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# Effect of Obturation Technique on Stresses Induced in Telescopic Retained Partial Denture (*In vitro* Study)

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**Abstract**

**AIM:** The purpose of this study was to evaluate the effect of obturation techniques on the stresses induced on the abutment teeth and the supported prosthesis.

**MATERIALS AND METHODS:** A unilateral bounded edentulous space case design was chosen for this study, with telescopic retained partial dentures (TRPDs) selected as the treatment of choice. Two TRPDs were fabricated, the first pre-molar and second molar were used as abutments for the partial dentures. In the first group, the pre-molar was treated with the lateral compaction obturation technique. In the second group, the first pre-molar was treated with a vertical compaction obturation technique. The second molar was a common abutment in both groups and was left untreated. 50 Newtons were applied on the prostheses, with a strain gauge attached, and data were collected.

**RESULTS:** t-test showed the mean values of microstrain ($\mu\varepsilon$) induced in pre-molars treated with lateral compaction was 159.64 ± 10.46 $\mu\varepsilon$, whereas with vertical compaction was 12.14 ± 2.57 $\mu\varepsilon$, with statistical significance of $p < 0.05$.

**CONCLUSION:** Vertical obturation of endodontically treated teeth propagates less stress to the abutment teeth and to the supporting prostheses.

## Introduction

Partial edentulism is when one or more than one tooth is missing from a dental arch, but not the total loss of teeth. Unilateral bounded edentulous area is one of the most frequently occurring cases in partial edentulous patients. It occurs when there is an abutment tooth at each end of an edentulous space [1], [2].

Implant placement is the first line of treatment to restore edentulous spaces, especially in the bounded as it preserves the neighboring abutments. However, some systemic medical conditions contraindicate implant placement, besides to the high costs of implants [3], [4].

Fixed partial dentures are usually selected as a treatment of bounded edentulous area when minimal bone loss and adequate inter-arch space is present. When the conditions present are unfavorable fixed restorations become a contraindication, and removable partial dentures (RPDs) become treatment of choice [5].

There are many inherited problems with the use of RPD in unilateral bounded edentulous areas. First, there is the problem of bracing and stability, which is the resistance to horizontal forces. Unilateral RPDs need cross-arch stabilization to resist horizontal forces and to increase the size of the prosthesis, to avoid aspiration of the prosthesis [5].

Many RPDs designs have been utilized in unilateral bounded edentulous areas. One of the most successful designs used is the removable bridge design or the telescopic crown retained RPD (TRPD). Telescopic crown or double crown system consists of a metallic primary crown, which is milled to 2–4° or to 0° depending on the resilience needed. The primary crown is cemented to the natural abutments with cement. The secondary crown is fabricated as a part of the RPD framework, it fits on the primary crown and is usually made from metal too. Retention is gained by the friction between the metals of the primary and secondary crowns. TRPD provides stabilization of the abutment teeth, improves retention and support, and prevents aspiration of the prostheses. TRPD directs forces to the long axis of the tooth, thus decreasing torquing and stresses induced on the abutment teeth [6], [7].

Endodontically treated teeth can be used as abutments in TRPD if the teeth are well obturated, no periodontal disease, and adequate crown-root ratio is present [8]. More than 60% success rate of endodontically treated abutments was reported in short-span and long-span bridges [9].

Furthermore, changing of the obturation technique can have a direct effect on the stresses induced to the supporting structures in the over-denture prosthesis, thus affecting the long-term prognosis of the abutment teeth and the prosthesis [10].

Various filling techniques have been advocated for root canal obturation [11], [12]. Thermoplasticized gutta-percha techniques offered efficient sealing properties and satisfactory outcomes. However, although the vertical continuous wave of condensation technique (CWC) creates minimal stresses in comparison to other techniques such as lateral compaction, there is a possibility for microcrack propagation because of forces applied using pluggers. Regarding both techniques, the hydraulic forces sent the gutta-percha in one or two unequal and unpredictable lateral or apical directions [13]. These types of stresses induced during obturation might have a future effect on root dentin affecting the long-term survival of the tooth, especially when used as an abutment liable to extra under stresses [10].

Several methods have been used in analyzing stress–strain relationship. Finite element analysis is a widely used method, it utilizes computerized data and numerical methods in analyzing stress distribution [14]. Another method is the strain gauges, in which electronic gauges' measure stress induced in an object by applied load [10].

Will changing the obturation technique affect the supported prosthesis?

### *Hypothesis*

Changing the obturation technique does affect stresses on the supported prosthesis.

## Materials and Methods

### *Study design and aim*

A unilateral bounded edentulous space case design was chosen for this study, with telescopic retained partial dentures (TRPDs) selected as the treatment of choice.

Two TRPDs were fabricated, the first premolar and second molar were used as abutments for the partial dentures. In the first group, the premolar was treated with the lateral compaction obturation technique. In the second group, the first premolar was treated with a vertical compaction obturation technique. The second molar was a common abutment in both groups and was left untreated. The aim of this study was to evaluate the effect of obturation techniques on the stresses induced on the abutment teeth and the supported prosthesis.

### *Endodontic treatment*

A total number of 16 single-rooted young permanent first mandibular premolar teeth with an average length of 21 mm ± 0.5 mm were used in this study. Coronal access cavity preparation was carried out and the working length was determined by introducing a size 10 K-file (Mani Inc.) in the canal until the tip of the file became visible at the apical foramen.

After working length determination, the canal was checked using a size 15 K-file to ensure the initial canal size before further canal preparation. The canal was enlarged using the EdgeFile X7 system (EdgeEndo, USA) up to a size 40/0.04 taper according to the manufacturer's recommendation using a continuous rotation motion at 400 rpm speed and 2.5 Ncm torque using an endodontic micromotor. From the wide range of sizes of files included in this system, files used in this study were selected in the following sequence: The coronal third was preflared with file (#17/0.04) followed by file (#20/0.04), file (#25/0.04), file (#30/0.04), file (#35/0.04) and file (#40/0.04). Before introducing each file, the root canal was irrigated with 5.25% NaOCl and the canal was recapitulated. EDTA cream was used as a lubricant for all files with every insertion and reinsertion. Canals were then dried with size #40 absorbent paper points and stored in an incubator at 37°C and 100% humidity until obturation. Eight premolars were obturated using the CWC technique whereas the other eight pre-molars were obturated using the cold lateral compaction technique.

Regarding CWC, root canal obturation was done using EQ Plus system (Metabiomed Co., LTD, Korea). Gutta-percha pellet (Metabiomed Co., LTD, Korea) was inserted into the guttapercha slot of the corded obturation gun by pulling out the plunger and adjusting the temperature at 200°C. The master gutta-percha cone (#40/0.04 taper) that matched with the prepared root canal was coated with NeoSEALER Flo root canal sealer (Avalon Biomed, USA) and inserted into the canal. The excess gutta-percha was cut by a heated obturating pen tip. The heated pen tip with gutta-percha was inserted to 4 mm short of the working length. The warmed gutta-percha was compacted with a hand plugger (Dentsply Maillefer, Switzerland). The rest of the canal was filled with the obturating gun and compacted with a larger plugger.

Regarding the cold lateral compaction technique, #40 Gutta-percha cone with a 0.04 Taper (Diadent, Korea) was placed in the root canals and suitable-sized finger spreader was selected. Root canal sealer was applied with the master cone and then inserted into the root canal. Gutta-percha compaction was performed with the previously selected finger spreader (Diadent, Korea), and accessory cones were placed.

Subsequently, all teeth were radiographed in buccolingual and mesiodistal directions to evaluate the quality of filling for adequacy. Teeth were then stored in an incubator at 37°C and 100% humidity until further use.

### *Fabrication of testing model*

8 pseudo-realistic models were fabricated to imitate the long-span bounded edentulous area, with a lower first premolar placed at each end of the model, then in the middle of the model, a lower second molar was inserted equidistance from both premolars. The second molar will be used as a common abutment in both groups. 1 mm of tissue mimic (GENESIS, Korea) was inserted around the roots of the abutments imitating the periodontium. 3mm of tissue mimic (GENESIS, Korea) was placed on the model to resemble the mucosa [15]. The three abutments were prepared to a 6 degree convergence with a shoulder finish line.

### *Fabrication of TRPDs*

The primary crown was waxed up using milling wax (DEGUSSA, Germany) for all the abutment teeth and milled to zero degrees. The primary crowns were cast using chrome-cobalt alloy (BEGO, Germany). The secondary crowns with the framework of the partial denture for both models were waxed up and modeled. The wax of the secondary crown with the framework was casted with chrome-cobalt alloy (BEGO, Germany). An acrylic second premolar and first molar teeth (ACROSTONE, Egypt) were attached to the framework to restore the edentulous space using self-cure acrylic resin (ACROSTONE, Egypt) Figure 1.

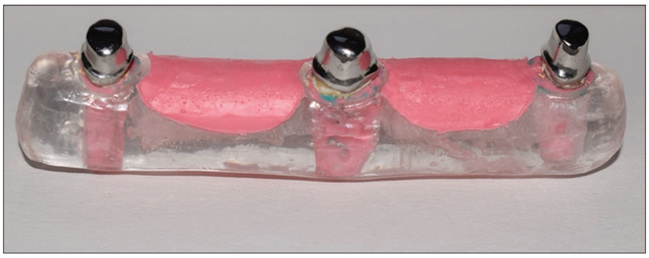

*Figure 1: Model with primary coping cemented on the prepared abutments*

### *Measurement set-up*

Strain gauges (Kyowa Strain Gauges, Japan) used in this study had a length of 1 mm, width of 2.4mm, and nominal resistance of 120 Ohm. Strain gauges were connected to lead wires 100 cm in length. Strain gauges were attached to the buccal and lingual surfaces of the coronal one-third of the roots of the abutments (first premolars and second molar) in the model. Moreover, strain gauges were attached to the buccal surface of the prostheses. Gauges on the prostheses were placed at a lower level than the abutment teeth, so the load would reach the abutments first. Furthermore, gauges on the prostheses were placed off the axis of the load application. Universal testing machine ZWICK was used in testing. A 50 Newton load was applied at middle of the TRPD, at junction between the acrylic second premolar and the first molar. Data were collected and statistically analyzed Figure 2.

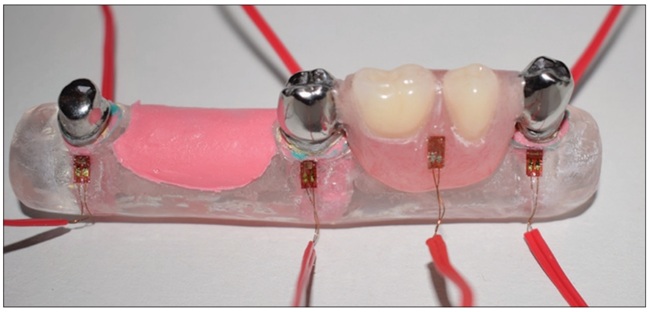

*Figure 2: Strain gauges placed on the abutments and prosthesis*

## Results

T-test showed the mean values of microstrain (με) induced in premolars treated with lateral compaction was 159.64 ± 10.46 με, whereas the mean values of microstrain (με) induced in the pre-molars treated with vertical compaction was 12.14 ± 2.57 με. There was a statistically significance difference between the two obturation techniques of $p < 0.05$. T value is 51.22. The untreated second molar recorded a mean value of 214.64 ± 10.08 με in both groups.

T-test showed the mean values of microstrain (με) induced in the prostheses were 84.29 ± 1.81 με and 6.86 ± 0.77 με in the TRPD supported with lateral compaction and in the TRPD supported by the vertical compaction respectively. There was a statistically significance difference between the two TRPDs of $p < 0.05$. T value is 46.53, Table 1.

**Table 1: The mean values of microstrain (με) induced in teeth obturated with both techniques and TRPD with standard deviation**

| Obturation technique | First pre-molar | Second molar | TRPD |
|---|---|---|---|
| Lateral compaction | 159.64 ± 10.46 με | 214.6429 ± 10.08 με | 84.29 ± 1.81 με |
| Vertical compaction | 12.14 ± 2.57 με* | | 6.86 ± 0.77 με* |

*Statistical significance is present, TRPD: Telescopic retained partial denture.

## Discussion

50 Newtons were applied on both groups, with abutments obturated with lateral compaction showing a statistically significance difference in the stresses induced in the abutments when compared with abutments obturated with vertical compaction,

this result coincides with Elsherbini *et al*. [10] In which, lateral compaction caused higher stresses in the abutment teeth than vertical compaction. This could be explained by the possible wedging action of the spreader within the root canal, either by direct contact with the root canal or indirectly through the gutta-percha filling, which in turn exerts pressure on canal walls [16]. Moreover, microcracks can be induced in dentin by lateral compaction instrumentation, or propagation of existing microcracks [17]. This is in concurrence with Kumaran *et al*. [18] who revealed significantly higher number of dentinal defects after lateral compaction with gutta-percha. Furthermore, the heterogenous elasticity between radicular dentin and the sealer in lateral obturation propagates stresses in the abutments [19].

The second molar showed higher stresses than the pre-molars in both groups, this can be related to higher surface area, thus more bearing of the loaded force, and this result coincides with Wang *et al*. [20] in which it was reported that multirooted abutments bear more stress than single rooted abutments.

The stresses induced in the TRPD were low compared to the abutments, this can be directly attributed to the nature of the prosthesis design. Force was applied on the occlusal surface of the teeth, underneath the teeth there is a metal framework connected to the secondary copings, so most of the force was directly directed towards the abutment teeth. Telescopic crowns direct the forces along the long axis of the abutments, that’s why the stresses recorded on the abutments were high. Moreover, the strain gauge attached to the TRPD was placed on the acrylic buccal flange, which is off the axis of the force applied, hence the low values of stresses recorded on the prosthesis. This result is supported by Saito *et al*. [21] and Igarashi *et al*. [22] reported that telescopic crown transmitted more force to the abutment teeth. Since the forces are directed to the occlusal aspect of the abutments, leading to greater movement of the abutments with higher stresses. Furthermore, it was demonstrated that telescopic crowns transmitted less stresses and shear to the prosthesis when compared with other treatment modalities. Our result is to Ahn *et al*. [23] who found that stresses were higher at the loading site more than the abutment teeth, and this can be related to the position of the strain gauges. In Ahn, the strain gauge was placed at the loading position, so all load was recorded by the strain gauge, however in our study as mentioned before the strain gauge was placed off the axis of load application.

The difference between the stresses in the two TRPDs groups can be directly related to their support, which is mainly the abutment teeth and the ridge. Under controlled co-factors, the endodontic treatment of the abutment teeth was the only changing factor in the groups.

## Conclusion

Within the limitations of the study, it can be concluded that vertical obturation for endodontically treated teeth propagates less stresses to the abutment teeth and to the supported prostheses. This prolongs the service and prognosis of the treatment prosthesis and the abutment teeth.

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