FRACTURE RESISTANCE OF COMPUTER AIDED ENDO-CROWNS VERSUS CONVENTIONAL CORE-SUPPORTED COMPUTER AIDED FULL CROWNS

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Abstract

The purpose of the present study was to investigate the fracture resistance of computer aided endo-crowns versus conventional core-supported computer aided full crowns.

Ninety human teeth were collected, 30 for each type (maxillary central incisors, maxillary 1st premolars and maxillary 1st molars). Specimens were divided into 3 groups (n=10) according to restoration used: 1) PC: Post-core and crown; 2) NC: Nayyar core and crown and 3) EC: Endo-crown. Each group was further subdivided into 3 subgroups according to the tooth used: I (Incisor), P (Premolar) and M (Molar). For group PC: Fiber post (Radix, Dentsply Maillefer) were cemented using resin cement (Calibra Dual Cure, Denstply Detrey GmbH). For group NC: 3 mm of gutta percha of every canal was removed. For groups PC and NC, after etching and bonding of root-face, transparent core former (Coltène/ Whaledent) was filled with SDR (Smart Dentine Replacement, Dentsply Detrey GmbH) and inverted onto root-face and cured. All specimens were individually scanned and thermocycled for 1000 cycles then submitted to compression test using universal testing machine (Instron 8874; Instron Corp.) Fracture was confirmed by sudden drop in load readings. Subgroup IPC scored the highest mean among group I and subgroup PNC scored the highest mean among group P. One-Way ANOVA detected significant differences among groups I and M with $p < 0.05$ in I and M groups. Regarding P group, P-value was > 0.05 indicating no significant differences among group.

Endocrown showed the highest fracture resistance means in molars, while Nayyar core and crown showed the highest fracture resistance means in premolars. However, post-core and crown revealed the highest fracture resistance means in incisors.

Keywords: CAD CAM - Endo-crown - Nayyar core - post-core - compressive strength.

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RÉSISTANCE AUX FRACTURES DES ENDO-COURONNES ASSISTÉES PAR ORDINATEUR PAR RAPPORT AUX COURONNES CONVENTIONNELLES ASSISTÉES PAR ORDINATEUR

Résumé

Le but de la présente étude était d'étudier la résistance à la rupture des couronnes à ancrage endodontique assistées par ordinateur par rapport aux couronnes complètes conventionnelles assistées par ordinateur.

Quatre-vingt-dix dents humaines ont été utilisées, 30 pour chaque type (incisives centrales maxillaires, 1ères prémolaires maxillaires et 1ères molaires maxillaires). Les échantillons ont été divisés en 3 groupes (n = 10) en fonction de la restauration utilisée: 1) FC: faux-moignon et couronne; 2) NC: noyau de Nayyar et couronne et 3) CE: couronne à ancrage endodontique. Chaque groupe a ensuite été subdivisé en 3 sous-groupes en fonction de la dent utilisée: I (incisive), P (prémolaire) et M (molaire). Tous les échantillons ont été scannés et thermocyclés individuellement pendant 1000 cycles, puis soumis à un test de compression à l'aide d'une machine de test universelle (Instron 8874; Instron Corp.). La fracture a été confirmée par une chute soudaine des lectures de charge.

Le premier groupe a obtenu la moyenne la plus élevée au niveau des incisives et le groupe 2 a obtenu la moyenne la plus élevée au niveau des prémolaires. Des différences significatives entre les groupes I et M ont été notées ($p < 0,05$). En ce qui concerne le groupe P, aucune différence significative n'a été détectée entre les groupes.

Les dents du groupe 3 ont présenté la plus grande résistance à la rupture au niveau des molaires, tandis que les dents du groupe 2 ont présenté la plus grande résistance à la fracture au niveau des prémolaires. Cependant, les dents du groupe 1 ont présenté les valeurs les plus élevées de point de vue résistance à la fracture au niveau des incisives.

Mots-clés : couronne conventionnelle - noyau de Nayyar – tenon en fibres de verre - résistance à la compression.

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Introduction

"Endodontic treatment is merely a space maintainer for implants". This is a famous joke, frequently told by implantologists and implant companies, which reflects serious challenges encased in restoring endodontically treated teeth (ETT) [1]. This must not be accepted as a fact because long standing success of ETT has been well documented in literature [2].

However, it cannot be denied that endodontically treated teeth pose great controversy in restorative dentistry. When oral functional and esthetic rehabilitation involves restoring endodontically treated tooth/teeth, dentist is faced by multiple challenges regarding ETT: "is the tooth in question restorable or must it be extracted? Does it need crown lengthening? Does it need retreatment? Will it serve as an optimum or questionable abutment? Does it need post and which type if yes? Will post strengthen the root? Should ferrule be made? If yes, how long? Etc.... A never ending dilemma!!

ETT are more liable to fracture as result of loss of tooth material following pathological process, endodontic procedures, and extensive tooth preparation for crown and bridge procedures. This biomechanical alteration may negatively impact long-term prognosis of ETT [3, 4].

This is why many studies have tried to set off specific guidelines for the necessity of post usage in ETT. However, posts themselves have their own drawbacks; presence of multiple interfaces, excessive removal of intraradicular dentine, possible off-axis drilling, possibility of apical microleakage in cases of short apical plug and difficulty of removal in case root canal retreatment is needed.

With recent advancements of adhesive philosophy in dentistry, use of post itself is highly questionable. Optimum post modulus of elasticity is clearly controversial. Stiff posts and cores may support coronal restoration better and lead to uniform stress distribution. However, catastrophic failure modes resembling vertical root fractures may result, if tooth was overloaded. On the other hand , elastic posts may undego bending when subjected to high load. This may leads to loss of prosthesis or failure, surprisingly tooth may be left intact for retreatment. Elastic post would also allow movement of restoration and thus increasing risk of leakage, secondary caries and root canal reinfection [5]. Adhesive dentistry promotes restoration of ETT with minimally invasive procedures because adhesion allows sufficient material retention without need for aggressive macro-retentive techniques [6].

As such, "Nayyar core" was first proposed in 1980 [7] and was named "corono-radicular stabilization". It is done by intraradicular prapartion of 2-4 mm from orifice of root canal and slightly undercutting pulp chamber to produce a retentive-core. It substituted its successor-the composite post-and preceded its grandfather- the amalgam post. "Nayyar core" was suggested and investigated by many authors to substitute posts and cores. Nevertheless, difficulty to relocate orifices in case endodontic retreatment is needed and presence of two interfaces were two major downsides of "Nayyar core".

In 1999, Bindl and Mörmann [8] proposed a treatment modality to ETT other than post/core supported crown, "endo-crown"- a one piece ceramic restoration, based on former work by Pissis [9]. Innovation of "Endo-crowns" has eliminated disadvantages of posts and cores as well as those of "Nayyar core". "Endo-crown" came in as simple solution to many problems. It is simply composed of restoration that occupies pulp chamber but not canals, and restores missing coronal portions of the tooth preserving by that maximum enamel and dentine to improve adhesion. It also eliminates lots of fabrication technical steps, such as post-cementation, core-buildup, crown temporization, and possible crown-lengthening, which may increase treatment cost and time. Its increased resistance and retention are attained through both, intra and extra-coronal aspects. Nevertheless, it must be kept in mind that incisors, premolars and molars have different internal as well as external anatomy of the crown and root structure. In addition to that, each tooth in each category experiences masticatory forces of different loads and directions [10-16].

"Endo-crowns" can be milled using computer aided techniques. CAD CAM hybrid ceramics has a dual-network structure that is thought to combine characteristics of ceramics and composites. In addition to high degree of elasticity that insures high load capacity following adhesive bonding.

We are transitioning into "endo-crown" era of restorative dentistry. As such, current study was conducted to verify if "endo-crowns" can surpass "post-core-crown" combinations and "Nayyar core- crown" combinations in restoring endodontically treated incisors, premolars and molars.

Materials and methods

Ninety human teeth were collected from Faculty of Dentistry, Beirut Arab University, Lebanon. Selection criteria implied that included teeth should be: 1) fractures-free as assessed radiographically and under microscope; 2) free of any carious lesion or restoration past the M-D CEJ; 3) free of any abnormalities; 3) of approximate sizes. Final sample of selected teeth included: 30 maxillary central incisors, 30 maxillary 1st premolars and 30 maxillary 1st molars. Teeth were cleaned and autoclaved at 15 Psi ,121°C for 40 min as recommended by Center for Disease Control and Prevention [17]. Teeth were then embedded in auto-polymerizing transparent acrylic resin (Vertex-Dental B.V.) 2mm below the cementoenamel junction (CEJ) forming blocks of 10 x 10 x 20 mm dimensions. Crowns were amputated horizontally close to mesiodistal CEJ. Canals were instrumented using K-files (Dentsply Maillefer) in step-back technique with intermitted irrigation using 2.5% sodium hypochlorite followed by 2ml of distilled water. Canals

Group	Subgroup	N
PC (Post-Core and Crown)	IPC (Incisor)	10
	PPC (Premolar)	10
	MPC (Molar)	10
NC (Nayyar Core and Crown)	INC (Incisor)	10
	PNC (Premolar)	10
	MNC (Molar)	10
EC (Endo-Crown)	IEC (Incisor)	10
	PEC (Premolar)	10
	MEC (Molar)	10
	Total	**90**

Table 1: Specimens grouping.

were thourghly dried and obturated using gutta-percha points (Dentsply Maillefer) and endodontic sealer (AH Plus, Dentsply, DeTrey) in lateral-condensation technique. Specimens were stored in distilled water for 72 hours at room temperature. Finally, specimens were randomly distributed into 3 groups according to restoration used (n=10) (Table 1).

For PC group, post-space preparation was started using Gates Glidden size 1 drill (Dentsply Maillefer) for gutta-percha removal then continued using Peeso reamers from size 1 to 3 (Largo, Dentsply Maillefer) and then completed using manufacturer-supplied drills. Self-etching adhesive (Xeno V+, Dentsply) were applied to canal walls using Microbrush-x for 20 seconds. Air blasts applied for 5 seconds to thin the material out then light-cured for 10 seconds (Elipar S10, 3M ESPE). Post was cleaned with alcohol then resin cement (Calibra Dual Cure, Dentsply Detrey GmbH) was auto-mixed and injected into canal and on adjusted Radix Fiber Post (Dentsply Maillefer, Switzerland). Fiber post was introduced into canal and excess cement was removed from around post using Microbrush. LED-curing light was applied 20 seconds on post-head. Using special gun, transparent core-former (Coltène/ Whaledent) was filled with SDR (Smart Dentine Replacement, Dentsply Detrey GmbH) and inverted onto root-face and light-cured.

For NC group, 3 mm of gutta percha of every canal was removed in the same manner as PC group. Canal walls and pulpal floor were adhesively treated. SDR was injected into canal walls and light-cured. Core-former were then filled with SDR to fom the core in same manner as PC group

For EC group, self-etching adhesive were applied to pulpal walls using Microbrush-x for 20 seconds. Air blasts applied for 5 seconds to thin the material out light-cured for 10 seconds.

For all groups, 0.5 mm chamfer finish line and 1.5 ferrule and were prepared using round-end taper bur with guiding-pin (8881 P, Komet, Brassseler) using parallelometer (Amann Girrbach,). Each specimen was placed individually in scanner (inEos X5, Sirona Dental Systems GmbH) in multi-die scanning mode. After completing scanning, crown was designed for teeth in groups PC and NC and endo-crown for teeth in group EC. Vita Enamic block (VITA Zahnfabrik H) was milled using Cerec MC XL milling machine (Sirona Dental Systems GmbH). Each crown was trial fitted on its corresponding tooth. All crowns were polished into high-gloss polish using Vita Enamic polishing-set (Vita Zahnfabrik H). Fitting surfaces of all crowns was degreased using alcohol prior to adhesive bonding. 5% hydrofluoric acid gel (Vita Ceramics Etch, Vita Zahnfabrik H) was applied to the fitting surfaces for 60 seconds. Then remaining acid was removed using water spray followed by an ultrasonic bath (BioSonic, UC 125, Coltène/ Whaledent AG, Switzerland), then air dried for 20 seconds. Silane coupling agent (Vitasil, Vita Zahnfabrik H) was applied to etched surfaces and left to dry completely. Calibra Dual Cure was auto-mixed and applied to fitting surface of each crown. Then, each crown was placed onto its corresponding tooth under static load of 5 kg for 10 min. Excess cement was then removed using a scaler (Figs. 1, 2 and 3).

All specimens were then thermocycled for 1000 cycles with the order of 20 seconds at 55°C and 20 seconds at 5°C with 10 seconds transport. Specimens were subjected to compressive force using universal-testing machine (Instron 8875; Instron Corp) under cross-head speed of 1.00 mm/min. Specimens were secured so that force was applied 45° on center of fossa in incisors and parallel to long axis of premolars and molars. Fracture in specimens was confirmed by a sudden drop of force measurements. Recorded data were coded then entered using statistical package SPSS version 16 and then summarized using descriptive statistics including: mean, standard-deviation, minimaum and maximum values. Significant differences between groups and subgroups were tested where p-values equal or less than t 0.05 were considered statistically significant.

Results

Considering the fracture resistance means among groups, the subgroup IPC scored the highest mean among group I (321.76±88.27) and subgroup

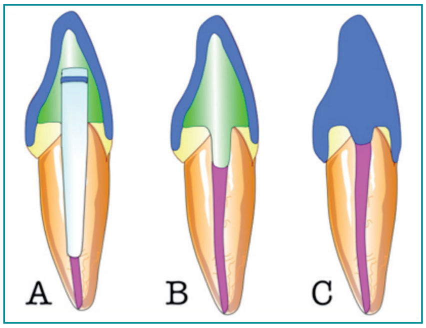

Fig. 1: A: Subgroup IPC; B: Subgroup INC; C: Subgroup IEC.

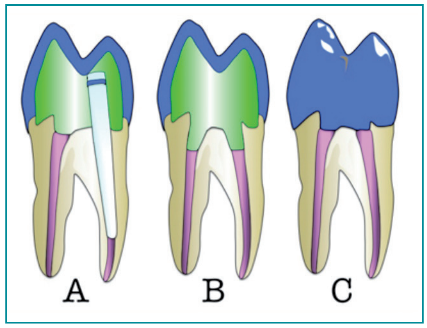

Fig. 2: A: Subgroup PPC; B: Subgroup PNC; C: Subgroup PEC.

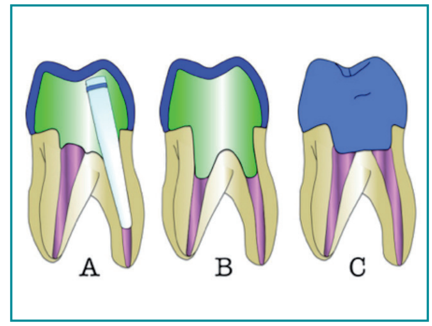

Fig. 3: A: Subgroup MPC; B: Subgroup MNC; C: Subgroup MEC.

PNC scored the highest mean among group P (345.33±139.37). Regarding the group M, subgroup MEC scored the highest mean levels (801.15±61.76) (Table 2).

One-Way ANOVA detected significant differences at 95% of confidence level in fracture resistance values among groups I and M with $p< 0.05$ in I and M groups. Regarding P group, no significant differences among group were noted ($p >0.05$).

Bonferroni Post-HocTest showed significant pairwise differences in fracture resistance values between groups ($p< 0.05$).

Mean differences indicates that fracture resistance (in Newtons) values in endo-crown group were lower than those of both Nayyar core and crown group and post-core and crown group in the incisors group. Fracture resistance (in Newtons) values in Nayyar core and crown group were also significantly lower than those of Post-Core and Crown Group in the Incisors Group. Algebraic sign of mean differences indicates also that fracture resistance (in Newtons) values in endocrown group were greater than those of both Nayyar core and crown group and post-core and crown group in the Molars group. Fracture resistance (in Newtons) values in Nayyar core and crown group were also significantly greater than those of post-core and crown group in the Molars group.

Discussion

In the current study, results revealed that restoring endodontically treated molars with endocrowns showed the highest fracture resistance means. This may be due to large pulp chamber which may provide restoration with more intra-pulpal resistance and retention forms. This corresponds with results obtained by several researchers [18-20]. Thanks to adhesive methods development, endocrowns could be a treatment option in restoring mutilated posterior teeth. Zogheib et al. in 2011 stated that, endocrowns preparation result in stable and wide surface which resist usual compressive loads on molars [21, 22]. The 3 to 4 mm mechanical anchorage inside pulp chambers added to the strong adhesive bond using resin cements with hard dental tissues, makes it unnecessary to use posts inside root canals. Endocrowns are also recommended in mutilated molars, narrow and short roots, limited inter-occlusal space or obturated canals. It offers more conservative tooth preparation compared with post /core preparation which could be considered one of its main advantages, in addition to absence of intervention in root canals, which decrease tooth-restoration interface and procedure time. In addition, molars restored with endocrowns provided more fracture resistance during loading, superior to those restored with fiber posts/cores and crowns. Bindl, Richter and Mörmann concluded that 87.1% of posterior teeth restored with endocrowns showed better resistance to fracture or debonding [8]. (8) Moreover, Biacchi and Basting [23] stated that endocrown in molars are more resistant to compressive forces when comparing it to molars restored with fiber post followed by crown. Dejak and Młotkowski.,2013 compared stresses generated in molars during mastication when restored with posts and cores or endocrowns, their results showed that, teeth restored by endocrowns were more resistant to failure than those with fiber posts/cores and crown [18].

Premolars showed the highest fracture resistance, when restored with Nayyar core, compared to fiber post and endocrown restorations in current study. These results were similar

Group	Subgroup	N	Mean± Std. Dev.	Min.	Max.
I (Incisor)	IPC (Post-Core and Crown)	10	321.76±88.27	198.45	398.72
	INC (Nayyar Core and Crown)	10	208.76±60.11	123.48	293.48
	IEC (Endo-Crown)	10	118.93±38.06	82.76	198.62
P (Premolar)	PPC (Post-Core and Crown)	10	229.78±71.11	109.73	298.72
	PNC (Nayyar Core and Crown)	10	345.33±139.37	4.671	498.42
	PEC (Endo-Crown)	10	292.41±85.73	123.87	398.43
M (Molar)	MPC (Post-Core and Crown)	10	384.94±57.52	289.84	455.67
	MNC (Nayyar Core and Crown)	10	603.43±72.00	487.23	698.61
	MEC (Endo-Crown)	10	801.15±61.76	697.08	894.62

Table 2: Descriptive statistics of fracture resistance values in newton.

Group	F value	P-Value	Significant diff.?
I	24.111	0.000	**YES**
P	3.153	0.059	No
M	105.662	0.000	**YES**

Table 3: One-Way ANOVA among groups.

to Tribst et al. [24] which stated that endocrowns for premolars is still not as proven as for molars. This could be due to reduced bonding area present in premolar pulp chamber, as well as increased lever effect due to crown height proportion in relation to tooth width that is evident by oblique force component, which is less in molars. Pissis et al. [9] stated that endocrowns preparations must be of 5mm depth, which is needed to obtain enough adhesive retention and better masticatory forces transmission to root, rarely found in premolars.(9) Similar results as current study was found in 1984 by Sorensen & Martinoff; post placement in premolars did not significantly affect success rate in premolars [25]. Conflicting results stated by Ferrari et al. [26] concluded according to a 2-year follow-up clinical study, that success rate for pulp premolars restored with full-crowns without posts was 70% compared to 82.5% with posts.

In the current study, the highest fracture resistance restoration for endodontically treated incisors was fiber post. Similar results were found by Sorensen & Martinoff in 1984, who investigated intracoronal reinforcement of ETT and found that best reinforcement for incisors is placement of post [25]. Additionally Giovani et al. [27] stated that "fracture resistance of teeth restored with short posts is 2–5 times lower than with conventional posts" . In contrary to these results, Hussain et al. [28] stated that 58,3% of structure is lost when incisors are prepared for post, which weaken the tooth. Biomechanics of incisors differ from molars, maybe due to its restricted tooth structure and higher bending movements acting on incisors teeth, which act negatively on restoration retention, subsequently clinical research investigating restoration of incisors using endocrowns is very limited.

Conclusions

Within the limitations of the present study, Endocrown showed highest fracture resistance means in molars. While Nayyar Core and crown showed highest fracture resistance means in premolars. However, Post-Core and crown revealed highest fracture resistance means in incisors.

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