REVISTA DE ODONTOLOGIA DA UNESP

ORIGINAL ARTICLE

Rev Odontol UNESP. 2017 July-Aug; 46(4): 220-226
Doi: http://dx.doi.org/10.1590/1807-2577.22916

 - ISSN 1807-2577

Comparison between aluminum chloride and tetryzoline hydrochloride for control of vertical gingival displacement and crevicular fluid

Comparação entre cloreto de alumínio e o cloridrato de tetrizolina no controle do afastamento gengival vertical e fluído crevicular

Clóvis Lamartine de MORAES MELO NETO[a*], Helder Fernando BORGES JUNIOR[a], Yasmin FIRMINO DE SOUZA[a], Gabriela Cristina SANTIN[a], Sérgio SÁBIO[a]

[a]UEM – Universidade Estadual de Maringá, Maringá, PR, Brasil

Resumo

Introdução: A utilização de fio de afastamento gengival com uma substância de afastamento gengival é um procedimento comum para se realizar uma moldagem com qualidade do término cervical em dentes com finalidade protética. **Objetivo:** Avaliar se o método mecânico-químico com cloridrato de tetrizolina a 0,05% ou cloreto de alumínio a 25% são capazes de reduzir o fluido crevicular e afastar o tecido gengival verticalmente em uma quantidade maior, estatisticamente significante, em comparação com o método mecânico de afastamento (sem substâncias químicas). **Material e método:** Dez pacientes foram selecionados, e os fios Ultrapak n° 000 e 1 foram posicionamos de maneira randomizada nos dentes 13, 21 e 23. Grupo I: fio sem substância química; Grupo II: fio impregnado com cloridrato de tetrizolina; Grupo III: fio impregnado com cloreto de alumínio. Utilizando modelos de gesso, foram capturadas trinta imagens com uma câmera acoplada a uma lupa, para análise do grau de afastamento. O fluxo crevicular foi quantificado através de uma balança de alta precisão, a partir de tiras de papel absorvente personalizadas para cada dente que recebeu afastamento gengival. **Resultado:** Não houve diferença estatística entre os três grupos quanto a quantidade de afastamento gengival vertical (Anova, p=0,26). Quanto a redução de fluido crevicular, não houve diferença entre os grupos teste e controle (Wilcoxon e Friedman, p < 0,05). **Conclusão:** A utilização do cloridrato de tetrizolina ou cloreto de alumínio em fio de afastamento gengival não melhorou a quantidade de afastamento vertical da gengiva e não reduziu a quantidade de fluido crevicular.

Descritores: Retração gengival; líquido do sulco gengival; sulco gengival.

Abstract

Introduction: The use of a gingival displacement cord with a gingival displacement substance is a common procedure for taking a quality impression of the cervical terminal in teeth for prosthetic purposes. **Objective:** To evaluate whether the mechanical-chemical method with 0.05% tetryzoline hydrochloride or 25% aluminum chloride is capable of reducing crevicular fluid, and displacing a statistically significant larger quantity of gingival tissue vertically, compared with the mechanical method (without chemical substances). **Material and method:** Ten patients were selected, and then No. 000 and 1 Ultrapak cords were randomly positioned on teeth 13, 21 and 23. Group I – cord with no chemical substance; Group II – cords impregnated with tetryzoline hydrochloride and Group III – cords impregnated with aluminum chloride. Using dental stone models, thirty images were captured with a camera coupled to a loupe to analyze the degree of gingival displacement. Crevicular fluid was quantified using a high-precision scale and individualized strips of absorbent paper for each tooth on which gingival displacement was performed. **Result:** There was no statistical difference between the three groups relative to the amount of vertical gingival displacement (Anova, p=0.26). As regards reduction in crevicular fluid, there was no difference between the test and control groups (Wilcoxon and Friedman, p < 0.05). **Conclusion:** The use of tetryzoline hydrochloride or aluminum chloride to impregnate the gingival displacement cord did not improve the quantity of vertical gingival displacement and did not reduce the amount of crevicular fluid.

Descriptors: Gingival recession; gingival crevicular fluid; gingiva.

INTRODUCTION

Taking the impression of a tooth that has been worn to receive a prosthetic crown requires high level of detailed reproduction. The model obtained by means of this procedure allows the technician to construct prosthetic crowns, facets, contact lenses and onlay / inlay restorations in the laboratory[1]. This step can frequently be difficult to perform, because the position of the gingival tissue prevents the impression material from penetrating into the gingival sulcus and correctly copying the cervical terminal[2].

Most of the impression materials such as addition silicones and polyether (elastomers) have hydrophobic[3] characteristics and this is a problem when there is a large volume of crevicular fluid within the gingival sulcus during impression-taking. Therefore, in order to achieve a quality impression, it is necessary to use gingival displacement methods and crevicular fluid control[1].

Both horizontal and vertical displacement of the gingival tissue must be achieved, as this is essential for obtaining an exact copy of the cervical terminal; furthermore, it is necessary to promote homeostasis of the tissues that may eventually become ulcerated[1,4].

Several methods of gingival displacement have been described in literature, among them mechanical, chemical, mechanical-chemical and surgical methods (gingival curettage and electrosurgery)[2,5]. The method most commonly used in clinical practice is the mechanical-chemical type[2], in which a substance is associated with a gingival displacement cord, for example. Chemicals for reducing the flow of crevicular fluid can be classified as astringent or hemostatic. The astringent types promote localized tissue contraction through chemical reaction with proteins, generating reduction in mucous secretions and bleeding. The hemostatic types are agents that reduce blood flow through the formation of clots and may stop hemorrhage[5].

Chemical agents that may, for example, be used for the mechanical-chemical method are: 0.1% or 8% racemic epinephrine; 5% or 25% aluminum chloride ($AlCl_3$); 13.3% ferric sulphate; 8% or 40% zinc chloride[4]. However, many of these chemical agents promote side effects or disadvantages to the patient and / or impression material, such as: racemic epinephrine, one of the agents that cause systemic[1] alterations, as it increases the systolic blood pressure and pulse rate[6,7]; ferric or ferrous salts may be corrosive and harmful to soft tissues, enamel and can stain the teeth[8]; zinc chloride, a caustic and chagasic substance[5], may cause damage to soft tissues and bone[8]; and $AlCl_3$, an anhydrous[5] astringent salt widely used in contemporary dentistry that has fewer adverse effects than other substances that can be used for this purpose[8]. In spite of this, $AlCl_3$ used at concentrations of over 10%[6] may cause tissue destruction and permanent gingival recession of 0.1 mm[9]. According to Tarighi, Khoroushi[8] (2014), $AlCl_3$ may interact in the polymerization process of polyvinyl siloxane-based (addition silicone) materials, however, this fact has been refuted by some authors who claim that there is no such correlation[10].

Therefore, research on gingival displacement techniques should develop methods or materials that allow correct copying of the cervical terminal. Many new substances have been tested in literature in an endeavor to find an agent capable of stagnating or reducing the amount of crevicular fluid flow and displacing the gingival tissue with minimal deleterious effects.

Bowles et al.[4], suggested the use of sympathomimetic amines capable of producing local vasoconstriction with minimal side effects. These substances are the active ingredients in various ophthalmic solutions and nasal decongestants, such as, for example, 0.05% tetryzoline hydrochloride. Additionally, according to Sábio et al.[11], the Afrin® decongestant (oxymetazoline hydrochloride) and Vislin® collyrium (tetryzoline hydrochloride) did not chemically affect the impression materials tested.

The objective of this study was to evaluate whether gingival displacement cords impregnated with chemical substances such as 0.05% tetryzoline hydrochloride or 25% $AlCl_3$ would be able to reduce crevicular flow and vertically displace a larger, statistically significant quantity of the gingival tissue, compared with a mechanical displacement method (without chemical substances).

MATERIAL AND METHOD

Patients from the dental clinic of the State University of Maringá (Brazil) participated in this study. All patients received clarifications regarding the objectives and procedures involved in the study, and signed a term of free and informed consent. The study received approval from the Research Ethics Committee on Studies with Human Beings of the university under process number 20183214.2.0000.0104.

The study was conducted with a convenience sample of patients attending the Integrated Adult Clinic of the undergraduate course in Dentistry, allocated during a period of eight months. The inclusion criteria were: men or women aged between 18 and 40 years; with good general systemic health status; good periodontal status (absence of gingivitis and periodontitis), and thick gingival biotype. Excluded from the study were: smokers; those with dental caries; abrasion; erosion; bleeding on probing; periodontal pockets; gingival recession; prosthetic posts or unsatisfactory restorations of the maxillary incisors or canines. Those who fitted the inclusion criteria – 36 patients - were invited to participate in the research, but only 10 (6 women and 4 men) signed the term of free and informed consent, and attended the scheduled procedure. The procedures were divided into two steps: Evaluation of vertical gingival displacement and the amount of fluid in the gingival sulcus.

In the first step, relative isolation of the area was performed with cotton rolls and a previously cut piece of adhesive tape (Con-tact®) was attached to the vestibular surface of teeth 13, 21 and 23, level with the gingival margin to record the initial position of the gingival tissue. The gingival displacement cords were then positioned. A size 000 (Ultrapak, Ultradent, USA) cord measuring 10 mm long was first placed in the gingival sulcus of each tooth. After this, one displacement cord No.1 (Ultrapak, Ultradent, USA) measuring 10 mm long was soaked in 0.05% tetryzoline hydrochloride (Mirabel®, Allergan Produtos Farmacêuticos LTDA, São Paulo, Brazil) for seven minutes (Group II); another was soaked in 25% aluminum chloride (Hemostop, Dentsply, Brazil) for seven minutes (Group III), and the last without contact with any type of substance (Group 1) (Figure 1). Then, in a randomized manner, each No.1

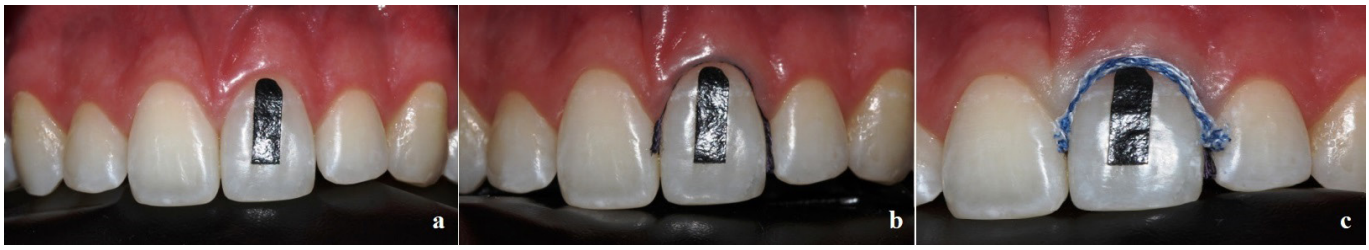

Figure 1. (a) Adhesive tape (Com-tact®) attached to vestibular surface of tooth 21; (b) Displacement cord (Ultrapak No. 000) positioned in gingival sulcus; (c) Displacement cord (Ultrapak No. 1) positioned over first cord.

displacement cord was placed on a tooth over the displacement cord No.000 (Ultrapak, Ultradent, USA).

After four minutes, the cords were removed and the area was dried with compressed air. Impressions were taken with addition silicone (3D - Angelus, Londrina, Brazil) and the impression was removed from the oral cavity after the silicone had cured. After two hours, the impression was filled with special type IV dental stone (Asfer, São Paulo, Brazil). The casts were cut into small blocks and each tooth submitted to gingival displacement was photographed using a camera coupled to a loupe (Olympus SZ-STS, Shinjuku-ku, Tokyo, Japan) (Figure 2). Thirty images were acquired and analyzed with the aid of the Image-Pro Plus program (version 4.5), which was used to measure the distance between the adhesive tape indicating the initial position of the gingival tissue up to the gingival margin after displacement. These measurements were performed by a different researcher (not the examiner). All images were acquired 24 to 48 hours after the dental stone had been cast.

In the second step, the impression from the previous procedure was used to prepare a strip of paper (Figure 3) adapted individually to the vestibular surface of teeth 13, 21 and 23 with the aim of quantifying crevicular fluid. Two identical paper strips were made for each tooth and each strip was stored in a duly labeled receptacle. With the lids open, the receptacles were placed in a hothouse at 37 °C to dry for 24 hours. After this, the receptacles were sealed and weighed using a precision scale (Mettler Toledo, model XS205, Greifensee, Switzerland).

Relative isolation was performed with cotton roles and a cheek retractor. The selected teeth were dried with compressed air and the first individualized strips of absorbent paper were inserted into the gingival sulcus to measure the amount of crevicular fluid prior to the displacement procedure. The paper strips were held in position for 60 seconds and placed in the respective receptacles. The displacement cords (Ultrapak sizes 000 and 1) were then positioned, as in the previous step, left for four minutes and removed. The teeth were dried with compressed air and the second individualized strips of absorbent paper were inserted into the gingival sulcus, held in position for 60 seconds and stored in the respective receptacles. The receptacles with the paper strips were weighed on a precision scale (Mettler Toledo, model XS205). The difference between the initial and final weight of each paper strip was determined, corresponding to the weight of the fluid expelled by the gingival sulcus and absorbed by the paper (Figure 4).

Figure 2. Model in special type IV dental stone cut into block.

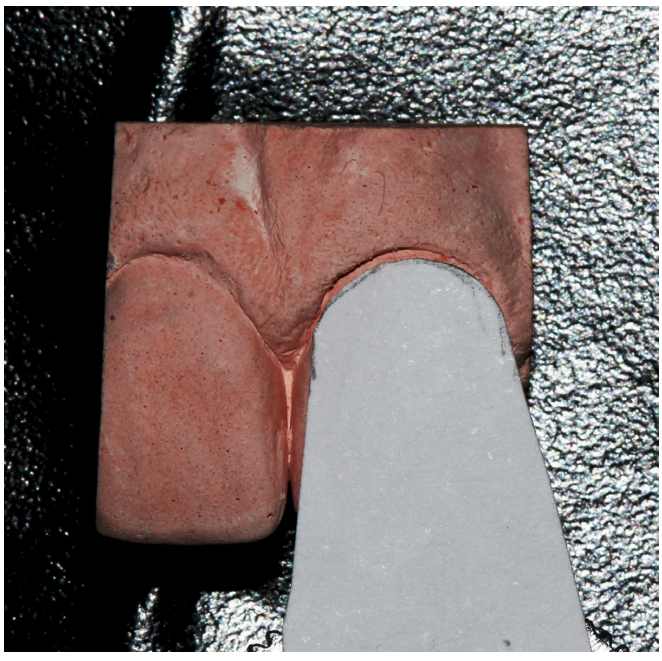

Figure 3. Confection of absorbent paper strip adapted to vestibular surface of tooth 21.

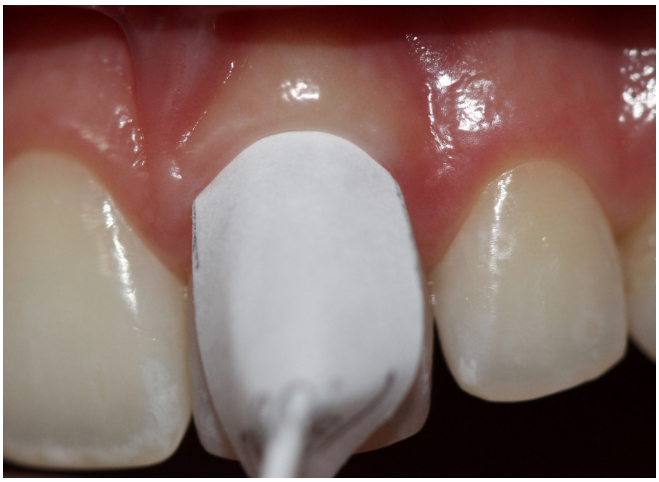

Figure 4. Strip of absorbent paper inserted into gingival sulcus.

The data were tabulated in a database and analyzed using the Statistical Package for Social Sciences (SPSS-IBM). The Shapiro-Wilk test used to test the normality of the data demonstrated nonparametric distribution. The ANOVA test was used to analyze the level of gingival displacement. The Wilcoxon test was used to analyze each group and the Friedman, for inter-group comparing the amount of crevicular fluid. The level of significance accepted was < 5%.

RESULT

The ANOVA test (Table 1) revealed no statistically significant difference among groups regarding the amount of vertical gingival displacement (p = 0.26).

In Table 2, the initial and final crevicular fluid quantity values within each group were compared by the Wilcoxon test (alfa = 0.05),

Table 1. Quantity of vertical gingival displacement (mm)

CONTROLE(I)		Tetryzoline hydrochloride(II)		Cloreto de Aluminio(III)	
Teeth	**Gingival displacement**	**Teeth**	**Gingival displacement**	**Teeth**	**Gingival displacement**
23	0.4038	13	0.4038	21	0.4230
23	0.3846	21	0.7307	13	0.4038
21	0.1923	13	0.3846	23	0.2884
13	0.3846	21	0.2692	23	0.2500
23	0.4038	21	0.1923	13	0.2211
21	0.3365	23	0.4038	13	0.2692
13	0.5769	21	0.5193	23	0.2115
23	0.4807	13	0.4038	21	0.2115
21	0.2307	23	0.1153	13	0.2692
13	0.1153	21	0.4807	23	0.3461
Mean	0.35092	Mean	0.39035	Mean	0.28938
Standard deviation	0.131	Standard deviation	0.165	Standard deviation	0.073

ANOVA test. The level of significance, p=0.26.

Table 2. Quantity of fluid in gingival sulcus before (initial) and after (final) gingival displacement process

Substance	*Control(I)*			*Tetryzoline hydrochloride (II)*			*Aluminum chloride(III)*		
	Initial (mg)	**Final (mg)**	**Difference**	**Initial (mg)**	**Final (mg)**	**Difference**	**Initial (mg)**	**Final (mg)**	**Difference**
Patient 1	1	0.7	-0.3	0.6	0.3	-0.3	0.7	0.9	0.2
Patient 2	0.4	0.2	-0.2	0.5	0.4	-0.1	0.2	0.3	0.1
Patient 3	0.6	0.9	0.3	0.4	0.7	0.3	0.6	0.8	0.2
Patient 4	0.8	0.4	-0.4	0.4	0.2	-0.2	0.6	0.4	-0.2
Patient 5	0.7	0.6	-0.1	0.6	0.4	-0.2	0.4	0.5	0.1
Patient 6	0.4	0.8	0.4	1.2	0.6	-0.6	0.7	0.3	-0.3
Patient 7	0.4	0.3	-0.1	0.7	0.5	-0.2	0.5	0.4	-0.1
Patient 8	0.4	0.4	0	0.7	0.4	-0.3	0.7	0.5	-0.2
Patient 9	0.9	0.5	-0.4	0.6	0.3	-0.3	0.7	0.6	-0.1
Patient 10	0.7	0.6	-0.1	0.5	0.3	-0.2	0.4	0.5	-0.1
Median (mg)	0.65	0.55	-0.1	0.6	0.4	-0.2	0.55	0.52	-0.1
	p-value = 0.282			**p-value = 0.039**			**p-value = 0.716**		

with a statistically significant difference only for tetryzoline hydrochloride.

The Friedman test revealed no statistically significant difference regarding the quantity of crevicular fluid between the groups I (without chemical substance) and Group II (cord impregnated with tetryzoline hydrochloride) (p = 0.92) or between Group I and Group III (cord impregnated with aluminum chloride) (p = 0.83). However, a statistically significant difference was found between Groups II and III (p = 0.037).

DISCUSSION

The elastomers used as impression materials alone do not have sufficient consistency to displace the gingival tissues. This is necessary to enable the impression material to penetrate into the gingival sulcus and overlap the cervical terminal[2]. In esthetic regions, vestibular surface and part of the proximal surfaces, the union between the crown and the cervical terminal should be camouflaged. For this purpose, the cervical terminal is positioned between 0.5 (ideal position)[2] or 1.0 mm inside the gingival sulcus. To precisely copy this tooth preparation, we must obtain a template that exposes the cervical terminal. The gingiva should be capable of being displaced between 0.6 or 1.1 mm vertically.

According to Donovan, Chee[2], Baharav et al.[12], Laufer et al.[13] and Chandra et al.[14], a horizontal width of 0.2 mm (approximately) can be obtained for the material to perform this task[2,12-14]. However, this width is maintained for a maximum of 60 seconds after removal of the cord, and later the gingival sulcus returns to its original position[14]. This is a factor that can hinder the impression-taking process, since the polymerization time of rubber-based materials, for example, can vary from 2 to 7 minutes[13]. The present study did not measure the amount of displacement obtained in the horizontal direction, however, this distance was observed to be insignificant, since neither the impression nor the plaster model showed horizontal displacement. The polymerization time of the impression material was probably longer than the recovery time and accommodation of the gingival tissue.

The amount of vertical gingival displacement obtained in this study showed mean values of 0.35 mm in Group (I) with the cord without chemical substance; 0.39 mm in Group (II) with cord impregnated with tetryzoline hydrochloride, and 0.28 mm in Group (III) with cord impregnated with $AlCl_3$; and in this situation there was no statistically significant difference between the groups. None of the methods was able to achieve gingival displacement beyond 0.5 mm, so that none of the situations tested in the present study would be able to displace a sufficient quantity of gingiva to expose the cervical terminal to a subgingival depth of 0.5 mm of a tooth prepared to receive a ceramic crown, for example.

Chaudhari et al.[15] compared three substances for gingival displacement. Two of them, by the mechanical-chemical method ($AlCl_3$ / tetryzoline) and one substance by the chemical method (Expasyl - 15% $AlCl_3$). The results showed that the gingival displacement between the $AlCl_3$ group and the tetryzoline hydrochloride group was comparable. In our study, there was no statistically significant difference in relation to gingival displacement between the two groups (II and III), nor were these groups able to provide a statistically significant gingival displacement value higher than that obtained in Group I (control).

During impression taking, other factors to consider are the hydrophobic[3] properties of the majority of impression materials, because the interior of the gingival sulcus is constantly irrigated by the crevicular fluid. In the case of inflamed gingival tissues - a frequent condition in teeth that will receive prosthetic crowns, this irrigation is more intense and may interfere in the penetration of the material during impression-taking. The gingival displacement process generally promotes changes in the microcirculation of periodontal tissues, causing inflammation and an increase in the amount of crevicular fluid production[16]. Phatale et al.[17] observed that junctional epithelium of teeth after gingival displacement with Ultrapak cord 00 impregnated with 5% $AlCl_3$ underwent major changes, such as intracellular degeneration and desquamation due to the chemical displacement methods used[17]. Therefore, the technique with gingival displacement cord, either associated with a chemical agent, or not, may damage the periodontal tissue and increase the amount of crevicular fluid[16-18]. Therefore, a sensitive technique associated with correct manipulation of the soft tissues[17] during the introduction of the gingival displacement cord can be a very important and effective factor to avoid exacerbated tissue irritations[1]. Moreover, it is important for the gingiva to be healthy and for the cervical terminal of the preparation not to be placed at exaggerated[2] depths.

The study of Wöstmann et al.[18], compared three methods of gingival displacement: namely, the mechanical-chemical (racemic epinephrine), chemical (Expasyl-15% $AlCl_3$) and mechanical (with cord only) for measuring the reduction in crevicular fluid. The cited authors observed that use of the mechanical method alone (with cotton yarn only) was not efficient for controlling the crevicular fluids; they found a greater increase in gingival fluid flow in this method. These findings were not in agreement with the results of the present study, since the mechanical method (Group I) showed no increase fluid production; furthermore, 25% $AlCl_3$ or 0.05% tetryzoline hydrochloride did not significantly reduce the crevicular fluid flow, when compared with Group I (Control). These data alone appeared to show that the mechanical barrier of the displacement cord was as capable of decreasing the crevicular fluid flow, as was the action of chemicals.

Tetryzoline hydrochloride (0.05%) (Group II) showed a higher level of crevicular fluid reduction than the results obtained with 25% $AlCl_3$ (Group III), which was statistically significant. Despite the apparent superiority of tetryzoline hydrochloride (Group II), this substance was not statistically superior to the control group (Group I) in which the gingival displacement cord was not impregnated with any chemical substance. Woody et al.[19] measured the pH values of $AlCl_3$, aluminum sulfate and ferric sulphate and found that they were extremely low, ranging from about 1.0 to about 3.1. Thus these substances may be potentially harmful to the dental structure and periodontal tissue. On the other hand, when Woody et al.[19] measured the pH of tetryzoline-based substances, they found that these chemical agents had a pH between 6.0 and 7.4 approximately[19], thus considered substances with a more acceptable pH[15,19], capable

of generating less cell damage or destruction[20]. In this situation, in spite of tetryzoline-based substances generating fewer side effects than $AlCl_3$, for example, their use would only be advantageous if they led to a reduction in crevicular fluid and/or an increase in the amount of satisfactory and significant gingival displacement obtained, thereby justifying their use.

In addition to correct impression-taking, excellent laboratory work is necessary for correct adaptation of a prosthesis to a dental preparation. Therefore the computer-assisted design and computer-assisted manufacturing (CAD/CAM) technology, such as, for example, the Cerec (Sirona), Lava (3M Espe) and Pro-cera (Nobel Biocare) systems have been increasingly used in dentistry. Even when copying the cervical terminal correctly, dentists depend on a quality dental prosthesis, and CAD/CAM may provide advantages in relation to the classical method of fabricating a prosthesis, such as efficiency (cost and time) use of materials such as Zirconia and the precision of prosthetic work, which are requisites for the longevity of a dental prosthesis[21]. Greater precision of prostheses in relation to the cervical terminal of the preparation means avoiding exaggerated marginal gaps that may generate dissolution of the cement, thereby increasing the potential of leakage, caries and periodontal disease. Moreover, this may avoid exaggerated space between the surface of the dental preparation and internal part of the crown, thereby avoiding fractures of the prosthetic part[22]. Therefore, clinical success depends on various factors, in addition to correct copying of the cervical terminal, and dentists must be alert to these at all stages during rehabilitation with dental prostheses.

Although a convenience sample was used, (which was a limitation of the study), the patients received the three types of treatment, in a randomized manner among teeth 13, 21 and 23, thus reducing the sample bias. However, the authors suggest that new clinical trials should be conducted.

CONCLUSION

Impregnating the gingival displacement cord with tetryzoline hydrochloride or $AlCl_3$ did not reduce the amount of gingival crevicular fluid produced in comparison with the gingival displacement cord without a chemical substance.

The different procedures used in the present study did not differ significantly with regard to the amount of gingival displacement. Therefore, there is no justification for the use of chemical substances during gingival displacement procedures.

REFERENCES

1. Sábio S, Correa GO, Sábio SS, Andrade HM. Utilização do cloridrato de tetrizolina para afastamento gengival em moldagens com silicona de adição. Rev Dental Press Estét. 2008 Jul-Set;5(3):45-54.
2. Donovan TE, Chee WW. Current concepts in gingival displacement. Dent Clin North Am. 2004 Apr;48(2):vi, 433-44. PMid:15172609. http://dx.doi.org/10.1016/j.cden.2003.12.012.
3. Wassell RW, Barker D, Walls AW. Crowns and other extra-coronal restorations: impression materials and technique. Br Dent J. 2002 Jun;192(12):679-84, 687-90. PMid:12125794. http://dx.doi.org/10.1038/sj.bdj.4801456.
4. Bowles WH, Tardy SJ, Vahadi A. Evaluation of new gingival retraction agents. J Dent Res. 1991 Nov;70(11):1447-9. PMid:1960257. http://dx.doi.org/10.1177/00220345910700111101.
5. Nemetz EH, Seibly W. The use of chemical agents in gingival retraction. Gen Dent. 1990 Mar-Apr;38(2):104-8. PMid:2132221.
6. Polat NT, Ozdemir AK, Turgut M. Effects of gingival retraction materials on gingival blood flow. Int J Prosthodont. 2007 Jan-Feb;20(1):57-62. PMid:17319365.
7. Donovan TE, Gandara BK, Nemetz H. Review and survey of medicaments used with gingival retraction cords. J Prosthet Dent. 1985 Apr;53(4):525-31. PMid:3889287. http://dx.doi.org/10.1016/0022-3913(85)90640-7.
8. Tarighi P, Khoroushi M. A review on common chemical hemostatic agents in restorative dentistry. Dent Res J (Isfahan). 2014 Jul-Aug;11(4):423-8. PMid:25225553.
9. Benson BW, Bomberg TJ, Hatch RA, Hoffman W Jr. Tissue displacement methods in fixed prosthodontics. J Prosthet Dent. 1986 Feb;55(2):175-81. PMid:3514852. http://dx.doi.org/10.1016/0022-3913(86)90336-7.
10. Machado CE, Guedes CG. Effects of sulfur-based hemostatic agents and gingival retraction cords handled with latex gloves on the polymerization of polyvinyl siloxane impression materials. J Appl Oral Sci. 2011 Nov-Dec;19(6):628-33. PMid:22230998. http://dx.doi.org/10.1590/S1678-77572011000600014.
11. Sábio S, Franciscone PA, Mondelli J. Effect of conventional and experimental gingival retraction solutions on the tensile strength and inhibition of polymerization of four types of impression materials. J Appl Oral Sci. 2008 Jul-Aug;16(4):280-5. PMid:19089261. http://dx.doi.org/10.1590/S1678-77572008000400010.
12. Baharav H, Laufer BZ, Langer Y, Cardash HS. The effect of displacement time on gingival crevice width. Int J Prosthodont. 1997 May-Jun;10(3):248-53. PMid:9484057.
13. Laufer BZ, Baharav H, Langer Y, Cardash HS. The closure of the gingival crevice following gingival retraction for impression making. J Oral Rehabil. 1997 Sep;24(9):629-35. PMid:9357742. http://dx.doi.org/10.1046/j.1365-2842.1997.00558.x.
14. Chandra S, Singh A, Gupta KK, Chandra C, Arora V. Effect of gingival displacement cord and cordless systems on the closure, displacement, and inflammation of the gingival crevice. J Prosthet Dent. 2016 Feb;115(2):177-82. PMid:26443067. http://dx.doi.org/10.1016/j.prosdent.2015.06.023.

15. Chaudhari J, Prajapati P, Patel J, Sethuraman R, Naveen YG. Comparative evaluation of the amount of gingival displacement produced by three different gingival retraction systems: an *in vivo* study. Contemp Clin Dent. 2015 Apr-Jun;6(2):189-95. PMid:26097353. http://dx.doi.org/10.4103/0976-237X.156043.

16. Zhulev EN, Zolotukhina EV, Saakian MI. The impact of retraction cord design on marginal gingiva status in patients with fixed dentures. Stomatologia. 2013;92(6):51-2.

17. Phatale S, Marawar PP, Byakod G, Lagdive SB, Kalburge JV. Effect of retraction materials on gingival health: A histopathological study. J Indian Soc Periodontol. 2010 Jan;14(1):35-9. PMid:20922077. http://dx.doi.org/10.4103/0972-124X.65436.

18. Wöstmann B, Rehmann P, Balkenhol M. Influence of different retraction techniques on crevicular fluid flow. Int J Prosthodont. 2008 May-Jun;21(3):215-6. PMid:18548958.

19. Woody RD, Miller A, Staffanou RS. Review of the pH of hemostatic agents used in tissue displacement. J Prosthet Dent. 1993 Aug;70(2):191-2. PMid:8371184. http://dx.doi.org/10.1016/0022-3913(93)90018-J.

20. Kopac I, Batista U, Cvetko E, Marion L. Viability of fibroblasts in cell culture after treatment with different chemical retraction agents. J Oral Rehabil. 2002 Jan;29(1):98-104. PMid:11844038. http://dx.doi.org/10.1046/j.1365-2842.2002.00790.x.

21. Karl M. *In vitro* studies on CAD/CAM restorations fabricated with Procera technology: an overview. Quintessence Int. 2015 Jul-Aug;46(7):561-74. http://dx.doi.org/10.3290/j.qi.a33937. PMid:25918760.

22. Mously HA, Finkelman M, Zandparsa R, Hirayama H. Marginal and internal adaptation of ceramic crown restorations fabricated with CAD/CAM technology and the heat-press technique. J Prosthet Dent. 2014 Aug;112(2):249-56. PMid:24795263. http://dx.doi.org/10.1016/j.prosdent.2014.03.017.

CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

*CORRESPONDING AUTHOR

Clóvis Lamartine de Moraes Melo Neto, Clínica Odontológica, UEM – Universidade Estadual de Maringá, Av. Mandacaru, 1550, Centro, 87080-000 Maringá - PR, Brasil, e-mail: lamartineclovis@gmail.com

Received: November 11, 2016
Accepted: April 28, 2017