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Comparative Evaluation of Vertical and Lateral Gingival Displacement Produced by Mechanical and Chemical Retraction Systems through Digital Impressions using Intraoral Scanner - An in-Vivo Study

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Abstract:-

- ***Background :***

Gingival retraction is crucial for impression making in fixed prosthodontics. This *invivo* study aimed at comparing the gingival retraction in vertical and lateral axes produced by mechanical and chemical retraction systems through digital impressions using intraoral scanner.

- ***Materials and Methods:***

This in vivo, experimental study included 15 subjects,in which further 3 sample groups were allotted making the sample size 45. The mean vertical and lateral gingival displacement done by mechanical and chemical methods was measured at five points of maxillary anterior teeth after preparation on digital impression files made through direct intraoral scanning. Comparison of the mean values without retraction and with different retraction systems were done. The results were analyzed using the One-Way ANOVA, unpaired/independent t test, The Shapiro–Wilk test and Levene's test.

- ***Results :***

The displacement cord, showed mean vertical displacement to be 0.75 mm and the lateral displacement 1.13 mm. For the retraction paste, the resultant mean vertical displacement was calculated to be 0.68 mm and the lateral displacement 0.67 mm. For vertical displacement, no significant differences were found between the cord and the paste. But statistically significant results were seen for the lateral displacement between the same groups.

- ***Conclusion:***

The cord/mechanical system showed a greater amount of displacement than the cordless/chemical system. Intraoral scanning was found to be an effective means of measuring gingival retraction.

Keywords:- *Gingival Retraction, Gingival Displacement, Intra Oral Scanning, Digital Impression, Retraction Cord, Cordless, Retraction Paste.*

I. INTRODUCTION

Tremendous progress has been made in the field of fixed prosthodontics and its success majorly depends on biological, mechanical and aesthetic principles. Both the effects of soft tissue on the abutment teeth and the effect of prosthesis on the soft tissue must be well understood for proper functioning of the prosthesis in terms of esthetics and longevity. It is crucial to record the prepared teeth margins accurately without error and to not let the gingival and periodontal factors affect the impression making. A major restraint of direct optical impressions is their limitation to line of sight. A clean sulcus is a requirement of paramount importance while making digital computer aided design/computer added manufacturing (CAD/ CAM) impressions. So as to make the recording of margins easier and error-free, gingival retraction is done.

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The glossary of prosthodontic terms ninth edition [1] defines gingival displacement as "displacement of the marginal gingiva away from a tooth." It is the atraumatic displacement of the gingiva away from abutment tooth. It aims at isolation and fluid as well as hemorrhage control during impression making, thus providing better visualization and improved accuracy.

Displacement is done in two axes, that is vertical and lateral/horizontal. By vertical displacement, the unprepared portion of the tooth apical to the finish line is exposed and by lateral displacement, the tissue moves away from the margins so that an adequate bulk of impression material can contact the prepared tooth. Various methods that are used are mechanical, chemico-mechanical, electrosurgical, rotary curettage and/or combination of these.

The aim of this study was to quantify the vertical(sulcus depth) and lateral (sulcus width) gingival displacement performance of two materials i.e., retraction cord(Sure endo) and retraction paste(3M ESPE capsule), along with their comparison with intraoral digital impression.

Thus far, the comparison of vertical and lateral displacement caused by various agents is measured through 3-D laser scanning devices, on models through digital Vernier callipers, optical microscope, under stereomicroscopes, profile projectors, digital scanning of cast using electron microscopy, extraoral scanning of the impression and measurement through software. The measurement tool used in this study was direct digital intraoral scan of the retracted tissue.

The null hypothesis was that there is no difference in the accuracy of gingival displacement with the two materials tested with and without retraction while making digital impressions with intraoral scanners.

II. MATERIALS AND METHODOLOGY

The study was prospective, in- vivo, comparative, experimental. It was carried out in Postgraduate Department of Prosthodontics, Government College of Dentistry, Indore (2021-22).The sample size of the study was 45. It includes subjects who came for the replacement of single maxillary anterior tooth through fixed prosthesis. 15 subjects were selected as per sample size determination and in each subject, further 3 sample groups were allotted. All eligible participants were explained the purpose, procedure of the study, possible alternatives, associated benefits, risks and an informed consent was obtained. The study was approved by the institutional ethical committee.

➢ *Sample Groups :*

- *Group I (Control) – Without gingival retraction*
- *Group II – Retraction with mechanical means (SURE-cord) (Figure 1)*
- *Group III– Retraction with chemical means (3M ESPE retraction capsule) (Figure 2)*

The specific details of the two materials used are mentioned in table 1.

Table 1 Specific details of Sure-Cord Retraction Cord, 3M ESPE Astringent Retraction Paste

Trade Name	Composition	Presentation	Application Method	Application Time	Removal	Manufacturer
Sure-cord retraction cord	100% cotton, knitted, non-impregnated	Translucent colour coded bottles with smart cutting cap	With cord packer – in pushing, caterpillar like motion	8 min	Mechanical removal	Sure-dent
3M ESPE astringent retraction paste	15% aluminium chloride hexahydrate (AlCl3. 6H20)	Unit-dose capsules (fits in any composite dispensing gun	Insertion of tip in sulcus and injecting.	2 min	Air-water syringe	3M ESPE

Fig 1 Knitted Cord

Fig 2 Retraction paste capsule

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The intraoral scanner used in the study was i500 (Medit) IOS was introduced in 2018 and is based on triangulation scanning technology. It uses image processing based on a 3D-inmotion video technology.

Tooth preparation was done, according to standard prosthodontic principles to receive full coverage PFM crown. Point indentations on mesio-buccal, mesio-lingual, disto-buccal, disto-lingual and mid-buccal point angles were made just above the finish line as reference points for measuring the sulcus depth and width for each retraction system.

After the preparation, digital intraoral impression of the prepared tooth was made through scanning to obtain digital values of depth and width of the gingival sulcus at these points. This gave the control value for each subject (Group I).

Retraction was done using the retraction cord system(Group II). The cord of adequate length was cut and impregnated with aluminium chloride solution (Haemostop, Pyrex) for 5 minutes [2]. Knitted cord of sizes #000 was packed in the sulcus using a serrated cord packer with minimal pressure for about 8 minutes. A digital scan was made after removal of the retraction cord and stored.

After an interval of 7 days, the gingival retraction using the other gingival retraction system i.e., retraction paste was performed. 3M ESPE cartridge (group III)-retraction paste with the dispensing tip was attached to the cartridge and loaded in the dispensing gun, material was slowly dispensed into the sulcus resting on the tooth without exerting any pressure with the tip on the gingiva. And digital scan was made and stored.

The gingival retraction was calculated at predetermined reference points i.e., midbuccal, mesio-buccal, mesio-lingual, disto-buccal and disto-lingual point angle, and average vertical and lateral displacements was measured on digitally scanned files. Digital scans were recorded and saved in STL file format. The files were then evaluated on CAD-CAM software i.e. Exocad for image analysis. It measured the linear gingival changes caused by displacement material to micrometre accuracy both in vertical and horizontal/lateral axes. The difference in measurement provided the retraction efficiency of a particular system.

All the steps including tooth preparation, retraction procedures, intraoral scanning and measurements on software were done by a single operator in supervision of senior prosthodontist to eliminate an operator's variability.

Fig 3 Group 1- (a & b) - Tooth Preparation (c) Intraoral Scanning of Prepared tooth

Fig 4 Group II : a) Retraction with Cord Technique b) after Retraction c) Intraoral Scanning

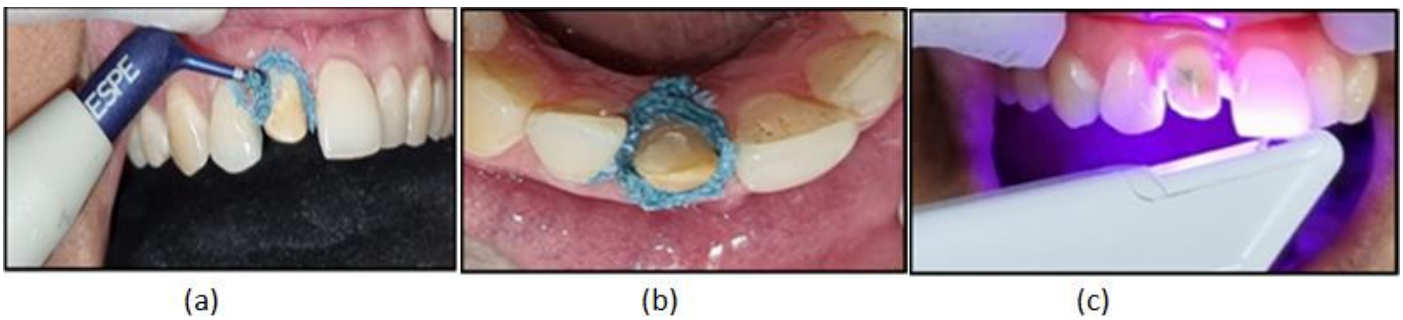

Fig 5 Group III - a, b) - Retraction with cordless system (c) Intraoral scanning

➢ *The Study Design is Summarized in the flowchart. (Figure 6)*

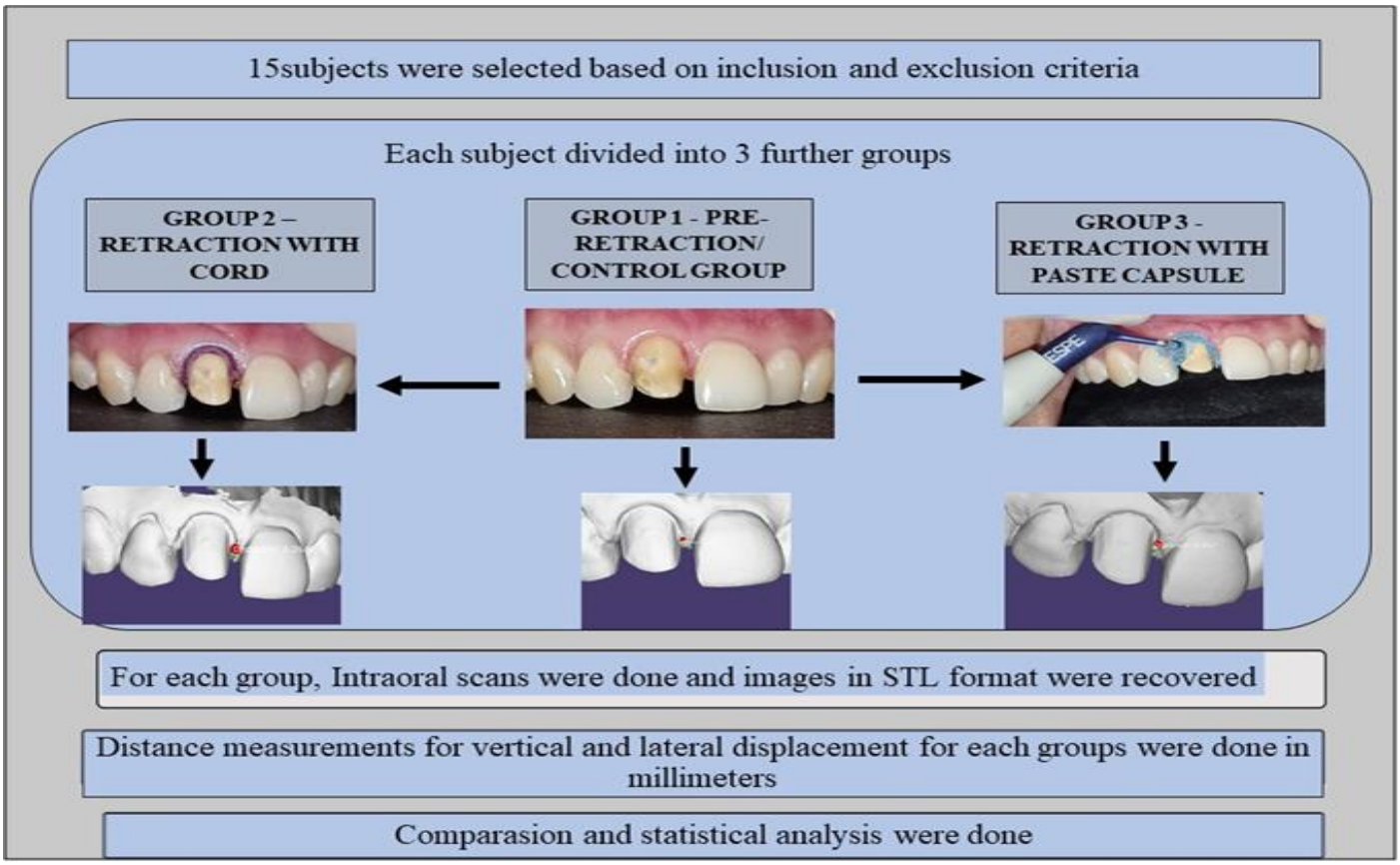

Fig 6: Study Design

The data for the present was analysed using the SPSS statistical software 23.0 version. The level of the significance for the present study was fixed at 5%. The intergroup comparison for the difference of mean scores between independent groups was done using the One-Way ANOVA and unpaired/independent t test. The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables. The data were found to be homogeneous and normally distributed.

III. RESULTS

➢ *Intergroup Comparison of Vertical Displacement* (all measurements in mm)

Table 2 and graph 1 shows the intergroup comparison between the three groups which was statistically significant when analysed using One-way ANOVA at p value of 0.001.

Table 2 Intergroup Comparison of Vertical Displacement

		Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value
Mesio Buccal	Group I	0.2123	0.08144	0.02103	.10	.33	0.001 (Sig)
	Group II	0.7694	0.18846	0.04866	.52	1.27	
	Group III	.7045	.12647	.03265	.54	.96	
Mesio Lingual	Group I	.2157	.05802	.01498	.09	.33	0.001 (Sig)
	Group II	.7521	.16696	.04311	.51	1.06	
	Group III	.6705	.14051	.03628	.48	.98	
Disto Buccal	Group I	.2124	.07676	.01982	.11	.34	0.001 (Sig)
	Group II	.7721	.18924	.04886	.46	1.02	
	Group III	.6809	.13945	.03601	.46	.98	
Disto Lingual	Group I	.2571	.13887	.03586	.11	.56	0.001 (Sig)
	Group II	.7699	.15010	.03875	.55	1.05	
	Group III	.6921	.10911	.02817	.47	.82	
Mid Buccal	Group I	.2198	.09415	.02431	.09	.36	0.001 (Sig)
	Group II	.7265	.15658	.04043	.54	1.02	
	Group III	.6530	.10707	.02765	.40	.79	

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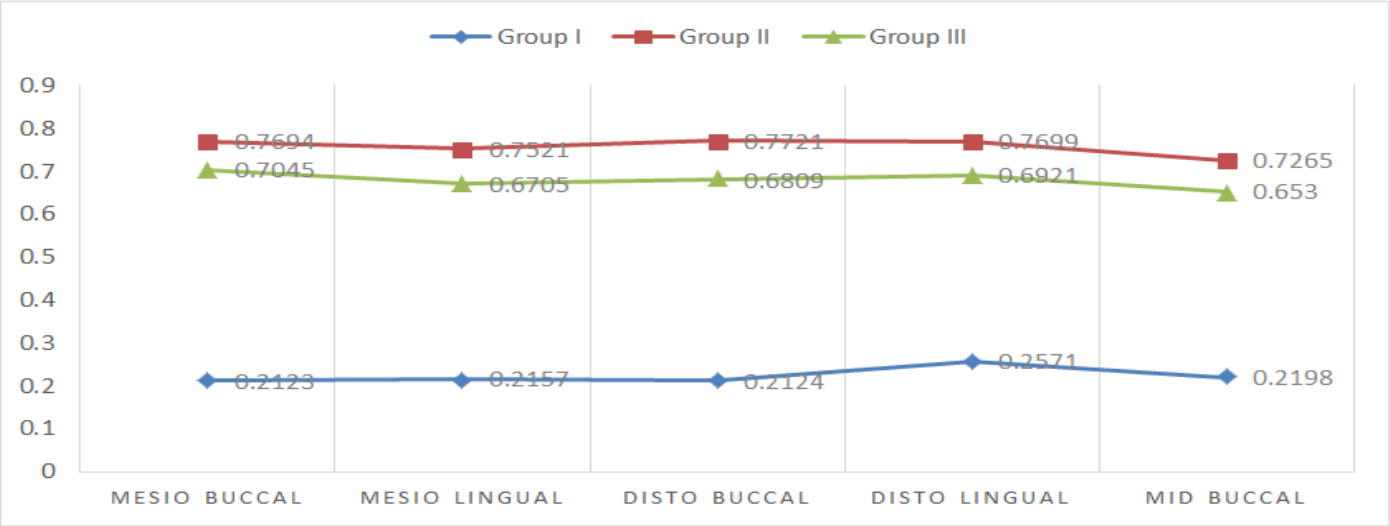


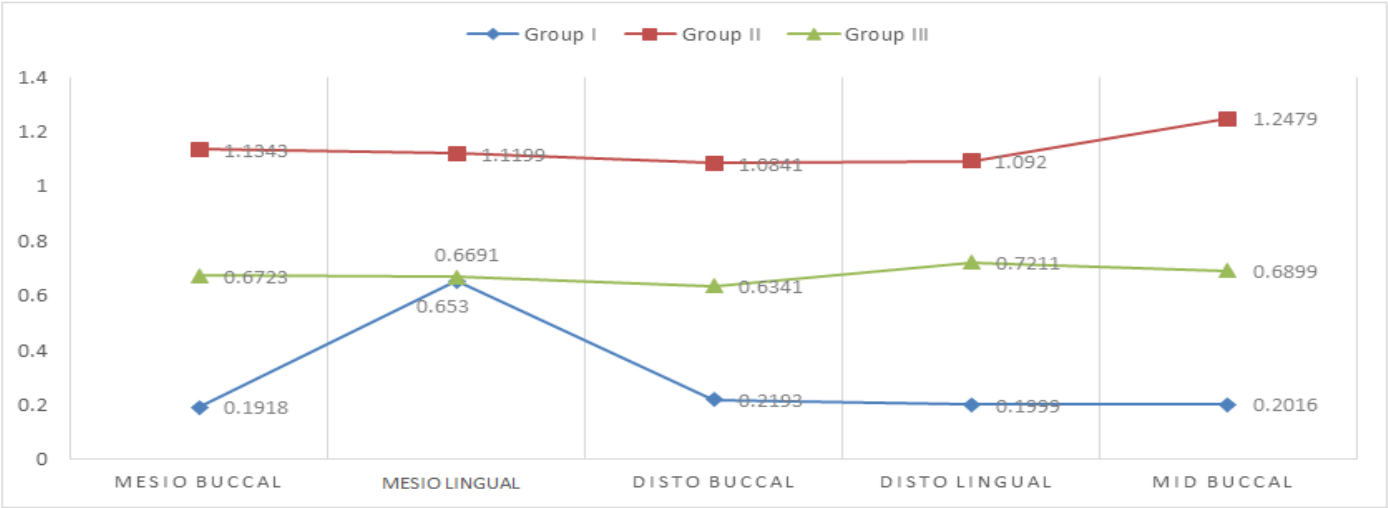
Graph 1: Comparison of Mean values obtained for vertical displacement in all groups

➢ *Intergroup Comparison of Lateral Displacement*
(all measurements in mm)

Table 3 and Graph 2 shows the intergroup comparison between the three groups which was statistically significant when analysed using One-way ANOVA at p value of 0.001.

Table 3 Intergroup Comparison of Lateral Displacement

		Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value
Mesio Buccal	Group I	.1918	.07490	.01934	.09	.32	0.001 (Sig)
	Group II	1.1343	.20308	.05244	.72	1.46	
	Group III	.6723	.12202	.03151	.45	.89	
Mesio Lingual	Group I	.2214	.09735	.02513	.10	.38	0.001 (Sig)
	Group II	1.1199	.18713	.04832	.73	1.34	
	Group III	.6691	.15449	.03989	.47	.97	
Disto Buccal	Group I	.2193	.09041	.02334	.11	.36	0.001 (Sig)
	Group II	1.0841	.33838	.08737	.11	1.55	
	Group III	.6341	.11662	.03011	.45	.84	
Disto Lingual	Group I	.1999	.06322	.01632	.10	.30	0.001 (Sig)
	Group II	1.0920	.14587	.03766	.88	1.34	
	Group III	.7211	.12729	.03286	.46	.99	
Mid Buccal	Group I	.2016	.08024	.02072	.11	.37	0.001 (Sig)
	Group II	1.2479	.20869	.05388	.85	1.52	
	Group III	.6899	.09688	.02501	.51	.86	



Graph 2: Comparison of mean values obtained for lateral displacement in all groups

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In our study, for the displacement cord, the resultant mean vertical displacement was calculated to be 0.75 mm and the lateral displacement 1.13 mm.

For the retraction paste, the resultant mean vertical displacement was calculated to be 0.68 mm and the lateral displacement 0.67 mm.

For vertical displacement, no significant differences were found between the cord and the paste. But statistically significant results were seen for the lateral displacement between the same groups. Overall, the cord group showed a greater amount of displacement than the cordless group.

IV. DISCUSSION

The intraoral digital impression technique has been used in prosthodontics to aid the CAD/CAM process. As a relatively new technique, the deficits in repeatability of the intraoral digital impression need to be solved, but dental products fabricated with intraoral digital impressions have presented accuracy on par with conventional impressions. They have excellent accuracy and can be manipulated on the screen for viewing preparation margins and details. 3 In addition, factors such as patient movement, swallowing, tray distortion, and moisture may negatively affect conventional impressions but not digital scans. 4,5,6

While making impressions for crown and bridge, the clinical tissue management and isolation of margins is a pre-requisite. [5,6] Otherwise, it becomes a task to scan and resultant margin recording is not clear and well-defined, especially for equi-gingival and subgingival finish lines. Therefore, gingival retraction is mandatory.

Among the gingival retraction methods, most frequently used is the mechanical method, which involves non-traumatic mechanical insertion of medicated cord into the sulcus depth. Currently, aluminium chloride is the most commonly used medicament because it is not associated with systemic side effects.[7] Therefore, in this study Knitted cord dipped in 15% Al_2Cl_3 was used. The size of the cord used was #000. Zeena Raja & Chandrasekharan Nair [8], in their clinical study concluded that knitted cords are better than braided cords, and they showed maximum retraction of 0.61 mm and retraction efficiency between different types of knitted cords (#000, 00, 0) remains similar i.e. 0.6mm.

Cordless displacement techniques have advantages over conventional cord techniques, including saving time, comfortable to the patient, better gingival displacement, decrease associated GCF flow, minimal application-generated pressure, and better maintenance of gingival health.9,10,11 .Various cordless retraction systems are available in pastes ,foams and gel forms, providing comparable displacement to the cord. Some of the most commonly used are: -

- *An addition-curing silicone foam (Magic Foam Cord, Coltène, Switzerland)*
- *A kaolin paste system (Expasyl, Pierre Rolland, Merignac, France)*
- *Kaolin and aluminium chloride base (3M™ Astringent Retraction Paste)*

The 3M ESPE system has barely been studied.[12,13] It is a fairly new entrant with ease of application, thin tips providing painless application, faster than rest of the materials and suitable viscosity. Due to its potential ,which can be deduced from the limited available literature, the scientific task was to systematically investigate its performance and compare it with standard cord technique. It showed significantly more horizontal displacement than Expasyl under healthy gingival conditions. [14]

In a randomized control trial done by Marwa Beleidy et al [15] ,to assess cordless techniques compared to conventional cords in gingival displacement and its effect on periodontal health. The comparison was done with Ultrapak, GingiTrac, Traxodent and NoCord utilizing a stereomicroscope. They concluded that cordless retraction systems showed similar horizontal gingival displacement compared to conventional cords.

Ashish Choudhary et al.[16], evaluated and compared of the amount of displacement of free gingiva with the use of a new retraction paste (3M ESPE) and retraction cord system (Ultrathin Gingival retraction Cord -SureEndo #000). They concluded that the use of traditional retraction cord may cause discomfort and potential damage to periodontium if used carelessly and cordless method was found to be more effective.

Renuka Prasanna, Kesava Reddy et al. [17], in their study compared two gingival displacement systems i.e., retraction cord and displacement paste. Both the test agents employed in this study achieved adequate sulcus width enlargement. Expasyl showed a better ability in achieving horizontal displacement of the gingival sulcus than the knitted impregnated retraction cord.

The result of this study was consistent with the studies done by Felipe V. Martins et al [12] , Kazemi et al and Apsari Indriyani et al.[18],in which they analyzed the efficacy of retraction cord with a haemostatic agent in comparison with retraction paste on lateral gingival displacement. They concluded gingival displacement width as a result of cord retraction with the haemostatic agent was larger compared to the retraction paste. Even though both of them are still considered to be effective in providing access for impression material [19]

In the literature, there are only a few studies regarding the vertical displacement of the gingival margin. Gajbhiye et al. obtained a mean value of 0.299 mm with a 25% aluminium chloride impregnated retraction cord[20] , a lower value than our measurements, but Thimmappa et al. obtained a higher mean value of 1.24 mm with a non-impregnated retraction cord [2].

Also, the various sites of measurements namely mesio-buccal, mesio-lingual, disto-buccal, distolingual line angles and mid-buccal area showed similar retraction confirming the fact that retraction is not related to a particular site in a healthy mouth. Baharav et al [21] found that there was no statistically significant difference found between the crevicular depths at the transitional line angles (2.2± 0.6mm) and the mid-buccal areas (1.9± 0.6mm) (P>0.2)2. [19]

Though the two test materials used in this study achieved similar amount of vertical displacement but statistically significant amount of horizontal displacement. The suggested null hypothesis was rejected as the statistical analysis revealed a significant difference of gingival retraction capacity between the materials tested.

It was concluded that the retraction produced by retraction cord was higher as the cord was pushed mechanically into the gingival sulcus. But it was observed that clinical handling of retraction cord was a tedious process and caused some amount of pain or discomfort to patient.[22] The retraction paste presented with adequate retraction of margins for intraoral scanner to record properly.

The advantages of this study compared with previous investigations were the *in vivo* design, as well as ease and accuracy of measurements through intraoral scanning and exocad software.

Limitations being comparison of materials was done only around healthy teeth. Further studies are needed with an increased sample size to evaluate the same parameters in different population group. Also, the performance of the material in the presence of gingivitis and periodontitis should also be examined, as well as different gingival thickness groups. More studies are required for evaluation of retraction in-vivo using intraoral scanners and other human errors, standardization errors and scanning errors should be considered.

V. CONCLUSION

➢ *Within the Limitations of this Study the following Conclusions were drawn:*

- Both the methods- retraction cord and retraction paste employed in this study achieved adequate sulcus width and depth. In terms of ease of clinical handling retraction paste is a better material.
- For vertical displacement or sulcus depth, the displacement cord showed mean retraction of 0.75mm and the retraction paste presented with 0.68 mm retraction. For lateral displacement or sulcus width, the displacement cord showed mean retraction of 1.13mm and lateral displacement of 0.67 mm
- For the two groups, statistical analysis for vertical displacement showed insignificant and for lateral displacement, it showed significant differences.
- Intraoral scanning was found to be an effective method to measure gingival retraction in vertical and horizontal axes.

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