A Randomized Clinical Trial of the *in vivo* effect of non-metallic vs metallic hand scalers on zirconia implant supported crowns during a year of peri-implant maintenance

Dr. Dayna L. Roemermann DMD* | Dr. Reem Atout MS* | Dr. Igor Pesun† | Dr. Rodrigo Franca† | Dr. Anastasia Kelekis-Cholakis Dip.Perio.* | Dr. S. Renvert ‡,

*Department of Dental Diagnostic and Surgical Sciences, Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, Manitoba

†Department of Restorative Dentistry Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, Manitoba

‡Oral Health Sciences, Kristianstad University, Kristianstad, Sweden

Correspondence Dayna Roemermann, Department of Dental Diagnostic and Surgical Sciences, Rady Faculty of Health Sciences, University of Manitoba, D343–790 Bannatyne Avenue, Winnipeg, Manitoba, R3E 0W2. **Email:** umroemed@myumanitoba.ca

Word Count: 3333 | Figures: 2 | Tables: 1 | References: 28

A randomized controlled clinical trial that compared the *in vivo* effect of non-metallic vs metallic scalers on the surface of screw retained zirconia implant supported crowns in patients undergoing one year of peri-implant maintenance. In addition, peri-implant tissue health was assessed clinically and via PICF cytokine assessment.

Short running title: Comparison of non-metallic and metallic scalers on zirconia implant crowns

One sentence summary: Metallic scalers produce more alterations to the abutment/crown zirconia surface, but no statistically significant difference was found between the degree of surface alterations and the amplitude of cytokine inflammation produced.

ABSTRACT

Background: This study examined whether the degree of abutment surface modification that may occur with regular periodontal instrumentation has a clinical impact in terms of increased plaque accumulation and increased peri-implant tissue inflammation on zirconia implant abutments.

Methods: 13 patients who had zirconia implant crowns were recruited in this randomized clinical trial. Each patient acted as their own control, and had either the buccal or lingual surface of their screw retained implant restoration scaled with a metallic scaler, and the other surface with a non-metallic scaler at 3, 6, 9 and 12 months. Cytokine testing of the peri-implant crevicular fluid was completed at 0, 3 and 12 months, for IL-2, IL-4, IL-6, IL-8, IL-10, TNF-α or IFNγ. Implant crowns were removed at 12 months and evaluated under an atomic force microscope for the R_A, or average roughness, and the R_Q, or root mean square roughness, scores. The implant crowns were polished and re-inserted.

Results: There were strong significant differences in surface roughness (R_Q and Ra) between the metallic and non-metallic scalers, with average R_Q values of 417.7m (s = 276.1nm) and 233.9nm (s = 155.6nm), and R_A values of 301.0nm (s = 214.2nm) and 176.1nm (s = 123.1nm) respectively. However, there were no significant associations between the type of scaler used and the amount of clinical inflammation or cytokine production.

Conclusion: Metallic scalers produce deeper, more aggressive surface alterations to the abutment/crown zirconia surface but there was no statistically significant difference between the degree of surface alterations, amount of BOP, and the amplitude of cytokine inflammation produced.

KEY WORDS: crowns, maintenance, cytokines, hygiene,

1. INTRODUCTION

The increasing success rates of dental implants [1], has resulted in an expanding percentage of the population deciding to undergo dental implant treatment to replace missing teeth. Dental implants are a good long-term option for both fully and partially edentulous patients [2] and the success rate has been reported to be 97.5% over 5 years [3]. The projected proportion of patients with a dental implant in 2026 could be as high as 23% [4]. Biofilm accumulation around dental implants can cause peri-implant tissue inflammation, a condition known as peri-implant mucositis [5]. Clinical signs include bleeding on gentle probing, erythema, and swelling or suppuration. There may be an increase in probing depth due to a decrease in resistance to probing of the peri- implant tissues [6]. In some cases, peri-implant mucositis may progress to a more severe inflammatory condition, which involves the loss of bone around the implant fixture, known as peri-implantitis [7]. Good patient oral hygiene practices and a professional peri-implant maintenance program are very important tools in preventing the onset of peri-implant diseases [7] [8].

Titanium has been extensively used for the fabrication of implant abutments due to its strength, resistance to malformation and the opportunity to fabricate as one piece. However, titanium abutments have been shown to produce a grayish appearance of the overlying tissue. Zirconia abutments offer a more esthetic alternative, especially in esthetic cases or in patients with a thin biotype. [9]. In addition, *in vivo*, zirconia appears to be less prone to bacterial

adhesion as compared to titanium [10]. Titanium is a metal, and can often suffer corrosion, whereas zirconia is made of ceramic, and will not corrode. This could account for healthier gingival tissues around an implant [9].

Instruments used for debridement of dental implants should be efficient, be effective in removing plaque and calculus, and should refrain from causing damage to the abutment/crown surface [11]. During the cleaning of the abutment/crown surface, contact of the implant scaler with the metal surface could create a roughened surface which may, in turn, increase the propensity of bacterial accumulation, and lead to pro-inflammatory changes in the peri-implant tissues [12]. Previous *in vitro* studies have examined the degree of roughness caused to titanium surfaces following instrumentation with various scalers and ultrasonic tips. Conventional stainless steel scalers have been shown to produce a significantly higher surface roughness when compared to non-metallic and novel metallic implant scalers. Scanning electron microscope images have shown remarkable scratches on the titanium implant surface from conventional stainless steel scalers [11 - 22]. As a result of this, specific implant instrumentation was developed to eliminate surface alterations from occurring. However, the application of non-metallic scalers to the implant surface has been labelled as inadequate in removing bacteria from a roughened implant surface [16]. Metallic scalers have been shown to debride the implant surface more effectively and efficiently [17]. It is important to note that previous studies have been carried out in standardized, *in vitro* titanium discs or abutments, and the results may not be applicable to clinical situations [11 – 12, 14 - 22]. Prior studies focused on titanium discs or abutments, even with the increasing popularity of zirconium.

This study wanted investigate whether the degree of abutment surface modification that may occur with regular periodontal instrumentation has a clinical impact in terms of increased plaque accumulation and increased peri-implant tissue inflammation on zirconia implant abutments. In other words, at what point do irregularities in the abutment surface caused by peri-implant instrumentation have a direct effect on the accumulation of plaque and inflammation on the zirconium implant surface *in vivo*.

The aim of this study was to compare the effects of non-metallic hand scalers with metallic hand scalers over a one year period, and evaluate the significance on the degree of surface alterations, on the abutment/crown zirconium surface. Testing of cytokines of the peri-implant crevicular fluid was performed to determine the amplitude of inflammation.

2. MATERIALS AND METHODS

2.1 Patient Population

This randomized clinical trial was approved by the University of Manitoba's Biomedical Research Ethics Board (HS21170 (B2017:124) and registered on Clinical-Trials.gov (NCT03316937). Subjects were recruited from the Dr. Sam Borden Periodontology Clinic, Dr. Gerald Niznick College of Dentistry, University of Manitoba, Winnipeg, Manitoba. 13 subjects, 10 female and 3 males, in the age range of 21 – 78 years who had single unit screw retained implant crowns placed by the University of Manitoba Undergraduate clinic were included. Inclusion criteria were (1) good systemic health, (2) non-smokers, and (3) patients with single,

screw retained, zirconia implant supported crowns. All patients were recruited by the dental receptionist or the dental hygienist and signed an informed consent form.

2.2 Clinical procedure

The buccal and lingual surface of the 13 participants' crowns were randomly assigned, with simple randomization. The dental hygienist, using a random number table, assigned each surface to receive scaling and root planing with either a nonmetallic scaler (Hu-Friedy Implacare IL LG1/2 non-metallic scaler), or a metallic scaler (Hu-Friedy Langer 1/2 metallic curette) after implant crown delivery. The assignment of "buccal or lingual metallic scaler" was kept sealed in the patients chart, so only the dental hygienist knew which side of the patients crown received each treatment until the crowns were reinserted at 12 months. Each patient acted as their own control and received their own scaler. One patient dropped out of the study at the 6 month mark.

Patients received scaling and root planing at 3, 6, 9 and 12 months by a calibrated dental hygienist. All surfaces of the implant were debrided for 1 minute using a transversal movement. Each patient received oral hygiene instructions by the hygienist at the end of each maintenance therapy appointment. Patients were instructed to use a Modified Stillman brushing technique twice per day and cross shoe shine flossing motion once per day. Each patient was provided with a three-month home care kit with dental aids which consisted of toothpaste, a toothbrush and implant floss.

Periodontal parameters were obtained at 0, 3, 6, 9 and 12 months by a calibrated periodontal resident. Patients were seen within one week of crown placement for baseline measurements. The parameters assessed at the implant site and patient level were modified plaque index (IPI) by Mombelli, modified gingival index (IBOP) by Mombelli, implant probing depths (PD) at six sites, presence of keratinized gingiva (KT), recession (REC), Full mouth plaque index (FPI) and Full mouth bleeding on probing (FBOP).

The Peri-implant Crevicular Fluid (PICF) was collected at 0, 3, and 12 months by isolating the implant site from saliva and introducing Periopaper strips into the buccal, mesial, distal and lingual sites of the implant sulcus for 30 seconds. The strips were placed in sealed Eppendorf tubes and transported by portable freezer to the laboratory where they were stored at -86 degrees Celsius. The Periopaper samples were treated for the detection and quantification of the following cytokines: Interleukin-2, Interleukin-4, Interleukin-6, Interleukin-8, Interleukin-10, Tumor Necrosis Factor alpha and Interferon gamma.

A MDS (Rockville, Maryland, USA) V-PLEX 7-plex custom panel Human Inflammatory Cytokines Kit was used in conjunction with a MSD MULTI-SPOT 96-well 10-Spot plate for the detection and quantification of the following cytokines: Interleukin-2, Interleukin-4, Interleukin-6, Interleukin-8, Interleukin-10, Tumor Necrosis Factor alpha and Interferon gamma.

Periopaper samples were treated to extract the cytokines by incubating the Periopaper in 70µl of extraction solution for one hour on ice, followed by a brief centrifugation. 50µl of the

supernatant was added directly to the plate. A solution of PBS, 0.1% BSA and 0.05% Tween-20 was used. Data was read using a MSD SECTOR Imager 2400. Units were expressed in pg/mL. Samples that did not have any detection were written as not a number (NaN), or an undefined value.

Periapical radiographs were obtained at baseline and 12 months. All radiographs were standardized by using the long cone paralleling technique. After 12 months, the implant crown was removed, and a healing abutment was placed. The crown's surface alterations were evaluated using atomic force microscopy (AFM) using the R_A, or average roughness, and the R_Q, or root mean square roughness, scores. The implant crown surface was then re-polished and re-inserted. Crowns were evaluated before delivery to determine adequate level of smoothness.

2.3 Atomic Force Microscope

Three dimensional images were produced using Atomic Force Microscopy (AFM), by scanning a sharp tip over the sample surface. A Dimension 3100 Scanning Probe Microscope (SPM) was used. Measurements were performed by the primary investigator and an engineer. NanoScope v6.13 Software was used to calculate the R_A and R_Q, scores. Sample sizes of 10nm and 40nm were taken for the mesial, distal, buccal and lingual sides of the crown.

2.4 Statistical methods

According to the sample size calculation for mean roughness score (R_A), 7 patients in each group were required, anticipating standard deviation of 0.05µm. In total, 13 patients were recruited in the trial. The primary outcome was the amount of surface roughness created between the metallic and non-metallic scalers. Secondary outcomes were the amplitude of inflammation based on the cytokines in the sulcus surrounding the implant, changes in probing depths, plaque score and amount of bleeding on probing.

For comparing the longitudinal measures, mixed-effects regression models were used. Bleeding on probing is associated with a patient's level of inflammation, and subsequently, cytokine levels, and therefore was used as a time-varying covariate to increase the statistical power. Each regression model included the predictors of treatment, time, and their reaction. To calculate the roughness measures, paired t-tests were completed, as there were no repeated measures. PROC MIXED of SAS version 9.3 was used for the analysis ††. †† SAS Institute Inc, Cary, North Carolina, USA.

3. RESULTS

3.1 Patient characteristics

Data from 12 patients, 3 males and 9 females were available at the end of the study for analysis. One patient failed to report for her 6 month maintenance appointment for unknown reasons, and was exited from the study. No patients reported smoking or changes in medical history throughout the study. Patients were recruited from December 1st, 2018 to May 5th, 2018 and were followed up until June 20th, 2019, when the crowns were removed at the end of

the 12 month period. Each patient received the metallic and non-metallic scaler on the buccal or lingual side of their crown. Baseline demographics are the same for each patient, as each patient acted as their own control.

3.2 OUTCOMES

There were strong significant differences in surface roughness (R_Q and Ra) between the metallic and non-metallic scalers. AFM images showed relatively smooth surfaces for those treated by the IMPLACARE™ II LG1/2 scaler and rougher surfaces, with deeper, broader grooves for those treated by the Langer 1/2 curette. The non-metallic scaler produced an average R_Q value of 233.9nm (SD = 155.6 nm), whereas the metallic scaler produced an average R_Q value of 417.7nm (SD = 276.08nm). The non-metallic scaler produced an average R_A value of 176.1nm (SD = 123.05nm) and the metallic scaler produced an average R_A of 301.0nm (SD = 214.2nm) (Figure 1). There was no difference in surface roughness (Ra and R_Q). when comparing if the buccal or lingual surface was treated. This was consistent with previous *in vitro* studies on titanium discs [11].

There were no significant differences between the non-metallic scaler and metallic scaler and cytokine response (Figure 2). Even though the metallic scaler produced more extensive surface alterations, there were no noted differences between the amplitude of inflammation. There was no significant difference between the two scalers and the amount of IL-2, a cytokine that promotes T-cell maturation. However, there was a significant increase in the levels of IL-2 between 0 and 12 months ($p = 0.0135$). There was no significant difference between the two

scalers and the amount of IL-6, a cytokine involved in periodontal destruction, produced, but there was a significant decrease in the amount of IL-6 between 0 and 12 months, which had a drastic decrease at 3 months ($p = 0.0376$). There was no significant difference between the non-metallic and metallic scaler and the amount of IL-8, a cytokine involved in neutrophil chemotaxis and phagocytosis, produced, but there was a significant increase in the amount of IL-8 between 0 and 12 months ($p = <0.001$). The non-metallic and metallic scalers did not produce a change in the amount of IL-4, IL-10, TNF-α or IFNγ.

Finally, an attempt was made to keep the patients' plaque accumulation and susceptibility to plaque accumulation to a minimum. The patients mean plaque score was 38% (SD = 15%) at baseline and 43% (SD = 14%) at 12 months. Bleeding on probing averaged under 20% for the 12 months, starting at 16% (SD = 6%) at baseline, and 12% (SD = 6%) at 12 months. Patients were recalled every three months for maintenance, and oral hygiene instructions were revisited. There was an average of 4.50mm (SD = 1.73mm) (Table 1) of keratinized gingiva on the buccal surfaces of all the crowns. No patients reported any discomfort, or difficulty in brushing or maintaining the dental implants. Periapical radiographs were obtained at baseline and 12 months. Crestal bone loss within the year was within normal limits, and did not exceed 0.2mm.

4. DISCUSSION

In this randomized clinical trial, clinical outcomes from the use of two different hand scalers on implant abutment surfaces was compared. The Implacare IL LG1/2 scaler was selected for the study, as it is made of plasteel, an unfilled resin, causing minimal alterations *in vitro*. The

plasteel material is more rigid and less flexible than other plastic implant scalers. The non-telfon hand scaler, the Langer 1/2 curette, was chosen due to the fact that it is a universal curette. Cleaning an implant using a metallic hand scaler, a Langer 1/2 curette, caused more scratching and roughness of the implant abutment surface. The metallic scaler, a stainless-steel alloy, aggressively altered the surface of the metal abutment and created deeper, broader scratches, as shown by the R_A and R_Q scores. There was a strong, significant difference between the metallic scaler and the non-metallic scaler when it came to comparing the R_A, or average roughness, and the R_Q, or root mean square roughness, scores. The non-metallic scaler also produced an increase in surface alterations, however it was not as aggressive. Fakhravar et al compared metal instruments to plastic instruments, *in vitro*, on titanium abutments. They also confirmed that plastic scalers induced roughness on the abutment surfaces, but the metal scalers induced more surface damages. They credited this difference to the sharp cutting metal blade of the metal scaler. Fakhravar et al stated that the surface changes of the plastic scaler, a universal scaler from Hu Friedy, could be explained by plastic particles and debris that were left behind on the titanium abutment surface [14]. However, there were no plastic particles left behind on the zirconium abutments in our study after use with the non-metallic scaler.

Prior studies have investigated surface alterations on titanium and titanium discs. These *in vitro* studies demonstrated that the metallic hand scaler produced surface alterations, which is coincident with our study [11 - 15]. It is well known that stainless steel scalers produce more alterations to the titanium implant abutment surface, and by extension it could be extrapolated that this could make an implant surface more susceptible to plaque and calculus accumulation,

and therefore induce more inflammation. Hallmon et al compared metallic, non-metallic and sonic instrumentation on titanium abutments and also concluded that the metallic scalers produced deeper grooves, scratches and surface alterations [20]. They also concluded that surface roughening could be consistent with plaque growth rates. However, our patients were on a 3 month periodontal maintenance, and the amount of surface irregularities was not coincident with plaque growth.

The difference between past studies and the current one is that they were not *in vivo* and did not demonstrate whether surface alterations affected inflammatory indices. In this study, however, there were no significant differences that were found in the levels of cytokines IL-2, IL-4, IL-6, IL-8, IL-10, TNF-α or INFγ between the non-metallic and metallic scalers. This demonstrated that under routine 3 month maintenance, the abutment surface alterations caused by metallic scalers did not produce statistically significant increase in inflammation in the implant sulcus. Even though the metallic scaler produced deeper, broader scratches on the abutment surface, in a patient, under regular maintenance, this did not produce an increase in inflammatory cytokines. Il-6, associated with periodontal destruction and bone resorption, actually significantly decreased in the subjects from 0 to 12 months, which was seen immediately after delivery of oral hygiene instructions and dental aids, between baseline and 3 months. Systematic reviews have researched the role of cytokines to distinguish peri-implant disease, and have determined that further research is needed [26 – 28]. Ghassib et al studied Il-1ß and Il-6 and concluded that the pro-inflammatory cytokines can be used as an adjunct tool, but that there was only moderate evidence to support this [26]. A systematic review completed

by Duarte et al established that proinflammatory cytokines, such as Il-1ß, demonstrated increased levels in implants with peri-implantitis compared to healthy implants. They also determined that proinflammatory cytokines are the most promising proteins to use for biomarkers, but that there was only moderate evidence to support this and further investigation was needed [27].

Previous *in vitro* studies showed that metallic scalers debride the abutment surface more effectively and efficiently [16, 17]. Patients were instructed to use the oral hygiene aids given, and had their plaque and bleeding on probing scores monitored. The mean bleeding on probing score ranged from 16% at 0 months to 12% at 12 months and the mean plaque score was 43% (SD = 14%) at 12 months. Patients were also seen under a 3 month maintenance, and levels of inflammation were kept at a minimum around the implant abutment. Using non-metallic scalers preserved the implant abutment surface, and the implant sulcus remained healthy. However, due to the patients regular maintenance, the scratched and damaged abutment surface had minimal inflammatory effect to the implant sulcus.

Patients were treated by one hygienist, who administered the same number of strokes per side, under the same pressure, and measurements were taken by a standardized periodontal resident to attempt to eliminate bias. Even though efforts were made to increase compliance with the patients, there could have been variations in oral hygiene practices that could affect the results. Other potential limitations of this study could be the small sample size and that only two scalers were compared. Different scaler tips are made of different manufacture material,

have different shape and design, different degrees of flexibility and have variations in contact angle. However, scalers were chosen that are used frequently today in North America. Patients were seen every 3 months for maintenance in a university setting, however, this may not be realistic in private practice. Patients are often seen every 6 months, which may affect the level of inflammation. As well, in this study, patients were followed over a 12 month period. The longer term effects on the implant abutment could be more detrimental.

5. CONCLUSION

From this randomized clinical trial, it can be concluded that stainless steel, metallic scalers produce deeper, more aggressive surface alterations to the abutment/crown zirconia surface *in vivo* in zirconia abutments. However, there was no statistically significant difference between the degree of surface alterations and the amplitude of cytokine inflammation produced, while patients were on regular maintenance therapy over a year.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Trenna Reeve for coordination with the University of Manitoba Under Graduate clinic and supervising delivery and removal of implant crowns, Michelle Dyck for performing all hygiene procedures and Jose Coreas for adjusting all crowns before replacement. Funding for this study was provided by the Dr. Gerald Niznick College of Dentistry Endownmen Fund, University of Manitoba. The expanding floss was donated to our clinic by Sunstar, the toothbrushes by Tepe and the toothpaste by Colgate. The Implacare IL

LG1/2 scalers and Langer 1/2 curettes were donated by HuFreidy. These companies were not involved in the protocol design or data analysis of the trial.

***Figure 1**. Summary of results of surface alterations, R_Q and R_A, of* non-metallic *vs metallic scalers*

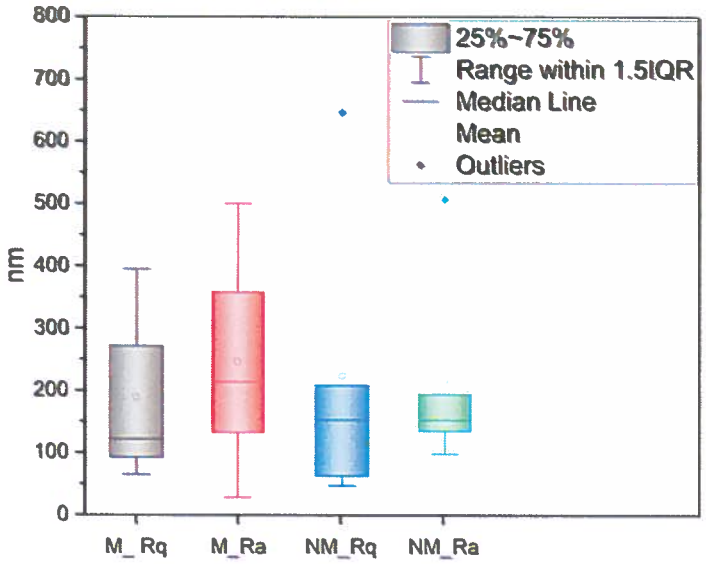

***Figure 2**. Summary of results of cytokine response, of* non-metallic *vs metallic scalers*

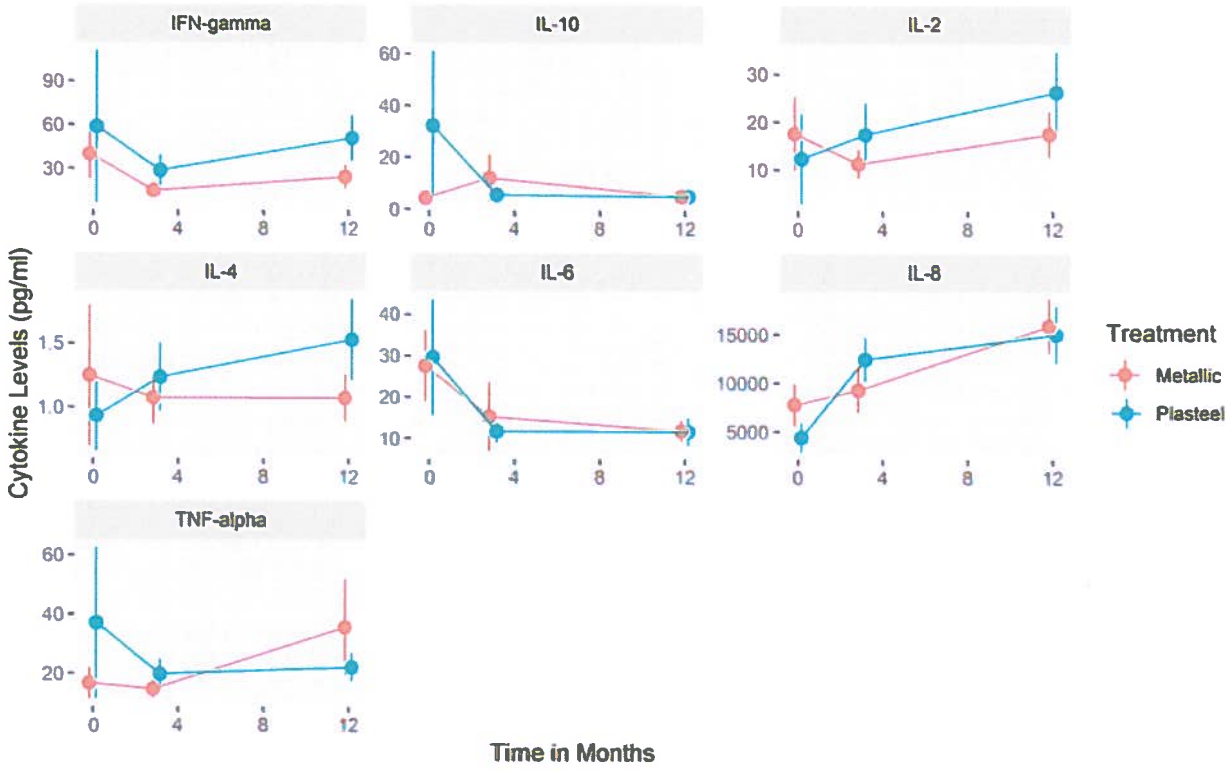

Table 1. *Average values of patients oral hygiene conditions*

Time	Full mouth mean plaque score	Full mouth mean BOP	Mean keratinized gingiva around implant
0 months	35% ± 15%	16% ± 6%	4.50 mm ± 1.73mm
3 months	49% ± 19%	16% ± 6%	4.00 mm ± 1.62mm
6 months	52% ± 18%	17% ± 8%	4.75mm ± 1.71mm
9 months	44% ± 18%	15% ± 9%	4.67mm ± 1.50mm
12 months	43% ± 14%	12% ± 6%	4.67mm ± 1.61mm

6. REFERENCES

1. Fugazzotto PA, Gulbransen HJ, Wheeler SL, Lindsay JA. The use of IMZ osseointegrated implants in partially and completely edentulous patients: success and failure rates of 2,023 implant cylinders up to 60+ months in function. The International journal of oral & maxillofacial implants. 1993;8(6):617-621
2. Lindquist LW, Carlsson GE, Jemt T. A prospective 15-year follow-up study of mandibular fixed prostheses supported by osseointegrated implants. Clinical Oral Implants Research. 1996;7(4):329-36.
3. Lindh T, Gunne J, Tillberg A, Molin M. A meta-analysis of implants in partial edentulism. Clinical Oral Implants Research. 1998;9(2):80-90
4. Elani HW, Starr JR, Da Silva JD, Gallucci GO. Trends in Dental Implant Use in the U.S., 1999-2016, and Projections to 2026. Journal of Restorative Dentistry. 2018;97(13):1424-30
5. Pontoriero, R, Tonelli MP, Carnevale G, Mombelli A, Nyman SR, Lang NP. Experimentally induced peri-implant mucositis. A clinical study in humans. Clinical Oral Implants Research. 1994;5(4):254-9
6. Berglundh T, Armitage G, et al. Peri-implant diseases and conditions: Consensus report of workgroup 4 of the 2017WorldWorkshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Periodontol. 2018;89(Suppl 1):S313–S318
7. Prathapachandran J, Suresh N. Management of peri-implantitis. Dental Research Journal. 2012;9(5):516-21

8. Lekholm U, Adell R, Lindhe J, Brånemark PI, Eriksson B, Rockler B, Lindvall AM, Yoneyama T. Marginal tissue reactions at osseointegrated titanium fixtures. (II) A cross-sectional retrospective study. International Journal of Oral and Maxillofacial Surgery. 1986;15(1):53-61
9. Linkevicius T, Vaitelis J. The effect of zirconia or titanium as abutment material on soft peri-implant tissues: a systematic review and meta-analysis. Clinical Oral Implants Research. 2015;11:139-47
10. Scarano A, Piatelli M, Caputi S, Favero GA, Piatelli A. Bacterial adhesion on commercially pure titanium and zirconium oxide disks: an in vivo human study. J Periodontol. 2004 Feb;75(2):292-6.
11. Baek SH, Shon WJ, Bae KS, Kum KY, Lee WC, Park YS. Evaluation of the safety and efficiency of novel metallic ultrasonic scaler tip on titanium surfaces. Clinical Oral Implants Research. 2011;23(11):1269-74
12. Mann, M, Parmar D, Walmsley AD, Lea SC. Effect of plastic-covered ultrasonic scalers on titanium implant surfaces. Clinical Oral Implants Research. 2012;23(1):76-82
13. Cha JK, Paeng K, Jung UW, Choi SH, Sanz M, Sanz-Martín I. The effect of five mechanical instrumentation protocols on implant surface topography and roughness. A scanning electron microscope and confocal laser scanning microscope analysis. Clinical Oral Implants Research. 2019
14. Fakhravar B, Khocht A, Jefferies SR, Suzuki JB. Probing and Scaling Instrumentation on Implant Abutment Surfaces. Implant Dentistry. 2012;21(4):311-6

15. Park JB, Kim N, Ko Y. Effects of Ultrasonic Scaler Tips and Toothbrush on Titanium Disc Surfaces Evaluated With Confocal Microscopy. Journal of Craniofacial Surgery. 2012;23(5):1552-8

16. Unursaikhan O, Lee JS, Cha JK, et al. Comparative evaluation of roughness of titanium surfaces treated by different hygiene instruments. Journal of Periodontal and Implant Science. 2012;42(3):88-94

17. Kawashima H, Sato S, Kishida M, Yagi H, Matsumoto K, Ito K. Treatment of Titanium Dental Implants With Three Piezoelectric Ultrasonic Scalers: An In Vivo Study. Journal of Periodontology. 2007;78(9):1689-94

18. Sato S, Kishida M, and Ito K. The Comparative Effect of Ultrasonic Scalers on Titanium Surfaces: An In Vitro Study. Journal of Periodontology. 2004;75(9):1269-73.

19. Augthun M, Tinschert J, Huber A. In Vitro Studies on the Effect of Cleaning Methods on Different Implant Surfaces. Journal of Periodontology. 1998;69(8):857-64.

20. Hallmon WW, Waldrop TC, Meffert RM, Wade BW. A comparative study of the effects of metallic, nonmetallic, and sonic instrumentation on titanium abutment surfaces. Implant Dentistry. 1996;11(1):96-100

21. Brookshire FV, Nagy WW, Dhuru VB, Ziebert GJ, Chada S. The qualitative effects of various types of hygiene instrumentation on commercially pure titanium and titanium alloy implant abutments: an in vitro and scanning electron microscope study. The Journal of Prosthetic Dentistry. 1997;78(3):286-94

22. Homiak AW, Cook PA, Deboer J. Effect of hygiene instrumentation on titanium abutments: A scanning electron microscopy study. The Journal of Prosthetic Dentistry. 1992;67(3):364-9

23. Speelman JA, Collaert B, Klinge B. Evaluation of different methods to clean titanium abutments. A scanning electron microscopic study. Clinical Oral Implants Research. 1992; 3(3):120-7.

24. Seol HY, Heo SJ, Koak JY, Kim SK, Baek SH, Lee SY. Surface alterations of several dental materials by a novel ultrasonic scaler tip. The International journal of oral & maxillofacial implants. 2012; 27(4):801-10

25. Linkevicius T, Vaitelis J. The effect of zirconia or titanium as abutment material on soft peri-implant tissues: a systematic review and meta-analysis. Clinical Oral Implants Research. 2015; 26(11):139-47

26. Ghassib I, Chen Z, Zhu J, Wang HL. Use of Il-1ß, Il-6, TNF-α and MMP-8 biomarkers to distinguish peri-implant diseases: A systematic review and meta-analysis. Clinical Implant Dentistry and Related Research. 2019; 21(1):190-207

27. Duarte PM, Serrão CR, Miranda TS, Zanatta LC, Bastos MF, Faveri M, Figueiredo LC, Feres M. Could cytokine levels in the peri-implant crevicular fluid be used to distinguish between healthy implants and implants with peri-implantitis? A systematic review. Journal of Periodontal Research. 2016; 51(6):689-698

28. Faot F, Nascimento GG, Bielemann AM, Campão TD, Leite FR, Quirynen M. Can peri-implant crevicular fluid assist in the diagnosis of peri-implantitis? A systematic review and meta-analysis. J Periodontol. 2015; 86(5):631-45.