CLINICAL

Evaluation of Effectiveness of Cement Removal From Implant-Retained Crowns Using a Proposed "Circular Crisscross" Flossing Technique

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Extruded cement during dental implant crown cementation may cause peri-implant diseases if not removed adequately. The purpose of this study was to evaluate the efficiency of removal of cement after cementation of implant crowns using an experimental circular crisscross flossing technique (CCFT) flossing technique, compared to the conventional "C"-shape flossing technique (CSFT). Twenty-four patients rendered 29 experimental and 29 control crowns. Prefabricated abutments were secured to the implant such that the margins were at least 1 mm subgingivally. The abutments were scanned using computer-aided design/computer-aided manufacturing technology and Emax crowns were fabricated in duplicates. Each crown was cemented individually and excess cement was removed using the CSFT and the CCFT techniques. After completion of cementation was completed, the screw access holes were accessed and the crown was unscrewed along with the abutment. The samples were disinfected using 70% ethanol for 10 minutes. Crowns were divided into 4 parts using a marker to facilitate measurement data collection. Vertical and horizontal measurements were made for extruded cement for each control and experimental groups by means of a digital microscope. One-hundred and seventeen measurements were made for each group. Mann–Whitney test was applied to verify statistical significance between the groups. The CCFT showed a highly statistically significant result (104.8 $\pm$ 13.66, $P < .0001$) for cement removal compared with the CSFT (291.8 $\pm$ 21.96, $P < .0001$). The vertical measurements of the extruded cement showed a median of 231.1 μm (IQR = 112.79–398.39) and 43.62 μm (IQR = 0–180.21) for the control and the experimental flossing techniques, respectively. The horizontal measurements of the extruded cement showed a median of 987.1 μm (IQR = 476.7–1,933.58) and 139.2 μm (IQR = 0–858.28) for the control and the experimental flossing techniques, respectively. The CCFT showed highly statistically significant less cement after implant crowns cementation when compared with the CSFT.

Key Words:* *flossing, implant crown, cement removal, novel cement removal technique, exesso cement

INTRODUCTION

Peri-implant diseases may occur after the successful osseointegration of endosseous implants as a result of an imbalance between bacterial load and host defense. Peri-implant disease presents in 2 forms: (1) peri-implant mucositis and (2) peri-implantitis. Peri-implant mucositis is defined as an inflamed mucosa with a bleeding index of 2 of more, having or not suppuration but without bone loss.[1] Even though currently the multifaceted etiology and clinical characteristics of peri-implantitis result in lack of consensus in its definition,[2] peri-implantitis is defined an extended inflammation from the mucosa into the implant supporting bone, which can be detected radiographically.[1]

Peri-implantitis has been reported to range from 1.4% to 53.5% for patients treated for periodontal disease.[3,4] This large range may be explained by differences in the clinical identification of peri-implantitis, sample selection, and the prevalence of maintenance care. In a meta-analysis with data from a total of 1497 participants, the frequency of peri-implantitis was 18.8% on a subject level and 9.6% on an implant level.[5] If undiagnosed, peri-implant disease may lead to complete loss of osseointegration and ultimately implant loss.[6]

Implant restorations may be screw or cement retained. Screw-retained crowns are better served when the implant alignment is favorable with the position of the crown.[7,8] If the alignment is not ideal, the prosthesis is usually cement retained in order to achieve esthetics. One of the disadvantages of cement-retained restorations is the high prevalence of residual subgingival cement.[9] The further subgingival is the restorative margin, the higher the difficulty it presents to remove the excess cement.[10]

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When comparing periodontal and peri-implant soft tissues, it is known that the peri-implant tissues are histologically different. Around teeth, the junctional epithelium and the connective tissue attachment show collagenous fibers inserted perpendicularly to the tooth root, unlike around an implant, where these fibers are positioned longitudinally, rendering a weak junction.[11] In the natural dentition, the biological and mechanical barriers tend to limit and compartmentalize the flow of excess cement subgingivally, while the peri-implant barrier does not, due to the weak connection of the peri-implant soft tissues with the implant abutment.[12]

The aim of this study is to evaluate the amount of subgingival cement present after implementing 2 different techniques to remove cement from single unit dental implant crowns. The conventional technique used was the "C" shape flossing technique (CSFT) and the experimental technique used was a "circular crisscross" flossing (CCFT) technique.

Materials and Methods

Patients

This study was approved by the University of Tennessee Health Sciences Institutional Review Board (No. 16-04590-XP). Consent forms were obtained from all the study participants.

Calibration

Only 1 provider conducted the data collection for this study. No calibration was required.

Clinical scanning for image acquisition

Vita Enamic (VITA Zahnfabrik, Bad Säckingen, Germany) crowns were fabricated using optical impression (CEREC 3; Sirona Dental Systems GmbH, Bensheim, Germany) taking, as follows:

1. Measurement of the amount of gingival tissues over the implant platform to assist in the selection of the abutment collar.
2. Measurement of the mesial–distal space for the crown in order to assist in the selection of the implant abutment.
3. Intra-oral prosthetic abutment selection where marginal was placed at least 1 mm below the gingival tissues.
4. Optical impression taking by means of Cerec 3 (Sirona Dental Systems) Omnicam.

VITA ENAMIC Crown fabrication

Fifty-eight VITA ENAMIC (VITA Zahnfabrik) blocks were used to fabricate 58 crowns for 24 patients using the CEREC 3 (Sirona Dental Systems). Each crown needed approximately 9–12 minutes for fabrication in the CEREC milling unit (CEREC MC XL; Sirona, Charlotte, NC). After fabrication, crowns were identified as control and experimental crowns by placing in separate labeled jars.

The time necessary for performance of the clinical portion of the study was be approximately 30 minutes per patient; (1) scanning (10–15 minutes) on the first visit; and, crown cementation (10–15 minutes) on the second visit. The first and second visits were standard visits already scheduled for the patient to receive his/her treatment planned crown. Therefore, no additional consultations were required for conduction of this research study. All the crowns were fabricated using computer-aided design/computer-aided manufacturing (CAD/CAM) technology (CEREC AC OMNI 3; Sirona). The technique used for crown fabrication was as follows:

1. Intraoral imaging was obtained by means of optical impressions (CEREC 3; Sirona Dental Systems), made following the manufacturer's recommendations. To prepare the optical imaging, OptraGate was placed to facilitate access to the treatment field. OptraGate is a clinical auxiliary device that retracts lips and cheeks during dental treatment. It enables a full view of the treatment field, facilitates the accessibility, and improves the moisture control in the oral cavity.
2. Standardized crowns from the CEREC database (third maxillary molar, Lee Culp Youth database; Sirona Dental Systems) were generated using ceramic blocks in the Cerec 3 CAD/CAM system (Sirona Dental Systems).

Crown cementation techniques

Control Group

The crowns were disinfected with alcohol gauze embedded with 70% alcohol for 10 minutes. The implant abutments were air dried and isolated with cotton rolls placed in the vestibule adjacent to the working site. A 4-mm length (in the diameter of the tube) of the extruded Rely-X Unicem 2 self-adhesive resin cement (3M ESPE, Seefeld, Germany) was placed around the intaglio margin of the crown and swirled around its entire diameter using an exploratory probe. The crown was positioned and the patient was asked to bite hard on top of a cotton tip applicator placed over the crown (Figure 1a through c). After the cement's initial set, the a 10-inch long waxed floss (Oral-B Essential floss, Proctor & Gamble, Cincinnati, Ohio) was passed through the mesial contact point and moved in the right-and-the left and up-and-down directions, as conducted in the "C"-shape flossing technique. The same technique was used on the distal aspect. The flossing procedure was performed for 15 seconds on each surface (mesial and distal) of the tooth. This step was for removal of excess cement sub- and supragingivally. Next, an exploratory probe was used subgingivally to remove additional excess cement.

Experimental Group

The crowns were disinfected with alcohol gauze embedded in 70% alcohol for 10 seconds. The implant abutments were dried and isolated with cotton rolls placed on the vestibule adjacent to the working site. Afterward, a 10-inch-long waxed floss (Oral-B Essential Floss) was passed through the mesial and distal contact points. A 4mm length (in the diameter of the tube) of the extruded Rely-X Unicem-2 self-adhesive resin cement (3M ESPE) was placed on the intaglio edge of the cervical aspect of the crown and swirled around its entire diameter using an exploratory probe. The crown was placed over the abutment intra-orally and the patient was asked to bite over a cotton tip applicator while the floss was crisscrossed (Figure 1d through f)

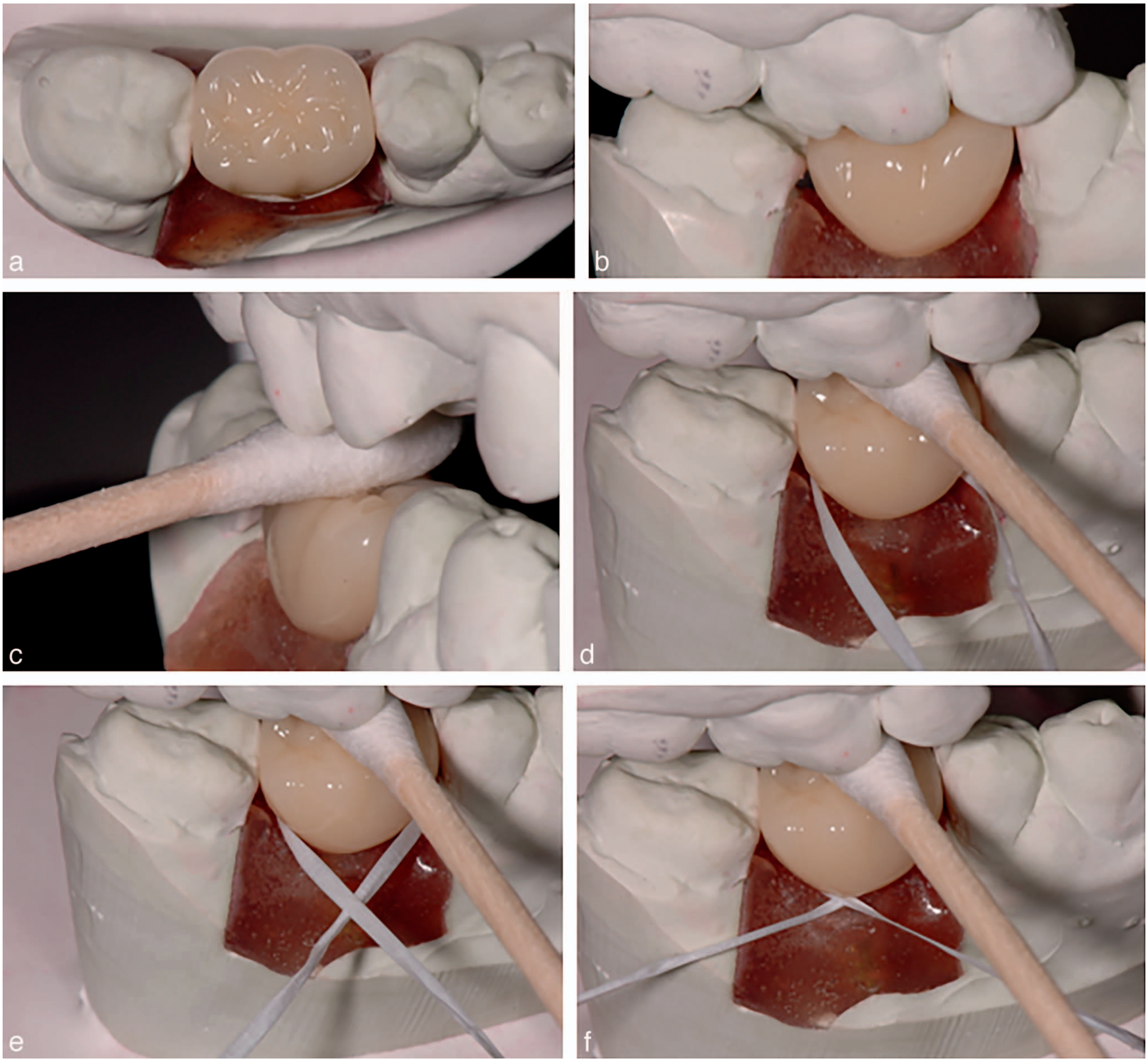


Figure 1. Experimental technique sequence: (a) Occlusal view of a Vita Enamic crown for implant #30. (b) Occlusal view of a Vita Enamic crown for implant #30. (c) Cotton applicator placed interocclusally in order to allow. (d) Thirty seconds later, the patient was asked to open his/her mouth and a dental floss was passed mesial and distally around the crown. (e) Dental floss is crossed. (f) Floss is taken subgingivally in order to remove cement using a back-and-forth movement pushing right and left hands, up and down. This allowed the crossed part of the floss to move from subgingivally to supragingivally for removal of excess cement.

mesial distally and back and forth movements were made with the floss going subgingivally as the fingers move the floss up and down into the peri-implant sulcus. As this movement is conducted, the floss is rolled into the right annular finger and the movement was repeated with the new part of the flow. Afterward, an exploratory probe was used to verify and remove any remaining excess cement.

Cold Sterilization of the Crowns

Thirty dental implant abutment crown conjugates were removed from the oral cavity, disinfected with 70% alcohol for 10 minutes.

Microscopic Measurements

After disinfection of the crowns, they were dried and divided into 4 quadrants (Figure 2a and b). Next, they were secured to the Keyence microscope (VHX Digital Multi-scan System; Keyence, Itasca, Ill) table using utility wax (Utility Wax White S 034-1880210). Each surface inside each of the established (marked) quadrants of the sample was fully inspected at ×100 magnification after aligning the prosthetic abutment crown interface at approximately 45° with the microscope lens. All the cement extruded from the interface abutment-crown were measured as to the highest vertical and horizontal extensions.

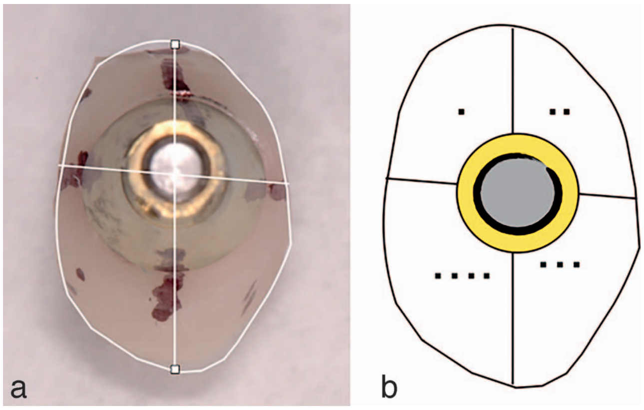


Figure 2. Prosthetic abutment diameter marking for standardization of measurements. (a) Crown division established in order to mark the areas to be read in all the surfaces. (b) Emax crown division made using permanent ink pen, which separated the crown into 4 spaces: (1) 1 dot, (2) 2 dots, (3) 3 dots, and (4) 4 dots. Markings were made at least 5 mm away from the prosthetic abutment-crown interface, in order to guide position of measurements.

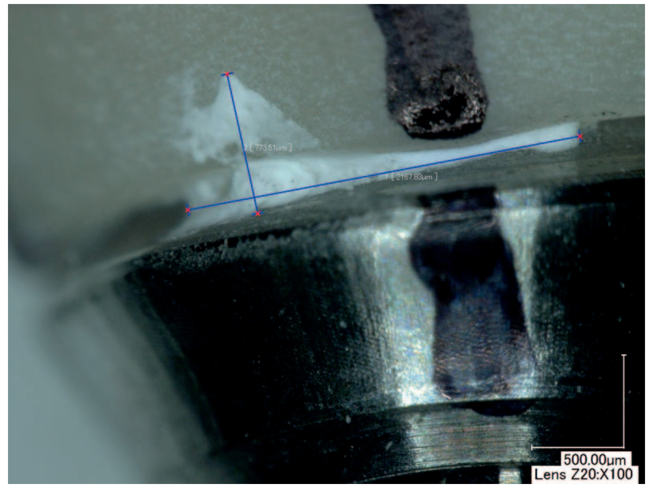


Figure 3. Image taken of the interface abutment-implant of a control implant crown by means of the Keyence microscope at ×100 magnification showing the horizontal (2167.83 μm) and vertical (773.51 μm) measurements of the extruded cement. Note black marking on mesial aspect of the crown, used to divide the crown into quadrants.

Equivalent sites that did not show presence of cement on the matching crowns were computed as zero. All measurements were tabulated for statistical analysis.

Statistical Analysis

The measurements of the extruded cement were tabulated for the experimental and control groups for the horizontal (Figure 4) and vertical (Figure 5) extensions of the extruded cement using the Keyence digital microscope. The one-way analysis of variance (ANOVA) test was used to assess normality of the data. The non-parametric Mann–Whitney statistical test was used to obtain distribution of data, which were expressed as median and interquartile range (Tables 1 and 2). The level of significance was set at $P < .05$ (SigmaPlot 13.0; Systat, San Jose, Calif) (Tables 1 and 2). Box plot data were obtained using the devtools, ggplot2, easyGgplot2, and gridExtra packages in the R statistical program (version 3.4.3, R Core Development Team, Vienna, Austria) (Figure 6a and b).

Results

Results were evaluated by an independent statistician who applied the Mann–Whitney test to verify statistical significance between the groups. The CCFT showed a statistically significant less result (104.8 ± 13.66, $P < .0001$) for cement removal compared with the CSFT (291.8 ± 21.96, $P < .0001$) (Table 2).

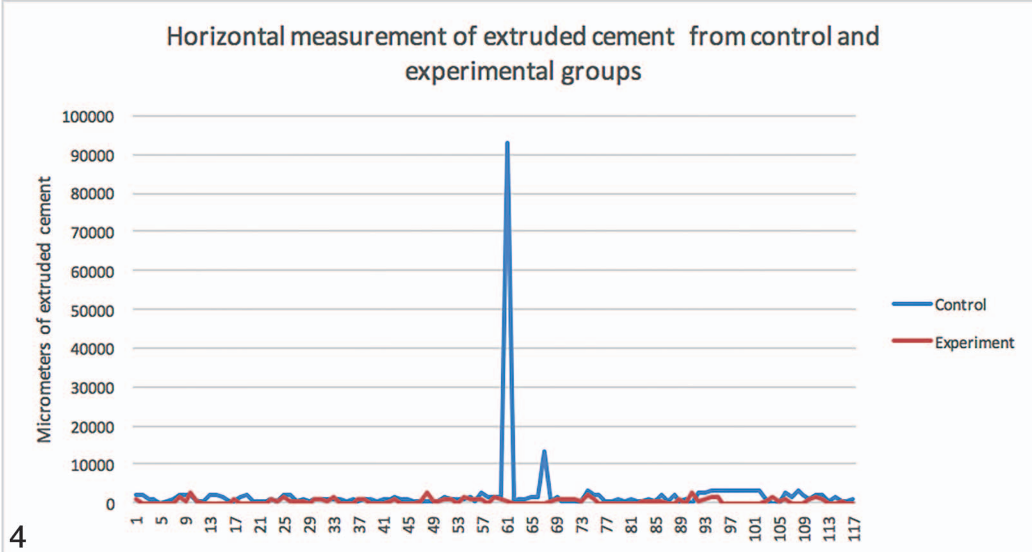
Data obtained for the vertical and horizontal measurements (μm) of the extruded cement on the crown and abutment surfaces after crown cementation and application of the control and experimental flossing techniques shown in Table 1. There is a high statistically significant difference ($P < .0001$) of more cement extruded from the CSFT group when compared to the CCFT group. The horizontal measurement of the extruded cement showed a median of 987.1 μm (IQR = 476.7–1933.58) and 139.2 μm (IQR = 0–858.28) for the CSFT and the CCCFT, respectively (Table 1).

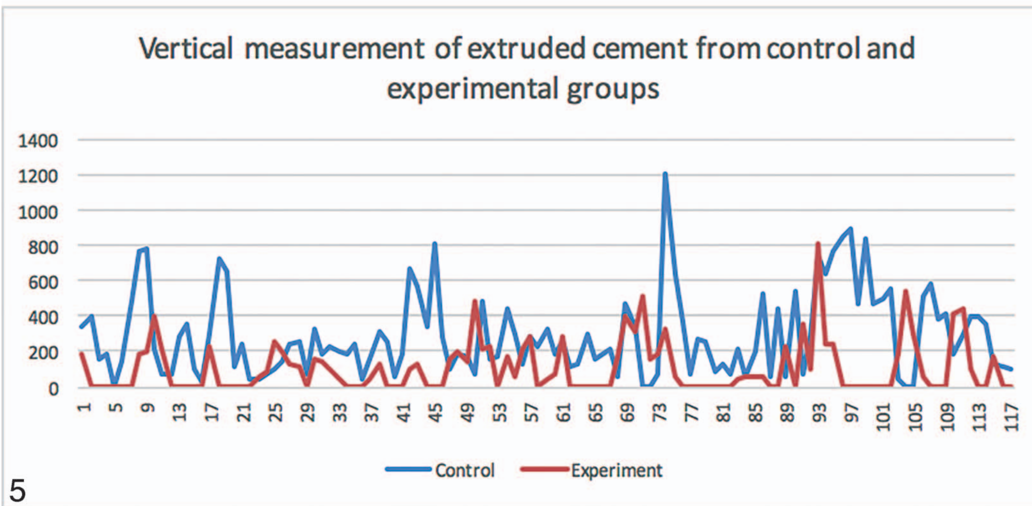
There was a highly statistically significant difference between both flossing techniques overall ($P < .0001$), with the experimental group showing more removal of cement from the crown-abutment interface when compared with the control group.

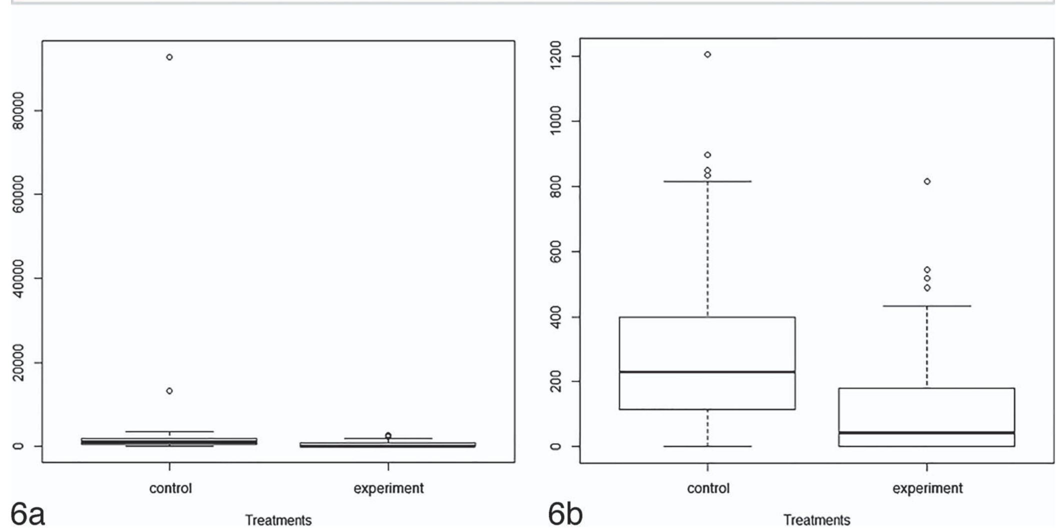
Box plots were evaluated comparing each group within the vertical and the horizontal measurements for extruded cement. The statistical commands used were from the devtools, ggplot2, easyGgplot2, and gridExtra packages of the R software (R Core Development Team) (Figure 6a and b). The vertical measurements within the control and experiment groups were less consistent when compared to the horizontal measurements within the control and experiment groups. The quartile 3 of the experiment is similar to the median of the control group in the horizontal measurements. Approximately 75% of the control group vertical measurements were higher than all of the vertical measurements of the experiment group, indicating that the control group showed superior cement extrusion in the vertical aspect when compared with the experiment group (Figure 6a). Approximately 25% of the vertical measurements of the control group were higher than the median of the experimental group. This reaffirmed that the control group showed superior cement extrusion in the vertical aspect when compared to the experiment group.

Discussion

Peri-implantitis has been reported to range from 1.4% to 53.5% for patients treated for periodontal disease.[3,4] One of the disadvantages of the cement-retained of crown is the possibility of subgingival extrusion of excess cement.[9] The further subgingival is the restorative margin, the higher is the







Figures 4–6. Figure 4. Vertical measurements of the extruded cement from the samples from each group (n = 117). Note the visually higher measurements for the control group (blue) than for the experiment group (red). **Figure 5.** Horizontal measurements of the extruded cement from the samples from each group (n = 117). Note the visually higher measurements for the control group (blue) than for the experiment group (red). Note one sample (# 61) showing a high measurement of cement (92 848 μm) when compared with the lowest measured horizontal length of extruded cement (0 μm), which was seen in both groups. **Figure 6.** (a) Boxplot for horizontal measurements of the extruded cement for the control and experiment groups. (b) Boxplot for vertical measurements of the extruded cement for the control and experiment groups using the devtools, ggplot2, easyGgplot2, and gridExtra packages of the R statistical program (version 3.4.3).

Table 1

Data with the sum of the vertical and horizontal measurements (μm) of the extruded cement on the crown and abutment surfaces after crown cementation and application of the control and experimental flossing techniques are shown

Data	Control Group	Experiment Group
Sum of the horizontal measurements	17 536*	9960*
Sum of the vertical measurements	17 614*	9882 *
Standard deviation (SD)	291 ± 21.96, n = 117	104 ± 13.66, n = 117

*Statistical significance ($P < .0001$).

difficulty of excess.[10] Histologically, the peri-implant soft tissues are less attached to the titanium fixture, due to the position of the collagenous fibers present in the connective tissues and the weak epithelial attachment, rendering a weak junction[11] for cement to flow into. Unlike the natural dentition, where cement extrusion tends to be limited and compartmentalize.[12] The present study compared vertical and horizontal lengths of the cement extruded during cementation of implant crowns after the application of a conventional "C" shape and experimental "circular crisscross" flossing techniques. Most samples had margins that were 1 mm or more below the gingival margin. A possible shortcoming of the study is not being able to control the depth of the abutment margins. These margins were at least 1mm subgingivally; therefore, there were crowns with deeper margins, which could have resulted in a less effective removal of the cement.

Wilson[9] conducted a prospective clinical endoscopic study on the positive relationship between excess cement and peri-implant diseases. He concluded that the excess dental cement was associated with signs of peri-implant disease in the majority (81%) of the cases. Clinical and endoscopic signs of peri-implant disease were absent in 74% of the test implants after the removal of excess cement. The present study shows an experimental technique to remove excess cement during delivery of the crown. The results showed an effective technique that may contribute to the reduction of subgingival excess cement, which the authors suggest may clinically reduce the percentage of implants affected with peri-implant diseases related to cement-retained rehabilitations.

Present and Levine[12] presented case reports on techniques to control or avoid cement around implant-retained restorations. Four different techniques were presented with the objective of eliminating and reducing the flow of cement subgingivally during the cementation process. The techniques were more time-consuming and some required additional laboratory modifications of the crown. However, these were case reports and they did not prove the advantage of any of the suggested techniques. The present study proposed and showed advantage of the experimental technique over the conventional technique using a digital microscopy.

This study showed a discrepant result for the horizontal extension of the extruded cement on the control group for sample #61 (Figure 5). The significant amount of extruded cement, when compared to the experimental counterpart, can be explained by the position of the implant (#14i) in the arch and the patient's limited mouth opening. However, the counterpart crown of the experimental group did not show the extensive amount of extruded cement. A possible explanation for this discrepancy between the groups is that the buccal and lingual aspects of the crown are not entirely approached during the conventional "C" shape flossing technique. Alternatively, the proposed "circular crisscross" technique showed statistically significantly less residual cement ($P < .0001$) on all aspects for all the samples studied. This technique allows the floss to reach the lingual/palatal and buccal/labial aspects of the crowns.

To our knowledge, there have been no previous reports in the literature that assessed the efficacy of the CSFT compared with the experimental CCFT in removal of cement during cementation of dental implant crowns.

Conclusion

Within the limitations of this study, the proposed experimental circular crisscross flossing technique showed statistically significantly less residual cement in the implant-abutment interface after cementation when compared with the conventional "C" shape flossing technique, according to the one-way ANOVA and Mann-Whitney statistical tests used.

Table 2

Mann–Whitney test conducted with vertical and horizontal measurements (μm) of the extruded cement for the control and experimental groups with median and interquartile range (IQR) values

	Horizontal (n = 117)		Vertical (n = 117)	
Groups	Median/SD	IQR	Median	IQR
Control	987.1*/291 ± 21.96	476.7–1933.58	231.1*/291 ± 21.96	112.79–398.39
Experimental	139.2*/104 ± 13.66	0–858.28	43.62*/104 ± 13.66	0–180.21

*Statistical significance ($P < .0001$).

Abbreviations

CAD/CAM: computer-aided design/computer-aided manufacturing
CCFT: "circular crisscross" flossing technique
CSFT: "C" shape flossing technique

Note

The authors do not have any conflict of interest.

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