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# Fracture Resistance of Teeth Restored with Composite Resin Versus Ceramic CAD/CAM Inlays

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***Abstract***
***Keywords:*** *Fracture resistance, resin nano ceramic, hybrid ceramics, CAD/CAM, Inlays.*
***Purpose:*** *to evaluate the fracture resistance of premolars restored with inlay restoration materials using Computer-Aided Design /Computer -Aided Manufacturing (CAD/CAM).*
***Materia and Method:*** *A total of thirty-two non-carious human maxillary premolar teeth were mounted in an acrylic block (2 mm below the cement-enamel junction). Twenty-four specimens received an operator prepared Class II MOD cavities without proximal boxes. The pulpal floor was prepared at a depth of 2 mm from the deepest point fissure to the cavity floor and an isthmus width of 3 mm bucco-lingually. All specimens were divided randomly into four main groups (8 teeth each); Group I: acting as (positive control group) of unprepared teeth. Group II: considered as (negative control group) with prepared unrestored mesio-oclusso-distal (MOD) class II cavity. Group III: MOD cavities were restored with resin nano-ceramic Grandio blocks CAD/CAM blocks. Group IV: MOD cavities were restored with hybrid ceramic Vita Enamic CAD/CAM blocks. All restored specimens were thermo cycled for 500 cycles from 5 to 55 degrees Celsius with 30 sec dwell time, and 20 seconds transfer time using thermo-cycling machine. The groups were then tested for fracture resistance using universal testing machine and loaded under compression at cross head speed of 0.5mm/min using steel cylinder with rounded end of 4mm diameter, adjusted parallel to long axis of tooth until failure by fracture of either tooth or restoration or both. Fracture strength value for each specimen was recorded in Newton. Fracture analysis was performed under a stereomicroscope (×16), and the mode of fracture for each specimen was determined. All data was collected, tabulated and statistically analyzed.*
***Results:*** *The restored groups were statistically possessing a fracture resistance significantly higher than both control groups.While no significant difference between the two materials used either resin nano ceramic Grandio nor Vita Enamic hybrid ceramic was recoded . Moreover, both restored groups recording fracture pattern mode IV complete fracture of specimen involving cusps and inlay restoration of 75% and 62.5% respectively.*
***Clinical significance:*** *More flexible and less rigid materials may be desirable for the restoration of posterior teeth to benefit from the inherent ability of teeth to flex under occlusal loading.*

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## I. Introduction

Recently, digital dentistry has been introduced and became a new challenge for dental practitioners. Computer-aided design/computer-aided manufacturing (CAD/CAM) technology is broadly used in daily dental practice due to its advantages such as its speed, ease of use, and quality of therapy.[1] This technology can be used in both the dental laboratory and the dental office with multiple applications including the fabrication of indirect restorations such as (inlays ,onlays, veneer).[2]

Generally, ceramic material has favorable properties for use as an indirect restoration due to its biocompatibility, strong physical properties and long-term clinical success. [3]

Over the years, indirect composite restorations have improved in relation to their mechanical properties in different ways: alteration of the composition (monomer resins, initiation systems); incorporation of high percentage filler particles; and polymerization modes (using high temperature and pressure for polymerization). These have improved both tensile and compressive strength, hardness, elastic modulus, and wear resistance. CAD/CAM technology allows for many alterations in manufacturing resulting in improved indirect composite restorations. CAD/CAM composite has the following main advantages compared to ceramic: it has less hardness and stiffness, so the opposing enamel exhibits less wear clinically. In addition, it is easily fabricated and repaired. It is also less brittle. Consequently, less catastrophic failure is expected as well as less chipping

and crack introduction during manufacturing. In addition, they are more compatible with milling machine and exhibit better marginal quality.[4-5-6] Different formulations have been introduced recently with different restorative material classifications such as ceramic-like materials, polymer infiltrated ceramics, CAD/CAM resin-based blocks, or nano- ceramics.[7] CAD/CAM composite restorative material can be classified based on their microstructural geometry- into two main types, resin with dispersed fillers and polymer infiltrated ceramic networks.[8]

Resin nanoceramics are made of nano-ceramic particles inserted in a highly cured resin matrix. Whereas hybrid ceramic is a resin composite that is obtained via the infiltration of a presintered ceramic network with a monomer mixture (dual ceramic-polymer network structure). In the true sense of the term hybrid, the processes for ceramic fabrication and composite resin fabrication were joined. Through this, a higher-volume fraction filler was achieved**.** [9-10]

Further investigation of CAD/CAM composite restorative material in many aspects such as mechanical properties, bonding, and biocompatibility is highly needed. Most importantly, their mechanical properties such as flexural strength, flexural modulus, modulus of resilience, and hardness that can predict the material clinical success and performance are important to be evaluated.[11,12]

Fracture resistance is one of the most critical factors influencing the survival rate of inlays, and the debate is currently ongoing on whether hybrid ceramics or nanofilled composite resin should be selected for CAD/CAM inlays.

## II. Materials and Method

Thirty-two non-carious human maxillary premolar teeth extracted for orthodontic reasons from patients aged from (18-25 years old).

The teeth with comparable size range and shape were used by measuring the buccolingual and mesiodistal widths in millimeters using periodontal probe, allowing a maximum deviation of 10% from the determined mean.

After careful examination using a magnifying glass and any tooth with visible cracks, hypoplasia, white spot lesion or caries on any surface defect were excluded from the study.

The selected teeth were thoroughly cleaned from calculus, tissue deposits, polished with pumice and rotating brush at conventional speed.

**Teeth grouping**

The 32 maxillary premolars were divided equally into four main groups (8 teeth each);

- **Group I:** premolars acting as positive control group of unprepared premolars.
- **Group II**: premolars acting as negative control group with prepared and unrestored mesio-oclusso-distal (MOD) class II cavity.
- **Group III:** Premolars were received MOD cavities and restored with nano-ceramic composite (Grandio blocs) CAD/CAM blocks.
- **Group IV:** Premolars were received MOD cavities and restored with hybrid ceramic (Vita Enamic) CAD/CAM blocks.

**Specimen preparation**

The teeth were disinfected in 0.5% chloramine T solution and stored in distilled water until use and used within 1 month. The teeth specimens roots were covered with a 0.3-mm layer of a polyether impression material simulating the periodontal ligament and embedded in a self-cure acrylic resin up to 2 mm below the cement-enamel junction. Root surfaces were dipped into melted wax to a depth of 2 mm below the C.E.J to produce a 0.2-0.3 mm layer and then mounted in polyvinyl plastic cylinders with self-cure acrylic resin 2 mm below the C.E.J. Each tooth was removed from the acrylic resin and the wax spacer was removed from the root and acrylic surfaces. Polyether impression material˚ was placed into the residual spaces and teeth were reinserted into the cylinders. Thus, the periodontal ligament was simulated to some extent.

**Cavity preparation**

A standardized MOD class II cavity without proximal boxes was prepared in premolar teeth using the inlay cavity preparation kit** in a high-speed hand piece with a copious water spray. The pulpal floor was at a depth of 2 mm from the deepest point fissure to the cavity floor and an isthmus width of 3 mm bucco-lingually. All preparations were free of undercuts with slight diverge occlusally by 4-6° degree .[13] Margins were prepared with 90° cavosurface angles. The inner angles of the cavities were rounded, and the margins were not beveled. During cavity preparation, the cavity dimensions were checked with periodontal probe.

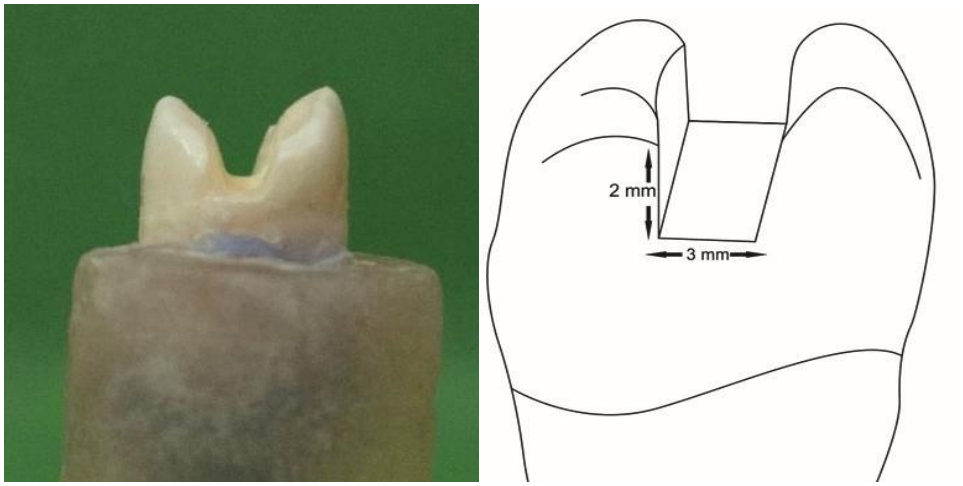


**Fig (IV-1):** specimen contour and dimensions of MOD cavity, pulpal depth 2mm and isthmus width 3mm buccolingually.

**Restoration Fabrication by CAD-CAM technology:**

**Step 1: Scanning the specimens:**

The prepared surface of each specimen was blocked out by spraying it with a scanning spray in order to avoid laser beam reflections then each tooth was scanned by digital scanner.

**Step 2: Designing the restorations:**

The restorations were designed using the software program (ExoCad 2019 software)[*]. The cement thickness (90 μm) was recorded in the software program.

**Step 3: Milling process:**

This was done by choosing the milling blanks then introducing them to the milling machine.

**Post-Milling:**

According to manufacturer's instructions, once the restoration is milled, it is carefully removed then put into ultrasonic cleaning bath filled with distilled water for 30 seconds to remove all residual dusts

**Inlays cementation procedures:**

**Surface treatment of the restoration**

According to manufacturer's instructions for **Grandio blocs** to obtain optimal bond the luting surface of the restoration was blasted with aluminum oxide (25-50 μ) at 1.5-2 bar**.** While for **Vita Enamic** appropriate acid etching with hydrofluoric acid 5 %for 60 seconds was applied on the luting surface of the restoration and rinsed with water for 30 seconds and dried for 20 seconds. For both of them then **silane** was applied to the luting surfaces for 60 seconds of waiting, then air was sprayed to spread it homogenously.

**Conditioning the prepared tooth:**

Selective acid etching technique was used for the enamel with phosphoric acid gel for 30s then rinse and gentle dried.

After that the bonding agent (**Futura bond**) was applied according to the manufacturer's instruction then light cured for 20 seconds using LED curing unit with light intensity (850-1000 mW/cm2)

Then **Duo-Link universal self- etch resin cement** (dual-cured cement) was applied to the luting surface of the restoration and inserted into cavity of corresponding tooth by finger pressure for 2 min. After that the specimens were placed in a device applying a force 50 Newton for 5 min to standardize the cement thickness in all specimens.[14] Then, according to manufacturer's instructions, light curing of dual-cured cement was done using LED curing unit with light intensity (850-1000 mW/cm2) for 20 seconds. And then stored in distilled water in 37 degree for 24 hours in 100% humidity in incubator until complete polymerization of resin cement occurs.

**Thermocycling of the specimens:**

All specimens were thermo cycled for 500 cycles from 5 to 55 degrees Celsius with 30 sec dwell time, and 20 seconds transfer time using thermo-cycling machine representing 6-month of clinical service.[15]

**Fracture resistance test:**

All specimen groups were tested for fracture resistance using universal testing machine** and loaded under compression until failure by fracture of either restoration or tooth or both. Compressive load was applied at cross head speed of 0.5 mm/min by means of steel cylinder with rounded end of 4 mm diameter, adjusted parallel to long axis of tooth. With the rounded end contacting the occlusal inclined planes of both buccal and lingual cusps. Fracture strength value for each specimen was recorded in Newton.[16]

**Fracture pattern:**

Fracture analysis was performed under a stereomicroscope (×16), and the mode of fracture for each specimen was classified according to the following:

- **Mode I:** adhesive fracture at the interface between the tooth and the restoration.
- **Mode II:** cohesive fracture of the tooth structure.
- **Mode III**: cohesive failure of the restoration
- **Mode IV**: complete fracture of the specimens involving the two cusps and the restoration.[17]

**Statistical analysis**

The collected mean fracture resistance values in Newton were collected, tabulated, and statistically analyzed using Statistical Package for Social Sciences (SPSS version 26) and the ANOVA (Analysis of Variance) was used to compare between the groups.

## III. Results

**V.1. Fracture resistance load for all experimental groups:**

Numerical variables were expressed using descriptive statistics as mean and standard deviation.

The mean load in Newton is necessary to induce fracture for all experimental groups: sound teeth, prepared unrestored teeth, and restored teeth either with Grandio blocks or Vita Enamic blocks are presented in tables (V-1) and (V-2) and graphically drawn in figure (V-1).

By using ANOVA test for comparing all experimental groups showed that there was highly significant difference between groups and it was found that the teeth restored with Vita Enamic ceramic (group IV) recorded the highest mean value of fracture resistance load [**1241.07 ± 89.91** N]. While the prepared unrestored teeth (group II) recorded the lowest mean value [**512.46 ± 152.23** N].

Then multiple comparison using Tukey's test was done to determine significant difference between every two groups. Tukey's test revealed that there was a highly significant difference between Intact teeth (group I) and prepared unrestored teeth (group II) [**1007.78 ± 168.34** N and **512.46 ± 152.23** N respectively], where there is a slightly higher and significant difference between teeth restored with hybrid ceramic Vita Enamic ceramic (group IV) and intact teeth (group I) and also a highly significant difference with prepared unrestored teeth (group II) [**1241.07 ± 89.91** N , **1007.78 ± 168.34** N and **512.46 ± 152.23** N respectively].

Meanwhile, there is a significant difference between teeth restored with resin nano ceramic Grandio (group III) and intact teeth (group I) and highly significant difference with the prepared unrestored teeth (group II) [**1179.83 ± 55.05**, **1007.78 ± 168.34** N and **512.46 ± 152.23** N respectively], but there is no significant difference between teeth restored with resin nano ceramic Grandio (group III) and teeth restored with hybrid ceramic Vita Enamic ceramic (group IV) which recorded a slightly higher fracture resistance, [**1179.83 ± 55.05** N and **1241.07 ± 89.91** N respectively] as shown in table (V-1,V-2 ) and Fig (V-1).

**Table (V-1):** statistical analysis, mean and standard deviation of fracture resistance loads in newton (N) for all tested groups; intact teeth, MOD prepared unrestored teeth, MOD restored teeth with resin nano ceramic Grandio inlays and MOD restored teeth with Vita Enamic ceramic inlays

| Groups | Range<br>Min - Max | Mean ± SD | ANOVA<br>F | <br>p-value |
|---|---|---|---|---|
| Group I<br>(+ve control) | **735.13 — 1278.41** | **1007.78 ± 168.34** | **55.755** | **0.000**** |
| Group II<br>(-ve control) | **276.54 — 729.34** | **512.46 ± 152.23** | | |
| Group III<br>(Grandio blocks) | **1094.67 — 1244.48** | **1179.83 ± 55.05** | | |
| Group IV<br>(Vita Enamic) | **1117.77 — 1396.39** | **1241.07 ± 89.91** | | |

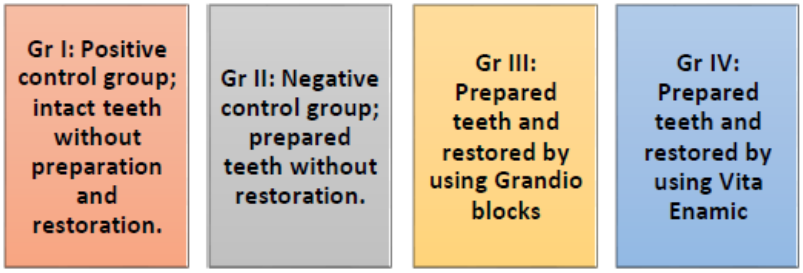


**Table (V-2):** Multiple comparison Tuckey's test for all tested groups was used to determine significant difference between every two groups.

| Tuckey's test | | |
|---|---|---|
| Gr I& Gr II | **Gr I& Gr III** | **Gr I& Gr IV** |
| 0.000** | **0.048*** | **0.005*** |
| Gr II& Gr III | **Gr II& Gr IV** | **Gr III& Gr IV** |
| 0.000** | **0.000**** | **0.762** |

*There is a significant difference at p-value <0.05(*), highly significant difference at p-value <0.001(**).*

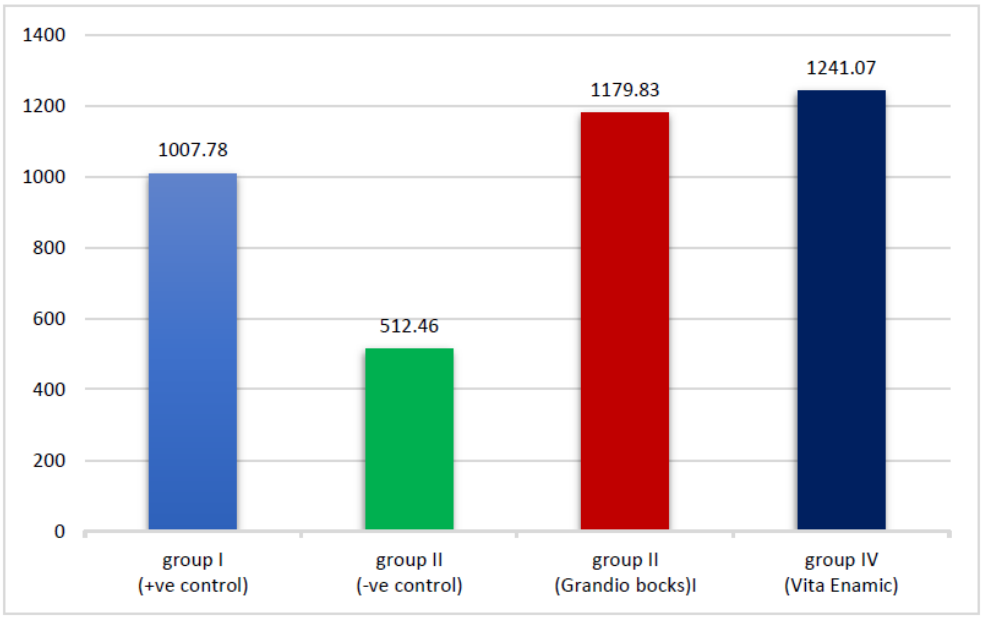


**Fig.(V-1): Column chart representing the mean fracture resistance values (N) for all tested groups.**

**V.2. Fracture pattern of specimens restored with resin-nano ceramic Grandio and hybrid ceramic Vita Enamic blocks.**

Different patterns of fracture were represented in the experimental groups. Fracture pattern was categorized as: **Mode I:** adhesive fracture at the interface between the tooth and the restoration. **Mode II:** cohesive fracture of the tooth structure. **Mode III**: cohesive failure of the restoration. **Mode IV**: complete fracture of the specimens involving the two cusps and the restoration.

In the present study, it was recorded that, specimens of premolars restored with Grandio blocks HFL resin nano ceramic inlays restorations (Group III) subject to 25% percent (n= 2/8) of mode II of cohesive fracture pattern of tooth structure and 75% percent (n= 6/8) of mode IV of complete fracture of the specimen involving cusps and inlay restorations.

On the other hand, specimens restored with hybrid ceramic Vita Enamic block inlay restorations (Group IV) subject to 37.5% percent (n= 3/8) of mode II cohesive fracture pattern of tooth structure and 62.5% percent (n= 5/8) of mode IV of complete fracture pattern of the specimens.

Meanwhile, both groups recorded zero percentage for (mode I) adhesive fracture at the interface between the tooth and the restoration and (mode III) cohesive failure of the restoration. Independent t-test was

used to comparing types mode of failure in each group, which showed that there is no significant difference between them.
Chi-square test was performed and revealed that there is no significant difference between them at p value 0.590 as shown in table (V-3) and finger (V-2) and (V-3).
Then the maximum load at which the fracture occurred for each group was expressed and independent t-test was used for each group, which showed that there is no significant difference between them as shown in table (V-4) and figure (V-4).

**Table (V-3):** comparison of fracture patterns for groups restored with resin nano ceramic Grandio block inlays and those of hybrid ceramic Vita Enamic one.

| Group | Mode of Failure | | | | | p-value |
|---|---|---|---|---|---|---|
| | **Mode I** | **Mode II** | **Mode III** | **Mode IV** | | |
| | **N (%)** | **N (%)** | **N (%)** | **N (%)** | | |
| group III | **0 (0%)** | **2 (25%)** | **0 (0%)** | **6 (75%)** | **0.291** | **0.590** |
| group IV | **0 (0%)** | **3 (37.5%)** | **0 (0%)** | **5 (62.5%)** | | |

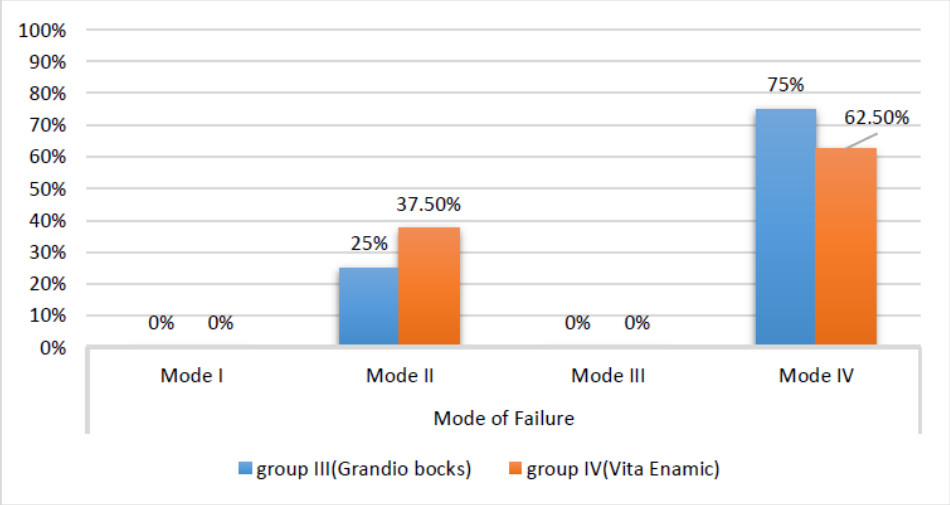


**Fig.(V-2): column chart representing different fracture patterns in percent for groups MOD prepared and restored with resin nano ceramics Grandio blocks and hybrid ceramics Vita Enamic blocks.**

**Table (V-4):** shows the maximum load at which the fracture occurred for each group and independent t-test was used to compare the mode of failure in each group, and showed that there was no significant difference between them.

| Maximum Load (N) | | | | |
|---|---|---|---|---|
| Groups | **Mode of Failure** | | **t** | **p-value** |
| | **II** | **IV** | | |
| | Mean ± SD | Mean ± SD | | |
| group III (Grandio blocks) | 1205.59 ±53.10 | 1171.24 ±57.67 | 0.546 | 0.488 |
| group IV (Vita Enamic) | 1282.54 ±33.43 | 1216.19 ±107.35 | 1.0025 | 0.350 |

*There is a significant difference at p-value <0.05(*), highly significant difference at p-value <0.001(**).*

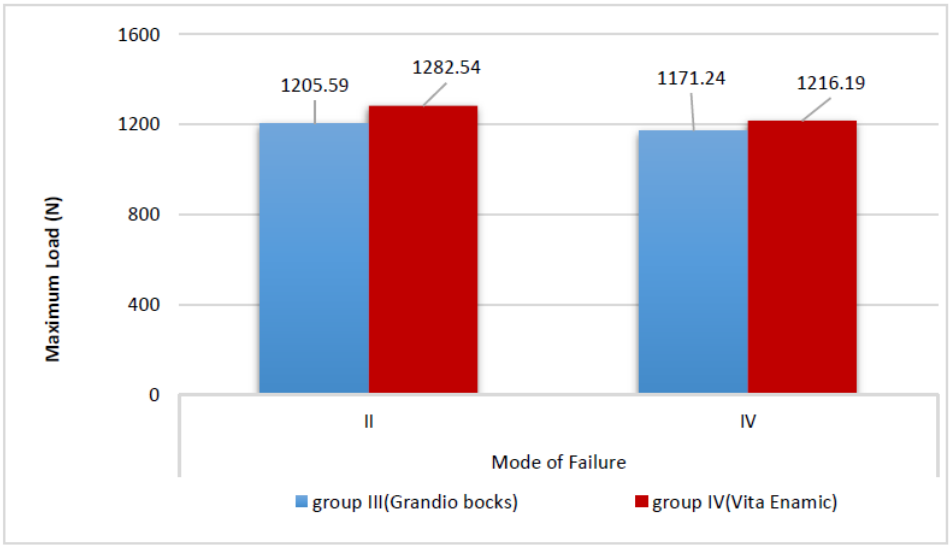


**Fig. (V-4): column chart representing different fracture patterns values in Newton for groups MOD prepared and restored with resin nano ceramics Grandio blocks and hybrid ceramics Vita Enamic blocks.**

**V.3. Correlation between fracture resistance value and mode of fracture pattern for restored groups:**
The value was less than 0.5 which revealed that there was no significant correlation between fracture resistance values and mode of fracture patterns as shown in table (v-5).

**Table (V-5):** Showing Spearman rank correlation between maximum load and mode of failure.

| Relation between maximum load and mode of failure | | |
|---|---|---|
| Groups | | **p-value** |
| group III (Grandio bocks) | **-0.378** | **0.356** |
| group IV (Vita Enamic) | **-0.507** | **0.200** |

## IV. Discussion

So recently many developments have taken place to prepare restorations that are long-lasting and resistant to forces in mouth, without compromising on esthetics. Different formulations have been introduced where composite and ceramic materials are used together with different material classifications such as ceramic-like materials, resin based blocks or resin-nano ceramic and hybrid ceramic CAD/CAM blocks.[7, 14, 18]

Mesio-occluso-distal (MOD) cavities were prepared in this study because they reduce cusp stiffness to one third of the level of sound teeth and weaken the remaining tooth structure so occlusal forces will cause more deformation in the cusps. Preparation was done according to previous studies equal to 2mm depth and 3mm width. Fracture test showed that the proximal box cavity decreased the fracture strength of teeth compared to the non-proximal box cavity.[13]

In the present study self-etch resin cement was used as bonding to the tooth structure is high as those of the total etch cement as they are popular among dentist because they are easy to use as they eliminate steps during application with the goal of reducing operator error and technique sensitivity. As for cement thickness selection it was reported that the cement thickness can vary between 20 and 200µm. Furthermore, ***Liu* B*, et al*** showed that the ideal cement thickness is 90 µm so that the least stress formation occurs in the restoration. In the present study, the cement thickness was determined as 90µm in all groups and calibrated automatically during fabrication of inlays and by using standard weight 50N during cementation. On the other hand, it has been claimed that cement thickness has inferior importance in overloading fracture tests.[19,20]

In the current study**,** Thermo cycling was performed according to The International Organization for Standardization protocol (stander ISO 11405) at 5 c & 55 c for 500 cycles (20 sec. dwell time, 10 sec. transfer time) and to reproduce thermal stresses that occur clinically. It is widely used artificial aging method[21,22]

There are different cross head speeds used for testing such as (0.1, 0.5, 1.0, 5.0, 10.0 mm/ min). Despite specimen loading finding showed no statically significant difference among cross head speeds between (0.5 and 5.0 mm/min). In the current study, 0.5 mm/min cross head speed was used and standardized for all tested groups in order to minimize the possible errors and make it useful as comparative study. In addition it

was stated that lower speeds are accompanied by greater plastic deformation, so higher fracture resistance measurements will be recorded.[23,24]

In the present in vitro study, mean value of the fracture resistance of intact sound teeth (group I) recorded 1007.78 ± 168.34 N which was statistically significantly higher than the prepared unrestored teeth (group II) which recorded 512.46 ± 152.23 N at p = 0.000. It was found that, these results agreed by **Teixeira ES, et al** (2016)**,** who found that the greater the amount of tooth structure removed significantly lowered the fracture resistance of the remaining tooth structure will be.[25] Also agreed with **Hafez S, et al** (2019) [26] in their results revealed that the intact teeth group recorded the highest fracture resistance mean value with significant difference compared to the prepared un restored group. Others also found that prepared maxillary premolars with large MOD lose 59% of their strength when tested occlusally with a compressive load. Intact teeth were more resistant to fracture than prepared unrestored teeth**.**[27]

The current study showed that both tested materials, resin nano ceramic Grandio inlays and Vita Enamic hybrid ceramic one were able to restore the tooth fracture resistance to reach a higher value than the sound control non restored teeth and this was closely in agreement with **Reymus M, et al** (2019)[28] who stated that, this may due to that resin nano ceramic and hybrid ceramic materials has a lower elastic modulus so more load is absorbed within the composite restorations and it transmits less of the applied load to the underlying tooth structure. More flexible and less rigid materials may be desirable for the restoration of posterior teeth given the inherent ability of teeth to flex under occlusal loading.

Whereas, the teeth restored by resin nano ceramic Grandio blocks inlays (group III) (1179.83± 55.06) N have fracture resistance mean value higher than sound positive control group (group I) (1007.78 ± 168.34) N and the negative prepared unrestored control (group II) (512.46 ± 152.23) N and the differences were statistically significant at p=0.048 and 0.000 respectively. On the other hand**, Savaş,TY , et al** (2019) [29] found that the inlay restored teeth showed similar fracture resistance mean value to intact unprepared teeth. This situation has been reported similarly in some studies.

Also, **Andrade GP , et al** (2018)[30] investigated the fracture resistance of occlusal veneers of Lava Ultimate, Vita Enamic and IPS e.max CAD (thicknesses of 0.6 mm and 1.5 mm) and reported that the mean values of fracture resistances of restored teeth similar to those of sound one and concluded that, the reason might be due to the elastic modulus of resin nanoceramic material which is close to that of dentin.

Moreover, this is disagreed with **Hafez S, et al** (2019) their results revealed that the intact teeth group recorded the highest fracture resistance with no statistical significant difference between the intact teeth group and that restored with resin nano ceramic Grandio inlays, but agreed that the Grandio inlays were statistically significantly higher than the prepared but not filled teeth group. [26]

Meanwhile, the mean value of fracture resistance of teeth restored by Vita Enamic ceramic (group IV) recoded (1241.07± 89.91 N) is higher than that of both control groups group I :( 1007.78 ± 168.34N) and group II: (512.46 ± 152.23N,) with statistical significant difference between the mean value of group IV and the control groups at p values 0.005 and 0.000 respectively.

This is disagreed with **Gürpınar,B, et al** (2020), who found that mean fracture resistance force of the control group was significantly higher than that of the LDC overlay, LDC occlusal veneer, PIC overlay and PIC occlusal veneer**.** [31] Also **, Wafaie RA, et al** (2018) [32] who reported that the laboratory composites and pressable glass ceramic inlays showed lower fracture strength than those of the sound teeth. This may be due to the different study design, teeth selection, cavity dimensions, and restoration thickness.

As for the restored groups, resin nano ceramic **Grandio group III and Vita enamic** hybrid ceramic **group IV** it was found that there was no significant difference between the mean values of both groups. The mean value of Vita enamic ceramic was recorded 1241.07± 89.91 N which is slightly higher than that of resin nano ceramic Grandio 1179.83± 55.06 N. This result was supported by **Sagsoz, O , Yildiz, M** (2018) [14] who found that there is no significant difference in fracture resistance between resin nano ceramic and hybrid ceramic inlays. **Porto TS, et al** (2018) [33] who found that Vita Enamic has higher fracture toughness than resin nano ceramic with no significant difference.

Also, **Habekos LdV, et al** (2007) [34] who found no significant difference in the fracture resistance values between the ceramic and composite inlay restorations; however, they reported that none of the restored teeth achieved the fracture resistance of the intact teeth, which unlike the present in-vitro study.

On the other hand the current study disagreed with **Egbert JS, et al** (2015) [35] who compared the fracture strengths and failure modes of ultrathin (0.3-mm) occlusal composite or hybrid ceramic veneers and reported that, Lava Ultimate (resin nano-ceramic) had significantly higher fracture strength than Paradigm MZ100 (Indirect composite), and Vita Enamic (hybrid ceramic), respectively. This may be due to different study design and material thickness. Also**, Albelasy E, et al** (2021) [36] who reported that when polymer inflterated ceramic network (PIC) and resin nano ceramic (RC)veneers were compared in a thickness of 1.0 mm in both storage times, RC demonstrated a significantly higher fracture resistance.

In relation to fracture pattern, results showed that group III specimens restored by resin nano ceramic Grandio inlays and group IV specimens restored with Vita Enamic ceramic showed 25% and 37,5% of specimens fracture pattern mode II respectively which is cohesive failure of tooth structure. Meanwhile, both groups subjecting to 75% and 62,5% of specimens fracture pattern mode IV respectively which is complete fracture of the specimen involving the cusps and the inlay restoration and statistically no significant difference was recorded between them. These results unlike study recorded by **Savas, TY, et al** (2019) [29] found that 40% of the resin nano ceramic inlay restorations showed catastrophic fracture involving tooth structure and restoration

On the other hand, **Guess PC, et al** (2011) [37] found that premolar teeth restored with standard prepared ceramic onlay restorations generally showed catastrophic fracture involving tooth structure and restorations, Also, similarly, **Yoon HI , et al** (2019) [38] reported that the different inlay and onlay restored teeth with varying designs of cavity showed predominantly catastrophic failures involving tooth structure and restorations .

More-over**, Reymus M, et al.** (2019) [28] found that the teeth restored with CAD /CAM composite showed predominantly cohesive failure mode within the luting composite. **Andrade JP, et al** (2018) [30] evaluated the effect of Different Computer-aided Design/Computer-aided Manufacturing (CAD/CAM) Materials and Thicknesses on the Fracture Resistance of Occlusal Veneers. They found that failures were predominantly repairable Vita Enamic 0.6 mm, and Vita Enamic 1.5 mm. The fractures were predominantly irreparable in sound teeth and Lava Ultimate 1.5 mm.

**Hafez S, et al** (2019) [26]**,** explained the catastrophic and mixed type of fracture mode involving tooth structure and restorations, as it may be due to the adhesively bonded inlay restorations using low modulus restorative materials may not only restores the missing tissues, but also reinforces the remaining structure of the prepared tooth, as it limits the stress intensity transmitted to the remaining tooth structures.[33] So, resin nano ceramic Grandio and Vita Enamic ceramic inlay restorations may increase fracture resistance of teeth through redistributing the stresses and may present elastic biomechanics similar to those of the sound tooth**.**

## V. Conclusion

- The results showed that restoring premolar teeth with resin nano-ceramic Grandio and hybrid ceramic Vita Enamic inlays not only rehabilitate missed tooth structure, but also increased the fracture resistance of the teeth.
- Statistically, there was no significant difference regarding the material used either resin nano-ceramics or hybrid ceramics.
- Regardless type of inlay restoration, statistically, there is no significant difference recorded between the fracture resistance and the fracture pattern of the specimens

## References


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