



Original article

Monolithic Endocrown Vs. Hybrid Intraradicular Post/Core/Crown Restorations for Endodontically Treated Teeth; Cross-sectional Study

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ABSTRACT

The gold standard for restoring Endodontically Treated Teeth (ETT) with successful clinical longevity requires having minimal invasive preparations and maximal tissue conservation. Many dentists still consider hybrid post/core/crown to be the first choice for restoring ETT. Endocrown is a viable alternative treatment modality to hybrid post/core/crown. This study aims to assess the proper judgment of dentists working in Riyadh, Saudi Arabia on the use of monolithic endocrown versus hybrid post/core/crown for restoring ETT. The IRB of Princess Nourah Bint Abdulrahman University (PNU) Institutional Review Board reviewed this study. The questionnaire was validated and electronically distributed. The participants were pre-informed that their responses are completely anonymous and used for professional purposes only. The questionnaire surveyed dentists working in Riyadh, Saudi Arabia, about their preference for different ETT restorative modalities at various clinical scenarios. Data were analyzed using One-way ANOVA and *t*-test. All *P*-values of < 0.05 were considered statistically significant. A total of 275 responses were collected; 61.45% were females and 38.55% males. 56% of them were general practitioners, while 16% were consultants. Prefabricated post/core was the most preferred technique among the participants (18.55%), followed by endocrown (12.36%), and lastly, cast post/core (8.73%). The amount of remaining tooth structure was the most influential in the treatment selection (30.18%), followed by the presence or absence of 1–2 mm ferrule (17.82%). Interocclusal space (12.36%) was the least influential factor. Endocrown recorded 63.27% as the most preferred line of treatment in case of insufficient interocclusal space. 40.36% preferred endocrown for patients with occlusal risk factors. The amount of the remaining tooth structure and the tooth position significantly affect the treatment options of the participants. Endocrown was the most preferred treatment modality for restoring ETT for patients with occlusal consideration.

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1. Background

Reconstruction of Endodontically Treated Teeth (ETT) with coronal destruction in clinical practice remains a challenge. ETT

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lose their mechanical properties, teeth become fragile and more prone to fracture due to mainly loss of tooth structure integrity (Sevimli et al., 2015). Extirpation of pulp tissue and loss of vitality deteriorate the neurosensory feedback system. This may lead to dentin's diminishing physical properties like modulus of elasticity and fracture resistance, which may contribute to the higher failure of ETT. However, a lack of evidence is apparent (Sedrez-Porto et al., 2017). Access cavity, enlargement of the pulp chamber, and loss of dentin supporting walls during endodontic treatment significantly decrease overall fracture resistance of teeth, increase cuspal deflection, and cuspal fracture. Therefore, maintaining and preserving tooth structure is the most critical factor when treating ETT (Sedrez-Porto et al., 2017).

It is essential to consider the following factors during the restoration of ETT; the number of remaining tooth structures, the

tooth's location in the dental arch, occlusal forces, and aesthetics where appropriate (Caplan et al., 2002). Prognosis of ETT depends on the success of root canal treatment, efficient obturation of the canal, and minimizing the leakage of oral fluids and bacteria into peri-radicular areas maintained by durable coronal restorations that seal and seat properly (Tabassum et al., 2016). It is crucial to have a well-planned coronal restoration to avoid the complications of ETT. The restoration of ETT usually involves a conventional post and core foundation system and crown or endocrown system.

Post and core is a dental restoration used to sufficiently build up tooth structure for future restoration with a crown when there is not enough tooth structure to properly retain the crown due to tooth structure loss to either decay or fracture (Sedrez-Porto et al., 2017). There are two essential rules to be followed in the selection of posts. First, the retention of the post to be able to resist the vertical forces. Second, the resistance of the post to be able to resist the horizontal and rotational forces. Post resistance is influenced by the ferrule, anti-rotational features, length of the post, and rigidity (Khaldi et al., 2020).

The post and core system types could be cast or prefabricated metal (para post) and fiber prefabricated post systems. However, the prefabricated post systems take less time to place. It does not involve any lab work and can be inserted immediately upon the decision to utilize it once the endodontic therapy has been completed and the post space created, leaving 4–5 mm of an apical seal. The length of the post hole is recorded. The post is shortened from its apical end to preserve the retentive tag for the core (Deepak M. Vikhe, 2021).

Moreover, various luting agents as zinc phosphate and self-adhesive/conventional resin types of cement may be used to lute these posts. Composite or amalgam built up freehand. Final preparation of crown then final impression (Sedrez-Porto et al., 2017). While in custom-made cast post and core system removing caries, old restoration removal of GP, post space, and final preparation for the crown should be done before taking the impression. In this system, there are two different techniques. It could be direct or indirect. Direct technique pattern can either be made using inlay wax (GC Inlay wax medium) or pattern resin. The conventional indirect technique uses an elastomeric impression material along with some reinforcement. The reinforcement could be a paper clip, orthodontic wire, plastic posts, toothpicks, etc. It is more time-consuming because it involves lab work (Shaikh et al., 2017).

Several studies show that metal posts and glass fiber posts present different mechanical properties. Metal posts have a higher elastic modulus than dentin. It can increase the risk of root fracture and catastrophic failure. On the contrary, glass fiber posts have mechanical properties similar to dentin and exhibit relatively uniform stress distribution to the root. In comparison to other post types, it is easy to place, cost-effective, esthetic, low catastrophic failure rates and consequent failures related to their use, mostly involving post debonding (Sarkis-Onofre et al., 2015; Atlas et al., 2019).

Patients require and inquire about three criteria when restoring their teeth; longevity and durability, esthetics, and minimum conservative teeth preparation. Until recently, many dentists considered conventional post and core crowns to be the only choice for restoring severely destroyed ETT. However, with the advancement of adhesive dentistry, endocrown, a single unit relatively conservative restoration is used as a viable alternative treatment modality to conventional post/core & crown. In 1999, Bindl and Mormann described endocrown for the first time as an adhesive endodontic crown. They defined it as a total porcelain crown fixed to endodontically treated posterior teeth. The gold standard for restoring severely destructed ETT with successful clinical longevity is minimal invasive preparations, maximal tissue conservation, avoiding overtreatment, and the ability to reintroduce root canal treatment

in case of complications (Sevimli et al., 2015). The preceding gold standards for restoring badly destroyed ETT, justify implementing endocrown in the prosthetic treatment plan of endodontically treated teeth (Sevimli et al., 2015). Moreover, various clinical cases as calcified root canals, fractured instrument, or narrow canals advocate the use of endocrown as an alternative treatment option for endodontically treated teeth (Dogui et al., 2018).

The endocrown approach utilizes the pulp chamber and the cavity margin with no root canal involvement. This results in less removal of tooth structure and achieving macro-micro mechanical retention from the pulp chamber walls and the adhesive cementation system (Tzimas et al., 2018). The characteristics of the preparation of endocrowns are jointly prepared parallel occlusal surfaces. It provides stress resistance and supragingival cervical margin. This maintains periodontium health and facilitates impression taking (Tzimas et al., 2018). The occlusal portion in the endocrown has high fracture resistance. Its thickness varies from 3 to 7 mm higher than the conventional crown (Sevimli et al., 2015). Therefore, no additional macro-retentive preparation or ferrule is needed. Incorporating a ferrule does not offer any significant difference in fracture resistance with non-ferrule prepared endocrown (Tzimas et al., 2018).

Endocrown restoration is fabricated using a conventional heat-pressed or computer-aided design/ computer-aided manufacturing (CAD/ CAM) system. CAD/CAM technology is widely used nowadays in dental settings. It has the advantage of providing high-quality restoration in a very short chair side time. Since the development of CAD/Cam, many related materials have been utilized (Tzimas et al., 2018; El-Damanhoury et al., 2015). The most common materials used for endocrown are leucite reinforced, lithium disilicate reinforced ceramics, and monolithic zirconia ceramics. Lithium disilicate is one of the most used materials for endocrown. It has good aesthetic value and adequate mechanical strength (Guo et al., 2016; Carvalho et al., 2016). Resin composite materials have recently been developed and used. Nanoceramic resin restorative materials have a modulus of elasticity similar to dentine, less crack propagation, and higher fracture resistance than ceramics (Sevimli et al., 2015). However, microleakage is a problem in resin composite materials (El-Damanhoury et al., 2015). Moreover, it has less strength and fracture resistance than disilicate lithium glass-ceramic (Guo et al., 2016).

The recent application of endocrown in clinical practice presented several merits over posts and cores. Endocrowns aim to maintain ETT compromised structure's biomechanical integrity and preserve maximum tooth structure for bonding (Sevimli et al., 2015). This approach results in minimal tooth structure loss, superior mechanical properties, fewer clinical steps, and reduced cost (Carvalho et al., 2016). Esthetic properties are also superb. Additionally, they present a significant advantage when posts are contraindicated due to short or narrow canals. Despite the increased popularity of endocrown restorations among dental practitioners, the question that remains is whether clinicians should consider using endocrown instead of conventional treatments with intra-radicular posts. Several in vitro studies have investigated the performance of endocrown compared to traditional post retained crowns. Studies have reported that endocrown have a comparable or even superior fracture strength to conventional crowns when used in molars, premolars, and even incisors (Sevimli et al., 2015; Carvalho et al., 2016). However, to the best of our knowledge, there is still scarce clinical evidence in the literature. Nevertheless, in vitro evaluations reporting on the fracture strength of endocrown are reasonably available; thereby, observational studies consider this subject and the clinician's opinions (Rayyan et al., 2019).

To meet the patient's needs and expectations with long-term restorative success, dentists should be familiar with every avail-

able dental treatment option. The purpose of this study is to assess the ability of the dentists working in Riyadh, Saudi Arabia, to select the proper clinical situation for the use of monolithic endocrown vs. hybrid intra-radicular post/core and crown to restore endodontically treated teeth.

2. Methodology:

This cross-sectional study was conducted to assess the use of monolithic endocrown vs. hybrid intra-radicular post/core & crown to restore endodontically treated teeth among dentists working in Riyadh city, Saudi Arabia. Institutional Review Board (IRB) ethical approval was obtained from Princess Nourah bint Abdulrahman University Research Centre on September 16th, 2019. The survey in this study was adapted from a previously validated and published questionnaire (Ratnakar et al., 2014). For validation, four arbitrators from the college of dentistry, Princess Nourah bint Abdulrahman University (PNU), self-assessed and evaluated the questionnaire. The questionnaire was modified according to their inputs. The questionnaire consisted of three parts; the first part gathered demographic information about the participants, including gender sex, age group, clinical specialty, clinical title, and workplace. The second and third parts consisted of sixteen multiple choice type questions. The second section of the questionnaire collected information about the frequency of using posts, the type of post/core material used, and the final extra coronal restoration choice for restoring endodontically treated teeth. The third and last section of the questionnaire collected information about different restoration techniques for endodontically treated teeth at different clinical scenarios.

The survey targeted 1000 Saudi and non-Saudi dentists, either general practitioners, residents, specialists, and consultants treating ETT working in Riyadh, Saudi Arabia. According to sample size calculation using Power Analysis and Sample Size (PASS) software, a sample size of 345 from a population of 1000 produces a two-sided 95% confidence interval with a precision (half-width) 0.0500 when the actual proportion is near 66.35%.

The questionnaire was converted to an online electronic form using Google Forms (Google Forms, 2019; a free web-based survey generator). A link to the questionnaire was generated and distributed via email and social media platforms. The questionnaire link was left open for six months. A reminder to participate was sent twice after every three weeks apart after the initial invitation. The collected data from 275 dentists were analyzed using computer software SPSS 16 (SPSS, Inc. Chicago, IL, USA). Frequencies and percentages were calculated for the various participant responses. ANOVA Regression Test was used and P-values of < 0.05 or less were considered statistically significant.

3. Results

In this study, a total of 275 dentists in Riyadh, Saudi Arabia, completed the survey and provided their demographic information (Table 1). Out of the 275 participants, 61.45% (169 response) were females while 38.55% (106 response) were males. The majority of the participants 72% were in the age range from 25 to 35 years old. The majority of respondents were general dentists 56% followed by consultants 16% (Table 1).

Out of the surveyed dentists, 78.95% are placing 1–5 posts per week. 42.98% of the participants believe that intra-radicular post reinforces ETT, while the remaining participants do agree. The majority of the participants (80.70%) believe that the ferrule effect can increase the fracture resistance of ETT (Table 2).

Generally, prefabricated post/core is the most preferred technique among the participants (18.55%), followed by endocrown

Table 1
Socio-Demographic Characteristic of the Dentists Participating in The Survey.

Characteristics	(Number)	(Percentage)
<i>Gender</i>		
Female	169	61.45
Male	106	38.55
<i>Age Group</i>		
25–35	198	72.00
36–45	51	18.55
46–55	19	6.91
>55	7	2.55
<i>Clinical Title</i>		
Consultant	45	16.36
Specialist	51	18.55
Resident	25	9.09
General dentist	154	56.00
<i>Specialty</i>		
Prosthodontics	55	20.00
Restorative dentistry	29	10.55
Endodontics	34	12.36
Others	157	57.09
<i>Work Place</i>		
Hospitals	63	22.90
Educational institution	89	32.36
Dental center	84	30.54
Other	39	14.18

(12.36%) and lastly cast post/core (8.73%). The amount of remaining tooth structure was the most influential factor in the treatment selection (30.18%), followed by the presence or absence of 1–2 mm ferrule (17.82%). The least influential factor was the interocclusal space (12.36%). (Table 2).

Almost half (53.51%) of the participants, considered prefabricated fiber post and composite core to be the most retentive post and core system. 52.63% preferred to use it due to its longevity. The most used cement for post cementation by more than half of the participants (54.39%) is composite resin cement. 28.95% of respondents showed that loss of retention is the most common cause of failure of restored ETT (Table 2).

In case the where the remaining tooth structure is greater than 50%, 45.61% of respondents are restoring ETT anterior tooth with a tooth-colored restoration, while 32.46% are restoring ETT posterior tooth with a tooth-colored crown (Table 2).

In case that the remaining tooth structure is 50%, almost the same percentages (36.84%– 35.09%) would restore ETT anterior tooth with a tooth-colored crown and prefabricated post and tooth-colored core and crown, while 40.35% are restoring ETT posterior tooth with a prefabricated post and tooth-colored core and crown (Table 2).

In cases where the remaining tooth structure is < 50%, 39.47% would restore ETT anterior tooth with a prefabricated post and tooth-colored core and crown. Almost the same percentages (29.82–28.95%) would restore ETT posterior tooth with a prefabricated post and tooth-colored core and crown and custom made a metal post and core with a tooth-colored crown (Table 2).

Generally, 29.73% of the participants are using prefabricated post and tooth-colored core and crown to restore ETT (Fig. 1).

Endocrown recorded 63.16% as the most preferred line of treatment to restore an ETT in case of insufficient inter-occlusal space, while 40.35% preferred endocrown for a patient with occlusal risk factors, such as bruxism or unfavorable occlusal relationships (Table 2). Generally, 51.84% of the participants would prefer endocrown in both cases (Fig. 2).

There is a significant relationship between the age of the participants and the belief that intra-radicular post reinforces ETT, with correlation coefficient = 0.17, P-Value = 0.03 (P < 0.05). About half (50%) of the youngest dentists (25–35 years), as well as 37.25 % of

Table 2
Participating Dentists Responses to The Questions, by Percentage of Respondents to Each Item.

Items	A	B	C	D	E	F
1. How many intraradicular posts do you place in root canal treated teeth per week?	78.95%	16.67%	4.39%			
2. Do you believe that intraradicular post reinforce the endodontically treated teeth (ETT)?	42.98%	43.86%	13.16%			
3. Do you believe that ferrule effect can increase the fracture resistance of ETT?	80.70%	9.65%	9.65%			
4. What is/are your preferred fabrication technique for intraradicular post to restore ETT?	18.55%	8.73%	12.36%	30.18%	12.36%	17.82%
5. Which type of intraradicular post fabrication technique do you prefer regarding retention?	6.14%	53.51%	7.89%	13.16%	7.89%	11.40%
6. Which type of intraradicular post fabrication technique do you prefer regarding longevity?	8.77%	52.63%	3.51%	14.91%	6.14%	14.04%
7. What is the type of cement you commonly use for intraradicular post cementation?	7.89%	2.63%	16.67%	18.42%	54.39%	
8. What is the most frequent failure of ETT?	24.56%	16.67%	20.18%	28.95%	9.65%	
9. What is your preferred line of treatment to restore an anterior ETT with >50% remaining sound tooth structure (minimum loss of tooth structure)?	45.61%	24.56%	15.79%	3.51%	4.39%	6.14%
10. What is your preferred line of treatment to restore a posterior ETT with >50% remaining sound tooth structure (minimum loss of tooth structure)?	18.42%	32.46%	17.54%	10.53%	1.75%	19.30%
11. What is your preferred line of treatment to restore an anterior ETT with 50% remaining sound tooth structure (Up to one-half of the coronal tooth structure missing)?	10.53%	36.84%	35.09%	4.39%	9.65%	3.51%
12. What is your preferred line of treatment to restore a posterior ETT with 50% remaining sound tooth structure (Up to one-half of the coronal tooth structure missing)?	6.14%	16.67%	40.35%	11.40%	7.89%	17.54%
13. What is your preferred line of treatment to restore an anterior ETT with < 50%: All or more than one-half of the coronal tooth structure missing?	7.89%	10.53%	39.47%	16.67%	14.91%	10.53%
14. What is your preferred line of treatment to restore a posterior ETT with < 50%: All or more than one-half of the coronal tooth structure missing?	5.26%	5.26%	29.82%	28.95%	12.28%	18.42%
15. What is your preferred line of treatment to restore an ETT while the inter-occlusal space is insufficient?	14.04%	14.91%	7.89%	63.16%		
16. What is your preferred line of treatment to restore an ETT in patients with occlusal risk factors, such as bruxism or unfavorable occlusal relationships?	19.30%	25.44%	14.91%	40.35%		

the dentists between 36 and 45 years old, believed that the EET becomes stronger after post/core restoration. However, 100 % of the dentists more than 46 years old do not believe in that (Table 3).

There is a significant relationship between the age of the participants and the most preferred Intra-RadicularPost (IRP) fabrication technique in terms of retention, with correlation coefficient = 0.2, P-Value = 0.04 (P < 0.05). Most dentists between 25 and 35 years (61.1%) and 71.43 % of the dentists more than 55 years old believed that Prefabricated fiber post and composite core is the most retentive post. 47.37 % of the dentists between 46 and 55 years old selected endocrown. However, custom made metal post and core was chosen by 28.57 % of the oldest age group (Table 3). Generally, almost half of the participants (53%) considered prefabricated fiber post and composite core as the most retentive post and core system.

There is a significant relationship between the number of intra-radicular posts placed by the participant/week and the preferred intra-radicular post-fabrication technique in terms of longevity, with P-Value = 0.04 (P < 0.05). More than half of all the dentists placed 1-5posts/week, 6-10 posts/week, and more than 10 posts /week, considered prefabricated fiber post and composite core the best technique regarding longevity (Table 2).

There is a significant relationship between gender and the preferred line of treatment to restore a posterior teeth ETT with < 50% of remaining sound tooth structure, with P-Value = 0.004 (P < 0.05). About one-third of females (33.14%) chose prefabricated post and tooth-colored core and crown as the preferred line of treatment to restore ETT with < 50% sound tooth structure. On the other hand, about one-third of males (33.96%) chose custom-made metal posts and core with a tooth-colored crown as the preferred line of treatment in such cases (Table 4).

There is a significant relationship between the specialty of the participants and the commonly used cement for IRP, with correlation coefficient = -0.29, P-Value = 0.009 (P < 0.05). Most of the prosthodontists (74.55 %) used composite resin cement for IRP cementation, while all restorative dentists, half of the endodontists, and about 40% of the dentists from other specialties also use composite resin cement (Table 5).

There is a significant relationship between the specialty of the participants and the belief of the most frequent failure of ETT, with P-Value = 0.019 (P < 0.05). Prosthodontists and restorative dentists consider the loss of retention as the major cause of frequent failures of ETT with (34.5%) and (41.38%) respectively. More than half of endodontists (55.88%) consider endodontic failure as the main cause of ETT failure (Table 5).

There is a significant relationship between the clinical title of the participants and the most reported frequent failure of ETT, with P-Value = 0.004 (P < 0.05). About half of the consultants (42.22 %) consider the loss of retention as the main cause of frequent failure of ETT. Additionally, one-quarter of general dentists (25.9%) reported the loss of retention as the main cause of failure of ETT followed by root fracture. 29.41% of specialists and (40%) of residents reported endodontic failure as the main cause of ETT failure (Table 6).

4. Discussion

This study is the first attempt to comprehensively and objectively assess dentists' ability working in Riyadh, Saudi Arabia, to select the proper clinical situations for the use of monolithic endocrown vs. hybrid intra-radicular post/core and crown to restore endodontically treated teeth.

Despite sending multiple reminders, only 275 returned the completed questionnaire, representing a response rate of around 28%. This response is statistically adequate and greater than 10 %

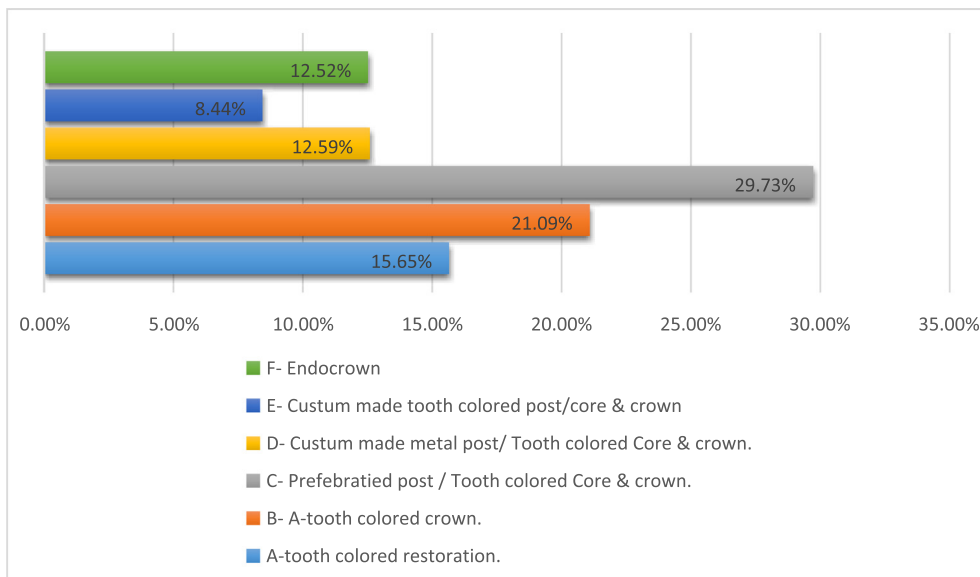


Fig. 1. Preferred line of treatment of ETT according to the tooth position and the amount of the remaining tooth structure.

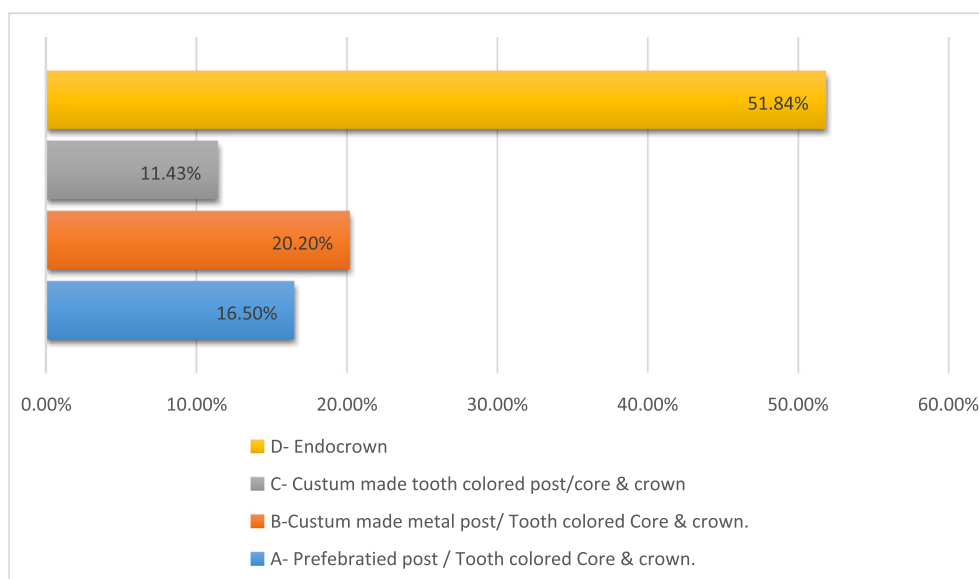


Fig. 2. Collective response for preferred line of treatment of ETT in case of insufficient interocclusal space and presence of occlusal risk factors.

of the overall population size (Verma et al., 1991; Ronán Conroy et al., 1986; Ross, 2004). However, the respondents' characteristics may have been different from those of the entire target population in a way that influenced the results. Therefore, some over-or underestimation cannot be excluded and the results should be generalized with caution.

Inconsistent with the established high level of evidence that stated the primary purpose of the intra-radicular post is to retain the core, about half of the participants (42.98%) believe that intra-radicular post reinforces ETT, which might influence the high percentage of its use (78.95%) among the participant dentists. This result is consistent with another study done among dentists in the north region of Saudi Arabia (Akbar, 2015).

Regarding the ferrule effect, the vast majority of respondents (>80%) believe that ferrule can increase the fracture resistance of ETT. A previous study considered ferrule as an essential principle for long-term success when post used. However, the incorporation

of ferrule did not significantly influence the clinical outcomes in using endocrown (Tzimas et al., 2018).

Following the findings of multiple survey studies on dentists, this study found that prefabricated post/core is the most preferred technique among the participants (Sarkis-Onofre et al., 2015; Wahab et al., 2021), followed by endocrown, and cast post and core.

Biomechanical properties of ETT teeth play a principal role in selecting the proper restoration followed by endodontic therapy. Loss of structural integrity has been identified as the main cause of fracture in ETT (Sevimli et al., 2015). Accordingly, the remaining tooth structure was the most influential factor in the treatment selection among the respondents, followed by a 1–2 mm ferrule presence or absence. In contrast, the least influential factor was the interocclusal space.

The use of fiber posts has been increasing in recent years compared to different other types of posts (Atlas et al., 2019). Half of the participants (53.51%) in this study considered prefabricated

Table 3
Cross Tabulation of Age and Various Significant Variables.

Characteristics	Options	Age Groups								Total		P value
		25-30		36-45		46-55		>55		(n)	%	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)			
Q2: Do you believe that intraradicular post reinforce the endodontically treated teeth (ETT)?	Yes	99	50	19	37.25	0	0	0	0	118	43	0.03
	No	72	36.4	22	43.14	19	100	7	100	120	43.6	
	Not sure	27	13.6	10	19.61	0	0	0	0	37	13.4	
Q5: Which type of intraradicular post fabrication technique do you prefer regarding retention?	Total per Age group	198	72	51	18.55	19	6.91	7	2.55	275	100	0.04
	Prefabricated metal post and amalgam / composite core	10	5.05	6	11.76	0	0	0	0	16	5.82	
	Prefabricated fiber post and composite core	121	61.1	15	29.41	5	26.32	5	71.43	146	53.1	
	Prefabricated ceramic post and composite core	19	9.6	4	7.84	0	0	0	0	23	8.36	
	Custom made metal post and Core	14	7.07	14	27.45	3	15.79	2	28.57	33	12	
	Custom made zirconia post and core	17	8.59	4	7.84	2	10.53	0	0	23	8.36	
Q8: What is the most frequent failure of ETT?	Endocrown	17	8.59	8	15.69	9	47.37	0	0	34	12.36	< 0.000001
	Total per Age group	198	72	51	18.55	19	6.91	7	2.55	275	100	
	Endodontic failure	60	30.3	7	13.73	0	0	0	0	67	24.36	
	Crown fracture	36	18.18	7	13.73	2	10.53	0	0	45	16.36	
	Root fracture	46	23.23	6	11.76	2	10.53	2	28.57	56	20.36	
	Loss of retention	46	23.23	19	37.25	12	63.16	2	28.57	79	28.73	
	No failure	10	5.05	12	23.53	3	15.79	3	42.86	28	10.18	
	Total	198	72	51	18.55	19	6.91	7	2.55	275	100	

Table 4
Cross Tabulation of Gender and Various Significant Variables.

Characteristics	Options	Female		Male		Total		P value
		n	%	n	%	n	%	
Q8: What is the most frequent failure of ETT?	Endodontic failure	51	30.18	17	16.04	68	24.73	<0.00001
	Crown fracture	27	15.98	19	17.92	46	16.73	
	Root fracture	24	14.2	31	29.25	55	20	
	Loss of retention	58	34.32	22	20.75	80	29.09	
	No failure	9	5.33	17	16.04	26	9.45	
	Total	169	61.45	106	38.55	275	100	
Q11: What is your preferred line of treatment to restore an anterior ETT with 50% remaining sound tooth structure (Up to one-half of the coronal tooth structure missing)?	Tooth colored restoration	14	8.28	14	13.21	28	10.18	0.035
	Tooth colored crown	77	45.56	24	22.64	101	36.73	
	Prefabricated post and tooth colored core and crown.	58	34.32	39	36.79	97	35.27	
	Custom made metal post and core with tooth colored crown	5	2.96	7	6.6	12	4.36	
	Custom made tooth colored post and core and crown	12	7.1	15	14.15	27	9.82	
	Endocrown	3	1.78	7	6.6	10	3.64	
	Total	169	61.45	106	38.55	275	100	
Q14: What is your preferred line of treatment to restore a posterior ETT with < 50%: All or more than one-half of the coronal tooth structure missing?	Tooth colored restoration	0	0	15	14.15	15	5.45	0.004
	Tooth colored crown	5	2.96	10	9.43	15	5.45	
	Prefabricated post and tooth colored core and crown.	56	33.14	27	25.47	83	30.18	
	Custom made metal post and core with tooth colored crown	43	25.44	36	33.96	79	28.73	
	Custom made tooth colored post and core and crown	22	13.02	12	11.32	34	12.36	
	Endocrown	43	25.44	6	5.66	49	17.82	
	Total	169	61.45	106	38.55	275	100	

Table 5
Cross Tabulation of Specialty and Various Significant Variables.

Characteristics	Options	Specialty Groups								Total		P value
		Prosthodontics		Restorative dentistry		Endodontics		Others		(n)	(%)	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)			
Q7: What is the type of cement you commonly use for intraradicular post cementation?	Zinc phosphate	0	0	0	0	7	20.59	14	8.92	21	7.64	0.009
	Zinc polycarboxylate	0	0	0	0	0	0	7	4.46	7	2.55	
	Glass ionomer	12	21.82	0	0	0	0	34	21.66	46	16.73	
	Reinforced glass ionomer	2	3.64	0	0	10	29.41	39	24.84	51	18.55	
	Composite resin cement	41	74.55	29	100	17	50	63	40.13	150	54.55	
	Total	55	20	29	10.55	34	12.36	157	57.09	275	100	
Q8: What is the most frequent failure of ETT?	Endodontic failure	9	16.36	2	6.9	19	55.88	36	22.93	66	24	0.019
	Crown fracture	7	12.73	7	24.14	2	5.88	30	19.11	46	16.73	
	Root fracture	15	27.27	3	10.34	3	8.82	36	22.93	57	20.73	
	Loss of retention	19	34.55	12	41.38	5	14.71	43	27.39	79	28.73	
	No failure	5	9.09	5	17.24	5	14.71	12	7.64	27	9.82	
	Total	55	20	29	10.55	34	12.36	157	57.09	275	100	

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Table 6
Cross Tabulation of Clinical title and Various Significant Variables.

Characteristics	Options	Specialty Groups								Total		P value
		Consultant		Specialist		Resident		General dentist		(n)	(%)	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)			
Q8: What is the most frequent failure of ETT?	Endodontic failure	9	20	15	29.41	10	40	34	22.08	68	24.73	0.004
	Crown fracture	5	11.11	10	19.61	5	20	27	17.53	47	17.09	
	Root fracture	7	15.56	7	13.73	3	12	39	25.32	56	20.36	
	Loss of retention	19	42.22	12	23.53	7	28	40	25.97	78	28.36	
	No failure	5	11.11	7	13.73	0	0	14	9.09	26	9.45	
	Total	45	16.36	51	18.55	25	9.09	154	56	275	100	

fiber post and composite core as the most retentive post and core system. They chose longevity as the main reason for its use. In a study done by (Sarkis-Onofre et al., 2015), the cast metal posts were slightly more preferable among their participants. However, they highlighted that dentists with post-graduate training tend to prefer glass fiber posts as their first choice to restore ETT, whereas non-specialists tend to prefer cast metal posts (Atlas et al., 2019). The same study revealed that resin cement was the most commonly selected material among participants (Atlas et al., 2019). This is consistent with the results of this study.

Regarding restoring ETT with a tooth-colored crown, 45.6% of the participants chose to restore the anterior ETT with tooth-colored restoration while (32.46%) decided to restore the posterior ETT with a tooth-colored crown in cases where the remaining tooth structure was more than 50%. A previous study by (Sarkis-Onofre et al., 2015) revealed that in ETT with three or four coronal walls left, at least one marginal ridge remaining, and no undermined cavity walls, direct adhesive restoration may be considered an alternative cuspal coverage. For posterior teeth with few or weakened coronal walls, cuspal coverage with an adhesively placed onlay, a partial crown, or a conventional crown is advised (Sarkis-Onofre et al., 2015).

In the case of the remaining tooth structure is 50%, almost similar percentage (36.84%–35.09%) of the participants chose to restore the anterior ETT with tooth-colored crown and prefabricated post and tooth-colored core and crown. The percentage increased to (40.35%) to restore the posterior ETT with prefabricated post and tooth-colored core and crown of half of the tooth structure preserved. A study done by (Aurélio et al., 2016) revealed that a comprehensive literature review recommends restoration of root-filled molars and premolars exhibiting limited tissue loss, that is, with 50% or more of the coronal structure preserved, without post-placement, especially when cusp protection is preplanned.

Furthermore, (Sevimli et al., 2015) a review study revealed that since the coronal structure is enough to provide restoration stability, retention, and strength, teeth with existing medium-sized restorations that require root canal therapy do not need a post-core restoration. Complete occlusal coverage, such as an endocrown or onlay restorations, is suggested using a composite resin liner-base to create an even cavity preparation and fill undercuts.

When a tooth has more than 50% of the coronal structure missing, post and core foundation is preferable. The choice of appropriate post and core restorations is often complicated and should be guided by knowledge of their physical properties (Guldener et al., 2017). In this study, the results show that about (39.47%) of respondents preferred to restore ETT anterior tooth with a prefabricated post and tooth-colored core and crown in cases where more than 50% of coronal tooth structure is missing. Furthermore, considering the same case, (29.82 %) are restoring ETT posterior tooth with a prefabricated post and tooth-colored core and crown and custom-made a metal post and core with a tooth-colored crown. A study by Guldener et al., 2017 revealed that if the coronal structure is highly damaged, with considerable loss of tooth structure, post-placement and core build-up are needed, followed by full coronal coverage.

On the other hand, our findings revealed that (63.16%) of dental practitioners in Riyadh, Saudi Arabia, uses endocrown as the most preferable treatment line to restore an ETT in cases of insufficient inter-occlusal space. 40.35% preferred endocrown for a patient with occlusal risk factors such as bruxism or unfavorable occlusal relationships. In support of these results, Sedrez-Porto et al., (2016) demonstrated that endocrown restorations have high fracture strength and are preferred more than other conventional treatments using posts, direct composite resin, or inlay/ onlay restorations. Moreover, endocrown seem a more reliable alternative for load-bearing teeth (Dogui et al., 2018).

Another study by Sevimli et al., (2015) compared equivalent stresses in molars restored with endocrowns versus posts and cores during masticatory. Simulations concluded that under physiological loads, ceramic endocrowns ideally cemented in molars are more resistant to failure and fracture than those with fiber-reinforced composite (FRC) posts and other conventional restorations. Additionally, this study indicates that the majority of the participants take into consideration the following factors; the amount of the remaining tooth structure, the interocclusal space, and the presence or absence of 1–2 mm ferrule effect when selecting the line of treatment to restore ETT. This suggests that dental practitioners in Saudi Arabia follow the treatment strategies of ETT under the current state of evidence-based knowledge.

The observed results of the correlation between the participant's age and the belief that intra-radicular post reinforces ETT were statistically significant P -value = 0.03 ($P < 0.05$). About half (50%) of the youngest dentists (25–35 years), (37.25 %) of the dentists between 36 and 45, believed that the EET has become stronger after post/core restoration. In contrast, 100 % of dentists more than 46 years old do not believe in that. There is also a significant statistical relationship was noted between the participant's age and the most preferred Intra-Radicular Post (IRP) fabrication technique in terms of retention. 61.1% of dentists (below 35) believed that prefabricated fiber post and composite core is the most retentive post. However, this percentage decreases to 26.3 % among age group 46 to 55 years old dentists. A possible explanation is that young recently graduated dentists are more conversant with updated literature and are probably more influenced by continuous professional development courses. In a study done in Brazil by (Sedrez-Porto et al., 2017) results showed that dentists have a preference for cast metal posts. This was attributed to the lack of continuing education courses after graduation.

In addition, this study found there is a significant relationship between the number of intra-radicular posts placed by the participant/week and the preferred intra-radicular post-fabrication technique in terms of longevity p -value = 0.04 ($P < 0.05$). The majority of the present survey respondents favored prefabricated fiber post and composite core as the best technique regarding longevity. In another similar study, Sedrez-Porto et al., (2017) noted that prefabricated post was preferable to most dentists. This is because prefabricated posts are easier to fabricate with much minimum time and visits.

There are many identified causes of failure of ETT that are post retained. Some of them are endodontic failure, loss of retention, root fracture, recurrent caries, and periodontal diseases (Terry et al., 2010). In this study, the correlation between participants' specialty and the most frequent cause of failure of ETT, is statistically significant with a P -value < 0.05 . Prosthodontists and restorative dentists reported a loss of retention as the most frequent cause of failure of ETT. On the other hand, endodontists reported endodontic failure as the most frequent cause of ETT failure. The results of this study are contrary to the results of another similar study done in India. In that study prosthodontists and general dentists reported endodontic failure as the main cause of the failure of ETT. Endodontists reported the loss of retention of posts as the most frequent cause of ETT failure in the same study (Kavlekar et al., 2016). In another study done by Olcay et al., (2018) revealed that restorative and endodontic were the most frequent reasons for failure and prosthetics as the most common reason for extraction.

Concerning the participants' specialty and the commonly used cement for IRP, there is a statistically significant relationship P -value = 0.009 ($P < 0.05$). Most of the prosthodontists (74.55%) used composite resin cement for intra-radicular post cementation. All restorative dentists, half of the endodontists, and 40% of the dentists from other specialties also commonly use composite resin cement. Most of the respondents in this investigation favored using

composite resin cement for intra-radicular posts. This result may be attributed to the fact that the adhesive cementation system provides reliable and long-lasting bonding to root canals, where mechanical retention is compromised (Maroulakos et al., 2018). Successful adhesion to the radicular dentin relies on various factors. These factors include; morphology of dentinal tissue, materials used during endodontic treatment, technique for adhesive cementation of the endodontic post, and the geometric characteristics of the root canal space. In addition, post-surface treatments and proper selection of root canal irrigants and adhesives are other factors for the bond strength (Sedrez-Porto et al., 2017). A study by Sarkis-Onofre et al., (2015) has demonstrated that the use of resin composite core material was preferred for luting endodontic posts due to the simplicity and homogeneity of using the same material for the post and core placement.

5. Conclusion

The amount of the remaining tooth structure and the tooth position significantly affect the participants' treatment options. When a tooth has more than 50% of the coronal structure missing, post and core foundation was preferable. Prefabricated fiber post and composite core are considered the most clinical used post and core systems.

Endocrown was selected as the most preferred treatment modality for restoring ETT for patients with occlusal consideration. As monolithic endocrowns have superior fracture resistance when compared to those restored with hybrid post/core/crown. Moreover, when the coronal structure is enough to provide restoration stability, retention, and strength, ETT does not need a post-core restoration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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