Longevity of class 2 direct restorations in root-filled teeth: A retrospective clinical study

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Longevity of second-class post-endodontic direct restorations on posterior teeth: a retrospective clinical study

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Introduction

Endodontically treated teeth show alterations in biomechanical and neuro-receptive behaviours in comparison with vital teeth. Loss of pulpal tissue causes dehydration [1], demineralisation [2], collagen alterations, and proprioceptor reduction [3]. Many studies of the biomechanical analysis of vital and non-vital teeth have shown unanimously that the amount of residual tissue is the most important factor related to resistance to masticatory loads [4,5]. Architectural changes related to primary causes leading to endodontic treatment, such as caries or fracture for trauma with loss of the marginal crest [5] and cusp thickness reduction [6], or clinical procedures necessary to perform endodontic treatment such as removal of the demineralised anatomical portion of the tooth crown and the pulp chamber roof [5], are the real intervening factor in reducing structural resistance of endodontically treated teeth. The direct clinical consequence of these biomechanical alterations is an increase in vertical and corono-radicular fractures under gingival margins, compared with vital teeth [7].

To confirm the theory, previous retrospective studies concluded that MOD restorations, in particular those in amalgam, are associated with the highest risk of fracture in endodontically treated teeth [8]. This is why complete cusp coverage is considered the gold standard therapeutic approach for MOD cavities in endodontically treated teeth [9]. Among teeth types, maxillary premolars and molars have the highest incidence of fracture [10,11], and, due to horizontal masticatory loads, shearing cusps are the most affected, with a ratio of 3:2 for maxillary and 3:1 for mandibular teeth [1,12].

The prognosis of endodontically treated teeth depends on the choice of the ‘correct’ restorative technique and on masticatory stresses. Those considerations underline the fact that endodontically treated teeth need complex strategies for their restoration and multidisciplinary treatment. In the past, it was the general opinion of many dental practitioners that endodontically treated teeth needed a post-endodontic post and a total crown for their rehabilitation [2,13]. The need for a full-coverage crown to prevent root fracture in endodontically treated posterior teeth has been supported by *in vitro* studies [3,14,15] and by retrospective clinical studies [4,5,16,17]. Sorensen and Martinoff [5,17] reviewed 1273 endodontically treated teeth that had been restored from 1 to 25 years previously. Statistical analysis showed that coronal coverage did not significantly improve the rate of clinical success for anterior teeth, whereas it did improve success rates for premolars and molars. However, biomechanical analysis of residual dental tissue, the reliable quality of the actual adhesion protocol and systems, and the availability of aesthetic restorative materials ended with a review of this treatment paradigm.

Today, the choice of the 'best' protocol and material to use in post-endodontic restoration depends on the amount of residual dental tissue, periodontal condition, number of restorations to perform, coronal and root morphology, static and dynamic occlusal contacts, oral hygiene, risk of caries, cost of the restoration, and patient health conditions [6,11]. Furthermore, according to the concepts of minimally invasive dentistry, pursuing the criterion of maximum preservation of remaining sound tooth structure to increase resistance, direct composite restorations are considered a valid option for treatment. This minimally invasive approach for endodontic-treated elements has become a valid choice due to the good quality of bonding adhesive systems on enamel and dentin and the high-performance properties of resin composite materials [5,18]. In fact, some recent studies, have reported no difference between full-crown and direct restorations [7,19,20] of endodontically treated posterior teeth.

Fibre post outcome and function remain controversial. Several *in vitro* studies have demonstrated that the insertion of a fibre post within a direct composite restoration increases the fracture resistance of endodontically treated teeth [8,21]. Unfortunately, few clinical studies have assessed whether the insertion of fibre posts within direct restorations affects the survival of endodontically treated teeth [9,22]. However, several works, both clinical and in vitro, have demonstrated that in teeth with cusp coverage, the survival rate was similar in presence or in absence of a post in the canal root [10,11,23,24].

The aim of this retrospective clinical study was to evaluate the survival rate of endodontically treated posterior teeth restored with direct resin composite with or without the insertion of a fibre post. The null hypothesis was that the survival rate of endodontically treated teeth restored with direct composite restorations was not higher for teeth restored with a fibre post than teeth reconstructed with composite resin only, without a fibre post.

Materials and Methods

This study was designed as a retrospective longitudinal evaluation of post-endodontic direct posterior resin composite restorations performed with or without fibre post insertion. The study was carried out in accordance with the ethical principles of the World Medical Association Declaration of Helsinki.

Patients enrolled in the study presented at least one posterior tooth with a post-endodontic restoration and a follow-up period of at least 12 months. Recruited patients were treated in the Department of Cariology and Operative Dentistry of the Dental School Lingotto, University of Turin, from January 2008 to December 2011 for second-class restorations subsequent to endodontic treatment caused by caries or fractures, irreversible pulpitis, or pulpal necrosis. Exclusion criteria were: root-filled teeth with significant loss of tooth structure, which needed indirect restorations, teeth without at least one approximal contact, FMPS > 20%, absence of an opposing dentition with occlusal load, and patients with a history of bruxism. 298 patients were selected using pre-established inclusion criteria. They were contacted by phone, between January and March 2013, and a follow-up visit was scheduled for each patient who agreed to participate in the study.

Restorative Procedures

Undergraduate students in the fifth year of the Dentistry program at the University of Turin performed all post-endodontic restorations considered. In all cases, a standardised clinical procedure was followed strictly. A rubber dam (Nic tone Dental Dam, Mdc Dental, Jalisco, Mexico) was used to provide proper field isolation. Accurate caries removal was obtained with tungsten multi-blade burs (Komet, Lemgo, Germany) mounted on a low-speed hand piece (Intracompact, Kavo, Bismarckring, Germany) under cooling spray water with the help of a caries detector, based on 0.5% basic fuchsine (Caries Detector, Kuraray Medical Inc., Sakazu, Japan). Once the cavity preparation was completed, enamel cavity margins were finished with a diamond fine-grained bur (Komet, Lemgo, Germany) mounted on a high-speed hand piece (Intracompact, Kavo, Bismarckring, Germany). In teeth restored with a fibre post (RDT, Saint Egreve, France) an appropriate post space was prepared. Coronal gutta-percha was removed using a Largo #1 and #2 drill and the post space was prepared with dedicated drills mounted on a low-speed hand piece (Intracompact, Kavo, Bismarckring, Germany) with a cooling spray of water, leaving at least 4 mm of intact apical seal. A dual-curing three-step etch-and-rinse adhesive system (All Bond 2, Bisco, Schaumburg, IL, USA), was used for both coronal tissue hybridisation and for fibre post luting procedures, in this case in combination with a dual-cure resin cement (Duolink, Bisco, Schaumburg, IL, USA). Fibre posts were then cured with a light-emitting diode lamp (Translux, Power Blue, Heraeus, Kultzer, Hanau, Germany) for 40 s, at an intensity of 1200 mW/cm^2. Composite restorations were completed with a 0.5-mm layer of flowable composite (Venus Flow, Heraeus Kultzer, Germany) on dentinal substrate and a nanohybrid composite (Venus Diamond, Heraeus Kultzer, Germany) in oblique stratification to minimise polymerisation shrinkage stresses. Each increment was cured for 20 s with the same lamp. To avoid formation of an oxygen inhibition layer, an additional 20-s light curing was performed after the application of glycerin gel to each restoration. Coarse finishing was accomplished with carbide burs under water irrigation and final finishing was accomplished with 25-µm diamond rotating burs (Komet-Brasseler, Lemgo, Germany), diamond-impregnated resin polishers (PoGo, Dentsply, USA), pastes and aluminium oxide disks with decreasing abrasiveness (Sof-Lex XT, 3M ESPE, St. Paul, USA), and finally polished with paste and a rinse toothbrush (Occlubrush, Kerr Dental Corporation, Bioggio, Switzerland), mounted on a blue ring contrangle (INTRAcompact, Kavo, Bismarckring, Germany).

Outcome Evaluation

Two independent and blinded calibrated operators performed follow-up examinations. In cases of disagreement, a both examiners performed a third evaluation to reach a consensus. Before clinical examinations, some patient-related information was recorded, such as name, gender, date of birth, smoking habits, presence of parafunction, caries risk, use of the Cariogram software[25], type of treatment, treatment date, type of restoration provided, size of the cavity, and date of extraction.

The patients were then examined clinically and radiographically. Failures and complications were recorded, such as periodontal or endodontic failure, tooth extraction, root fracture, post fracture, post debonding, and replacement of the composite restoration. Finally, evaluation of the functional restorations in terms of marginal adaptation, restoration integrity, colour match, marginal discolouration, surface roughness, and the presence of caries was performed using the modified USPHS criteria (Table 1).

Restoration characteristics, including the number of unacceptable restorations, failures, and complications were, described with descriptive statistics using percentages of the overall number of samples. The performance of the experimental restorations, obtained using the USPHS criteria, was assessed using Friedman's analysis of variance test. The level of significance was set at $p < 0.05$. Statistical analyses were conducted using the SW Minitab software (ver. 15; Minitab Inc., State College, PA, USA).

Results

The study population consisted of 247 patients and 376 endodontically treated teeth (180 premolars, 196 molars) restored with second-class direct composite resin. Two groups were defined based on the absence (Group A) or presence (Group B) of endodontic fibre posts within the composite restoration.

Group A consisted of 128 patients (68 male, 60 female) with a mean age of 46.2 years. In total, 178 teeth (88 premolars, 90 molars) were evaluated after a mean observation period of 34.44 months. Group B consisted of 119 patients (54 male, 65 female) with a mean age of 48.7 years. In total, 198 teeth (92 premolars, 106 molars) were evaluated after a mean observation period of 35.37 months.

The distribution according to patient-related factors is shown in Table 2, while the distribution of the restorations and reasons for failure per group are shown in Table 3.

The results showed that in Group A, 78,12% of the restorations appeared functional at the follow-up. The remaining 21,88% of posterior elements failed functionally; this was attributed to marginal infiltration in 7.69% of cases with restoration replacement needed; in 6.16%, the indication for tooth extraction was unrelated to the restoration characteristics; in 4.16% to composite material fracture; in 3.08% to remaining dental wall fracture; and in 1.54% to irreparable root fracture. In 1.54% of the analysed dental elements clinical and functional success was revealed but with evidence of a periapical endodontic lesion. In 9.23% of cases, the original restoration was replaced with a full crown adhesive or a traditional restoration.

In Group B, 94,94% of posterior elements were considered functionally preserved. The failures were due to irreparable fracture of the dental crown in 2.44% of cases and to extraction for endodontic reasons in 2.44%. In 7.32% of cases, the original restoration underwent an indirect cuspal coverage. In Tables 4 and 5, the absolute values and percentages of USPHS-modified criteria are shown.

In a statistical analysis, we compared restorative quality after long-term follow-up considering cavity design and the presence or absence of fibre post placement. Differences between group A and B were statistically significant only for three of the USPHS categories considered: marginal integrity, marginal discolouration, and restoration integrity ($p < 0.05$; Figs. 1, 2). No difference was found between the two groups in terms of colour match, surface roughness, and secondary caries intersession.

Discussion

The influence of fibre post insertion on the longevity of second-class direct composite post-endodontic restorations was evaluated retrospectively. In retrospective observational studies, the data to be analysed are restricted to the available information and patients and materials are not selected specifically or divided randomly into groups. The longevity of a restoration may be affected by a patient's habits, such as oral hygiene and smoking, and their susceptibility to caries. For this reason, all of these conditions were considered and evaluated during follow-up examination, leading to the conclusion that they were fairly equally distributed between the two groups, thus not influencing the results obtained in this study. Moreover, patients treated by undergraduate dental students were recruited for this study because in these cases, a strict procedural protocol, described above, was followed and the same materials were used.

This study involved only the evaluation of premolars and molars that were restored with proximal direct composite restorations after endodontic treatment. Considering the results obtained, the null hypothesis of this clinical retrospective study must be rejected because the post-endodontic direct restorations supported by fibre posts *were* more durable than restorations without fibre posts after 3 years of follow-up. In Group A, 80% of the teeth examined at the follow-up visit were functional, while in Group B, 95.12% of restorations were functional.

The present findings revealed that marginal discolouration and marginal integrity were significantly worse in Group A. Fibre post insertion within a composite restoration may improve the ability of the tooth-restoration complex to absorb the occlusal loads along the major axis of the tooth [26], might increases the resistance of the endodontically treated tooth [6,27], and may cause less cuspal deflection, thus reducing the possibility of marginal leakage that creates a gap at the tooth-restoration interface with consequent marginal infiltration [28]. Thus, this study shows that fibre post placement could improve marginal sealing and resistance under occlusal load because of decreased cuspal deformation compared with teeth restored without a fibre post. A previous randomised clinical trial, conducted by Bitter et al. [22], found significant differences between the post group and no-post group only when no coronal wall was present after 32 months of follow-up. However, in this paper both anterior and posterior restorations were considered and fewer patients were included in the long-term evaluation. These factors may explain the apparent inconsistencies with the present study.

The marginal composite fracture risk was higher in Group A (4.61%) than Group B (0%). The fracture toughness thus seemed greatly reduced if endodontically treated teeth were rebuilt using a direct technique without inserting a post. These results are consistent with the *in vitro* study of Scotti et al. [6] on the fracture toughness of maxillary premolar endodontically treated and restored with direct and indirect techniques in association or not with a fibre post. Fibre post placement within direct restoration enhanced the resistance of the weakest remaining coronal structures, probably due to a wider distribution of forces along the adhesive interface [29]. Endodontic posts with a modulus of elasticity similar to dentin, when subjected to compressive loads, better absorb the forces concentrated in the root, reducing the risk of fracture. Additionally, the use of a fibre post may optimise eventual crack patterns, making endodontically treated teeth more likely to be restored if a coronal fracture happens[30,31]. Another study, by Nothdurft et al. [32], showed that fibre post-supported composite restorations in class II cavities significantly increased the resistance to extra-axial forces. The results of the present study were also consistent with a 2-year prospective clinical trial conducted by Ferrari et al. on 240 endodontically treated premolars restored with a full crown, showing greater resistance to fracture in those elements that were associated with dental cuspal coverage using a fibre post, than those with cuspal coverage alone [23]. In contrast, some *in vitro* studies have shown how endodontically treated premolars without fibre post placement had fracture toughness similar to those with a fibre post. Mohammadi et al. reported the comparable behaviour of endodontically treated maxillary premolars restored with a direct technique with or without a fibre post and subjected to compressive forces parallel to the longitudinal axis of the tooth until fracture [27]. Mohammadi et al.'s conclusions can be attributed a greater amount of tooth structure removal during post-space preparation and to an additional adhesive interface, which likely participated in the propagation of microcracks, resulting in a reduction in fracture toughness. Another *in vitro* study, by Krejci et al., affirmed that any restoration avoiding post space preparation, with less sacrifice of residual sound tissue, might result in greater resistance to fracture, regardless of the degree of impairment of the dental structure[33]. The inconsistencies between these studies are likely attributable to differences in the type of material used for direct restorations, the tooth type, and the direction of the applied loads.

However, it is widely accepted that a coronal fracture pattern could be more unfavourable in the case of direct restorations without a fibre post due to a worse distribution of loading stresses [31,34]. In the present study, in Group B, 2.44% of restorations suffered coronal fractures, but in all cases, the tooth was recoverable. This suggests that fibre post placement could reduce the coronal fracture percentage, and even in fracture cases, could promote a restorable fracture pattern. This result is consistent with an *in vitro* study by Costa et al., which suggested that favourable fracture patterns were largely associated with post placement [34]. Furthermore, another *in vitro* study, by Sorrentino et al., showed that endodontically treated premolars with MOD cavities showed an increased prevalence of recoverable fractures in cases of direct restorations with associated fibre post placement, while in those cases without posts, most of the fractures were unrecoverable [31].

In our study, in both groups, direct restorations immediately replaced with full indirect crown (~10% in both groups) showed no functional failure, confirming the results of the study conducted by Aquilino and Caplan [35], supporting that, especially in posterior elements, cuspal coverage is essential to improve the longevity of endodontically treated teeth.

Conclusions

In post-endodontic direct restorations, fibre post placement could increase the functional long-term success rate (95.12% in Group B) versus direct restoration without post insertion (80% in Group A). Clinical indications for direct restorations of posterior dental elements, which are not expected to be replaced with a full cuspal coverage restoration for at least 3 years, favour the placement of a fibre post during the reconstruction to increase longevity and the quality of restoration. However, with current techniques and materials, indirect restoration still appears to be the gold standard for the rehabilitation of endodontically treated elements, whereas for anterior elements, fibre post placement in direct restoration appears less important, although further studies are needed to confirm this.

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Tables

Tables 1*: Quality criteria (USPHS) applied for assessment of the functional restorations.*

Category	Criterion

Marginal adaptation	ALPHA: Restoration is contiguous with existing anatomical form, explorer does not catch. BRAVO: Explorer catches, no crevice is visible into which explorer will penetrate. CHARLIE: Obvious crevice at margin, dentin or base exposed. DELTA: Restoration mobile, fractured partially or totally.
Restoration integrity	ALPHA: No material defect, no crack. BRAVO: Two or more cracks not compromising marginal integrity or contacts. CHARLIE: Restorative fractures compromising marginal integrity or contacts. DELTA: Partial or complete restorative loss.
Colour match	ALPHA: Very good colour match. BRAVO: Slight mismatch in colour, shade, or translucency. CHARLIE: Obvious mismatch, outside the normal range. DELTA: Gross mismatch.
Marginal discolouration	ALPHA: No discolouration evident. BRAVO: Slight staining: can be polished away. CHARLIE: Obvious staining: cannot be polished away. DELTA: Gross staining.
Surface roughness	ALPHA: Smooth surface. BRAVO: Slightly rough or pitted. CHARLIE: Rough, cannot be refinished. DELTA: Surface deeply pitted, irregular grooves.
Caries	ALPHA: No evidence of caries. CHARLIE: Caries is evident, contiguous with the margin of the restoration.

***Table 2**: Patient-related factors recorded at the follow-up visit.*

	GROUP A	GROUP B
Smoking	29.33%	23.91%
Presence of parafunctions	32%	26.08%
Low caries risk	33.3%	34.78%
Moderate caries risk	30.67%	41.3%
High caries risk	36%	23.9%

Table 3*: Rates of failure and complications, expressed as percentages, in the two groups.*

	GROUP A			GROUP B		
	II cl. OM/OD	II cl. MOD	Full crown	II cl. OM/OD	II cl. MOD	Full crown
Extracted tooth	0%	0%	0%	0%	2,44%	0%
Extraction prognosis	3.08%	1.54%	0%	0%	0%	0%
Root fracture	0%	1.54%	0%	0%	0%	0%
Fibre-post fracture	/	/	/	0%	0%	0%
Fibre-post debonding	/	/	/	0%	0%	0%
Restoration replacement prognosis	4.61%	3.08%	0%	0%	0%	0%
Coronal fracture	0%	1.54%	0%	2.44%	0%	0%
Composite restoration fracture	4.61%	0%	0%	0%	0%	0%
Cuspal coverage	/	/	9.23%	/	/	7.32%
Functional restoration	50.66%	18.23%	9.23%	67.56%	20.06%	7.32%
Presence of lesion of endodontic origin	0%	1.54%	0%	0%	0%	0%
Presence of periodontal lesion	0%	0%	0%	0%	0%	0%
Total teeth analysed	62.96%	25.93%	11.11%	70%	22.50%	7.50%

.

Table 4: *USPHS criteria values and rates in group A.*

	II class OM/OD	II class MOD	**Total**
MARGINAL DISCOLOURATION Alpha	33.33%	14.58%	**47.91%**
Bravo	29.17%	12.50%	**41.67%**
Charlie	8.33%	0%	**8.33%**
Delta	0%	2.08%	**2.08%**
MARGINAL INTEGRITY Alpha	35.42%	6.25%	**41.67%**
Bravo	20.83%	14.58%	**35.41%**
Charlie	8.33%	4.17%	**12.50%**
Delta	6.25%	4.17%	**10.42%**

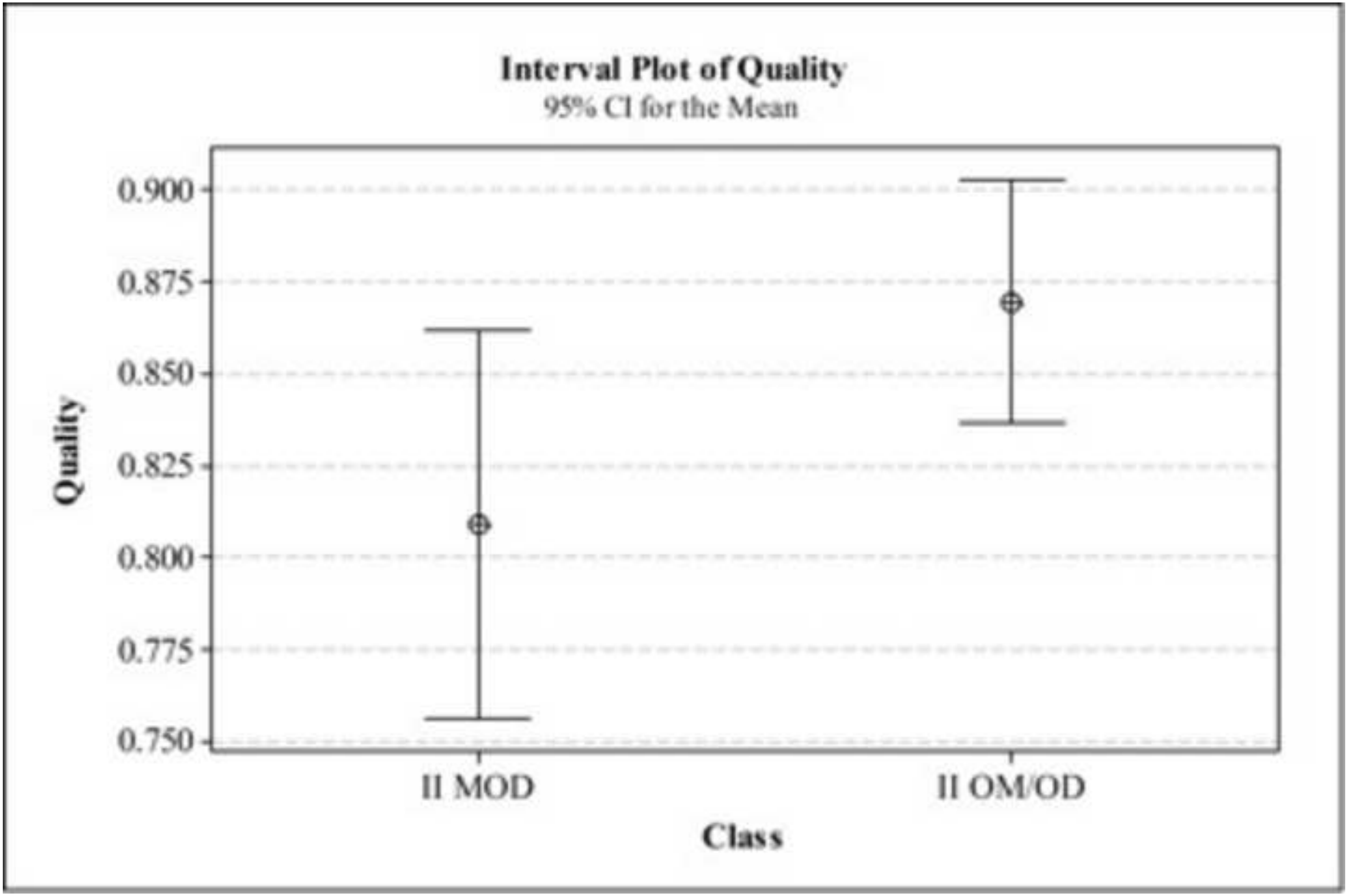
RESTORATION INTEGRITY Alpha	43.75%	14.58%	**58.33%**
Bravo	18.75%	12.50%	**31.25%**
Charlie	0%	2.08%	**2.08%**
Delta	8.33%	0%	**8.33%**
COLOUR MATCH Alpha	85.29%	89.28%	**86.45%**
Bravo	14.71%	10.72%	**13.55%**
Charlie	0%	0%	**0%**
Delta	0%	0%	**0%**
SURFACE ROUGHNESS Alpha	88.23%	96.42%	**89.58%**
Bravo	11.77%	3.58%	**10.42%**
Charlie	0%	0%	**0%**
Delta	0%	0%	**0%**
SECONDARY CARIES Alpha	100%	6.25%	**98.95%**
Bravo	0%	0%	**1.05%**
Charlie	0%	0%	**0%**
Delta	0%	0%	**0%**

***Table 5**: USPHS criteria values and rates in group B.*

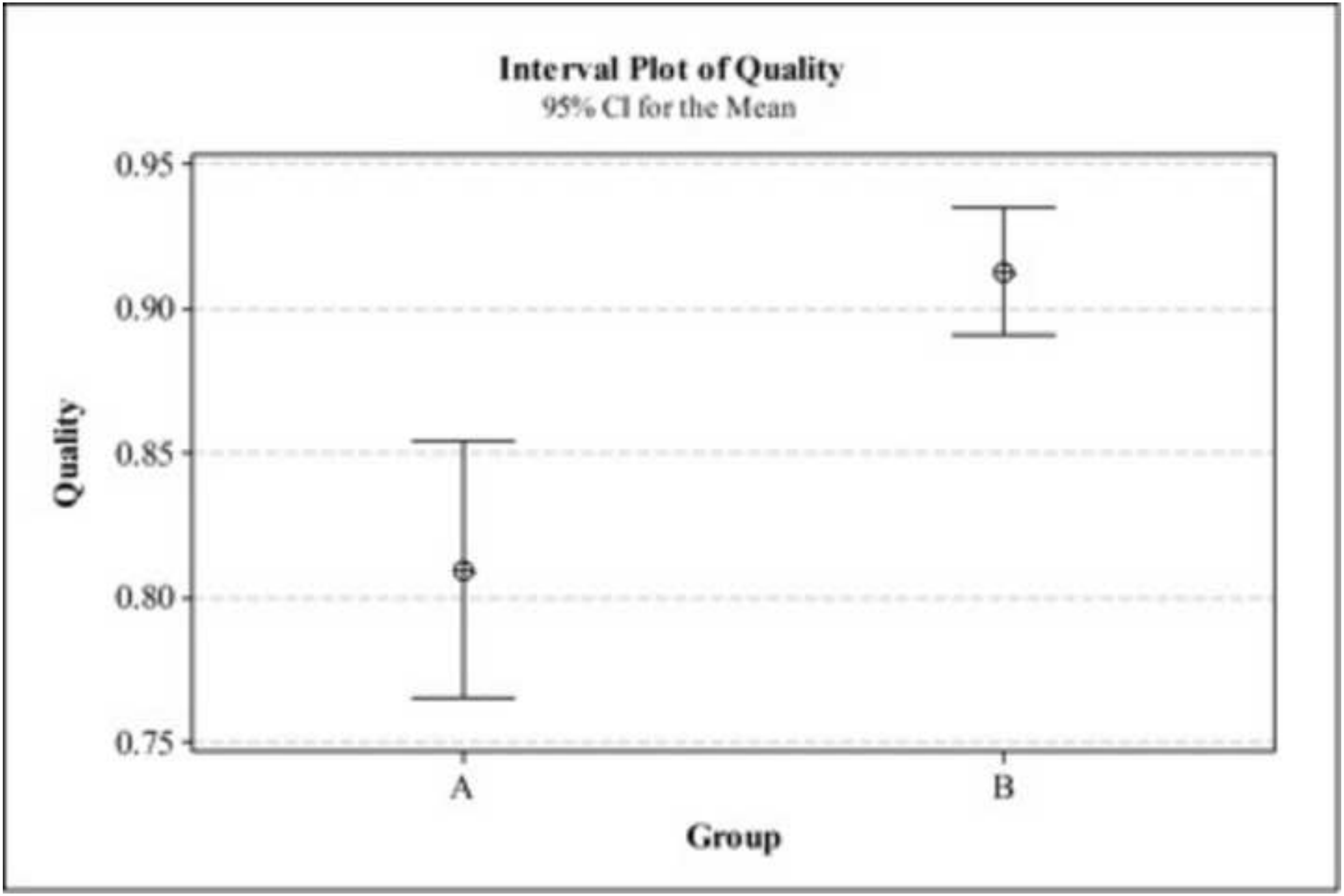
	II class OM/OD	II class MOD	**Total**
MARGINAL DISCOLOURATION Alpha	47.22%	5.55%	**52.77%**
Bravo	27.78%	16.67%	**44.45%**
Charlie	2.78%	0%	**2.78%**
Delta	0%	0%	**0%**
MARGINAL INTEGRITY Alpha	58.33%	8.33%	**66.66%**
Bravo	16.67%	13.89%	**30.56%**
Charlie	2.78%	0%	**2.78%**

Delta	0%	0%	**0%**
RESTORATION INTEGRITY Alpha	51.35%	2.78%	**54.13%**
Bravo	24.32%	19.44%	**43.76%**
Charlie	0%	0%	**0%**
Delta	0%	0%	**0%**
COLOUR MATCH Alpha	94.64%	100%	**95.65%**
Bravo	10,16%	0%	**8,33%**
Charlie	0%	0%	**0%**
Delta	0%	0%	**0%**
SURFACE ROUGHNESS Alpha	100%	100%	**100%**
Bravo	0%	0%	**0%**
Charlie	0%	0%	**0%**
Delta	0%	0%	**0%**
SECONDARY CARIES Alpha	100%	100%	**100%**
Bravo	0%	0%	**0%**
Charlie	0%	0%	**0%**
Delta	0%	0%	**0%**

Figure


Interval Plot of Quality
95% CI for the Mean
Quality
0.900
0.875
0.850
0.825
0.800
0.775
0.750
II MOD
II OM/OD
Class

Figure


Interval Plot of Quality
95% CI for the Mean
0.95
0.90
0.85
0.80
0.75
Quality
A
B
Group

Acknowledgments

The authors deny any conflict of interest related to this study.