocrowns and crowns for premolars

Figure 4

Kaplan-Meier success curve of endocrowns and crowns for molars