ISSN 0973-2063 (online) 0973-8894 (print)

Bioinformation 22(10): 6589-6595 (2026)

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BIOINFORMATION
Discovery at the interface of physical and biological sciences

BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(10)

Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026

DOI: 10.6026/973206300226589

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

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Edited by Vini Mehta
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Citation: Kumari *et al*. Bioinformation 22(10): 6589-6595 (2026)

Cord vs NoCord™ VPS retraction: Effects on gingival displacement, gingival health and impression quality

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ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 6589-6595 (2026)
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Abstract:
Accurate reproduction of subgingival finish lines remains challenging in fixed prosthodontics because conventional gingival retraction is technique-sensitive and may cause soft tissue trauma. This split-mouth clinical study evaluated 34 patients requiring anterior full-coverage restorations by comparing NoCord vinyl polysiloxane with SURE-Cord knitted retraction cord for gingival displacement, health, patient comfort and impression quality. SURE-Cord achieved significantly greater horizontal and vertical displacement, whereas NoCord vinyl polysiloxane produced less immediate post-operative inflammation and greater patient comfort ($p<0.05$). Gingival health returned toward baseline within 7 days with both techniques, indicating comparable overall clinical performance. Thus, data support NoCord vinyl polysiloxane as a simplified, tissue-friendly alternative to conventional cord retraction for fixed prosthodontic impressions.

Keywords: Gingival retraction, NoCord VPS, retraction cord, vinyl polysiloxane, gingival displacement, gingival index, prosthodontics, impression quality

Background:
Accurate marginal fit and periodontal health is the primary requirement for fixed prosthodontic success. During the impression process, it is crucial to replicate the occlusal plane to ensure fabrication of the restoration with the highest degree of marginal integrity and ultimately minimizing the potential for plaque area, recurrent caries, periodontal inflammation and restoration failure **[1]**. The difficulty of impression making increases when the restorative margins are extended to the gingival crest or into the gingival sulcus for esthetic or functional reasons due to interference with the surrounding soft tissues, gingival crevicular fluid and bleeding. Therefore, secure movement of the gums is a needed and critical step in many fixed prosthodontic processes, which allow a good sealing of the finishing line and the correct recording of the prepared tooth **[2].** Since it is known to to produce predictable lateral and vertical displacement of gingival tissues and to control sulcular fluid and minor hemorrhage, conventional gingival displacement is generally considered to be the "gold standard". Knit, braid or twist cords impregnated with hemostatic agents like aluminum chloride, which provide mechanical tissue displacement and chemical hemostasis, are widely used. Although these methods are effective, additional clinical time is needed and these can still cause temporary gingival trauma, discomfort and bleeding with excessive force being put on the cord while insertion **[3].** The escalating need for minimally invasive restorative treatment modalities has been accompanied by the evolution of a variety of gingival displacement systems which have become more user-friendly and maintained better periodontal health. Alternatives to the traditional cord techniques are referred to as cordless gingival displacement materials (CPDM) that utilize polyvinyl siloxane (VPS) technology **[4]**. These materials are self-retracting in that they also contain astringent materials that can manage moisture and apply gentle pressure on the gingival tissue during impression polymerization, all in one clinical step. A system like this results in chairside savings, removes the need for cord packing and can even enhance peace of mind for patient comfort and convenience for operators **[5].** The evolution of newer gingival displacement materials has given greater emphasis to atraumatic gingival management and preservation of periodontal tissues while achieving adequate gingival displacement for accurate impression making **[6]**. Several comparisons have been made between the conventional and modern techniques with the results showing that impression making is successful not only because of the imprinted dimensional stability of impression materials, but also because of the adequate Management of the Gingival Sulcus. Thus, the choice of technique for gingival displacement has been one of the important parameters that determine the success of the indirect restorations **[7].** The usefulness of conventional retraction cords has been compared with cordless gingival displacement systems based on the measurement of horizontal and vertical gingival displacement, quality of the impression and reaction of the periodontal tissues in more than a few clinical studies **[8]**. In most of the previously reported studies, mechanical displacement of the gingiva has been reported to be produced to a larger extent with the conventional cord techniques due to direct mechanical expansion of the sulcus **[9]**. In hospitals, however, modern cordless systems have been clinically shown to produce good displacements with much less immediate gingival tissue inflammation, easier clinical procedures and similar impression quality. The results of this study demonstrate that self-retracting VPS systems could be a useful alternative for the use in common fixed prosthodontic procedures and the impact on the tissue is minimal **[10].** Therefore, it is of interest to compare the clinical and technical results of horizontal and vertical gingival displacement, gingival health and impression quality between the newer SD system and the traditional cord system and to measure the ability of the SD

system to minimize damage to periodontal tissues while providing clinical benefits.

Materials and Methods:

Study design:

The present study was purposed as Prospective, Comparative, Split mouth clinical study. In a split-mouth design, the biological variability between different individuals was reduced by having each individual as the or her own control. The NoCord™ VPS self-retracting impression system was compared with the aluminum chloride 25% impregnated conventional knitted gingival retraction cord (SURE-Cord).

Study setting:

The study was done in Department of Prosthodontics and Crown & Bridge, Hazaribag College of Dental Sciences & Hospital, Hazaribagh, Jharkhand, India. It was performed after getting approval from the Institutional Ethics Committee (HCDSHIEC2024/002). Handling all procedures as per ethical guidelines of the 'Declaration of Helsinki'. All subjects gave their informed consent in writing prior to inclusion.

Study duration:

Study was carried out for 12 months period from recruitment of the patients to their clinical procedures till evaluation at the end of the study, data collection and statistical analysis.

Sample size determination:

G*Power software (Version 3.1.9.7, Heinrich-Heine University, Düsseldorf, Germany) was used to calculate the sample size for this study in which the findings of previous clinical trials of gingival displacement systems were used.

Considering:

[1] Confidence level (α) = 0.05
[2] Study power = 80%
[3] Effect size derived from the literature.

The minimum sample size was calculated to be 34 people.

Study population:

Patients attending the Department of Prosthodontics and Crown & Bridge who required full-coverage restorations of maxillary anterior teeth were screened for eligibility.

Inclusion criteria:

The participants who met all the following criteria were included:

[1] Age ≥18 years
[2] Thick gingival biotype
[3] Healthy gingival and periodontal tissues
[4] Requirement of full-coverage restoration for maxillary anterior teeth
[5] Ability to provide informed written consent

Exclusion criteria:

Patients presenting with any of the following conditions were excluded:

[1] Thin gingival biotype
[2] Severe malalignment of anterior teeth
[3] Active periodontal disease
[4] Systemic diseases affecting periodontal healing
[5] Immunocompromised individuals
[6] Pregnant or lactating women
[7] Smokers or tobacco users
[8] Allergy to impression materials
[9] Uncooperative patients

Sampling technique:

A convenience sampling method was used. A consecutive sampling method was used, so that the required number of patients matching the selection criteria was collected.

Study groups:

A split-mouth design was employed. Each patient underwent both interventions:

[1] **Intervention A**: NoCord™ VPS Self-Retracting Impression System
[2] **Intervention B**: Impression using 25% aluminium chloride impregnated SURE-Cord knitted gingival retraction cord and conventional addition silicone putty-wash impression. The allocation of intervention sides was randomized using a computer-generated randomization sequence.

Clinical procedure:

There were 3 visits with the patient to finish the clinical protocol.

Visit I (Day 1):

Type III dental stone was used for making the diagnostic alginate impressions.

A uniform 2 mm spacer was used to make custom acrylic trays.

All the ceramic crowns were prepared to the standard using an equigingival shoulder.

Baseline recordings included:

[1] Vertical gingival displacement
[2] Gingival sulcus depth
[3] Gingival Index

Then the VPS system was used as per the manufacturer's instructions, which was called as the NoCord™ VPS System.

Directly after taking the impression:

[1] Measures in the vertical direction of the gingival movement were taken.
[2] Gingival Index was reviewed again.
[3] The quality of the impressions was assessed.
[4] Type IV dies stone was used to pour impressions.

Visit II (Day 7):

After a week patients returned. Again, baseline Gingival Index was charted. The aluminum chloride solution was slowly turned into SURE-Cord and inserted into the sulcus, ensuring the product was placed into the gaps between the teeth and around the gingival margins. The estimated period of time the cord was secured was about 10 minutes.

Following cord removal:
[1] The vertical gingival displacement was measured.
[2] The recording of Gingival Index was performed.
[3] A VPS impression was taken, using a conventional putty-wash technique.
[4] The quality of the impressions was evaluated.
[5] Die stone material was used to make casts.

Visit III (Day 14):
[1] Then the persons were called back after a seven days.
[2] To measure the recovery of the tissues after gingival retracting procedures, the Gingival Index was measured.

Measurement of horizontal gingival displacement:
Die stone casts were sectioned and the horizontal displacement of gingiva was evaluated. The prepared tooth width was measured mesiodistally. Midpoint was located and plotted. Buccolingual sections were made of each cast with a precision die cutter. Measurements were taken by the use of a calibrated image analysis computer program and a stereomicroscope. Displacement was recorded in a plane parallel to the gingival margin: the distance between the gingival crest and the middle of the buccal surface of the tooth prepared.

Measurement of vertical gingival displacement:
The vertical gingival displacement was clinically measured at mid-buccal at an aspect with the help of a calibrated digital vernier caliper.

Measurements were recorded:
[1] Before intervention
[2] Immediately after gingival retraction

Gingival health assessment:
Löe and Silness Gingival Index (1963) were used as the index to assess gingival health.

Evaluation undertaken at:
[1] Baseline
[2] Immediately after retraction
[3] Seven days after intervention
[4] Scores ranged from 0 to 3 according to standard criteria.

Impression quality assessment:
All impressions were independently evaluated by two blinded prosthodontists.

The gingival finish line reproduction was graded as:
[1] Score 0: Excellent reproduction, no defects.
[2] Score 1: Sufficient – minor defects (< 2 mm) noted; otherwise an acceptable impression.
[3] Score 2: Unacceptable impression (major defects (>2 mm).

Inter-examiner agreement was carried out prior to final scoring.

Outcome measures:
Primary outcomes:
[1] Horizontal gingival displacement
[2] Vertical gingival displacement

Secondary outcomes:
[1] Rating of the health of gums (Gingival Index)
[2] Impression quality
[3] To assess tissue reaction after 7 days

Data collection:
Data for clinical measurements were obtained using standardized case record forms. All stereomicroscopic measurements were made by one calibrated investigator without knowing about intervention.

Statistical analysis:
All data were entered into Microsoft EXCEL and analysed in IBM SPSS Statistics version 25.0. Means and standard deviations were used to represent continuous variables while frequencies and percentages were used to present the categorical variables. The Shapirowilk test was used to determine normal distributions. The horizontal gingival displacement was normal distributed and hence a paired STT was used for its intergroup comparison.

Variables including:
[1] Vertical gingival displacement
[2] Sulcus depth
[3] Gingival Index
[4] Impression quality

Analyses used the Wilcoxon signed-rank test because they were either ordinal or had a non-normal distribution. Friedman test was applied to the changes in Gingival Index obtained longitudinal. Cohen's kappa co-efficient was used to assess intra-examiner agreement when dealing with assessment of impression quality. All analyses used a p-value <0.05 test level for statistical significance.

Results:
This prospective split-mouth clinical study included 34 patients who needed full-coverage restorations of their anterior teeth in the maxillary arch. None of the subjects dropped out of the study protocol and gingival retraction were successfully accomplished on each patient with both techniques. Participants were given both interventions (NoCord™ VPS impression system; SURE-Cord knitted gingival retraction cord containing 25% aluminum chloride), thus reducing inter-individual variability. The clinical assessment was carried out in terms of horizontal gingival displacement, vertical gingival displacement, the Löe and Silness Gingival Index for the assessment of gingival health and impression quality. Paired comparison approach was used for statistical analysis as each participant was his/her control. Means ± standard deviation (SD) were calculated for data from continuous variables and frequencies and percentages were calculated for data of categorical variables. A p value of less than 0.05 was set as a statistical significance. Both gingival

retraction systems were able to displace the gums horizontally. With regard to the mean horizontal gingival displacement, the NoCord™ VPS system achieved a value of 0.31 ± 0.05 mm compared to 0.39 ± 0.06 mm for the SURE-Cord system, with the latter having a significantly larger mean gingival displacement. The accuracy of the two methods was found to be different, with mean difference of 0.08 mm (very significant at p<0.001). Both systems produced horizontal displacement better than the minimum of 2 mm that was found to be clinically acceptable for making the elastomeric impression, but superior tissue displacement was obtained with the conventional knitted retraction cord. Increased mechanical expansion due to the direct packing of SURE-Cord in the gingival sulcus creates continuous lateral pressure which provides the greater mechanical expansion. In contrast, the NoCord™ VPS system used mostly the flow properties of the impression material and its astringent component to make the impression material displace the tissues. Although the ranges of Displacement were slightly less, the amount produced was clinically significant for recording finish lines for all the patients **(Table 1).** There were no differences in baseline vertical gingival measurement, indicating uniform periodontal conditions prior to intervention. There was a significant vertical gingival displacement in both the study groups after gingival retraction (p <0.001). When the intergroup comparison was performed, there was significantly more vertical tissue displacement with the SURE-Cord technique (p = 0.004) and the NoCord™ VPS system resulted in an average increase of only 0.28 mm. These results suggest that both methods were the effective ones to expose the finish line vertically, with the ability to make an impression that was satisfactory. However, traditional cord packing resulted in more sulcular opening from the mechanical movement and chemical hemostasis. In any case, no matter this difference, there was still enough vertical displacement to make a correct clinical diagnosis with NoCord™ VPS **(Table 2).** Both groups had very good Gingival Index scores at baseline, with no significant difference between the two interventions (p = 0.812). Inflammation was observed after gingival retraction in both groups and is considered a transient inflammatory reaction after gingival manipulation. There were significantly fewer mice that increased after NoCord™ VPS (0.47 ± 0.51) than after SURE-Cord (0.91 ± 0.62) (p<0.001). The results of this trial support the hypothesis that the mechanical retraction of tissue with a retraction cord produced greater immediate trauma than did the self-releasing system. Gingival Index scores in both groups were significantly lower at the 7 day follow-up and were near baseline scores. No statistically significant difference (p = 0.684) would signify that there was no difference between the recovery of gingival tissues when using either method of gingival retraction. There was no evidence of chronic inflammation, ulceration or gingival recession in any of the participants throughout the course of the study. In general, these results reflect overall evidence of a higher degree of temporary inflammation following placement of conventional cord, but there was favorable periodontal healing from both techniques within one week after placement **(Table 3).** The results of both the gingival retraction systems were excellent clinically created impressions. The marginal reproduction was excellent (82.4% of the impressions) and acceptable (17.6%) due to very slight surface defects < 2 mm. 100% of the impressions were accepted. Likewise, the fact that 88.2% of the impressions taken with the SURE-Cord under standard conditions were rated excellent and 11.8% acceptable indicated its excellent performance in making impressions in that category. None of the impressions showed significant flaws, such as defects that need to be reproduced. There was no significant difference between SURE-Cord and the other technique (p = 0.527) despite a higher percentage of excellent impressions with SURE-Cord **(Table 4)**. There was agreement that both techniques were able to obtain a correct gingival line and clinically acceptably impressions for definitive prosthodontic restorations. The impression quality from the NoCord™ VPS indicates sufficient quality to allow for simultaneous gingival displacement and impression taking in many routine restorations, thus reducing clinical time and increasing efficiency without compromising impression quality.

Table 1: Comparison of Horizontal Gingival Displacement between NoCord™ VPS and SURE-Cord Systems

Gingival Retraction System	Mean Horizontal Displacement (mm)	SD	Mean Difference	p value
NoCord VPS	0.31	0.05		
SURE-Cord	0.39	0.06	0.08	**<0.001**

Table 2: Comparison of Vertical Gingival Displacement Before and After Gingival Retraction

Gingival Retraction System	Baseline (mm) Mean ± SD	Post-retraction (mm) Mean ± SD	Mean Increase (mm)	p value
NoCord VPS	0.89 ± 0.11	1.17 ± 0.13	0.28	**<0.001**
SURE-Cord	0.88 ± 0.10	1.24 ± 0.12	0.36	**<0.001**
Intergroup comparison	—	—	—	**0.004**

Table 3: Comparison of Gingival Health (Löe and Silness Gingival Index)

Time Interval	NoCord™ VPS Mean ± SD	SURE-Cord Mean ± SD	p value
Baseline	0.12 ± 0.33	0.13 ± 0.34	0.812
Immediately after retraction	0.47 ± 0.51	0.91 ± 0.62	**<0.001**
Seven days after retraction	0.18 ± 0.39	0.21 ± 0.41	0.684

Table 4: Comparison of Impression Quality between the Two Gingival Retraction Systems

Impression Quality	NoCord™ VPS n (%)	SURE-Cord n (%)	p value
Excellent (Score 0)	28 (82.4%)	30 (88.2%)	0.527
Acceptable (Score 1)	6 (17.6%)	4 (11.8%)	
Unacceptable (Score 2)	0 (0%)	0 (0%)	

Discussion:

The incorporation of a good subgingival finish line is an important factor for the success of fixed prosthodontic restorations in the long term. Ideally the gingival displacement should give enough horizontal and vertical sulcus enlargement while maintaining periodontal health and causing minimal to no discomfort for the patient. A split-mouth clinical study was designed to compare the clinical performance of the following two impression systems: the NoCord™ VPS self-retracting impression system and the SURE-Cord knitted retraction cord impregnated with 25% aluminum chloride. The results showed that both methods resulted in clinically acceptable gingival displacement and excellent impression quality. The conventional cord retraction had significantly greater horizontal and vertical gingival displacement; however, the immediate gingival inflammation was shown to be significantly less with NoCord VPS, which shows a more atraumatic tissue response. SURE-Cord system showed significant horizontal gingival displacement in comparison to NoCord™ VPS in the present study. Also, mechanical packing of the knitted cord within the gingival sulcus, in addition to haemostatic effect of the AlCl3, helped to cause a greater lateral displacement of the gingival tissues. However, the movement effect on NoCord™ VPS was sufficient for good impression taking accuracy. These results corroborate Bud's findings in which he stressed the importance of sufficient gingival exposure for either a conventional or a contemporary displacement system, with the finish line being fully documented during impression taking **[11].** Recent improvement in impressions techniques has brought to the forefront the need to preserve gingival architecture without compromising impression accuracy. Before impression making, appropriate tissue management is one of the most important determinant of the marginal accuracy, irrespective of the impression technique, said Sudhapalli. Both gingival displacement systems produced good impressions in the present study and although the amount of tissue displaced varied between the two systems, both were effective **[12].** The above mentioned superior displacement of the gingiva achieved with the conventional cord technique within the present study has been confirmed by the conducted randomized clinical trial by Kuhn *et al.*, who found that the gingival condition has significant influence on the success of the different types of gingival displacements. Their research indicated that the mechanical retraction cords usually result in a more significant sulcular depth than cordless systems, especially in normal gingival tissues. Likewise, although the displacement values produced by NoCord™ VPS were a little less in the present study, the displacement observed was sufficient for successful marginal reproduction, which enhances the clinical applicability of NoCord™ VPS **[13].** Other physical properties of elastomeric impression materials also play an important role in the accuracy of an impression. According to Sedlačík, modern elastomeric materials have excellent elastic recovery, dimensional stability and tear resistance and therefore allow the production of very fine surface details even in the relatively conservative displacement of the tissue. These properties of the material are probably responsible for the very good impression quality that was obtained with this comparatively low gingival displacer, NoCord™ VPS **[14].** One of the findings of the present investigation was the significantly reduced Gingival Index found immediately after use of NoCord™ VPS compared with SURE-Cord. Lack of mechanical cord packing would have resulted in less injury to the epithelium and compression of the tissue, reducing inflammation. A similar study was reported by Mehta *et al.*, who compared the various gingival displacement systems and noted that gingival responses were favorable with the polyvinyl siloxane type of gingival displacement materials with clinically acceptable gingival displacement. Results indicate that these minimally invasive displacement systems do not adversely affect the quality of impressions but would eliminate soft tissue trauma **[15].** Remarkable advances in restorative dentistry have led preference to the least compromising methods and digital procedures. When evaluating gingival displacement techniques for definitive digital impressions, El Ashry *et al.* found that today's cordless systems offer reliable gingival displacement and are associated with greater patient comfort and reduced clinical time. Their randomized controlled trial showed that conventional cord techniques still yielded a greater displacement, but that there was no significant difference in the overall accuracy of the definitive impressions using different cord techniques. The present results are similar to these conclusions, as suggest that the use of NoCord™ VPS is feasible in the current clinical practice of prosthodontics without compromising clinical accuracy **[16].** Another direct comparison study, carried out by Acar *et al.* describes the clinical study they have led where cordless and conventional gingival displacement systems were compared, which is also corroborated by the results that have been shown in the present study. Conventional retractors were found to displace the gums to a significantly greater amount compared to the cordless retractors, which had greater patient acceptance, less gum trauma and comparable levels of impression quality. The present investigation also showed that significantly less immediate gingival inflammation occurred with NoCord™ VPS with only a handful of subjects yielding poor impression quality. The pairing of these consistent results with the evidence that has been accumulating in the literature justifies the use of the self-retracting impression material as an effective means of impression taking to overcome the conventional cord method **[17].** To reduce patient variability as much as possible, the split mouth design used in the present study was employed, providing each patient to act as her own control. Tooth preparation, impression techniques, gingival specification and periodontal examination were further standardized to further increase the reliability of the results. A comprehensive evaluation of the effectiveness of both gingival retraction systems has been obtained through objective evaluation of horizontal gingival displacement using stereomicroscopic analysis in addition to clinical measurement of vertical gingival displacement. In summary, the results of the present study show that when the greatest amount of gingival displacement is needed, SURE-Cord can still be utilized as the preferred technique, especially with deep subgingival finish

lines or complicated restorative procedures. In contrast, NoCord™ VPS has the benefits of less tissue trauma, easier clinical procedures, less chair work time and high impression quality, which make it a valuable alternative for the most common fixed prosthodontic cases. Further clinical studies should be performed to make use of a larger sample size, a longer follow-up period and further assess use of digital intraoral scanning techniques to establish evidence-based guidelines for the choice of the optimal gingival displacement method in the future.

Conclusion:

NoCord™ VPS and SURE-Cord provided clinically acceptable gingival displacement and impression quality for fixed restorations. SURE-Cord achieved greater horizontal and vertical gingival displacement, whereas NoCord™ VPS caused less immediate gingival inflammation and involved a simpler, less traumatic procedure. Both techniques showed acceptable periodontal healing by 7 days, supporting NoCord™ VPS as a potential alternative to conventional cord retraction for routine fixed restorations

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