ORIGINAL ARTICLE

UDC: 615.463::616.314]:616.314-089.843
DOI: https://doi.org/10.2298/VSP221110016D

The effect of different cementation techniques on the amount of remaining excess cement depending on the crown-abutment margin level

Uticaj različitih tehnika cementiranja na količinu rezidualnog cementa u zavisnosti od lokalizacije margine krunica-nosač

Aleksandar Djordjević, Jelena Todić, Sanja Simić, Dragoslav Lazić, Zoran Vlahović, Ljiljana Šubarić

University of Priština/Kosovska Mitrovica, Faculty of Medical Sciences, Department of Dentistry, Kosovska Mitrovica, Serbia

Abstract

Background/Aim. One of the disadvantages of the cement-retained fixed implant-supported restorations is the residual cement, which is found on the superstructure after the cementation procedure and has been identified as a risk factor for the occurrence of peri-implantitis. The aim of the study was to examine the influence of cementation techniques on the amount of residual cement at different levels of demarcation of the abutment in relation to the gingiva in the process of cementing restorations on implants. **Methods.** The research was conducted in *in vitro* conditions on casts obtained after implant placement. The abutments are milled at the level of the gingiva, 1.5 mm subgingivally and 3 mm subgingivally**.** Zirconium dioxide ceramic restorations were cemented using a standard cementation technique, a cementation technique using Teflon tape, and a precementation method using a silicone replica of the abutment and a 3D printed replica. The amount of residual cement was measured by photograph analysis. Adobe Photoshop was used for software analysis of photographs and determination of cement surface. Statistical data processing was performed in the SPSS program, and the Kruskal-Wallis test was used for data analysis. **Results.** A comparative analysis of the effectiveness of cementation techniques at the gingival margin level revealed a statistically significant difference in the amount of residual cement in relation to the cementation technique ($p < 0.001$). Analyzing the cementation technique effectiveness at the level of the finish line, 1.5 mm subgingivally, it was established that there was a statistically significant difference in the amount of residual cement compared to the cementation technique ($p = 0.001$). Comparing the effectiveness of cementation techniques at the 3 mm subgingival finish line level, it was established that there was a statistically significant difference in the amount of residual cement compared to the cementation technique ($p < 0.001$). **Conclusion.** Subgingival localization significantly affects the amount of residual cement in fixed prosthetic restorations on implants. Applying precementation techniques significantly reduces the amount of residual cement.

Key words:
dental cements; dental implantation; denture, partial, fixed; in vitro techniques; methods.

Apstrakt

Uvod/Cilj. Jedan od nedostataka cementom fiksiranih nadoknada na implantatima predstavlja rezidualni cement, koji se nalazi na suprastrukturi nakon postupka cementiranja i označen je kao faktor rizika od pojave periimplantitisa. Cilj rada bio je da se ispita uticaj tehnika cementiranja na količinu rezidualnog cementa na različitim nivoima demarkacije nosača (*abutment*) u odnosu na gingivu u postupku cementiranja nadoknada na implantatima. **Metode.** Istraživanje je sprovedeno u *in vitro* uslovima na radnim modelima dobijenim nakon ugradnje implantata. Nosači su frezovani u nivou gingive, subgingivalno 1.5 mm i subgingivalno 3 mm. Nadoknade od cirkonijum dioksid keramike cementirane su standardnom tehnikom cementiranja, tehnikom cementiranja upotrebom teflonske trake i metodom precementiranja, upotrebom silikonske replike nosača i 3D štampane replike. Merenje količine rezidualnog cementa vršeno je analizom fotografije. Za potrebe softverske analize fotografije i određivanja površine cementa korišćen je program *Adobe Photoshop*. Statistička obrada podataka rađena je u SPSS programu, a za analizu podataka korišćen je Kruskal-Wallis test. **Rezultati.** Uporednom analizom efikasnosti tehnika cementiranja na nivou gingivalne margine ustanovljeno je da je postojala statistički značajna razlika u količini zaostalog cementa u odnosu na tehniku cementiranja ($p < 0,001$). Analizom efikasnosti tehnika cementiranja na nivou demarkacije 1.5

Correspondence to: Aleksandar Djordjević, University of Priština/Kosovska Mitrovica, Faculty of Medical Sciences, Department of Dentistry, Anri Dinana bb, 38 220 Kosovska Mitrovica, Serbia. E-mail: sasa-91@live.com

mm, ustanovljeno je da je postojala statistički značajna razlika u količini zaostalog cementa u odnosu na tehniku cementiranja ($p = 0{,}001$). Upoređivanjem efikasnosti tehnika cementiranja na nivou demarkacije 3 mm, ustanovljeno je da je postojala statistički značajna razlika u količini zaostalog cementa u odnosu na tehniku cementiranja ($p < 0{,}001$). **Zaključak.** Subgingivalna lokalizacija značajno utiče na količinu rezidualnog cementa kod fiksnih protetskih nadoknada na implantatima. Primenom tehnika precementiranja značajno se smanjuje količina rezidualnog cementa.

Ključne reči:
stomatološki cementi; stomatološka implantacija; zubna proteza, parcijalna, fiksna; in vitro; metodi.

Introduction

Fixed implant-supported prosthetic restorations can be screw-retained or cement retained. Both have their advantages and limitations [1]. The main advantage of screw-retained restorations is retrievability, while fracturing of the screw and achieving passive fit in the construction of a larger span are more complex and represent the most common challenges [2]. As an alternative, restorations fixed by the cementing process have been presented. These restorations are similar to conventional ones; they are technically simple to make, less sensitive to errors, and allow better passive fitting of the compensation in long-span constructions [3]. Various studies have shown that the biggest disadvantage of cement restorations on implants is residual cement (excess cement) [4, 5].

The presence of residual cement can lead to biological complications in the form of peri-implant mucositis and peri-implantitis [6]. Peri-implantitis, a pathological condition affecting the peri-implant tissues, is characterized by gingival inflammation and progressive bone loss around the implant [7]. Residual cement was found in a large number of patients with clinical or radiological signs of peri-implantitis [8].

Biological variations in the attachment epithelium, collagen fibers, and the relationship of the peri-implant tissues with the implant compared to the natural tooth result in a higher degree of permeability. Differences in peri-implant soft tissue structures allow the flow of cement deep below the gingival level leading to difficulty removing it in clinical conditions [9].

Various factors affect the cement flow in the cementing process, as well as the appearance of residual cement. Some of them are the amount of cement used, the cementation technique, the design of the abutment, and the gingival emergence profile; the location of the crown-abutment margin is mentioned as an important means [10].

The localization of the crown-abutment margin can be above the gingiva, at the gingival level, or below the gingival level [11]. In order to achieve better aesthetic results in clinical conditions, most therapists opt for subgingival localization of the crown-abutment margin. Belser et al. [12] proposed subgingival localization of the crown-abutment margin at the level of 1–2 mm, while Andersson et al. [13] proposed subgingival localization of the margin in order to achieve a better emergency profile defined by the superstructure, which is still the starting point of many clinicians. In order to control the amount of residual cement, various cementation techniques have been presented. The most commonly used cementation techniques are the standard technique [14], the technique using polytetrafluoroethylene (PTFE) tape, i.e., the Teflon tape [15], and precementation techniques with an abutment replica made in different ways [16]. However, there is not enough data in the literature about which cementation technique gives the best results depending on the localization of the margin finish line. The aim of this study was to examine the effectiveness of different cementation techniques on the amount of remaining excess cement depending on the crown-abutment margin location level.

Methods

The research was conducted *in vitro* on 3D-printed casts with artificial gingiva obtained after the implants were placed in clinical conditions. Specimens were divided into three groups in relation to the margin location (equigingival, subgingival 1.5 mm, and subgingival 3 mm). In each group, five measurements were made for each tested cementation technique.

The process of placing dental implants was achieved according to a two-phase protocol (MIS Implants Technologies Ltd, Israel) (Figure 1). The procedure of taking an impression was carried out according to a digital protocol. A scan body was placed on the implant, and an intraoral scanner 3Shape (3Shape, Copenhagen K, Denmark) was used for the scanning procedure (Figure 2). Digital master casts with artificial gingival masks were printed with a 3D printer (Asiga, MaxUV, Alexandria, Australia). Abutments were placed in the working models and milled (AF350, Amann Girrbach, Austria) using a titanium burr with shoulder finish line design (Edenta®, Austria).

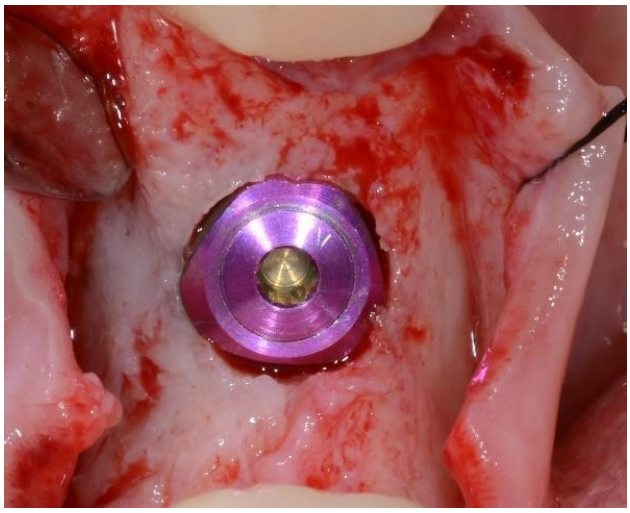

Fig. 1 – Implant placement in clinical conditions.

Fig. 2 – Intraoral digital scanning protocol.

The crowns were made with CAD/CAM technology from zirconium dioxide ceramics (SHOFU Disk ZR Lucent Supra, Shofu Dental Corporation, USA). The superstructures were designed in TRIOS Design Studio (3Shape, Copenhagen K Denmark). In the design of the superstructures, a space for cement of 50 μm was provided between the abutment and the crown. Furthermore, in the crown design process, an opening was created for access to the abutment screw, which enabled the removal of the abutment-crown sculpt from the replica after cementing for the photographing procedure. The opening was closed with a composite (GC Gradia Direct Posterior, GC Corporation, Alsip, USA) before the cementation procedure to prevent any effect on the cement flow. The restorations were finished with polishing and glazing. The standard cementation technique (ST) involved the preparation of cement according to the manufacturer's instructions. The same amount of cement (0.06 mL) was defined and applied to the crown using a 1 mL syringe. Following cement placement, the crown was settled on the abutment with moderate digital compression and controlled pressure. After setting, excess cement was removed with a probe, curette, and interdental floss (Super floss, OralB) using magnification under an operating microscope Zumax (Zumax Medical Co., Ltd UK) at ×16 magnification.

The second cementation technique, the PTFE technique, involved placing and adapting a Teflon tape under the margin of the abutment and crown junction (Figure 3). Cementation protocol and excess cement was removed according to the standard protocol (Figure 4).

Fig. 3 – Teflon tape placed to prevent cement flow.

Fig. 4 – Crown placed on abutment during cementation procedure.

The third and fourth tested techniques are precementation procedures. In the third tested cementation technique, the silicone replica technique, abutment replicas were made of silicone (polyvinyl siloxane) and used for the precementation procedure. Teflon tape is placed into the superstructures, which aims to provide space for luting material. Consequently, silicone (PD Presigum light body, Allershausen, Germany) was inserted into the crown space (Figure 5). The silicone key replica was used to extrude the cement in the precementation procedure (Figure 6).

Fig. 5 – Making a silicone replica key.

Fig. 6 – Silicone replica used for precementation procedure.

The fourth cementation technique, the digital replica technique, was also tested, where instead of silicone, an abutment replica was printed with a 3D printer (Asiga, MaxUV, Alexandria, Australia). Since the abutments were scanned for suprastructure design, the same file was used for replica printing. Printed 3D resin replicas were used for the precementation procedure (Figures 7 and 8). Zinc oxide non-eugenol cement (Temp-Bond™, Kerr Corporation, USA) was used in the cementation procedure.

The amount of residual cement was measured by photograph analysis. A Digital Single Lens Reflex (DSLR) camera (Nikon, D7200) with a macro lens (Nikon 105 mm) and softbox flashes was used for photography. On the camera, a holder designed to accept the abutment-superstructure unit was fixed. The holder was used to ensure the same distance between the camera lens and the object being photographed. After the cementation procedure, the abutment-crown assembly was removed from the model and placed on the holder for the photography procedure. Photography was performed from four directions – mesial, distal, vestibular, and oral. Adobe Photoshop (Adobe©, San Jose, California, USA) was used for software analysis of photographs and measurement of residual cement surface area (Figure 9). The resulting numerical values are summed for each photo and displayed as a unique area in pixels.

Depending on the type of variables and normal distribution, data description is description is presented with numbers, arithmetic mean ± standard deviation, median, and range (minimum–maximum). The Kruskal-Wallis test was used as a method for testing statistical hypotheses. Statistical hypotheses were tested at the level of statistical significance (alpha level) of 0.05. All data were processed in the IBM SPSS Statistics 22 (SPSS Inc., Chicago, IL, USA) software package.

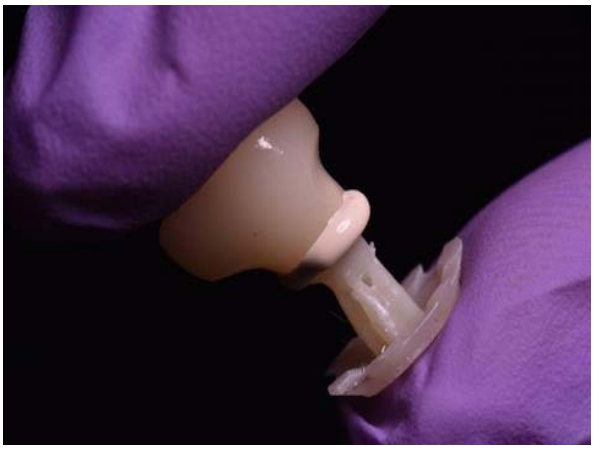

Fig. 7 – 3D-printed abutment replica used for precementation procedure.

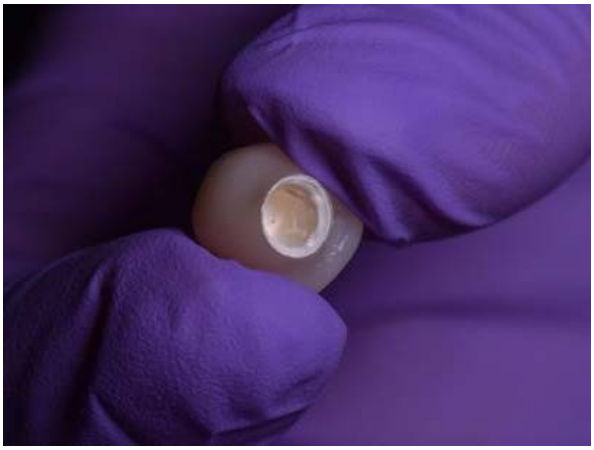

Fig. 8 – Remaining cement in the crown after the precementation procedure.

Fig. 9 – Measurement of residual cement area in software after photographing.

Results

A comparative analysis of the effectiveness of the cementation techniques at the equigingival level found that there was a statistically significant difference in the amount of residual cement compared to the cementation technique (Kruskal-Wallis = 17.857; $p < 0.001$) (Table 1).

Analyzing the effectiveness of the cementation techniques at the 1.5 mm subgingival margin position, it was established that there was a statistically significant difference in the amount of residual cement in relation to the cementation technique (Kruskal-Wallis = 17.583; $p = 0.001$) (Table 2).

A comparative analysis of the effectiveness of the cementation techniques at the 3 mm subgingival margin position revealed that there was a statistically significant difference in the amount of residual cement compared to the cementation technique (Kruskal-Wallis = 17.857; $p < 0.001$) (Table 3).

Depending on the cement margin location, there was a statistically significant difference in the amount of residual cement in all tested techniques (Kruskal-Wallis = 12,5; $p = 0.002$) (Figure 10).

Table 1

Values shown in pixels of different cementation techniques with margin at the gingival level

Cementation technique	n	mean ± SD	median	min–max
Standard	5	30787,2 ± 533,3	30456	30326–31423
Silicone replica	5	14014,0 ± 432,7	13872	13592–14597
PTFE	5	29854,4 ± 193,7	29785	29628–30129
Digital replica	5	11396,8 ± 395,6	11489	10784–11744

SD – standard deviation; min – minimum; max – maximum; PTFE – polytetrafluoroethylene i.e. Teflon tape.

Table 2

Values shown in pixels of different cementation techniques with 1.5 mm subgingival margin level

Cementation technique	n	mean ± SD	median	min–max
Standard	5	127120,8 ± 1586,7	126937	125260–129370
Silicone replica	5	15991,6 ± 98,6	16005	15836–16078
PTFE	5	123849,6 ± 1252,1	124352	122279–125321
Digital replica	5	11602,8 ± 408,0	11753	11000–11944

For abbreviations, see Table 1.

Table 3

Values in pixels of different cementation techniques with 3 mm subgingival margin level

Cementation technique	n	mean ± SD	median	min–max
Standard	5	152093,6 ± 1805,0	151670	150369–154214
Silicone replica	5	16651,8 ± 325,8	16606	16167–17012
PTFE	5	149146,2 ± 1043,1	149047	148018–150350
Digital replica	5	12200,2 ± 280,0	12123	11896–12612

For abbreviations, see Table 1.

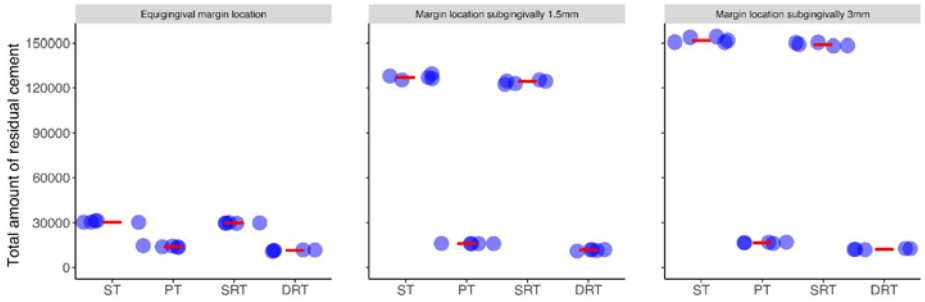

Fig. 10 – The values of residual cement amount in pixels of each individual measurement in relation to cementing technique and localization of margin location (represented by blue circles). The red line indicates the median. ST – standard technique; PT – polytetrafluoroethylene technique; SRT – silicone replica technique; DRT – digital replica technique.

Discussion

In our study, the largest amount of cement was found at the localization of a margin 3 mm below the gingival level using the ST. The results of our research are in correlation with the study of Linkevicius et al. [17], who indicate that deeper subgingival localization of the abutment-crown margin is a risk factor for remaining excess cement occurrence. The inability to remove cement from visually inaccessible places and places with more difficult access are major risk factors that can lead to residual cement occurrence [18]. The results that subgingival localization of the margin location leads to more difficult cement removal have been also confirmed in the study by Agar et al. [19]. This research also states that insisting on cement removal can lead to mechanical damage to the abutment and superstructure, which represents a point for the accumulation of dental plaque with consequent inflammation of the peri-implant soft tissues. In our research, when the localization of the abutment-crown margin was 1.5 mm subgingivally, there was a difference in relation to the position of 3 mm, but this difference was not statistically significant. Research indicates that any subgingival localization represents a potential risk of residual cement [6, 11]. In a clinical study by Wilson [8], it is stated that clinicians overestimate their ability to remove excess cement. In this study, up to 80% of the restorations had residual cement, even though the subjects were sure the excess cement had been completely removed. In our study, a statistically significantly smaller difference in the amount of cement was confirmed when the localization was at the level of the gingiva. The appearance of residual cement was present in the proximal regions due to the more difficult access because of the adjacent teeth; however, the total amount of cement differs significantly compared to other locations.

In addition to the difference in the amount of cement, it was observed, in our study, that the depth of margin location also affects the direction of cement flow. In the case of the margin positioned at 3 mm, part of the residual cement was located deep below the abutment-restoration margin, in some parts even at the junction of the abutment and the implant replica. In contrast, with a margin location at 1.5 mm below the gingival level, excess cement was retained in the space of the artificially formed sulcus in the region of the junction of the restoration, with the abutment higher in the occlusal direction.

The results of our study also show that the cementation technique plays an important role in the amount of residual cement. The highest amount of residual cement was observed with the ST. Studies by Wadhwani et al. [20] indicate that with the ST, the most important thing is the method of cement application and the amount of cement used. This research found that the majority of clinicians use significantly more cement than is really necessary, which leads to the appearance of residual cement due to the impossibility of its removal in deeply positioned margin positions.

Our research showed that the use of Teflon tape in deeply localized margins has no effect on the amount of residual cement. It was noted, however, that the placement of Teflon tape affects the direction of cement movement, preventing the flow of the cement in the direction of the implants. Furthermore, during the experiment, it was noted that using Teflon tape is more difficult to manipulate; it is time-consuming and can lead to splitting and entrapment between the crown and abutment, especially at the subgingival margin location. Similar observations were confirmed by Andrijauskas et al. [21], who compared the retraction cord and dental dam technique.

Our study showed that the amount of residual cement could be significantly reduced using a cementation technique with precementation procedures with the help of a replica abutment. Regardless of superstructure-abutment junction depth, a minimal amount of residual cement was identified. The results of our research are correlated with the study of Jagathpal et al. [16], who state in their research that the precementation procedures reduce the risk of residual cement, especially when a 3D-printed abutment replica model was used as an analog. However, there is not enough data in the literature on whether this amount of cement is sufficient for the long-term retention of the restoration and the utility value of the techniques in multi-member constructions, and further research in this direction is necessary.

Conclusion

With all limitations of *in vitro* study, it can be concluded that subgingival localization significantly affects the amount of residual cement in fixed prosthetic restorations on implants by cementing with a ST. By applying precementation techniques, the amount of residual cement can be reduced even in subgingival localizations of abutment-crown margins.

REFERENCES

1. *Wittneben JG, Joda T, Weber HP, Brägger U.* Screw retained vs. cement retained implant-supported fixed dental prosthesis. Periodontol 2000 2017; 73(1): 141–51.
2. *Lee A, Okayasu K, Wang HL.* Screw- versus cement-retained implant restorations: Current concepts. Implant Dent 2010; 19(1): 8–15.
3. *Ma S, Fenton A.* Screw- versus cement-retained implant prostheses: a systematic review of prosthodontic maintenance and complications. Int J Prosthodont 2015; 28(2): 127–45.
4. *Pesce P, Canullo L, Grusovin MG, de Bruyn H, Cosyn J, Pera P.* Systematic review of some prosthetic risk factors for periimplantitis. J Prosthet Dent 2015; 114(3): 346–50.
5. *Korsch M, Obst U, Walther W.* Cement-associated periimplantitis: a retrospective clinical observational study of fixed implant-supported restorations using a methacrylate cement. Clin Oral Implants Res 2014; 25(7): 797–802.
6. *Quaranta A, Lim ZW, Tang J, Perrotti V, Leichter J.* The Impact of Residual Subgingival Cement on Biological Complications

Around Dental Implants: A Systematic Review. Implant Dent 2017; 26(3): 465–74.
7. *Staubli N, Walter C, Schmidt JC, Weiger R, Zitzmann NU*. Excess cement and the risk of peri-implant disease - a systematic review. Clin Oral Implants Res 2017; 28(10): 1278–90.
8. *Wilson TG Jr*. The positive relationship between excess cement and peri-implant disease: a prospective clinical endoscopic study. J Periodontol 2009; 80(9): 1388–92.
9. *Korsch M, Walther W, Bartols A*. Cement-associated peri-implant mucositis. A 1-year follow-up after excess cement removal on the peri-implant tissue of dental implants. Clin Implant Dent Relat Res 2017; 19(3): 523–9.
10. *Linkevicius T*. How Abutment Margin Design Influences Cement Flow: Abutment Selection and Cement Margin Site. In: *Wadhwani C,* editor. Cementation in Dental Implantology: An Evidence-Based Guide. 2015th ed. Berlin: Springer; 2015. p. 101–12.
11. *Gehrke P, Bleuel K, Fischer C, Sader R*. Influence of margin location and luting material on the amount of undetected cement excess on CAD/CAM implant abutments and cement-retained zirconia crowns: an in-vitro study. BMC Oral Health 2019; 19(1): 111.
12. *Belser UC, Mericske-Stern R, Bernard JP, Taylor TD*. Prosthetic management of the partially dentate patient with fixed implant restorations. Clin Oral Implants Res 2000; 11(Suppl 1): 126–45.
13. *Andersson B, Odman P, Lindvall AM, Brånemark PI*. Cemented single crowns on osseointegrated implants after 5 years: results from a prospective study on CeraOne. Int J Prosthodont 1998; 11(3): 212–8.
14. *Canullo L, Cocchetto R, Marinotti F, Oltra DP, Diago MP, Loi I*. Clinical evaluation of an improved cementation technique for implant-supported restorations: a randomized controlled trial. Clin Oral Implants Res 2016; 27(12): 1492–9.
15. *Hess TA*. A technique to eliminate subgingival cement adhesion to implant abutments by using polytetrafluoroethylene tape. J Prosthet Dent 2014; 112(2): 365–8.
16. *Jagathpal AJ, Vally ZI, Sykes LM, du Toit J*. Comparison of excess cement around implant crown margins by using 3 extraoral cementation techniques. J Prosthet Dent 2021; 126(1): 95–101.
17. *Linkevicius T, Vindasiute E, Puisys A, Peciuliene V*. The influence of margin location on the amount of undetected cement excess after delivery of cement-retained implant restorations. Clin Oral Implants Res 2011; 22(12): 1379–84.
18. *Sancho-Puchades M, Crameri D, Özcan M, Sailer I, Jung RE, Hämmerle CHF,* et al. The influence of the emergence profile on the amount of undetected cement excess after delivery of cement-retained implant reconstructions. Clin Oral Implants Res 2017; 28(12): 1515–22.
19. *Agar JR, Cameron SM, Hughbanks JC, Parker MH*. Cement removal from restorations luted to titanium abutments with simulated subgingival margins. J Prosthet Dent 1997; 78(1): 43–7.
20. *Wadhwani C, Hess T, Piñeyro A, Opler R, Chung KH*. Cement application techniques in luting implant-supported crowns: a quantitative and qualitative survey. Int J Oral Maxillofac Implants 2012; 27(4): 859–64.
21. *Andrijauskas P, Zukauskas S, Alkimavicius J, Peciuliene V, Linkevicius T*. Comparing effectiveness of rubber dam and gingival displacement cord with copy abutment in reducing residual cement in cement-retained implant crowns: A crossover RCT. Clin Oral Implants Res 2021; 32(5): 549–58.

Received on November 10, 2022
Revised on February 22, 2023
Accepted on February 24, 2023
Online First March 2023