Abstract. – OBJECTIVE: Conventional use of retraction cord in soft tissue management is effective only when the non-resilient nature of material does not jeopardize gingival health. Therefore this study aims to clinically evaluate the gingival displacement, ease of application and bleeding from polytetrafluoroethylene (PTFE) retraction cord.

PATIENTS AND METHODS: This study is a single-center, parallel-group, randomized controlled clinical trial (1:1). Sixty patients indicated for full coverage metal-ceramic restoration for first molars were enrolled and randomly allocated to experimental (PTFE Cord) and control (conventional plain retraction cord) groups. After crown preparation and isolation, a pre-displacement impression was made. Assigned gingival displacement material was applied for 5 minutes, followed by post-displacement impression. Casts were prepared and used for assessment of mean horizontal gingival displacement by measuring displacement using a stereomicroscope (20 x). Post-displacement gingival bleeding and ease of application were also assessed clinically. t-test and Chi-square tests were used for statistical assessment of gingival displacement, gingival bleeding and ease of application.

RESULTS: Gingival displacement, bleeding and ease of application were similar among study groups (p > 0.05). Mean gingival displacement in the experimental group was 197.1 µm, and 167.7 µm in the control group. Bleeding was observed in 30% and 20% of cases of experimental and control group, respectively. Non-impregnated gingival retraction cord and PTFE cord displayed similar outcomes of gingival displacement, ease of placement and bleeding after cord removal.

CONCLUSIONS: Post-displacement bleeding and discomfort for PTFE cord placement suggest that this technique needs improvement. Therefore further studies are warranted to improve and investigate the physical and biological response to PTFE retraction cord.

Key Words: Gingival displacement, Polytetrafluoroethylene, Retraction cord, Bleeding, Application.

Introduction

Indirect fixed restorations require equi-gingival and sub-gingival finish line in order to fulfil the esthetic and functional requirement1. Therefore, precise recording and duplication of these finish lines is an important step in order to ensure marginal fit of the restoration. The inability to achieve the marginal integrity leads to future restorative failure2. Displacement of the gingival marginal tissue is an important preliminary step that is attributed to the vertical and lateral
Gingival displacement with PTFE

displacement of gingival tissue, making the finish line more accessible for impression making. Exposed preparation margins allow the impression material to flow into the sulcus and record the finish lines accurately, resulting in adequate marginal integrity of the prosthesis with desired emergence profile.

Various techniques and materials have been introduced for displacing the gingival tissue before recording the finish line. Broadly, these methods are classified as mechanical, chemo-mechanical, electrosurgical, rotary curettage, and a combination of these techniques. Mechanical method for gingival displacement include the use of rubber dam, copper bands, and retraction cords, producing physical displacement of gingiva away from prepared tooth to allow improved visibility and access. Gingival retraction cord is the conventional mechanical technique for gingival deflection, and both impregnated and non-impregnated cords are employed. However, retraction cords demonstrate multiple disadvantages, including, technique sensitivity, trauma to junctional epithelium, inflammation and gingival recession, patient discomfort and bleeding. A study by Wadhwani and Ansong described positive association between peri-implant disease and remnants of retraction cord system. Although, retraction cord application is still the gold standard for soft tissue retraction and is commonly employed due to its cost-effectiveness and reliability. Alternative techniques and materials for soft tissue retraction have been introduced to replace use of retraction cords with cordless techniques like paste, gels, foams, lasers and surgery. In addition, use of lasers have been proposed for soft tissue management during crown preparation, impression stage and around restorations. It is suggested that the use of lasers in sulcus conditioning allow for minimal soft tissue damage as compared to conventional (mechanical and surgical) techniques.

Polytetrafluoroethylene (PTFE) tape is a synthetic fluoropolymer known for its low coefficient of friction, non-reactive, heat stable nature, low cost, and non-adherent property. PTFE tape, also known as Teflon or Plumber’s Tape, has been used widely in clinical medicine and dentistry. PTFE is relatively inert and possess ability to resist various solvents and acids used in dentistry. A study by Sattar et al, explained different uses of PTFE tape in restorative dentistry, and concluded that it helps in isolation of operative field, protects peri implant tissue by serving as an atraumatic barrier during cementation and removal of subgingival luting cement particles. Other studies also elaborated its use in clinical dentistry. However, evidence related to the role of PTFE for gingival displacement, its ease of placement, and removal from gingival crevice is limited.

According to indexed literature, it was identified that gingival retraction cord displaces gingival tissue; its ease of placement and bleeding after cord removal has also been assessed. In a study by Acar et al, a clinical comparison of cordless and conventional cord displacement techniques were made concerning their clinical performance and effect on impression quality. From the results of their study it was identified that the retraction cap with paste group demonstrated superior outcomes for ease of cord application and bleeding as compared to the aluminum chloride impregnated cord group. Similarly, in a study by Kumbuloglu at el, the effect of different gingival retraction techniques on the surface properties of the impression material used along with their clinical performance was assessed. Outcomes of their study revealed that untreated, medium-braided, and epinephrine-impregnated cord systems were clinically more successful than other cord systems. However, the effect of PTFE tape on gingival displacement for recording of margin for porcelain fused to metal crown, its ease of placement and bleeding after cord removal has not been evaluated. It is hypothesized that gingival retraction and displacement, ease of placement and bleeding tendency will be similar for PTFE and conventional gingival retraction cord. Therefore, the aim of the present study was to assess the effect of conventional retraction cord and PTFE tape on gingival displacement, ease of placement, and bleeding after cord removal.

Patients and Methods

Ethical Considerations

The project was approved by ethical committee of the Dow University of Health Sciences, with reference no. IRB-1358/DUHS/Approval/2019/101. The protocol for this single center, parallel-group, randomized controlled trial was registered at www.clinicaltrials.gov (Study Identifier: NCT04087226) database. The study was conducted in accordance with the declaration of Helsinki (2013) and the CONSORT guidelines. The CONSORT flow diagram for the study.
methodology is presented as Figure 1. Study subjects having indication for porcelain fused-to-metal restoration on permanent mandibular molar teeth were evaluated for fulfillment of eligibility criteria by the principal investigator (HN). Subjects who qualified for the selection criteria were verbally informed about the procedure and associated risks and benefits. Subjects willing to participate in the study completed a written consent and patients were able to opt out of the study anytime during the duration of the trial without any consequences.

**Study Settings and Population**

The study was performed at the department of prosthodontics, Dow University of Health Sciences, Karachi, Pakistan. The analysis of casts was performed in Bioinformatics and Molecular Medicine Laboratory, DUHS. Samples were collected from October 2019 to September 2020 using non-probability consecutive sampling technique.

The inclusion criteria comprised of patients aged above 18 years with indication of full-coverage fixed restoration on permanent mandibular molar teeth with equi-gingival margin. The included teeth had probing depth of 2-3 mm, along with healthy soft tissues, showing no signs of bleeding on probing. Teeth with developmental anomaly (anatomical), class V restorations, periodontal surgery and crown lengthening, patients with bleeding disorders, smoker, smokeless tobacco users, and pregnancy were excluded.

The sample size was estimated, incorporating mean and SD from a previous study, using Pass software v.11 and test for two independent sample mean at 95% confidence interval, and 80% power. The mean (SD) for conventional cord group was 0.46 (0.03) and for expasyl group was 0.34 (0.04). The calculated sample size was 12 specimens per group. However the sample in each group was kept at 30 per group to gain statistical strength. A total of 60 patients were included in the study.

**Study Procedure and Preparations**

The human mandibular molars were anaes-thetized under local anesthesia (Medicaine® Inj. 1:100,000) for preparation of indirect full-coverage porcelain fused-to-metal crown. The standard prosthodontic principles were followed to prepare the equi-gingival tooth preparation margin. The tooth preparation procedure employed high-speed air turbine (Synea, W&H, Bürmoos, Austria) using appropriate sized diamond burs

![Figure 1. CONSORT flow diagram for patient selection and evaluation.](image-url)
(Komet, USA) with water spray in order to avoid thermal damage to the tooth. The tooth preparation parameters included, 1.5 to 2 mm occlusal reduction, 1.5-2 mm labial reduction with rounded shoulder finish line and a lingual reduction of 1.0-1.5 mm, with chamfer finish line. The restoration having an occlusal contact and palatal margin in metal alloy was preferred. A pre displacement (gingiva) impression was recorded using single stage putty light combination technique (I-SIL™ Premium Putty and Light body, Ivoclar, Vivadent, India), using sectional stock tray under strict moisture control using cotton rolls and a suction device. All study participants were allocated randomly to two study groups [conventional retraction cord (control) and PTFE tape (experimental group)] through software-generated random numbers on the basis of gingival retraction cord system employed.

**Group A: Gingival retraction cord (Control group)**

Gingival displacement around prepared teeth was performed using a size 0 non-impregnated knitted cotton retraction cord (Retreat® K Henry Schein, Melville, NY, USA) with a diameter of 1 mm, among 30 study participants (Figure 2).

**Group B: PTFE cord (Experimental group)**

Gingival displacement around prepared teeth among 30 study participants was performed. A strip of commercially available PTFE tape (Mishoo®, Linan Linfeng Fluorine, Plastics Co. Ltd., Hangzhou, Zhejiang, China) was placed on a glass slab, followed by placing of 3/0 silk suture (Glysilk, Huaiyin Medical instruments Co. Ltd., Huaian, Jiangsu, China) (diameter, 0.2 mm) over the tape. The edge of tape was manually turned over the suture to envelope it. Another glass slab was used to roll the tape into cord form under uniform pressure by sliding it gently. The edges of the cord were then cut with a scissors to ensure a cord length of 10 cm (Figure 3). Thirty cords were prepared repeating the same methodology by a single operator. Each cord was placed under a stereomicroscope (Olympus Stereo Microscope Systems, SZX7, Edmund Optics, York, UK) to measure its diameter at the mid-point and the value was recorded. The mean (± SD) thickness of the cords was 882.36 ± 0.13 µm.

The retraction cord and PTFE cord were packed into the sulcus, starting from mesial interproximal surface with cord packer instrument (Hu-Friedy, Chicago, USA) by single operator. The cord packer instrument was placed in such a way that it faces toward the gingival sulcus to push the cord in the sulcus using minimal finger pressure. The cords were placed circumferentially around the tooth. The cords in both groups were slowly removed while moist with the help of a tweezer after 5 minutes of placement. Before recording post displacement impression, the tooth surface was washed followed by a gentle blast of compressed air. This was followed by post displacement polyvinyl siloxane impression using the same impression technique. Both the recorded impressions were labelled for identification purpose.

**Assessment of Gingival Bleeding**

Presence and absence of gingival bleeding after removal of gingival retraction material from gingival sulcus due to displacement trauma was assessed in each patient by two calibrated examiners. The evaluation was performed on all surfaces (buccal, mesial, lingual, and distal). Presence was defined as visible bleeding from gingiva after removal of cord. However, absence was defined as no visible sign of bleeding after cord removal.

**Ease of Application**

Ease of cord placement into the gingival sulcus was defined as placement of retraction cord only once into the crevice, without any dislocation.
However, “difficult application” was considered if the cord required placement more than once due to dislocation from gingival crevice.

**Evaluation of Gingival Displacement**

The recorded impressions were poured in type IV dental stone (Dentsply, Petrópolis, Rio de Janeiro, Brazil). The models were labeled accordingly and were transported in a plastic bag to the laboratory for analysis (Figure 4). The base of all the models was trimmed to an equal height using model trimmer to avoid any discrepancy in pre and post displacement models. Before microscopic assessment, crest of buccal gingiva was marked on all samples using a fine lead tip. Another marking was performed to identify three points on the sample, where measurements were to be recorded i.e., mesial line angle, mid-buccal point, and distal line angle. The samples were assessed for sulcus width under stereomicroscope.
Gingival displacement with PTFE (Olympus Stereo Microscope Systems, SZX7, Edmund Optics, York, UK), at 20× magnification (Figure 5).

For measuring the distance between crest of gingival margin and uncut tooth surface, an Image J software was utilized to process and measure this distance. After calibration of scale, pre and post displacement sulcular width was recorded at mesio-buccal, mid-buccal, and disto-buccal points of each tooth and arithmetic mean of these values was noted. The difference between pre-displacement and post-displacement mean sulcular width was computed and labelled as horizontal gingival displacement for that specimen.

**Statistical Analysis**

Data normality was assessed using Kolmogorov-Smirnov test. Mean and standard deviations (SD) were calculated and by applying two-sample independent t-test, their comparison for gingival displacement for PTFE cord and conventional cord was assessed. Comparison of ease of cord application and bleeding after cord removal between the two groups was identified using Chi-square test and logistic regression analysis. A p value of < 0.05 was considered statistically significant.

**Results**

Thirty patients each were allocated to group A (Retraction cord-Control) and group B (PTFE cord), respectively. Out of sixty cases, 38 (63.3%) patients were females [Control=20 (33.4) and PTFE=18 (30)] and 22 (36.6) were males [Control=12 (20) and PTFE=10 (16.66)]. The mean age of subjects included in the control group was 36.5 ± 12.9 years and in PTFE cord group was 30.5 ± 10.5 years. All teeth included in the study were mandibular molars (Table I).

The mean gingival displacement observed in the experimental group was found to be statistically similar to the mean displacement observed in the control (Table II). 30% (n=9) of the patients experienced bleeding after PTFE cord removal as compared to 20% (n=6) cases in control group (Table III). 53.3% (n=16) of subjects in PTFE group showed difficulty of cord placement and 43.3% (n=13) cases in control group demonstrated difficulty in cord placement (p > 0.05) (Table IV).

**Discussion**

The present in vivo study was based on the hypothesis that there is no significant difference

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<th>Characteristics</th>
<th>N = 60 control</th>
<th>PTFE</th>
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<td>Gender</td>
<td></td>
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<tr>
<td>Female</td>
<td>20 (33.4)</td>
<td>18 (30)</td>
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<tr>
<td>Male</td>
<td>12 (20)</td>
<td>10 (16.6)</td>
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<tr>
<td>Age (years)</td>
<td>36.5 ± 12.9</td>
<td>30.5 ± 10.5</td>
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in gingival displacement, ease of placement and bleeding after cord removal when conventional retraction cord and PTFE cord were used. The postulated hypothesis was accepted as both the control and the experimental retraction techniques displayed statistically similar outcomes.

There are various techniques to assess sulcus dilation or gingival displacement produced by any gingival retraction system, including, digital imagery, indirect assessment on a microscope and indirect assessment with a 3D scanner device. The existing study used an indirect assessment method by using a stereo microscope. A stone model was prepared from polyvinylsiloxane impression material, which was used for measurement of horizontal gingival displacement. Similar assessment method has been employed by previous studies. The choice of gingival displacement technique used for impressions in fixed prosthodontics depends upon personal preference of practitioner. However, literature has revealed that most practitioners prefer the use of retraction cord, either plain or impregnated with chemical agents.

The surface detail reproduction of polyvinyl siloxane is reported to be adversely affected by the medicaments present in chemically impregnated cord as reported by Mahony et al. Therefore, the present study has used plain retraction cord in comparison to experimental PTFE cord in order to avoid any discrepancy.

The result of the current clinical trial showed no significant difference in mean horizontal gingival displacement among both the groups as mean displacement produced was 197.1 µm by PTFE group and 167.7 µm by conventional retraction cord (p > 0.05). However, clinically PTFE cord produced slightly greater displacement than the conventional plain retraction cord used. This can be attributed to the configuration and organization of the retraction agents in the present study. The PTFE cord was fabricated using rolled over tape of 0.88 mm compared to 1 mm diameter of size 0 retraction cord. However, the PTFE cord was difficult to place clinically in patients due to its less rigid and unraveling nature. The unraveling nature of the PTFE cord may have physically displaced the gingival tissues. Moreover, a study

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<th>Table II. Gingival displacement among study groups.</th>
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<tr>
<td>Study group</td>
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<tr>
<td>PTFE cord (experimental)</td>
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<td>Retraction cord (control)</td>
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*Independent sample t-test.

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<th>Table III. Comparison of bleeding among study groups.</th>
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<tr>
<td>Bleeding</td>
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<td>Present</td>
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<td>Absent</td>
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*Chi-square test, Logistic regression.

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<th>Table IV. Ease of Application of retraction agents among study groups.</th>
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<tr>
<td>Ease of application</td>
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<tr>
<td>Easy</td>
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<tr>
<td>Difficult</td>
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*Chi-square test, Logistic regression.
by Vasakthy and Asharaf, stated that 0.22 mm would be the optimum retraction required in order to record gingival finish lines. However, retraction cord treated specimens demonstrated less displacement then the optimally required. This could be due to the difference in diameter of the both cords used, as adequate diameter is required to displace the gingiva. A survey result showed that using small diameter cord is the primary mistake dentist make during gingival displacement in restorative procedures. Interestingly, an in-vitro experimental study about the effect of impression margin thickness on linear accuracy of addition silicone impression material suggests that sulcus width of 0.15 mm and greater provides consistent results with minimal margin distortion; however, authors recommend some additional displacement to allow for reversion of tissues.

Post-displacement bleeding has a detrimental effect on the quality of impression, especially when hydrophobic elastomeric impression materials are employed. It was identified that application of retraction cord system may result in epithelial attachment injury which causes distress to the patient during cord placement, at times demanding local anesthesia. This may also induce bleeding and oozing from gingival margin leading to treatment difficulty. From the results of the existing study it was identified that only 20% of control and 30% of experimental group patients demonstrated bleeding after cord removal. Both the groups showed no significant difference in bleeding after cord removal ($p > 0.05$). The plausible explanation for this finding was that both groups work on the same mode of action i.e., mechanical displacement. In the study by Kumbuloglu et al, no difference was observed in bleeding between impregnated and non-impregnated retraction cords used for gingival displacement. However, bleeding in 20% and 30% of patients is clinically significant and complicates impression-taking in patients. Therefore, to minimize the incidence of bleeding on retraction agent removal, adjunctive use of haemostatic agents is indicated. Further studies are warranted to investigate the clinical gingival displacement outcomes for impregnated PTFE cords.

Ease of application for any displacement system is another critical criterion that helps a clinician set preferences to choose retraction cord system. It was previously reported that ease of cord placement is influenced by consistency of retraction cord and it is associated with packing easiness. Moreover, it was also stated that compared with other cords, braided or knitted types provide easier manipulation for the clinician. In the existing study, the investigated groups displayed similar outcomes for ease of cord placement, as 46.6% PTFE subjects and 56.6% conventional cord patients showed easy application ($p > 0.05$). This is in accordance with the findings of study conducted by Acar et al. They reported insignificant difference in ease of cord placement between non-impregnated cord and aluminium chloride impregnated cords. The possible reason for the findings of the abovementioned study may be the same type of displacement mechanism used. Although insignificant difference was observed between the study groups, a clinically significant number of patients showed difficulty in cord placement. Thus, on the basis of these findings it can be indicated that PTFE cord needs further improvement prior to be recommended as a potential clinical alternative to traditional retraction cord system. Future studies should be conducted emphasizing the physical and biological properties of PTFE retraction cords.

**Limitations**

The outcomes of the present study should be interpreted in light of the inherent limitations. The impact of gingival thickness and varied sulcus depth can influence the gingival displacement, however this could not be controlled among the study patients. Moreover, the influence of gingival displacement material on the long-term periodontal health was not assessed, as the study included short-term assessment. In addition, gingival displacement, ease of displacement, and bleeding after cord removal, are influenced by the inherent tooth anatomy; however, only mandibular molars were included for assessment in the present study. Gingival displacement was assessed on the buccal surface of the tooth only, which could have influenced the overall study outcomes. Therefore, further studies comparing the gingival displacement using contemporary and conventional retraction agents with standardized protocol and conditions are warranted.

**Conclusions**

Non-impregnated gingival retraction cord and PTFE cord displayed similar outcomes of gingival displacement, ease of placement and bleeding after cord removal. Nevertheless, the post
displacement bleeding and discomfort of PTFE cord placement suggests that this technique needs improvement. Therefore further studies are warranted to improve and investigate the physical and biological response to PTFE retraction cord.

Conflict of Interest
The Authors declare that they have no conflict of interests.

Ethics Approval
The study protocol was reviewed by the ethics and review committee of Dr Ishrat-ul-EBad Institute of Oral Health Sciences, Dow University of Health Sciences, with IRB-1358/ DUHS/Approval/2019/101.

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Authors’ Contribution
Conceptualization, HN, BK, MAL, NA, WAF, MA, AAS, FV, TA, KAA; methodology, HN, BK, MAL, NA, WAF, MA, AAS; software, HN, BK, MA, AAS, FV, TA, KAA; validation, HN, BK, WAF, MA, AAS, KAA; formal analysis, HN, NA, AAS, FV, TA, KAA; resources, HN, BK, FV, TA, KAA; data curation, HN, MAL, WAF, MA, FV, TA; writing—original draft preparation, FV, KAA, TA; writing—review and editing, HN, BK, MAL, NA, WAF, MA. The authors have read and agreed to the published version of the manuscript.

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