



# A CLINICAL COMPARISON OF CORDLESS AND CONVENTIONAL DISPLACEMENT SYSTEMS REGARDING CLINICAL PERFORMANCE AND IMPRESSION QUALITY

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**Statement of problem.** It is not clear whether newly introduced cordless displacement systems are better able to manage gingiva than conventional systems.

**Purpose.** The purpose of this *in vivo* study was to evaluate the gingival management ability of 4 different displacement methods with a standardized subgingival preparation finish line.

**Material and methods.** The effects of 4 displacement techniques on gingival management and impression quality were evaluated by means of 6 evaluation criteria. A subgingival preparation finish line of between 1 and 2 mm was ensured, and the buccal aspects of 252 ( $n=63$ ) teeth were clinically assessed for ease of application, time spent, bleeding, remnants, and dilatation. The complete reproduction of the preparation finish line and the bubble and void formations on polyether impressions were also evaluated. The data were statistically analyzed with the  $\chi^2$  test ( $\alpha=.05$ ). The Bonferroni correction was used to control Type I error for the pairwise comparison groups ( $\alpha=.008$ ).

**Results.** Statistically significant differences were found for all criteria among the groups ( $P<.05$ ). The nonimpregnated displacement cord group was the least effective group in terms of bleeding and impression quality ( $P<.008$ ). The aluminum chloride impregnated cord group and the displacement paste with cap group were found to be comparable in terms of remnants, dilatation, and impression quality ( $P>.008$ ). The retraction cap with paste group showed better results for ease of application, time spent, and bleeding than the aluminum chloride impregnated cord group ( $P<.008$ ). Although the group with aluminum chloride impregnated cord, displacement paste, and cap showed better results for dilatation, it was time consuming and difficult ( $P<.008$ ).

**Conclusions.** Except for the nonimpregnated cord group, all of the groups were comparable and clinically useful, with perfect or acceptable impression qualities. (J Prosthet Dent 2013;■:■-■)

## CLINICAL IMPLICATIONS

When a 1- to 2-mm-deep subgingival preparation finish line is formed on a healthy gingival margin, the displacement paste and cap application may be the first choice, giving the benefits of hemostasis, time saving, and ease of application.

Marginal adaptation is crucial for the long-term clinical success of complete-coverage restorations. Lack of marginal

adaptation may cause periodontal tissue inflammation and may increase the risk of recurrent caries, especially for

subgingivally located crown margins.<sup>1</sup> Although restorative margins should remain coronal to the sulcus,<sup>2</sup> it is

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understood that certain conditions necessitate placement of subgingival margins. These may include esthetic concerns, the need for increased retention form, refinement of preexisting margins, root caries, cervical abrasion, and root sensitivity.<sup>3</sup> In these circumstances, adjacent gingival tissues must be displaced laterally and vertically, and gingival fluid seepage and hemorrhage should be controlled to ensure acceptable impressions.<sup>4-7</sup> In other words, hemostasis and displacement of the gingiva should be part of gingival management.<sup>8</sup> The most common gingival management procedures are mechanical or mechanochemical methods that use displacement cords alone or with hemostatic agents.<sup>5,9-11</sup> Various types of displacement cords, application methods, and impregnation medicaments have been evaluated clinically and histologically.<sup>5,12-14</sup>

Recently, cordless techniques such as expanding polymers and expanding paste-like gingival displacement materials have been introduced which are said to save time and enhance patient comfort while being minimally invasive. Expasyl (Kerr Corp), a paste-like material containing aluminum chloride as the hemostatic agent and kaolin as the expanding material,<sup>15,16</sup> and Magic FoamCord (MFC) (Coltène/Whaledent AG), an expanding vinyl polysiloxane material without a hemostatic agent,<sup>8,15</sup> have been discussed in previous studies. The newly introduced Traxodent Hemodent Paste Retraction System (Premier Dental Products Co) comprises a 15% aluminum chloride topical paste and cotton caps and is designed to enhance gingival displacement and assist hemostasis. Although the system was introduced as an alternative to displacement cord methods, the paste material may also be used with displacement cord.

Although crucial advances have been made in the hydrophilicity of impression materials<sup>17</sup> and in their ability to reproduce detail,<sup>18</sup> making an impression is still a concern, especially when preparation finish lines are located subgingivally. The proper choice of

displacement method may enhance impression quality and clinician performance and may reduce chair time. The purpose of this study was to compare the effectiveness of 4 different displacement methods. The null hypothesis was that the displacement methods tested would not differ significantly in terms of clinical performance and impression quality.

## MATERIAL AND METHODS

The project (D-KA12/07) was approved by the Ethics Committee of Baskent University, Ankara, Turkey. A total of 4 displacement methods were evaluated in this study (Table I). Materials used are shown in Table II. Individuals requiring single-unit indirect partial fixed dental prostheses were recruited from the Baskent University Department of Prosthodontics. In this prospective clinical study, a total of 252 participants were treated by 4 investigators after having taken part in the dental hygiene program. To achieve uniform calibration among the investigators, the application procedures and evaluation criteria for the displacement methods were discussed

and agreed by all investigators at the beginning of the study. The prerequisites for inclusion in the study were freedom from active gingival periodontal inflammation, probing depths of less than 3 mm, and no bleeding on probing. After the participants had been fully informed about the nature of the investigation and had provided written consents, they were allocated to one of the groups with a blocked randomization method.

The study included crown preparation for metal ceramic and ceramic restorations. A chamfer or shoulder finish line was preferred according to the restoration type. The position of the preparation finish line was measured with a periodontal probe with respect to the crest of the marginal gingiva. Margins were positioned 1 to 2 mm subgingivally, and caution was exercised to avoid injury to gingival tissue. A schematic representation of gingival displacement methods is shown in Figure 1, and the group names are defined in Table I. In group NIC, the displacement cord (Premier Dental Products Co) was not immersed in any solutions or medicaments before insertion. Care was taken to wet the cord

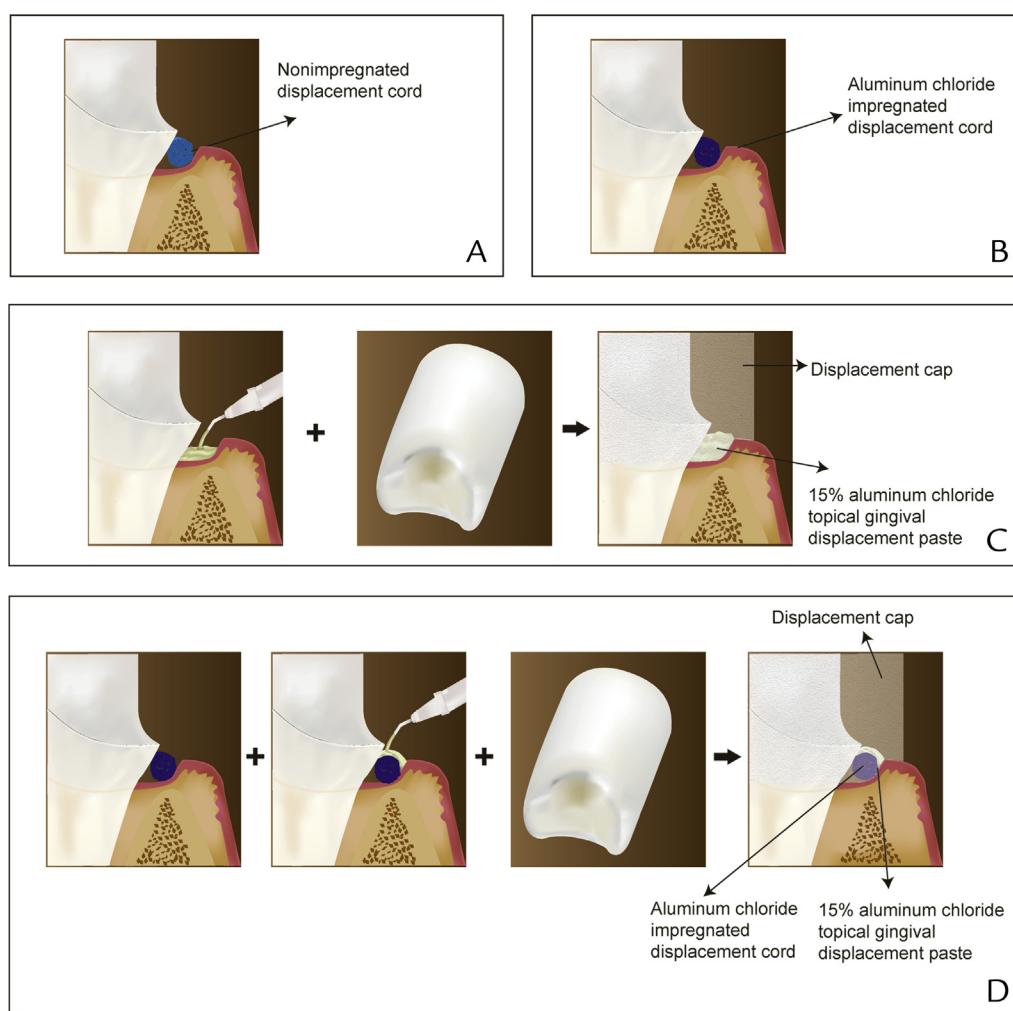
**TABLE I.** Gingival displacement methods evaluated

Group	Displacement Method
NIC	Nonimpregnated displacement cord
IC	Aluminum chloride impregnated displacement cord
PC	15% aluminum chloride topical gingival displacement paste + displacement cap
ICPC	Aluminum chloride impregnated displacement cord + 15% aluminum chloride topical gingival displacement paste + displacement cap

NIC, nonimpregnated cord; IC, impregnated cord; PC, paste and cap; ICPC, impregnated cord, paste, and cap.

**TABLE II.** Description and manufacturer information for materials evaluated

Product	Manufacturer	Batch No.
Knit-Pak retraction cord (knitted; epinephrine-free)	Premier Dental Products Co	1151B
Hemoban topical hemostatic solution	Sultan Healthcare	0213110210
Traxodent Hemodent Paste Retraction System	Premier Dental Products Co	9007091 (Paste) 121808 (Cap)



**1** Schematic views of gingival displacement methods. A, Placement of nonimpregnated displacement cord into sulcus. B, Placement of aluminum chloride impregnated displacement cord into sulcus. C, Injection paste material and packing of displacement cap into sulcus. D, Placement of aluminum chloride impregnated displacement cord, injection paste material, and displacement cap into sulcus.

thoroughly before removal from the sulcus to prevent trauma and hemorrhage.<sup>10</sup> In group IC, displacement cords were used with aluminum chloride soaking solutions. In group PC, the Traxodent Hemudent Paste Retraction System (Premier Dental Products Co) was used according to the manufacturer's instructions. In group ICPC, a modified Traxodent Hemudent Paste Retraction System was used with an aluminum chloride impregnated cord. A blunt-ended instrument was used to gently pack the cord into the sulcus in groups NIC, IC, and ICPC. Each cord remained in place for 15 minutes and was removed while wet. One gingival displacement method was used for each abutment tooth. Before the impression

was made, the prepared tooth was rinsed, and a gentle blast of compressed air was applied to the dentin surface from a distance of 20 cm. Impressions were made with polyether impression material (Impregum Garant L DuoSoft; 3M ESPE AG) in a disposable double-arch impression tray (Occlusion Tray Color, DP 70002 50PC Posterior; Médical Dental Pacific). After removing the gingival displacement cords and caps, clinical performance was ranked by the clinician. To standardize the rankings, only the easily visible and accessible buccal aspects of the teeth were evaluated. The impressions were examined under  $\times 2.5$  magnification. None of the impressions were repeated with the same method. Each impression

was included in the evaluation. Six criteria were formulated to evaluate the clinical performance of displacement cords (**Table III**).

A total sample size of 252 (n=63) was estimated with a power of 85% and 0.25 effect size at the 5% significance level. The sampling size calculation was performed by using the G-Power 3.1.3 Blocked Randomization Method (Block Stratified Randomization Installation 2.0.0.0, copyright 2010 by Steven Piantadosi, MD, PhD, Cedars-Sinai Medical Center) to reduce bias and achieve balance in the allocation of participants to the treatment groups. The statistical analysis was performed with statistical software (SPSS for Windows, 2009, v17.0; SPSS Inc). The  $\chi^2$

TABLE III. Evaluation criteria

Question	Answers
How easily was the displacement method applied?	<b>Easy:</b> Packing of cord and/or cap into sulcus once and without displacement. <b>Difficult:</b> Packing of cord and/or cap into sulcus more than once and/or occurrence of cord or cap displacement from sulcus.
How rapidly was the displacement method applied?	<b>Time saving:</b> Time needed to pack cord and/or cap into sulcus is short. <b>Acceptable:</b> Time needed to pack cord and/or cap into sulcus is not short but still acceptable. <b>Time consuming:</b> Significant amounts of time needed to pack cord and/or cap into sulcus.
Was there a bleeding evident after removal of cord and/or paste-cap system?	<b>No:</b> Absence of bleeding in sulcus after removal of cord and/or paste-cap system. <b>Yes:</b> Presence of bleeding observed in sulcus after removal of cord and/or paste-cap system.
Were there any remnants in the gingival sulcus after removal of cord and/or paste-cap system?	<b>No:</b> Absence of debris in sulcus after cord and/or cap removal. <b>Yes:</b> Presence of debris in sulcus after cord and/or cap removal.
Did the gingival sulcus dilate?	<b>Yes:</b> Observable separation of gingival tissue from tooth surface at finishing line of preparation. <b>No:</b> Gingival tissue was not separated, and finishing line of preparation could not be observed completely.
What was the quality of the gingival margins on the impression?	<b>Perfect:</b> Absence of voids or bubbles and perfect reproduction of preparation finish line. <b>Acceptable:</b> Minimal defects not involving preparation finish line (up to 2 mm in diameter) that could be corrected by technician on cast. <b>Unacceptable:</b> If impression had bigger voids or bubbles (more than 2 mm in diameter) or defects involving preparation finish line.

test was used ( $\alpha=.05$ ). Bonferroni-type adjustment was used for each pair of treatment groups. Therefore, according to Bonferroni correction in the condition that  $P<.008$  ( $\alpha=.05/6$ ), the results were accepted as statistically significant.

## RESULTS

The success rate of gingival management for the 4 displacement methods and their effect on the marginal quality of impressions was evaluated. Polyether impressions of 252 prepared teeth and their marginal gingiva were examined by 4 clinicians. The results of the data analysis are shown in Table IV and Figure 2. The data were analyzed for the percentage of success. Six evaluation criteria were analyzed for each displacement method, and statistically significant

differences were found for all criteria among the groups ( $P<.05$ ). Aluminum chloride soaking solution had no effect on either the ease of packing the cord ( $P=.278$ ) or the time needed for cord placement ( $P=.839$ ). Group PC's technique was the fastest ( $P<.008$ ) and was also easier than the techniques in groups IC and ICPC ( $P<.008$ ). Group ICPC had the most difficult and time-consuming technique ( $P<.008$ ). Significant differences in bleeding were noted after the displacement system was removed ( $P<.05$ ); additionally, recurrence of bleeding after displacement application removal was more frequent in group NIC (85%). Less bleeding was noted in group PC than in group IC ( $P<.008$ ). No significant differences were noted between groups IC and ICPC ( $P=.028$ ) on gingival bleeding after cord removal. Although

statistically significant differences were not seen between groups PC and ICPC ( $P=.115$ ), there were still significant clinical differences; gingival bleeding after displacement system removal occurred only 3 times in PC. Fewer remnants were seen in the NIC group than in the other 3 groups ( $P<.05$ ). Although no significant differences were noted among groups NIC, IC, and PC ( $P=.168$ ), there were still clinical differences; rinsing the gingival sulcus carefully might be recommended in group PC and especially in group ICPC. Dilatation was best in group ICPC and worst in group NIC, and no statistical differences were observed between groups IC and PC ( $P=.803$ ). Group ICPC showed better dilatation than group PC ( $P<.008$ ). Significantly worse gingival margin quality rates of impressions were observed in group NIC, and higher rates were observed in group ICPC. Significant differences in gingival quality rates of impression were noted between group NIC and other groups of the study ( $P<.008$ ). No significant differences were noted between groups IC and PC ( $P=.361$ ), PC and ICPC ( $P=.838$ ), or IC and ICPC ( $P=.143$ ).

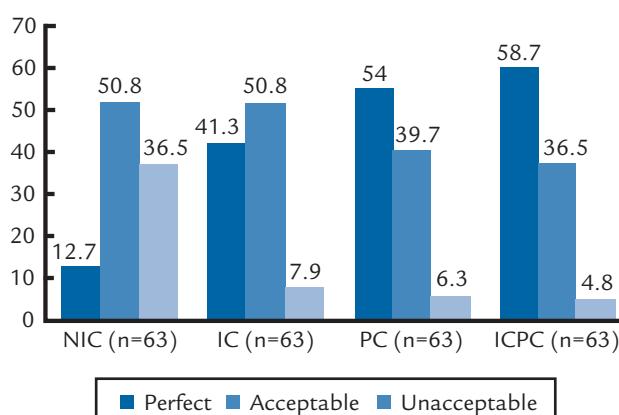
## DISCUSSION

The null hypothesis that the displacement methods tested would show no significant difference with regard to the evaluation criteria was rejected. In the present study, both the detail of impressions and the clinical performance (that is, ease of application, time spent, bleeding, dilatation, and remnants) could be evaluated with the determined criteria. To the authors' knowledge, no consensus regarding the criteria for evaluating the clinical performance of displacement methods exists in the literature. Weir and Williams<sup>14</sup> evaluated bleeding after cord displacement. Yang et al<sup>16</sup> evaluated dilatation while scanning duplicated stone models with a 3-dimensional laser scanning device; Al Hamad et al<sup>15</sup> investigated the effects on both periodontal health and bleeding; Jokstad<sup>12</sup> determined 6 evaluation criteria

**TABLE IV.** Clinical evaluation results for marginal gingival displacement

Groups (n=252)	Insertion Into Crevice (%)		Time Spent for Displacement (%)		Recurrent Bleeding After Displacement System Removal (%)		Remnants in Sulcus After Displacement System Removal (%)		Dilatation of Sulcus After Displacement System Removal (%)		
	Easy	Difficult	Time-Saving	Acceptable	Time-Consuming	No Bleeding	Bleeding	No Remnants	Remnants	Dilatation	No Dilatation
NIC (n=63) Nonimpregnated displacement cord	82.5	17.5	17.5	61.9	20.6	14.3	85.7	84.1	15.9	71.4	28.6
IC (n=63) Aluminum chloride impregnated displacement cord	74.6	25.4	14.3	66.7	19.0	71.4	28.6	58.7	41.3	85.7	14.3
PC (n=63) 15% aluminum chloride topical gingival displacement paste + displacement cap	95.2	4.8	79.4	17.5	3.2	95.2	4.8	74.6	25.4	84.1	15.9
ICPC (n=63) Aluminum chloride impregnated displacement cord + 15% aluminum chloride topical gingival displacement paste + displacement cap	41.3	58.7	6.3	30.2	63.5	87.3	12.7	66.7	33.3	100.0	.0

NIC, nonimpregnated cord; IC, impregnated cord; PC, paste and cap; ICPC, impregnated cord, paste, and cap.



**2** Distribution of impression quality. (NIC, nonimpregnated cord; IC, impregnated cord; PC, paste and cap; ICPC, impregnated cord, paste, and cap.)

for the clinical performance of displacement cords; Kumbuloglu et al<sup>13</sup> modified these criteria and evaluated both clinical performance and impression quality; and Beier et al<sup>8</sup> evaluated only impression quality. In

the present study, the evaluation criteria of Jokstad,<sup>12</sup> Kumbuloglu et al,<sup>13</sup> and Beier et al<sup>8</sup> were unified, and a total of 6 evaluation criteria were determined.

In spite of the increased hydrophilicity of impression materials,<sup>17</sup>

providing a dry state is still necessary for the success of an impression. Gingival fluid seepage and hemorrhage should be controlled, especially when elastomeric impression materials are used; therefore, bleeding after cord or cap displacement is a major concern of gingival deflection.<sup>10</sup> In the present study, except for the NIC group, aluminum chloride, either in solution or in topical paste form, was used for hemostasis. Displacement cord was used in combination with an aluminum chloride hemostatic agent in the IC group; a 15% aluminum chloride topical gingival displacement paste was used for hemostasis in group PC; and both an aluminum chloride hemostatic agent and a 15% aluminum chloride topical gingival displacement paste were used for hemostasis in group ICPC.

The results of the current study indicate the effect of aluminum chloride

on hemostasis. Bleeding after cord removal was significantly higher (85.7%) in the NIC group than in the IC group (28.6%). This is in agreement with the findings of a previous study.<sup>14</sup> Additionally, Al Hamad et al<sup>15</sup> stated that bleeding during and after displacement application was seen only with the use of the nonimpregnated cords, even for periodontally healthy unprepared teeth. However, Kumbuloglu et al<sup>13</sup> found that there may be no observable difference in bleeding after cord removal between impregnated and nonimpregnated displacement cord groups. The difference between the findings of Kumbuloglu et al<sup>13</sup> and those of the present study might originate in the discrepancy of preparation finish line depths, which were positioned deeper in the present study. Beier et al<sup>8</sup> also mentioned the role of preparation finish line depths in the success of gingival management. Additionally, it is certain that the use of displacement systems with hemostatic agents reduces gingival bleeding resulting from accidental soft tissue injury associated with the preparation. This is in agreement with the findings of a previous study that found displacement cord placement or removal might cause bleeding even in the healthy gingiva of unprepared teeth.<sup>15</sup>

In the present study, fewer remnants were seen in the crevice after the use of nonimpregnated cords than in the other 3 groups. In a similar previous study, the use of aluminum chloride impregnated cord led to more remnants than the use of nonimpregnated cord.<sup>13</sup> No significant differences were noted among groups IC, PC, and ICPC ( $P=.168$ ) with regard to remnants. Notwithstanding, in the authors' clinical experience, special care should be taken to remove the aluminum chloride in paste form while using the Traxodent System.

To achieve well-adapted crown margins, the free gingival margin must be effectively displaced. Finger et al<sup>18</sup> found a positive correlation between the reproducibility of the impression and the width of the sulcus. Baharav et al<sup>6</sup> stated that impression accuracy

may be greater in sulci wider than 0.15 mm at the level of the finish line. In the present study, there were significant differences in dilatation among the groups ( $P<.05$ ). However, no statistical or clinically observable differences were noted between the groups of aluminum chloride impregnated cord and the group of cap and paste (containing 15% topical aluminum chloride). This result agrees with the result of a previous study that found an increase in the sulcus width after displacement with impregnated cord and an injection-type material containing 15% aluminum chloride.<sup>16</sup> Additionally, however, the current study found that impregnated cords produce better dilatation than nonimpregnated cords, contradicting the finding of a previous study.<sup>13</sup>

In the current study, polyether impression materials were used because of their ability to reproduce fine detail in a narrow sulcus.<sup>17,18</sup> However, Johnson et al<sup>7</sup> stated that the preparation finish line was the most critical defect area, and inadequate gingival displacement was the most common clinical error. Therefore, this study also focused on impression quality. Except for the nonimpregnated cord group, all of the evaluated techniques had similar results for impression quality ( $P=.383$ ). This is in particular agreement with the findings of another previous study.<sup>8</sup> MFC, a nonhemostatic system, was found compatible with the single-cord technique when epigingival and subgingival (<2) preparation finish lines were used after hemostasis had been achieved.<sup>8,9</sup> However, in group PC of the current study, the Traxodent system containing 15% aluminum chloride topical gingival displacement paste was used by itself, and only 6.3% of the impressions were found unacceptable. Kumbuloglu et al<sup>13</sup> found that nonimpregnated cord groups exhibited the highest-quality gingival margins, whereas in the current study 36.5% of the impressions for the nonimpregnated cord group were found unacceptable. The disparity between these findings might be attributed to the difference between the preparation finish

lines, which were shallow in the previous study.

Most displacement methods have already been evaluated as to whether or not they are effective for gingival management and impression quality. However, few studies have investigated their ease of application,<sup>12,13</sup> and to the authors' knowledge there is no information regarding chair time and displacement application. This study focused on ease of application and the time needed for displacement methods in addition to other evaluation criteria. According to the results of the current study, the Traxodent cap and paste system was found to be easier ( $P=.001$ ) and less time consuming ( $P<.001$ ) than the aluminum chloride impregnated cord application, although no statistical difference was found between dilatation ( $P=.803$ ) and impression quality ( $P=.361$ ). Nonetheless, in the authors' experience, the cotton compression caps may not adapt well interproximally, so displacement was sometimes insufficient when adjacent teeth were in close proximity. In the present study, only the buccal aspect of the preparation finish line was evaluated, and thus the results of the study were not affected.

Whenever possible, the margin of the preparation should be located supragingivally<sup>4</sup>; however, certain conditions may require the placement of subgingival margins.<sup>3</sup> Moreover, Reitemeier et al<sup>19</sup> evaluated 240 participants with 480 metal ceramic crowns in a prospective clinical trial and found that subgingival placement of posterior crown margins was more common than supragingival or gingival crest placement. Hence, to improve the clinical implications of the study,<sup>5</sup> abutment teeth intended to be prepared with 1- to 2-mm-deep preparation finish lines were included in this research. Beier et al<sup>8</sup> found that the MFC cordless displacement system was less effective in teeth with deep preparation finish lines (>2 mm). Although the present study did not focus on deep preparation finish lines, in the authors' opinion and clinical experience, the Traxodent Hemudent Paste

Retraction System might be effective for deep preparation finish lines because of its topical aluminum chloride content. Additionally, although crown margins may be placed subgingivally, it is highly likely that margins will eventually be located supragingivally and greater attachment loss will be seen.<sup>2</sup>

There are limitations to this study, because certain clinical conditions potentially influence the gingival displacement. These include the phenotype of gingiva, the type of teeth (adjacent teeth, angulations), clinical accessibility, and compliance of the patient, and, consequently, the reported results should be interpreted with caution. This study focused on the effectiveness of gingival displacement and the success of impressions. However, patient comfort, gingival injury during application, or gingival recession after application might be evaluated in future studies. In the present study only the Traxodent Hemudent Paste Retraction System was evaluated. Further clinical investigations are needed to investigate the clinical performance of newly formulated displacement systems.

## CONCLUSIONS

Within the limitations of this study, the following conclusions were reached. The displacement methods evaluated have a statistically significant effect on marginal gingival management and impression quality with regard to the evaluation criteria of this study ( $P<.05$ ). The use of aluminum chloride with displacement cord decreased the incidence of bleeding after cord removal and increased impression quality ( $P<.008$ ). The use of the displacement paste and cap technique was easy and

time efficient, and it caused less bleeding than the impregnated displacement cord application ( $P<.008$ ). These 2 systems were similar with regard to dilatation ( $P=.803$ ) and impression quality ( $P=.361$ ) and left the same amount of remnants ( $P=.059$ ). The use of displacement cord, paste, and cap together had advantages for bleeding, dilatation, and impression quality, although it was time consuming and difficult.

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