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Comparative Evaluation of the Clinical Efficacy of Three Different Gingival Retraction Systems: An in Vivo Study

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Abstract

Introduction: In fixed prosthodontics, precise soft tissue management is essential for capturing accurate subgingival margins during impression making. This in vivo crossover study evaluated and compared the lateral gingival displacement efficacy of three distinct systems: retraction cord impregnated with 25% aluminium chloride, the 3M™ ESPE™ Astringent Retraction Capsule, and Traxodent® Retraction Paste.

Method: Measurements were obtained from 15 subjects with healthy, unprepared maxillary central incisors over intervention periods separated by a 2-week washout interval. Impressions were recorded pre and post retraction using three different gingival retraction materials and impressions were poured to obtain 60 casts. Cross-sectioned stone casts were analysed under an optical microscope for lateral gingival displacement.

Result: Statistical analysis demonstrated a highly significant differences ($p < 0.001$) among the evaluated systems. The impregnated retraction cord demonstrated the highest mean lateral displacement 588.36µm, followed by the retraction capsule 441.68 µm and the retraction paste 312.79 µm.

Conclusion: Within the limits of this in vivo study, significant differences in horizontal gingival displacement were observed among the three evaluated systems. The horizontal displacement requirement of 200 µm was exceeded by all three systems. The maximum gingival displacement was recorded for impregnated retraction cord, followed by the retraction capsule (3M ESPE), with the lowest value observed for retraction paste (Traxodent).

Keywords: Aluminium Chloride, Microscope, Malocclusion, Prosthodontics.

Introduction

The ultimate success and biological longevity of fixed restorations depend heavily on the harmony between the prosthesis and adjacent periodontal tissues[1]. To ensure accurate marginal adaptation and prevent future gingival inflammation or recession, the finish lines of the preparation must be precisely recorded during impression making, which necessitates temporary displacement of the gingival sulcus in both the vertical and lateral dimensions. A minimum lateral crevicular width of 200 µm is widely considered essential to allow adequate bulk of elastomeric impression material to flow into the sulcus without tearing upon removal[2, 3].

Traditionally, mechanical tissue displacement using retraction cords has served as the clinical standard. However, cord packing can be technically challenging, time-consuming, and uncomfortable for the patient.[4] Furthermore, excessive force risks damaging the junctional epithelium and violating the biological width, potentially leading to permanent gingival recession or bone loss.[4] To mitigate these drawbacks, contemporary cordless paste and capsule systems have emerged; these systems employ chemical astringents together with gentle mechanical or hydrostatic pressure to displace tissue with reduced trauma.[5]

This in vivo investigation directly compared the physical lateral displacement achieved by an advanced impregnated retraction cord against two popular modern cordless systems on unprepared teeth to establish an unbiased performance benchmark.

Materials and Methods

A clinical sample of 15 healthy subjects aged 18–30 years was selected following institutional ethical approval. The study was conducted in Department of Prosthodontics, Bhojia Dental College, Bhud, Baddi. and the measurements were made at ICMR, New Delhi.

Strict inclusion criteria demanded a full complement of teeth, healthy periodontal biotypes, and an absence of malocclusion, crowding, or anterior diastemas. Subjects with systemic diseases or pre-existing periodontal conditions were excluded.

Clinical Protocol

Unprepared maxillary right central incisors served as the experimental model. Baseline pre-retraction impressions were recorded using a one-step putty-wash technique with Aveu Addition Silicone Putty and light body material in a sectional tray. The impressions were disinfected and poured using Type IV die stone (Kalabhai Pvt Ltd, Mumbai, India).

Pre-gingival displacement impressions were made using a putty wash impression technique(Fig.1) with Aveu Addition Silicone Putty (Dental Avenue India Pvt. Ltd., Gurgaon, Haryana, India) and light body in a sectional tray in the anterior maxillary region on the unprepared tooth. The manufacturer's directions were followed.

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Equal amount of base and catalyst were mixed for 30 seconds and loaded onto the tray. Light body impression material was dispensed onto the tray and the unprepared tooth. The loaded tray was then firmly seated in the mouth for 3 minutes and subsequently removed. Cotton rolls were used to isolate the maxillary anterior region to ensure a saliva-free surface. The impression obtained was rinsed under running tap water, disinfected in a 5.25% sodium hypochlorite solution, and poured using Type IV die stone (Kalabhai Pvt Ltd, Mumbai, India) to obtain a cast.

Three retraction materials namely Roeko Stay-Put® retraction cord(fig.2), 3M™ ESPE™ Astringent Retraction Paste (15% aluminum chloride) (Fig.3) and Traxodent® Retraction Paste (15% aluminum chloride hexahydrate) (Fig.4) were executed sequentially on the same participants, separated by a 2-week washout phase to permit tissue recovery.

Group 1 (Retraction Cord): Roeko Stay-Put® retraction cord was soaked in a 25% buffered aluminium chloride solution (Prevest Hemostal Liquid) and packed into the labial sulcus for 5 minutes via a single-cord technique (Fig.5).

Group 2 (Retraction Capsule): 3M™ ESPE™ Astringent Retraction Paste (15% aluminum chloride) was injected directly into the sulcus (Fig.6) via its specialized capsule dispenser tip and left for 2 minutes before being thoroughly rinsed.

Group 3 (Retraction Paste): Traxodent® Retraction Paste (15% aluminum chloride hexahydrate) was syringed into the sulcus (Fig.7), for 2 minutes before rinsing.

Post-retraction impressions were obtained immediately following material removal for each group using Aveu Addition Silicone Putty and light body and poured using Type IV Die stone (Kalabhai Pvt Ltd, Mumbai, India) to obtain a casts.

Laboratory and Microscopic Analysis

The stone casts were trimmed to create flat, uniform bases. The precise anatomic midline of each central incisor was marked using a digital vernier caliper, and the casts were sectioned cleanly in the apico-coronal direction using a specialized die-cutting machine. The sectioned halves (Fig.8) were positioned under Leica DM IL LED Inverted Microscope at 4× magnification. Utilizing specialized image analysis software, the absolute lateral width from the tooth structure to the crest of the gingiva was recorded in micrometers (µm)(Fig:9,10,11,12).

Statistical Analysis

The collected data were tabulated on MS Office Excel Sheet, version 2019 (Microsoft, Redmond, WA) and analysed using SPSS 23.0. Descriptive Statistics like mean and standard deviations (SD) were calculated for the obtained lateral gingival displacement values. Normality of data distribution was assessed using the Shapiro-Wilk test prior to selecting parametric or non-parametric tests; all four groups showed normal distribution ($p > 0.05$), justifying a parametric approach. As the same 15 subjects were assessed under all four conditions (pre-retraction plus three retraction groups), a repeated-measures (within-subjects) design was applied. One-way repeated-measures ANOVA compared overall mean lateral gingival displacement across the four groups, and paired t-tests were subsequently performed for all six pairwise comparisons to identify specific between-group differences, given the statistical dependence of repeated measurements on the same subjects. Significance was set at $p < 0.05$.

Results

Table 1 and Graph 1 shows the Comparison of lateral gingival displacement from pre-retraction to each group. The mean (SD) lateral gingival displacement at the pre-

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retraction stage was 165.71 (14.86) µm. The retraction cord group demonstrated the greatest mean (SD) displacement at 754.07 (12.66) µm, followed by the retraction capsule group at 607.39 (16.59) µm. The retraction paste group exhibited the lowest displacement among the tested interventions, with a mean (SD) of 478.51 (14.48) µm. Table 2 shows comparison of net lateral gingival displacement (Graph.2) between the three gingival retraction systems. The mean (SD) lateral gingival displacement was highest in the retraction cord group at 588.35 (5.94) µm. The retraction capsule group demonstrated a mean (SD) displacement of 441.68 (6.51) µm, while the retraction paste group showed the lowest value at 312.79 (4.85) µm. According to the ANOVA test, a statistically significant difference was noted between the groups concerning the mean lateral gingival retraction (P = 0.001) (Table 3)(graph3).

Intergroup analysis revealed a highly statistically significant difference in corrected lateral gingival displacement among the three retraction systems ($p < 0.001$).

Discussion

In fixed prosthodontics, soft tissue management represents a critical determinant of restoration success. The relationship between dental prostheses and the surrounding periodontal tissues fundamentally governs the long-term prognosis of fixed partial dentures. Precise tissue management protocols are indispensable for ensuring comprehensive recording of preparation margins which in turn governs the success and longevity of prosthesis.

This in vivo study was undertaken to comparatively evaluate the lateral gingival displacement achieved by three gingival retraction systems, namely, impregnated retraction cord (Stay-Roeko® with 25% aluminium chloride astringent), retraction capsule (3M ESPE), and retraction paste (Traxodent® Premier), in 15 subjects using unprepared maxillary anterior teeth as the study model with a 14-day interval between each system to allow complete gingival recovery. Unprepared teeth were selected to eliminate the confounding effects of mechanical trauma, inflammatory response, and altered sulcular anatomy that accompany tooth preparation, thereby allowing a more reliable and unbiased comparison of the retraction systems.

In the present study, Roeko Stay-Put® retraction cord impregnated with 25% aluminium chloride solution (Hemostal) produced the highest mean lateral gingival displacement of 588.36 ± 5.94 µm, which was statistically significantly greater than both the retraction capsule ($p < 0.001$) and retraction paste ($p < 0.001$). The Roeko Stay-Put® cord is a braided cord incorporating an ultrafine metal filament core, which confers superior shape retention and allows the cord to remain stably seated within the sulcus once packed, thereby maintaining consistent lateral pressure throughout the retraction period. Aluminium chloride is known to cause vasoconstriction, which leads to gingival shrinkage, and acts as an astringent by precipitating proteins and constricting blood vessels[6]. The single cord technique was employed in the study. With regard to placement duration, the recommended retraction cord dwell time reported across various studies ranges from 1 to 30 minutes. In the present study, the retraction cord was placed for 5 minutes. This is consistent with the findings of Baharav et al[7]., who reported no significant difference in crevicular width at displacement times of four, six, or eight minutes with impregnated cord, suggesting that a 5-minute placement duration, as employed in the present study, is clinically adequate to achieve maximum lateral displacement without necessitating prolonged cord retention.

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The retraction capsule (3M ESPE) produced a mean lateral gingival displacement of 441.68 ± 6.51 µm in the present study, which was statistically significantly greater than the retraction paste ($p < 0.001$) but significantly less than the retraction cord ($p < 0.001$). This ranks the 3M retraction capsule as the second most effective retraction system in the present study. The 3M ESPE capsule delivers 15% aluminium chloride paste through a long, slim nozzle with a soft edge that enables controlled intrasulcular delivery[8]. The white orientation ring on the nozzle corresponds to the dimensions of a periodontal probe, which helps prevent over insertion and sulcular trauma. The high-viscosity paste, once delivered into the sulcus, exerts both chemical and mild mechanical pressure on the gingival tissue, contributing to effective displacement while also providing haemostasis[8].

The retraction paste (Traxodent® Premier) produced the lowest mean lateral gingival displacement of 312.79 ± 4.85 µm among the three systems evaluated in the present study. Zala et al[9], Tiwari et al[10], Sachdev et al[11], and Indriyani et al[12] have reported that retraction pastes provide less gingival displacement compared to cord-based systems, yet achieve the clinically necessary threshold. Traxodent contains approximately 15% aluminium chloride in a soft paste formulation and is delivered via a syringe, with a comprecap used to hold the paste in place and the patient instructed to bite over it for the manufacturer-recommended two-minute application time[8]. The mechanism of action involves light pressure exerted on the sulcus, simultaneous absorption of excess crevicular fluid and blood, and chemical astringent action of aluminium chloride[6]. While this mechanism is gentler than cord packing, it is clinically relevant as it causes less iatrogenic trauma, is easier to apply.

All three retraction systems in the present study produced post-retraction sulcular widths that were statistically significantly greater than the baseline ($p < 0.001$), confirming that each material was effective in achieving clinically meaningful gingival displacement.

In the present study, the retraction cord, while providing the maximum lateral displacement, was associated with the least patient comfort and required the most technical skill and procedural time for placement. Care was taken during cord placement to avoid gingival laceration, as the packing instrument must be angled toward the tooth to guide the cord into the sulcus without injuring the gingival tissue[13]. These clinical limitations of retraction cord have been well documented in the literature and have contributed to the growing interest in cordless alternatives[14]. In contrast, the retraction capsule (3M ESPE) and retraction paste (Traxodent) were easier to apply, required less clinical time, and were associated with greater patient comfort. These cordless materials are particularly advantageous in patients with narrow or inflamed sulci, where cord placement may be difficult or cause excessive trauma[15].

This study has certain limitations. The sample comprised dental students with healthy, unprepared teeth, which may not represent the clinical scenario of prepared teeth with subgingival margins, where mechanical trauma and inflammation can alter sulcular behavior[5]. Only lateral displacement was assessed; vertical displacement, tissue recovery, histological changes, and impression quality were not evaluated[9].The sample size (n=15), though statistically adequate, limits generalizability across varying gingival biotypes and periodontal status[5]. Larger studies on clinically prepared teeth with diverse biotypes are warranted.

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Conclusion

In conclusion, Roeko Stay-Put® retraction provided the maximum lateral gingival retraction among the three materials studied in this study. Retraction capsules (3M ESPE) and retraction paste (Traxodent) were easier to apply when compared to retraction cord an. The retraction capsule and retraction paste provided more patient comfort than the retraction cord.

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Legend Figures, Tables and Graphs:

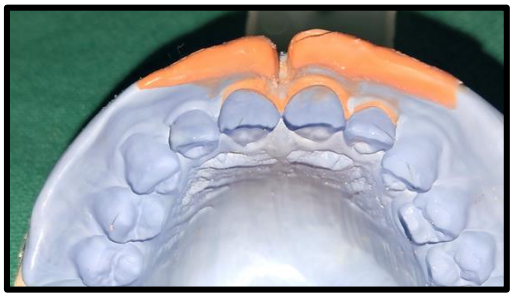


Fig.1: Single step putty wash impression



Fig.2: Retraction cord with astringent solution



Fig.3: 3M retraction capsule with dispensing gun

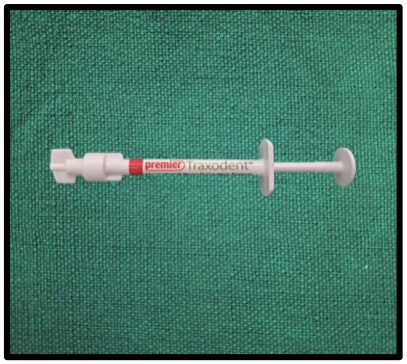


Fig.4: Traxodent Retraction Paste



Fig.5: Gingival retraction done using stay put retraction cord



Fig.6: Gingival retraction done using 3M Retraction capsule



Fig.7: Gingival retraction done using Traxodent retraction paste

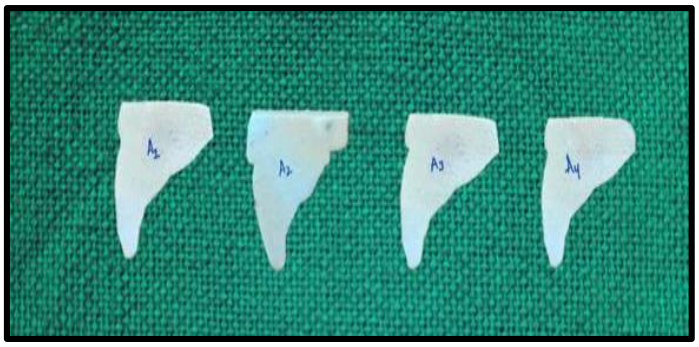


Fig.8: Samples obtained after apico-coronal sectioning of casts

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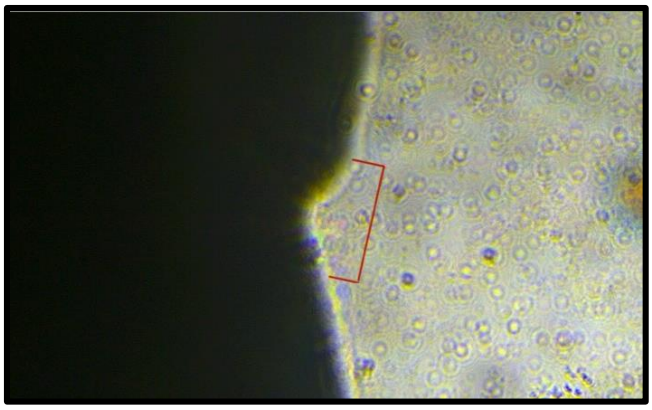


Fig.9: Digital image of Pre-retraction gingival sulcus

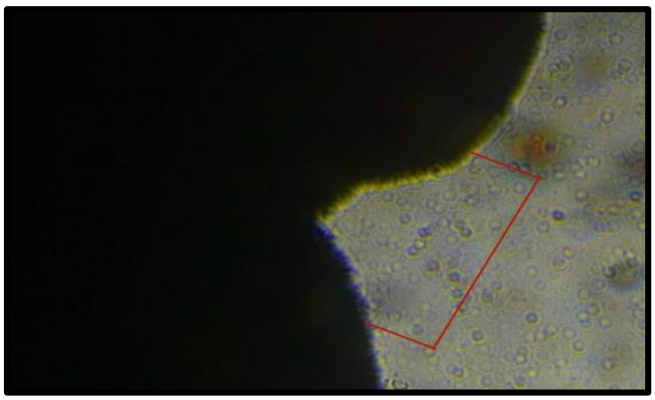


Fig.10: Digital image of gingival retraction by retraction cord

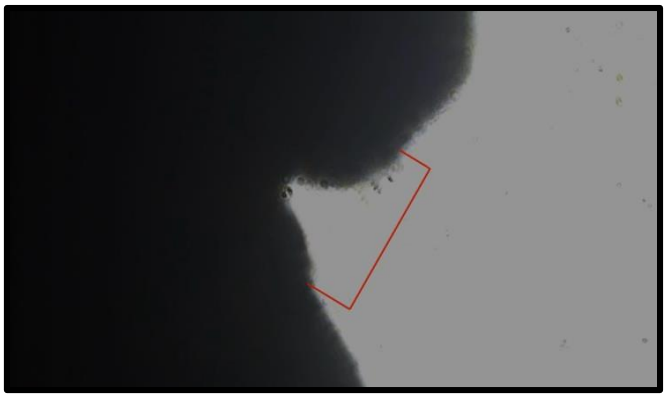


Fig.11: Digital image of gingival retraction by 3M retraction capsule

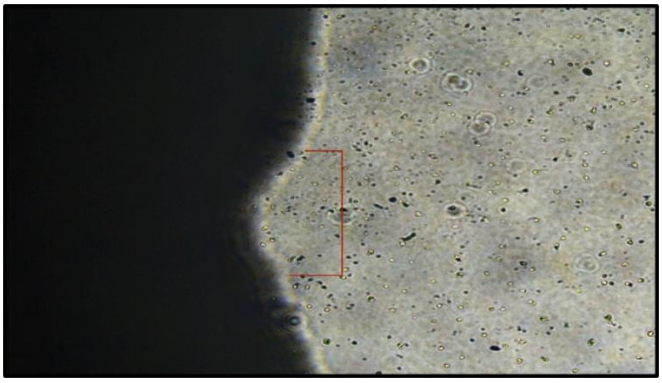


Fig.12: Digital image of gingival retraction by retraction paste

Table 1. Comparison of lateral gingival displacement from pre-retraction to each group. (N = 15)

Group	Mean (µm)	SD (µm)	Median (µm)	Min (µm)	Max (µm)
Pre-retraction	165.71	14.86	162.50	146.2	200.0
Retraction Cord	754.07	12.66	755.10	732.2	771.3
Retraction Capsule	607.39	16.59	610.50	572.9	630.7
Retraction Paste	478.51	14.48	476.98	458.2	500.7

Table 2: Comparison of net lateral gingival displacement between the three gingival retraction systems (N = 15)

Group	Mean lateral gingival displacement (SD)	p-value
Retraction cord	588.35 (5.94)	<0.001
Retraction capsule	441.68 (6.51)	
Retraction paste	312.79 (4.85)	

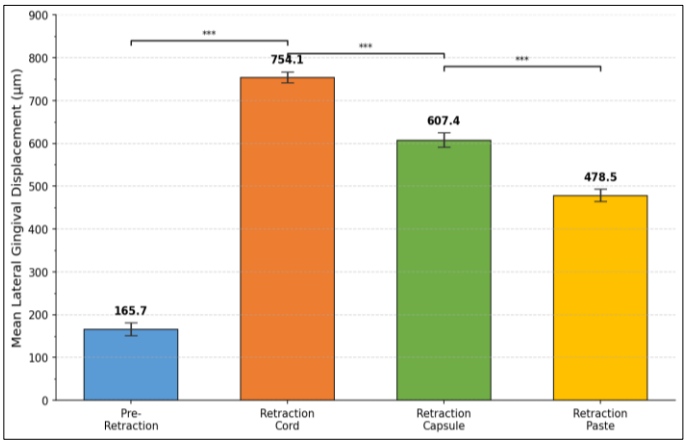
Table 3: Intergroup pairwise comparison of values of gingival displacement for all four groups

S. No	Groups Compared	Mean (SD) µm — Group A	Mean (SD) µm — Group B	Mean Difference (µm)	p-value
1	Pre-retraction vs Retraction Cord	165.71 (14.86)	754.07 (12.66)	588.36	<0.001*
2	Pre-retraction vs Retraction Capsule	165.71 (14.86)	607.39 (16.59)	441.68	<0.001*

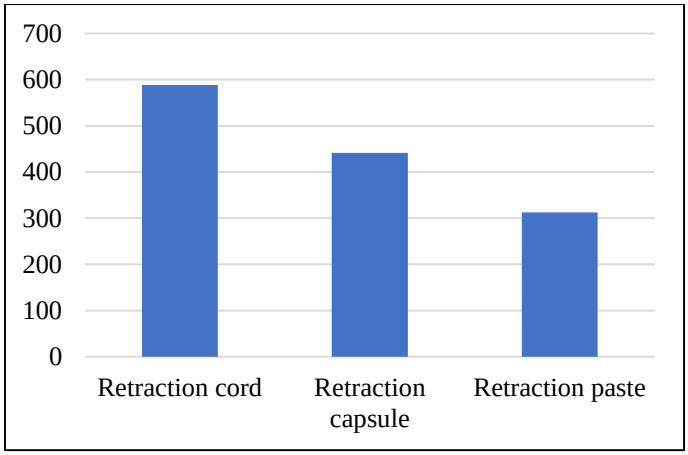
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S. No	Groups Compared	Mean (SD) µm — Group A	Mean (SD) µm — Group B	Mean Difference (µm)	p-value
3	Pre-retraction vs Retraction Paste	165.71 (14.86)	478.51 (14.48)	312.80	<0.001*
4	Retraction Cord vs Retraction Capsule	754.07 (12.66)	607.39 (16.59)	146.68	<0.001*
5	Retraction Cord vs Retraction Paste	754.07 (12.66)	478.51 (14.48)	275.56	<0.001*
6	Retraction Capsule vs Retraction Paste	607.39 (16.59)	478.51 (14.48)	128.88	<0.001*

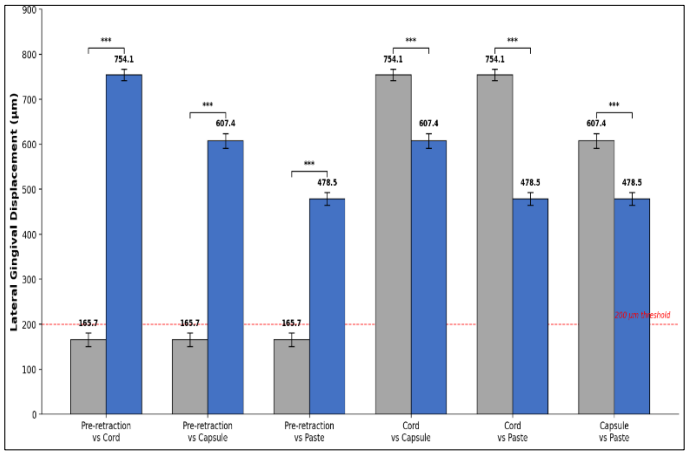
Graph 1: Comparison of lateral gingival displacement from pre-retraction to each group. *** p < 0.001.



Graph 2: Comparison of lateral gingival displacement between the three gingival retraction systems



Graph 3: Intergroup pairwise comparison of values of gingival displacement for all four groups



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