IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 22, Issue 12 Ser.1 (December. 2023), PP 51-55
www.iosrjournals.org

Comparative Evaluation Of Pressure Generated And Displacement Observed In Different Gingival Retraction Materials-An In-Vitro Study

Dr. Pooja K. Shettigar [1], Dr. Arti Wadkar [2],Dr. Monika S. Lokhande[3]
[1](MDS Prosthodontics, Nair Hospital Dental College, Mumbai,India)
[2](MDS Prosthodontics, Ex HOD and Professor, Nair Hospital Dental College, Mumbai,India)
[3](MDS Prosthodontics, Nair Hospital Dental College, Mumbai,India)

Abstract:
Background*: In dentistry, poor displacement achieved by retraction materials, results in suboptimal impressions, while excessive pressure risks gingival trauma. The purpose of the study was to understand the pressure exerted by gingival retraction materials and its correlation to the amount of displacement observed.*
Materials and Methods*: The present study was conducted among 3 gingival retraction materials: Group 1 - Impregnated Retraction Cord (Knit-Pak TM+), Group 2 - Traxodent Retraction Paste and Group 3 - 3M ESPE Retraction Astringent Paste for which an idealized tooth and gingival sulcus model was fabricated. Pressure was recorded by means of Flexi Force Sensor Resistor and the lateral displacement was measured by Stereomicroscope and the measurements were then compared using image analysing software.*
Results*: This study revealed that Group1 exerted significantly higher pressure than both Group 2 and 3, while pressure values between the paste-based systems (Group 2 and 3) did not significantly differ. Interestingly, Group 3 demonstrated the greatest displacement, followed by Group 2 and 1. Notably, Group 1 exhibited a negative pressure-displacement correlation, in contrast to the positive correlation observed in Groups 2 and 3.*
Conclusion: *Knit Pak TM+, Traxodent, and 3M ESPE all exerted pressures that can be deemed atraumatic to the gingiva. However, an interesting distinction emerged regarding the relationship between pressure and displacement. Group 1 exhibited decreased displacement as pressure increased, while Group 2 and 3 demonstrated an increase in displacement as pressure levels rose. These findings offer critical insights into the performance dynamics of these gingival retraction materials.*
Key Word*: Gingival Retraction; Gingival Retraction Techniques; Pressure; Gingival displacement; Retraction Cord; Cordless Retraction System; Retraction Paste.*

Date of Submission: 26-11-2023 Date of Acceptance: 06-12-2023

I. Introduction

Achieving success with fixed prosthodontics requires a meticulous interplay of many aspects of dental treatment such as the properties of impression materials, techniques, moisture control, tissue management; all to enhance the impression quality which will help to reduce chair time.[1,2] Any failure to achieve the same can result in ill-fitting crowns, marginal leakage, gingival inflammation and risk of recurrent caries [3,4] Thus, it becomes critical for the clinicians to accurately record the margins with adequate focus on gingival retraction and homeostasis and have adequate knowledge regarding the potential risk of gingival recession on maintaining a healthy periodontium.[5]

Gingival displacement is defined as 'the deflection of marginal gingiva away from the tooth.[6] >0.2 mm of displacement is optimum to avoid incidences of voids, tearing of impression materials and less marginal accuracy.[7,8]To understand displacement techniques, the first step is to measure the sulcus depth which normally ranges from 0.25 to 3.0 mm and is susceptible to change with gingival inflammation.[7,9] The next aspect is to ensure a minimum of 0.15 to 0.20 mm of the sulcular width, to avoid tearing of the impression material while retrieving it from the sulcus.[10,11]

The methods of displacement include mechanical, mechano-chemical and surgical. Mechanical methods physically stretch the circumferential periodontal fibres to displace the gingiva. Thus rendering retraction cords with relative predictability, efficacy and cost effectiveness. However, its use can be laborious, time-consuming, and when inappropriately manipulated, can lead to direct injury and gingival recession around 0.2 ± 0.1 mm.[12- 14]Alternatively, the mechano-chemical methods such as impregnated retraction cords, gels or pastes control hemorrhage and shrink the gingival tissues.Thus are time-saving and associated with less patient discomfort, owing to its minimally invasive nature.[15]

However, there is a limited literature available that correlates the pressure generated with displacement during insertion of retraction materials. [16,17] Hence an in-vitro study was planned to understand the pressure exerted by retraction materials and its correlation to the amount of displacement. Thus enabling an in-vivo sulcus scenario and for more realistic measurements. The research hypothesis was that there exists no difference in the pressure generated between the cord and cordless retraction systems during its insertion and no correlation exists between pressure and displacement produced during gingival retraction.

II. Material And Methods

The ethical approval of this study was obtained from institutional ethics committee of Nair Hospital Dental College (EC/PG-16/PROSTHO/2019).

Study Design: Laboratory based study

Study Location: This was conducted at Nair Hospital Dental College ,Mumbai, India.

Study Duration: October 2019 to February 2021.

Sample size: 17 observations for each group; Group I- Knit-Pak™+ Cord, Group II- Traxodent Paste , Group III- 3M ESPE retraction astringent paste:

Procedure methodology

The factors considered for standardization included fabrication of an idealized circular tooth model, selection of material that simulates the gingiva and fabrication of a gingival sulcus model to minimize the effect of variable factors on the observations and the final result. An idealized circular tooth model was fabricated using DPI Self- Cure Tooth Moulding Powder. Its measurements were verified using Digital Vernier caliper and based on the mean dimensions of 6 maxillary anterior teeth.[18]A 4 x 5 mm acrylic extension was supplemented to resist the movement of the tooth model during the subsequent procedures. 3 permanent marks were made on the tooth model:

1) 8 mm from the occlusal portion: indicating the cementoenamel junction (CEJ)
2) 5 mm from the occlusal portion to act as a reference for clinical crown.
3) line passing through the center of the occlusal portion which is utilized as reference points in pressure calculation (Figure 1).

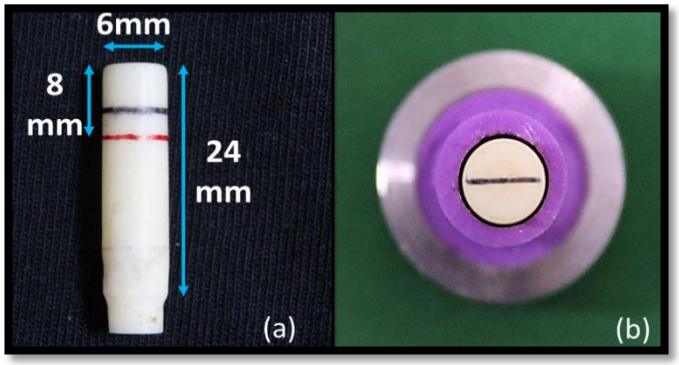

FIGURE 1. Cylindrical tooth model with Markings

In order to fabricate a gingival sulcus model, 3M ESPE Express XT VPS Impression Material was chosen since it has 4.10 MPa tensile strength which is close to the attached gingiva.[19-21].And for the fabrication of the sulcular model, a mould was machined from the Metallurgy Department, IIT-Bombay, incorporating the standard gingival sulcus depth, width and thickness of gingiva using Stainless Steel into 3 parts.[9,10,22]

Part A-Cylindrical Stud: For fabricating inner section of the gingival sulcus to incorporate the tooth model. This stud was divided into 3 sections: 1) The top portion = 8 mm long to equate the coronal length of the tooth model) and 6.4mm wide (6mm diameter+0.2mm sulcus width on each side).2) The middle portion=16 mm long to simulate the remaining root length and 6mm diameter 3) The lower portion was 4x5 mm to get locked into the circular depression of Part C.

Part B-For fabricating the Outer Diameter of the Gingival Sulcus Model: Total 19 mm long, 2mm thick and with 9.4mm of inner diameter with a slot created at the top portion of Part B to incorporate 3mm sulcus depth and 0.2mm sulcus width. The remaining width from this slot was 1.5 mm (which equates the thickness of gingiva)

Part C-For Fabricating The Base Of The Model: Total:10mm long and 20 mm wide with 2 cylindrical depression, one in its center to lock Part A and further the acrylic extension of the tooth model and second 2mm deep to lock part B. (Figure 2).

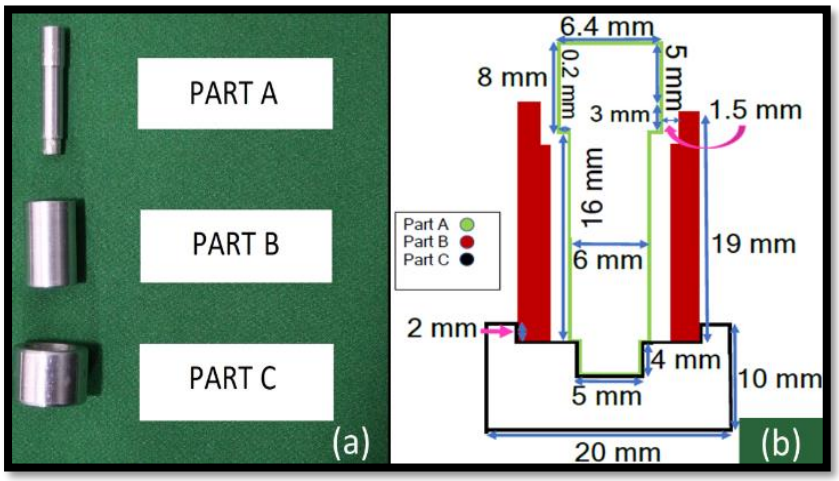

FIGURE 2. Parts of Mould of Gingival Sulcus Model (a) and Schematic diagram (b)

Once Part A,B,C were assembled together, 3M ESPE Express XT VPS Impression Material was injected between Parts A and B keeping the mixing tip constantly immersed in the paste to avoid air bubble formation. Once it reached its final setting time (4 minutes at 37°C room temperature), parts A and B were removed and the acrylic tooth model was then fitted into depression of Part C.

Pressure was recorded by means of A101 Flexi Force Sensor Resistor using Arduino Mega 2560 microcontroller board (Figure 3).Likewise the resultant displacement was measured using Leica S6D Stereomicroscope and the measurements were then compared using Moticam Image analyzing software. Each sample group were tested for 17 times by the operator to compare mean pressure generated with the corresponding displacement.Utilizing Arduino software, a mean of 10 pressure readings were noted. (To minimize sensitivity error of the sensor) while 2 readings along the diameter of the model were recorded indicating the mean lateral displacement produced.

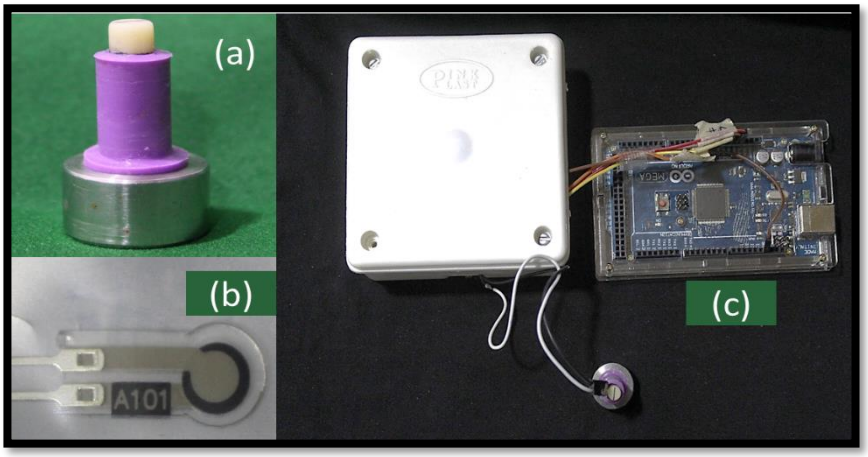

FIGURE 3. Final Setup of Gingival Sulcus & Tooth Model (a), A101 Flexi Force Sensor Resistor (b) and Arduino Mega 2560 microcontroller board (c)

Net Amount of Lateral Displacement Generated = Post displacement Value (Amount of Lateral Displacement Observed) -Pre Displacement Value (Sulcus Width of 0.2 mm)

Knit Pak TM+ Cord of 000 size was packed into the sulcus using Addler Cord Packer; completely encircling the sulcus circumference. Once the cord was packed, the image was captured on the Moticam software and corresponding to the pressure reading acquired on the Arduino software, lateral displacement was simultaneously measured. Similarly, calculations were made for Group 2 & 3. While Traxodent was dispensed by means of a sleek syringe with bendable tip, 3M ESPE retraction paste is available in the form of unit dose capsule with extra-fine, soft edge tip. Both the syringe and the tip were positioned parallel to axial plane of the tooth and injected consistently (Figure 4).

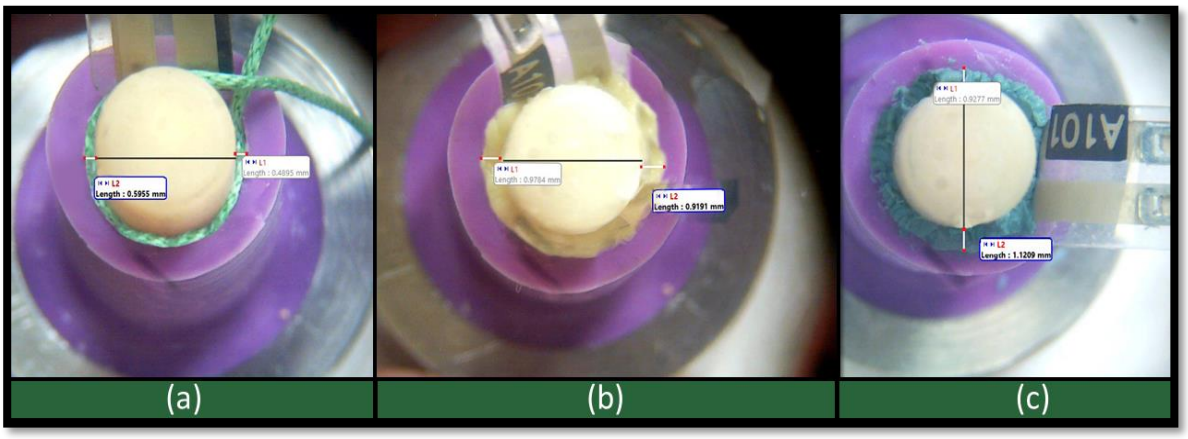

FIGURE 4. Moticam Software captured image for Knit Pak TM+ Cord(a),Traxodent retraction paste,(b) and Moticam Software captured image for 3M ESPE retraction paste

Statistical analysis

Data was analyzed using SPSS version 20 (SPSS Inc., Chicago, IL). Student's *t*-test was used to ascertain the significance of differences between mean values of two continuous variables and confirmed by nonparametric Mann-Whitney test. In addition, paired *t*-test was used to determine the difference between baseline and 2 years after regarding biochemistry parameters, and this was confirmed by the Wilcoxon test which was a nonparametric test that compares two paired groups. Chi-square and Fisher exact tests were performed to test for differences in proportions of categorical variables between two or more groups. The level $P < 0.05$ was considered as the cutoff value or significance.

III. Result

For the analysis of Pressure for the Retraction Materials: Table 1 compares the mean pressure between Group 1, 2 and 3. Mean pressure value for Group1: Knit Pak TM + was 35.29 psi while for Group 2: Traxodent, it was 23.79 psi and for Group 3 : 3M ESPE mean pressure was 24.35 psi. The p value of one way ANOVA test for comparison between Group 1, 2 and 3 was found statistically to be highly significant with higher values in Group 1 followed by Group 3 >2 suggestive that the pressure generated was highest for Knit Pak TM+ and least for Traxodent Retraction paste. Using Games – Howell Post Hoc Test, pair wise comparison of the Standard mean difference for mean pressure was performed. For Group 1 v/s 2 and for Group 1 v/s 3 mean pressure values were statistically highly significant ($p<0.01$). However for Group 2 v/s 3 pressure values were statistically non-significant($p>0.01$) This clearly demonstrated that Knit Pak Cord TM+ generated the highest pressure when compared with both the Retraction Pastes; however among the 2 pastes the pressure values were statistically insignificant.

Table 1. Inter-group and Pair-wise comparison of Mean Pressure values (Using one way ANOVA test):

(a) Inter group comparison of Pressure values (Using one way ANOVA test):					
	Group	Mean	Std. Deviation	Std. Error	p value of one way ANOVA
Pressure (N=17)	1	35.29159	6.582118	1.596398	0.000*
	2	23.78702	3.536971	0.857842	
	3	24.34588	5.124205	1.242802	

(b) Pair wise comparison of Standard mean difference for Mean Pressure generated using Games-Howell Post Hoc Test							
Dependent Variable	(X) Group	(Y) Group	Mean Difference (X-Y)	Std. Error	p Value	95% Confidence Interval	
						Lower Bound	Upper Bound
Pressure	1	2	11.504571*	1.812286	0.000**	6.98509	16.02405
	1	3	10.945706*	2.023127	0.000**	5.95971	15.93170
	2	3	-0.55865	1.5710116	0.927#	-4.29233	3.17460

For the analysis of Displacement for the Retraction Materials: Table 2 compares the mean displacement observed between Group 1, 2 and 3. Mean displacement value for Group1 was 0.32mm while for Group 2 was 0.59mm and for Group 3 it was 0.67mm.The p value of one way ANOVA test for Group 1, 2 and 3 was found statistically highly significant with highest displacement for 3M ESPE Retraction Astringent Paste and least for Knit Pak TM+. Using Games – Howell Post Hoc Test, pair wise comparison of the Standard mean difference for mean displacement was performed. The results were statistically similar to the pressure values, i.e. significant with Group 1 v/s 2 and 1 v/s 3, while non-significant with Group 2 v/s 3.

Table 2.Inter-group and Pair-wise comparison of Mean Displacement values (Using one way ANOVA test):

(a) Inter group comparison of Displacement values (Using one way ANOVA test):					
Displacement (N=17)	Group	Mean	Std. Deviation	Std. Error	p value of one way ANOVA
	1	0.32011	0.039536	0.009589	0.000*
	2	0.59164	0.098920	0.023992	
	3	0.66942	0.103401	0.103401	

(b) Pair wise comparison of Standard mean difference for Mean Pressure generated using Games-Howell Post Hoc Test							
Dependent Variable	(X) Group	(Y) Group	Mean Difference (X-Y)	Std. Error	p Value	95% Confidence Interval	
						Lower Bound	Upper Bound
Displacement	1	2	-0.271521*	0.025837	0.000**	-0.33665	-0.20639
	1	3	-0.349309*	0.026849	0.000**	-0.41709	-0.28153
	2	3	0.77788	0.034706	0.079#	-0.16308	-0.00751

For the analysis of Mean Pressure and Mean Displacement Correlation: A Pearson product-moment correlation was run to determine the relationship between one variable -Pressure (x) and the second -displacement (y). It was apparent from Table 3 and Figure 5 Traxodent and 3M Retraction Paste behaved similarly (r value =>0.7 i.e. highly significant positive & high correlation between x and y variables) which means as pressure increased so did the displacement; This was the reverse for Knit Pak TM+ Cord i.e. as pressure increased, displacement of the gingiva decreased (r value = -0.69, i.e. statistically highly significant negative & moderate correlation).

Table 3. Correlation of Mean Pressure and Mean Displacement for Group 1,2 and 3

		Group 1	**Group 2**	**Group 3**
Mean Displacement and Mean Pressure	Pearson Correlation r value	-0.699**	0.751**	0.759**
	P value	0.002	0.001	0.0010
	N	17	17	17

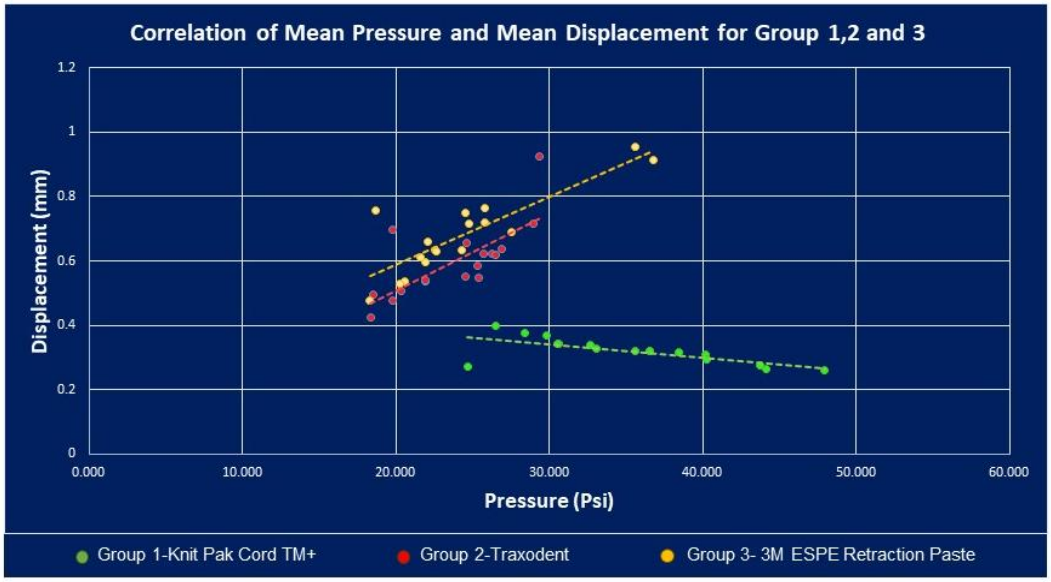

FIGURE 5. Correlation of mean pressure and mean displacement for Group1,2 & 3

IV. Discussion

In this in-vitro study, total 51 specimens (17 specimen per group) were studied with an objective to individually evaluate and compare the pressure generated and to correlate this pressure with the displacement observed among the retraction materials.The mean displacement value for Knit Pak TM+ retraction cord obtained in the present study was 0.32 ± 0.04mm while for Traxodent it0.59 ± 0.099 mm and for 3M ESPE it was 0.67 ± 0.103mm which were comparatively higher than that observed in the studies by Yang J-C et al[23] (2005) and Prasanna et al[24] (2013) where the mean displacement value of sulcus width was 0.21 ± 0.01 mm for the gingival retraction cord and 0.26 ± 0.02 mm for Expasyl paste. These variations in the present in-vitro study could be attributed to the testing conditions since this was performed on ideal acrylic tooth model under standard isolated conditions. As well these studies[23,24] showed heterogeneity in regards with testing methods for calculating displacement while the current study utilized Stereomicroscope and image analyzing software. When compared to Bennani V. et al [16] the pressure generated for Expasyl paste and for Knit Trax Cord was 258 psi which was way higher as compared to the present study. This could be related to the box-type study model that does not provide escape ways for the pressure resulting in higher values. This drawback was rectified in the present model by altering the geometry and by providing a 360º access that aids circumferential loading and pressure release for retraction materials.

The mean displacement values for 3M ESPE retraction paste and Traxodent obtained in the current study were 0.67 ± 0.103mm and 0.59 ± 0.099 mm which were in accordance with the study conducted by Qureshi SM et al[25] Rayyan MM et al[15].The probable reason for 3M ESPE in producing highest displacement is related to the consistency of the material and the extra fine tip of the capsule that provided easy access into the sulcus. A similar study was conducted by Bennani V et al[26,27] to measure the pressure and displacement achieved by 3 materials (Expasyl, Expasyl New, and KnitTrax Cord) using a similar acrylic tooth model with PVS to simulate the free gingiva; stereomicroscope was used to quantify the displacement while pressure gauge was used to measure

pressure. Both the pastes and the cord showed results which are within acceptable clinical parameters. The correlation behavior between pressure and gap showed that Expasyl and Expasyl New behaved similarly, while KnitTrax Cord was different which was consistent with the present study. This anomalous behavior could be attributed to their physical properties, unlike pastes, cords are porous and fibrous, so when compressed, they expel air or fluid from their pores, making them less effective at displacing gingiva. This limitation is due to their physical diameter, not the pressure applied by the clinician. Within the scope of this present study, the null hypothesis can be rejected stating that there exists a significant difference in the pressure generated between Retraction cord and the Retraction paste systems.

To conclude, the Retraction Paste Systems (Group 2 and 3) in comparison with Retraction Cord (Group 1) produces greater displacement and lesser pressure generation, but Group 3 i.e., 3M ESPE showed the most favorable results with maximum gingival displacement.

Within the limitation of this in-vitro study, there were certain shortcomings that need further considerations. They were as follows:

1. This in-vitro study doesn't simulate intra-oral conditions due to the absence of factors like saliva and temperature variations. Conducting an in-vivo study with long-term follow-up is crucial to provide a conclusive comparison between in-vivo and in-vitro data for more meaningful results.
2.Studies with a larger sample size need to be carried out to obtain more accurate results.
3.To achieve an improved accuracy, a realistic model of the human gingival sulcus, must be created using artificial saliva or serum with electrolytes to study how saliva or blood flow impacts retraction materials.
4.Finally, in the present study a limited number of 3 retraction materials were investigated. To generate more comparable data, further research with different retraction materials is suggested.

Hence further studies need to be conducted considering all these factors to get accurate data and efficacy of these retraction material.

V. Conclusion

Within limitations of the study, the following conclusion can be drawn:

1.Mean pressure generated followed an order of Group 1>3 > 2. Similarly, pairwise comparison of mean pressure for Group 1 v/s 2 and Group 1 v/s 3 demonstrated statistically highly significant results while for Group 2 v/s 3 results were statistically non – significant.
2.Mean displacement value followed an order of Group 3>2>1. Similarly, pairwise comparison for mean displacement was statistically highly significant when compared for Group 1 v/s2 and Group 1 v/s 3 whereas statistically non – significant for Group 2 v/s 3 .
3.Knit Pak TM+ Retraction cord showed negative correlation i.e. when pressure increased, displacement of the gingiva decreased.
4.While Traxodent and 3M Retraction Paste showed a positive correlation i.e. when pressure increased, displacement of the gingiva increased.

References

[1]. Sumanth K.S,.Shetty G,.Sonnahalli N. Impression Techniques In Fixed Prosthodontics.- A Review. International Journal Of Scientific Research. 2019;8(3),P17- 19.
[2]. Felton DA, Kanoy BE, Bayne SC, Wirthman GP. Effect Of In Vivo Crown Margin .. Discrepancies On Periodontal Health. J Prosthet Dent 1991;65:357-64.
[3]. Rosenstiel SF, Land MF, Fujimoto J. Contemporary Fixed Prosthodontics. 4th Ed. St.Louis: Mosby; 2006. P 432.
[4]. Beier US, Kranewitter R, Dumfahrt H. Quality Of Impressions After Use Of The Magic Foamcord Gingival Retraction System A Clinical Study Of 269 Abutment Teeth. Int J Prosthodont ,2009;22:143-7.
[5]. The Glossary Of Prosthodontic Terms: Ninth Edition. J Prosthet Dent. 2017 May;117(5S):E40.
[6]. Baba NZ, Goodacre CJ, Jekki R, Won J. Gingival Displacement For Impression Making In Fixed Prosthodontics: Contemporary Principles, Materials, And Techniques. Dent Clin North Am. 2014 Jan;58(1):45- 68
[7]. Gajbhiye V, Banerjee R, Jaiswal P, Chandak A, Radke U.Comparative Evaluation Of Three Gingival Displacement Materials For Efficacy In Tissue Management And Dimensional Accuracy. J Indian Prosthodont Soc. 2019 Apr-Jun;19(2):173-179
[8]. J. T., & Saturen, B. B. The Gingival Sulcus: A Clinical Study Of Its Depth.Journal Of Periodontology, 1954;25(4), 278–281.
[9]. Laufer BZ, Baharav H, Ganor Y, Cardash HS. The Effect Of Marginal Thickness On The Distortion Of Different Impression Materials.J Prosthet Dent. 1996 Nov;76(5):466-71
[10]. Claffey.N, Shanley.D. Relationship Of Gingival Thickness And Bleeding To Loss Of Probing Attachment In Shallow Sites Following Non Surgical Periodontal Therapy.J Clin Periodontol. 1986;13:654–57.
[11]. Adnan, Samira And Muhammad Atif Saleem Agwan. " Gingival Retraction Techniques: A Review. " Dental Update 45 (2018): 284-297
[12]. Feng, J, Aboyoussef H, Weiner S, Et Al: The Effect Of Gingival Retraction Procedures On Periodontal Indices And Crevicular Fluid Cytokine Levels: A Pilot Study. J Prosthet Dent 2006;15:108-112
[13]. Tabassum S, Adnan S, Khan FR. Gingival Retraction Methods: A Systematic Review. J Prosthodont 2017;26:637-43
[14]. Rayyan MM, Hussien ANM, Sayed NM, Abdallah R, Osman E, El Saad NA, Ramadan S. Comparison Of Four Cordless Gingival Displacement Systems: A Clinical Study. J Prosthet Dent. 2019 Feb;121(2):265-270.
[15]. Bennani V, Aarts JM, He LH. A Comparison Of Pressure Generated By Cordless Gingiva Displacement Techniques. J Prosthet Dent 2012;107:388-92.

[16]. Bennani V, Inger M, Aarts JM: Comparison Of Pressure Generated By Cordless Gingival Displacement Materials. J Prosthet Dent 2014;112:163-167
[17]. Ash MM, Wheeler's Dental Anatomy, Physiology And Occlusion. 7th Ed.Philadephila: WB Saunders; 1992 P.141-147.
[18]. Goktas S, Dmytryk JJ, Mcfetridge Poo. Biomechanical Behavior Of Oral Soft Tissues.Journal Of Periodontology. 2011 Aug;82(8):1178-86.
[19]. Choi JJE Et Al.Mechanical Properties Of Human Oral Mucosa Tissues Are Site Dependent:.A.Combined Biomechanical,Histological And Ultrastructural Approach. Clin Exp Dent Res. 2020 Dec;6(6):602-611.
[20]. Choi JJE, Chen S, Waddell JN. Investigation Of Dental Elastomers As Oral Mucosa Simulant Materials. Clin Exp Dent Res. 2021 Oct;7(5):754-762.
[21]. Goaslind GD, Robertson PB, Mahan CJ, Morrison WW, Olson JV. Thickness Of Facial Gingiva. J Periodontol. 1977 Dec;48(12):768-71.
[22]. Yang J-C, Tsai C-M, Chen M-S, Wei JY, Lee S-Y, Lin C-T. Clinical Study Of A Newly Developed Injection- Type Gingival Retraction Material.Journal Of Dental Sciences. 2005;24(3):147-151.
[23]. Prasanna, Gs & Reddy, Kumar, RKN Et Al: Evaluation Of.Efficacy Different Gingival Displacement Materials On Gingival Sulcus Width. J.Contemp Dent Pract .2013;14:217-221
[24]. Qureshi SM, Anasane NS, Kakade D. Comparative Evaluation Of The Amount Of Gingival Displacement Using Three Recent Gingival Retraction Systems - In Vivo Study. Contemp Clin Dent. 2020;11(1):28-33.
[25]. Bennani V, Aarts JM, Brunton P. A Randomized Controlled Clinical Trial Comparing The Use Of Displacement Cords And Aluminum Chloride Paste. J Esthet Restor Dent.2020 Jun;32(4):410-415
[26]. Bennani.V,Aarts.JM,Schumayer D. Correlation Of Pressure.And.Displacement.During Gingival Displacement: An In Vitro Study. J Prosthet Dent. 2016