A multicenter randomized, controlled clinical trial comparing the use of displacement cords, an aluminum chloride paste, and a combination of paste and cords for tissue displacement

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ABSTRACT

Statement of problem. Gingival recession after soft tissue displacement for impression making in fixed prosthodontics may pose a problem for treatment success in the esthetic areas of the mouth. Knowledge about the soft tissue reaction of common gingival displacement methods is limited.

Purpose. The purpose of this clinical randomized controlled trial (RCT) was to evaluate changes in the marginal soft tissue height with different gingival tissue displacement techniques for definitive impression making of natural teeth.

Material and methods. A total of 67 individuals were randomized to 3 groups. In test group 1 (P; n=22), only aluminum chloride paste was used to displace the gingiva. In test group 2 (CP; n=23), a cord was inserted, and aluminum chloride paste was also used. In the control group (C; n=22), 2 cords were used to displace the gingiva (double-cord technique). Clinical measurements of the gingival position were made before treatment began and at 30 ±10 days after prosthesis delivery. Study casts were fabricated at different stages of the treatment, standardized photographs were made, and changes in the buccal gingival position were measured using graphics editing software. In addition, the participants’ perception of the clinical procedure and the technicians’ evaluation of the die preparation were recorded. One-way ANOVA models were applied to compare the response variables among the groups: (a) the position of the gingival margin (millimeters), (b) mean probing pocket depth (millimeters), (c) gingival thickness (millimeters), (d) amount of keratinized tissue (millimeters), and (e) mean changes in gingival margin height (millimeters). Unpaired t tests were also used to compare the mean values between groups. For comparisons between different categories, chi-square tests were performed (a=0.05 for all tests).

Results. In the period between impression and delivery, a minor gain in gingival height of 0.058 mm (±0.13 SD) for P and 0.013 mm (±1.19 SD) for CP. However, a minor gingival recession of 0.049 mm (±0.13 SD) was reported for group C. The results for all groups showed that 21% of abutment teeth gained >0.1 mm in gingival height, 58% had stable gingival height (0 ±0.10 mm), 21% showed minor gingival recession (0.1 to 0.5 mm), and no abutment teeth showed moderate or severe gingival recession (>0.5 mm). The incidence of minor gingival recession was 8% in group P, 23% in group CP, and 32% in group C (P=.015). Fifteen participants (24%) experienced some discomfort after the procedure. The differences between the groups were not significant (P>.05). The laboratory technicians found the definitive die preparation significantly more challenging for group P (visual analog scale [VAS], 79) and CP (VAS, 82) than group C (mean VAS, 93; P=.003).

Conclusions. Minor or moderate gingival recession (<1 mm) is more likely to occur when conventional cords are used during impression making. However, the laboratory technicians found the die preparation significantly less challenging when the double-cord technique was used than when impressions were made using the paste displacement technique. (J Prosthet Dent 2018;119:82-88)
Clinical Implications

Impression procedures in fixed prosthodontics require cautious soft tissue manipulation for successful treatment. Knowledge of how displacement procedures affect impression quality, success, and the potential risk of gingival recession is critical for clinicians.

coronal tooth structure may necessitate subgingival marginal placement, requiring temporary gingival displacement before an impression is made. Gingival displacement methods can be divided into surgical, mechanical, chemical, and combinations of these.8

In 1951, Thompson9 described a purely mechanical method of gingival displacement using a moist cotton cord without additional medicaments. Later, the cotton cords were impregnated with different hemostatic agents.10 Studies evaluating gingival recession after the placement of cotton cords have either concluded that no recession occurred11,12 or that a mean recession of 0.2 mm was detected.13,14 The chemical-mechanical method has been established as effective15 and is the method used most frequently for gingival displacement.16

Cordless techniques, such as aluminum chloride pastes and polyvinyl siloxane (PVS) material, are recent options for gingival displacement.8 The efficacy of these materials has been established,17-20 but the authors are unaware of studies of associated gingival recession. The effect of aluminum chloride paste on gingival indices has been inconsistent. One study showed more pronounced transient gingival inflammation than with cords and PVS displacement material,21 but another study indicated no soft tissue effect.22 However, cordless techniques could be more comfortable for the patient.19 The purpose of this randomized controlled clinical trial (RCT) was to evaluate and compare 3 different methods of gingival tissue displacement by measuring the occurrence and magnitude of gingival recession, the participants’ perception of the intervention, and the technicians’ evaluation of the ease of die preparation.

MATERIAL AND METHODS

The study protocol was accepted by the National Bioethics Committee in Iceland (no. 08-136), and a study conduction notification was sent to the Icelandic Data Protection Authority. Participants gave their written informed consent for their contribution.

Sixty-seven medically healthy participants in need of a tooth-supported single crown or FDP were recruited. The trial was conducted in the Division of Prosthodontics, University of Iceland, and in 4 private clinics in Reykjavík, Iceland. The operators were general dentists, prosthodontists, and dental students directly supervised by faculty members. To achieve calibration among the investigators, the application procedures and evaluation criteria for the displacement methods were discussed and agreed upon by all investigators at the beginning of the study. All participants underwent scaling and root planing and received oral hygiene instructions prior to treatment. A maximum of 2 abutment teeth in each participant were included in the study. Tooth mobility was assessed using the Miller index.23 Recession and probing depths were measured on 6 sites per tooth. The presence or absence of bleeding on probing at 4 sites on the abutment teeth was recorded. The thickness of the gingival tissue on the abutment teeth was measured 2 mm apically to the gingival margin with a #15 endodontic file (Sterile K-Files; VDW). The width of the buccal gingiva at the abutment tooth was measured with a periodontal probe, and measurements were rounded to the nearest millimeter.

The participants were randomly divided into 2 test groups and 1 control group. Random allocation was achieved using opaque and sealed envelopes opened by the provider immediately before the impression procedure. Participants completed a pain response questionnaire by using a visual analog scale (VAS) on the day after the procedure and returned the questionnaire at the next clinical visit.

The dental laboratory technicians, who were blinded to which displacement method was used, were asked to evaluate the ease of die preparation, using the VAS, in which 0 indicated “impossible to detect the margin” and 100 indicated “no problem detecting the margin.”

Before displacement and definitive impression making, an irreversible hydrocolloid impression was made (Jeltrate; Dentsply Sirona) in a sectional impression tray lined with alginate adhesive material (Fix Tray Adhesive Aerosol; Dentsply Sirona). The alginate impression was poured immediately in die stone for the fabrication of study cast 1.

Twenty-two participants were randomly allocated to group P. Gingival displacement was accomplished with aluminum chloride paste alone. Twenty-three participants were randomly selected for group CP. Gingival displacement was accomplished by placing a fine cord (#000, #00, or #0) into the gingival sulcus on 3 sides of the abutment tooth (mesially, buccally, and distally) to displace the sulcus slightly. Then, aluminum chloride paste was applied to the gingival sulcus all around the abutment tooth. Twenty-two participants were randomly selected to group C. Prior to tooth preparation, a fine cord (#000, #00, or #0) with astringent medium was placed in the sulcus of the abutment tooth. Then, a second, larger cord (#1 or #2) was placed. Immediately before impression making, the second cord was removed. Knitted cotton cords were used (Ultrapak; Ultradent Products, Inc).
Two types of astringent media were used in the trial: 14% buffered aluminum chloride (Hemodent; Premier) and 20% ferric sulfate (ViscoStat; Ultradent Products, Inc). The impression material used was either polyether or PVS. There were no restrictions on how much time was used or how many attempts were made to obtain a sufficiently accurate impression as judged by the clinician. The time needed for impression making was not recorded, but the number of attempts was documented. Special care was taken to achieve an excellent marginal fit and contour of the provisional restorations, and participants were instructed to maintain healthy soft tissue surrounding it with floss and a soft toothbrush. At the time of definitive prosthesis delivery, an alginate impression was made before luting the prosthesis and study cast 2 was fabricated. A second alginate impression was made immediately after delivery, and study cast 3 was fabricated. Visit 4 took place 30 ±10 days after delivery of the prosthesis, an alginate impression was made, and study cast 4 was fabricated. Recordings of recession, probing depth, and bleeding on probing were made at this visit. A PVS putty index (President Putty; Coltène) was made in a tray for the study casts. The tray with the indices was seated in a model holder, and a set of grids for reference, the distance between the gingival zenith on images 1 and 2 was measured in millimeters, representing the changes in gingival position from before impression making until the time of delivery. The procedure was repeated to compare the gingival position immediately after delivery to that seen approximately 30 days after the luting of the definitive prosthesis (study casts 3 and 4).

Descriptive statistical information on the baseline characteristics of participants and abutment teeth was provided: standard deviation, 95% confidence interval, and percentage distribution for categorical characteristics. One-way ANOVA models were applied to compare the response variables among the groups: (a) the position of the gingival margin (millimeters), (b) mean probing pocket depth (millimeters), (c) gingival thickness (millimeters), (d) amount of keratinized tissue (millimeters), and (e) mean changes in gingival margin height (millimeters). Unpaired t tests were also used to compare the mean values between groups. For comparisons between different categories, chi-square tests were performed, and the overall P value derived from these models was reported. Furthermore, frequency distribution was made for changes in position of the gingival tissue. Multinomial logistic regression model was used to compare the frequency distributions among groups. For some participants, 2 teeth were included in the study. Consequently, the observations could not be considered independent, and a variance estimator allowing for intragroup correlation was applied. To test for measurement errors in the methodology, 25% of all measurements were repeated, and mean differences, 95% confidence intervals, and ranges were presented. The paired t test, Spearman rank correlation, and Bland-Altman plots were used to compare the different measurements for errors. The outcome of the VASs was presented with mean values, standard deviations, medians, and ranges. For comparisons between the different groups, the VAS was translated into categorical values by considering scores between 91 and 100 as positive values and all scores below 90 as negative values. All analyses were conducted with statistical software (Stata v12.2; StataCorp LLC).

RESULTS

Over a 2-year period, 67 participants with a mean ± SD of 49.8 years of age (±12.5), range, 20 to 80 years) at the time of impression making were included in the study. Five participants failed to return for visit 4, despite several attempts to contact them. Therefore, 92 abutment teeth were included in the evaluation: 25 participants had 2 abutments, and the remaining 42 had 1 abutment included in the study. Descriptive statistics of the groups are listed in Table 1.

No significant differences were found among the groups in terms of baseline characteristics, with the exception that all 3 abutment teeth that underwent presurgical prosthesis surgical crown lengthening were randomly allocated to group P. However, the minimum time from surgical intervention to impression making was 12 weeks, allowing the gingival tissue to mature. The number of impressions needed was, on average, 1.4 for group P (95% confidence interval [CI], 1.2-1.7; range, 1-3), 1.3 for group CP (95% CI, 1.1-1.5; range, 1-3), and 1.1 for group C (95% CI, 1.0-1.3; range, 1-2). Adequate impressions were achieved for 61% of the preparations in group P on the first attempt. The respective figures for groups CP and C were 76% and 86%. This difference did not reach statistical significance (P = .216). Two participants from P dropped out of the study as repeated impressions were made without obtaining adequate duplication of the preparation margin.

The changes in gingival margin position from before impression making to the time of prosthesis luting are summarized in Table 2. The frequency distribution was defined as follows: increase in soft tissue height...
(>0.1 mm), stable gingival height (0 ±0.1 mm), minor gingival recession (0.1 to 0.5 mm), moderate gingival recession (0.5 to 1.0 mm), and severe gingival recession (>1.0 mm). The incidence of minor gingival recession was 78% in group P, 23% in group CP, and 31% in group C. The difference in mean changes in the position of the gingiva between the groups was statistically significant ($P = .015$). Furthermore, the differences between P and C were significant ($P = .004$). The differences among P and CP and CP and C were not significant ($P > .05$).

The location of the gingival margin from the time of prosthesis insertion to 30 ±10 days after cementation was also evaluated by comparing images of study casts 3 and 4. The results are summarized in Table 3. The difference in frequency distribution regarding gingival position among the groups was statistically significant ($P < .001$).

Finally, the changes in soft tissue height during the entire observation period was evaluated by summarizing the measurements of the previous 2 sets of images (Table 4). The mean difference and the frequency distribution between the groups were statistically significant ($P = .009$ and .036). Further analysis using marginal linear prediction revealed a significant difference only between groups P and C ($P = .002$). Gingival recession did not
Table 4. Changes in gingival margin position from before impression making until 30 ±10 days after cementation (#1 to #4)

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (n=80)</th>
<th>Test group 1 (P) (n=23)</th>
<th>Test group 2 (CP) (n=30)</th>
<th>Control group (C) (n=27)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in gingival height (mm), mean (95% CI)</td>
<td>-0.001 (-0.054 to 0.051)</td>
<td>0.111 (0.030 to 0.193)</td>
<td>-0.011 (-0.113 to 0.092)</td>
<td>-0.087 (-0.160 to -0.014)</td>
<td>.009</td>
</tr>
<tr>
<td>Gain in gingival height &gt;0.1 mm, %</td>
<td>35</td>
<td>61</td>
<td>33</td>
<td>15</td>
<td>.036</td>
</tr>
<tr>
<td>Stable gingival margin 0 ±0.1 mm, %</td>
<td>40</td>
<td>22</td>
<td>47</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Minor gingival recession 0.1-0.5 mm, %</td>
<td>20</td>
<td>17</td>
<td>13</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Moderate gingival recession 0.5-1.0 mm, %</td>
<td>5</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Substantial gingival recession &gt;1.0 mm, %</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

C, control group; CP, test group 2; P, test group 1. *One-way ANOVA model with variance estimator allowing for intragroup correlation. **chi-square test from multinomial regression with variance estimator allowing for intragroup correlation.

differ significantly between thick (>1.5 mm) and thin (<1.5 mm) gingiva during the entire observation period (P<.72). Moreover, limited keratinized gingiva (<3 mm) did not significantly increase the risk of gingival recession compared with abutment teeth with a wider band of gingiva (P<.86).

Clinical soft tissue measurements of all abutment teeth assessed during the final visit showed that the crown margin was located on average 0.3 mm subgingivally (±0.73 mm). The crown margins in group P were located significantly (P=.034) more deeply subgingivally than in the other groups.

Three participants failed to return the pain questionnaire. Fifteen participants (24%) reported experiencing discomfort after the intervention. The mean score on VAS was 27 (±20). For these 15 participants, 21 teeth were involved, of which 10 were nonvital and 11 were vital. In P, 20% reported having pain, in CP 24%, and in C 29%. The differences were nonsignificant (P>.05).

The dental laboratory technician fabricating the definitive restoration was asked to evaluate the ability to detect the margin when ditching the cast. The results are summarized in Figure 1. In group P, the mean score on the VAS for the ease of die ditching was 79. For the 2 participants in P whose impressions were inadequate even though the impressions were repeated 3 times, the rank score was 0 on the VAS. In group CP, the mean score on the VAS was 82 (±22). In group C, the mean score on the VAS was 93 (±15). From a frequency distribution standpoint, for 35% of the preparations in P, the dental technicians evaluated it for ease of preparing the definitive cast (VAS, 91 to 100). The respective figures were 51% for CP and 81% for C (P=.003).

**DISCUSSION**

The authors are unaware of previous reports of the influence of aluminum chloride paste on gingival recession, and only a few clinical trials measured soft tissue position after impression making. Recession from cords has been reported to be 0.2 and 0.26 mm on average,13,14 which is comparable to the results from the control group in the present study. This study found that minor gingival recession is more likely to occur using cotton cords than aluminum chloride paste. Patient-related factors such as gingival thickness and width of keratinized tissue did not affect these results.

Based on the dental technicians’ evaluation, detection of the preparation margin was easier in the cord group than in the paste group. Additionally, in 2 participants randomized to group P, impression making failed because of a lack of marginal integrity. Both participants had preparations of mandibular molars. Published reports regarding quality of impressions with paste displacement are sparse. Cord displacement has been associated with good quality impressions and enhanced quality compared with the PVS cordless technique.24,25 Furthermore, difficulty in obtaining accurate impressions when the sulcular width is under 0.2 mm has been demonstrated.26 Insufficient lateral expansion of the gingival sulcus could be the cause of impression failures in group P and explain why the technician found it easier to detect the preparation margin in C than in P.

These results may be considered relevant for clinicians performing prosthetic rehabilitation of the natural dentition. Thus, to reduce gingival recession, they might choose to use paste rather than cords. However, they should also be aware that the marginal integrity of the impression and the ability of the technician to readily identify the marginal finishing line during die ditching might be compromised if only paste is used.

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**Figure 1.** VAS score for technicians’ evaluation of definitive cast fabrication. Green, test group 1 (P); orange, test group 2 (CP); indigo, control group (C). VAS, visual analog scale.
Changes in position of the gingival margin during the entire observation period were analyzed for all groups. From before impression making until 30 ±10 days after prosthesis delivery, 35% of the preparations showed increased soft tissue height, 40% stable gingival position, 20% minor gingival recession, and 5% moderate gingival recession. No severe gingival recession of more than 1.0 mm was observed. In approximately one-third of the preparations, an increase in soft tissue height was recorded. Comparing the groups, this was most prominent in P. One reason could be that the clinical procedure, that is, subgingival tooth preparation, tissue displacement, impression making, and the interim restoration caused gingival irritation resulting in increased gingival height from inflammation. Soft tissue irritation from the paste might also result in transient inflammation in the area, which may cause the difference observed between groups P and C. This agrees with a clinical study on the influence of aluminum chloride paste on soft tissue.21 Gingival inflammation after the insertion of FDPs with subgingivally placed crown margins may also be a factor. This has been discussed previously.27 However, these results and the fact that the clinical measurements of crown margins in P were, on average, located significantly more subgingivally than with the other groups supports the result of less recession using the paste compared with the cords.

In the present study, few instances of minor marginal irregularities in the definitive cast were reported in test groups P and CP. Not many studies address the possible interaction between displacement materials or medicaments and impression material polymerization, but one study has demonstrated that polyether polymerization may be prolonged in contact with aluminum chloride.28 Similarly, the results of the present study concur with the results of an in vitro study in which the use of medicaments such as ferric sulfate and aluminum chloride did not significantly affect the dimensional accuracy of PVS impression material; however, they had a significantly adverse effect on surface detail reproduction.29

The present study was a randomized controlled clinical trial with an adequate number of participants in a practice-based environment and thus is likely to accurately reflect regular dental practice. Even though more than 20 participants with at least 28 abutment teeth were recruited per group and several statistical differences were ascertained, whether the study has sufficient statistical power to detect all relevant differences, or avoid type II errors and significant confounding factors remains unknown. Additionally, methodological limitations are present that may affect the outcome. It is difficult to standardize the making of interim crowns. Increase in tissue height is an unforeseen result and could be influenced by interim crown misfit, as has been reported previously.30 Furthermore, operators had different levels of experience. Lack of clinical experience may increase the number of attempts needed to achieve an acceptable impression. An average range of 1.1 to 1.4 attempts per study group must be considered within the normal range.

As this RCT was conducted in academic and private practice settings, it was not feasible to standardize the type of displacement cords, the time required to place the cords, hemostatic agents, and impression material used. These factors were considered minor as everyone was following the same protocol. Moreover, the concealed randomization process should minimize their effect. However, the results may be more pertinent to a private practice setting than an academic environment.

CONCLUSIONS

Based on the findings of this randomized clinical trial, the following conclusions were drawn:

1. Minor or moderate soft tissue recession is more likely to occur with the double-cord technique for gingival displacement than with aluminum chloride paste.
2. However, the technicians found marginal finishing line detection significantly easier when the cords were used than with the paste.

REFERENCES

Noteworthy Abstracts of the Current Literature

The effect of reading aloud exercises for complete denture patients during the functional rehabilitation period

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Purpose. The focus of this study was to evaluate the effect of reading aloud on masticatory performance and patient satisfaction of patients rehabilitated with conventional complete dentures for the first time.

Material and Methods. Sixty-two edentulous patients who received conventional complete denture treatment for the first time were randomly divided into two equal groups. After insertion of the dentures, patients in group I were asked to read a newspaper three times per day for 4 weeks, while those in group II did not read. The reading duration increased by 5 minutes per week, from 5 minutes in the first week to 20 minutes in the fourth week. The patients' mouth opening during reading aloud was advised to gradually increase throughout the training project. Two and four weeks after insertion of the dentures, masticatory performance was assessed using the sieving method, and patient satisfaction was measured using a visual analogue scale, which combined the patient’s perceptions in relation to comfort, esthetics, stability, ability to talk, and ability to chew.

Results. There were significant improvements in masticatory performance with reading aloud exercises after the insertion of complete dentures (p<0.001) at the 2- and 4-week follow-up visits. Masticatory performance also showed significant improvement within each group in the follow-up periods (p<0.001). No significant differences were found between the two groups in patient satisfaction (p>0.05) at 2 weeks, but at 4 weeks, patient satisfaction regarding stability, ability to talk, and ability to chew was significantly higher for group I (p<0.001).

Conclusions. The results of this study suggest that reading aloud exercises significantly improved early masticatory performance and patient satisfaction for denture wearers who were treated with conventional complete dentures for the first time, and may be a useful clinical application for more effective denture treatment.

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