INFLUENCE OF DIFFERENT PERIODONTAL THERAPEUTIC PROTOCOLS ON CEMENTUM THICKNESS

Mihajlo Petrovski
Faculty of medical sciences, Goce Delcev University, Republic of N. Macedonia,
mihajlo.petrovski@ugd.edu.mk
Ana Minovska
Faculty of medical sciences, Goce Delcev University, Republic of N. Macedonia,
ana.minovska@ugd.edu.mk

Abstract: The main goal of periodontal therapy is to eliminate the infection and achieve healthy periodontal enviroment by removing bacterial deposits of dental plaque, dental calculus and the presence of subgingival concrements and endotoxins from the root surface. The ultimate goal of all periodontal procedures is to make the treated root surface biologically compatible with the host's periodontal tissues and to enable proper healing of the periodontium. During the initial periodontal treatment, mechanical debridement is performed on the periodontally compromised root surface to eliminate all calcified deposits (supra- and subgingival concrements), as well as bacteria and their cement endotoxins to restore the biological compatibility of the root to the disease. Thorough mechanical debridement of the root surfaces allows fibroblasts to attach to previously pathologically affected or non-affected areas of the tooth roots. This procedure is a significant prerequisite for proper regeneration of lost periodontal tissues. There are two basic therapeutic modalities in periodontology - conventional and laser-assisted therapy. Conventional therapy involves ultrasound instrumentation followed by mechanical debridement. Laser-assisted therapy involves laser treatment preceded by ultrasound instrumentation. Based on these facts, the main goal of this research was to determine the thickness of the remaining cement after performing different types of periodontal therapy procedures (ultrasound instrumentation, conventional therapy or laser-assisted periodontal therapy). For the realization of the main goal, a randomized controlled in vitro study was conducted. The examined sample included a total of 100 teeth that had an indication for extraction. The patients from whom the examined sample originated - extracted teeth - were older than 35 years. All extracted teeth that are part of the sample confirm the diagnosis - stage III and IV of periodontal disease according to the new classification framework of periodontal diseases from 2018. All research samples were divided into five groups of 20 teeth, according to which of the performed therapeutic procedures was applied. The basic division included the following groups: (I) samples treated with ultrasound instruments; (II) samples treated with ultrasound instruments and Gracey's curettes or conventional periodontal therapy; (III) samples treated with laser-assisted treatment using LiteTouch Er: YAG laser; (IV) samples from parodontal diseassed teeth and (V) control group: impacted teeth that have an indication for extraction or teeth that are extracted for non-periodontal cause (occlusal trauma, orthodontic therapy or prosthetic cause). With the SEM analysis of each of the examined surfaces, the thickness of cement was determined. Before the analysis of the samples with the help of SEM, an efficient procedure for dehydration and drying was performed in order to avoid the formation of artifacts that could distort the quality of the obtained microphotographs. After the analysis, it was noticed that the average thickness of the remaining cement after the performed therapy only with ultrasonic instrumentation was 146.0324 ± 13.42917 micrometers. The average thickness of the remaining cement after conventional periodontal therapy was the lowest and was 103.3144 ± 13.52161 micrometers. Finally, the thickness of the remaining cement after laser-assisted periodontal therapy in this study was 123.0332 ± 15.83445 micrometers. The result of SEM evaluation revealed a significant ($P < 0.001$) decrease in the thickness of cementum layer on the diseased root surfaces compared to the healthy surfaces. Based on the results of this study, we can conclude that during periodontal disease there is a significant reduction in the thickness of the cement in relation to the healthy tooth. Regarding the therapeutic modalities, it can be concluded that in conventional periodontal therapy there is a greatest loss of tooth cement. Also, it can be noted that the most appropriate therapeutic modality for periodontal disease is laser-assisted therapy in which there is no significant loss of cement.

Keywords: acellular extrinsic fibrilar cement; ER: YAG laser, periodontal therapy, laser assisted pocket debridement, cement thickness.

1. INTRODUCTION

During the complex pathogenetic activities caused by periodontal disease, the tooth root surface undergoes a numerous changes in physical and chemical structure, but also becomes cytotoxic due to the release of bacterial toxins that are embedded in the cementum of the tooth root. According to this, it is neccessary for therapeutic methods to focus on activities that result in their elimination. One of the most challenging aspects of periodontal therapy is the choice of a predictable approach for root surface modification primarily due to the fact that the biofilm influence negativly on the possibilities for regeneration and needs to be removed in toto.

A significant step towards successful periodontal regeneration can be achieved if the surface layer of cement is minimally removed, as the ultimate goal of all root scaling and planing procedures is to make the treated root surface biologically compatible with the periodontal tissues of the host. (Eschler & Rapley, 1991) Modern research in periodontal science is predominantly focused on the regeneration of acellular extrinsic fiber cementum due to its location.

The main goal of periodontal therapy is to eliminate the infection and achieve healthy periodontal enviroment by removing bacterial deposits of dental plaque, dental calculus and the presence of subgingival concrements and endotoxins from the root surface. The ultimate goal of all tooth root treatment procedures is to make the treated root surface biologically compatible with the host's periodontal tissues and to enable proper healing of the periodontium.

During the initial periodontal treatment, mechanical debridement is performed on the periodontal compromised root surface to eliminate all calcified deposits (supra- and subgingival concrements), as well as bacteria and their endotoxins to restore the biological compatibility of the root to the disease. Scientific data published in the past opossed about that the presence of an adequate amount of residual healthy and solid cement after mechanical treatment should be beneficial for the healing of periodontal wounds, especially in terms of tissue attachment and regeneration. (Lindskog et al, 1987)

Manual root scaling and planing are difficult procedures during non-surgical periodontal therapy. Therefore, more and more attention is targeted towards various instruments and devices that will increase the effectiveness of periodontal therapy. Ultrasound and rotating instruments can be used safely and effectively for debridement of periodontal diseased root surfaces, although there is a high risk of tissue damage if not used properly.

After complete removal of the concrements and necrotic cement, removal of the pathologically altered epithelial tissue and infiltrated connective tissue (a process also known as curettage) must be performed. This part of the procedure involves the elimination of the infection and the epithelium from the soft wall of the periodontal pocket with the ultimate goal - healing of the periodontal lesion.

Mechanical debridement of the root surfaces allows fibroblasts to attach to previously pathologically affected or non-affected areas of the tooth roots. This procedure is a significant prerequisite for proper regeneration of lost periodontal tissues.

Some authorities believe that ultrasound treatment of periodontal pockets is superior to mechanical treatment with hand instruments, in contex of the smoothness of the root surfaces and in the ability to remove subgingival concrements and dental plaque. However, the success of such treatment is often compromised by the existence of deep periodontal pockets.

Hand instruments also have some advantages, such as better control of the instrument, a sense of touch with which the surface roughness can be easily recognized and a smooth surface can be obtained. There are several disadvantages such as the duration of the intervention, the need for a bigger physical force to remove the calculus, the presence of bleeding, which limits visualization and access to the treatment site, the presence of pain, lack of access to the distal regions, as well as difficulties of adequate debridman of furcations and subsequent roughness of the root surface. (Oda et al, 2004)

Compared to the use of manual instruments, ultrasonic instruments leave more contaminated cement on the tooth surface after treatment, but are still ideally supplemented with mechanical debridman using hand instruments. When ultrasound instruments are used properly, the postoperative discomfort of the patients is reduced. However, there are a disadvantages of using ultrasonic instruments, other than the release of contaminating aerosols, such as the creation of potential damage to tooth structures, the formation of micro-cracks on tooth enamel and cement or the surfaces of porcelain crowns and bridges, surface roughness, risk of obstruction in patients with cardiac pacemakers, and leaving a smear layer after treatment of periodontal pockets. (Wilson, 1958; Chen et al, 1994; Dibart et al, 2004)

In relation to the aforementioned shortcomings of both manual instruments and ultrasonic devices for periodontal debridman, their replacement with more appropriate and efficient methods has always been considered in modern dental practice. This is the place, where the application of the Er: YAG laser with different wavelengths begins to be used for removing deposits from the root surfaces. In addition to the numerous positive effects that lasers have for non-surgical treatment of periodontal disease, in addition, when lasers are used properly during periodontal therapy, they can have other benefits such as reduced bleeding, swelling and discomfort for the patient during the intervention. (Paghdiwala, 1991; Lavu et al, 2015)

Cement is a highly mineralized connective tissue that covers the tooth root and sometimes part of the crown of the tooth. Cement have many similarities to bone tissue and extends from the tip of the root to the neck of the tooth. The thickness of the cementum at the root of the tooth varies depending on the localization, so the layer of cementum is the thinnest in the cervical region, while its thickness is bigger towards the apical third. As aging the thickness of the

cement increases. As a consequence of the successive deposition of cement, there is a mineralization of part of the Sharpey fibers located next to the root. (Petrovski & Terzieva-Petrovska, 2018)
The importance of the cervical third of cement is that it contains acellular extrinsic fibrillar cement and its regeneration is considered the gold standard for periodontal regeneration (Grzesik & Narayanan, 2002).
As a consequence of the progression of periodontal disease, as it is known comes with deepening of the periodontal pocket. As the pocket deepens, there is a significant destruction of the collagen fibers that end up in the cement. This destruction leads to exposure of the cement and it becomes subject of influences of the oral environment.
According to Gupta et al. (2013), the thickness of cement in periodontal diseased roots is lower compared to the thickness of cement in healthy areas. This is expected due to the various pathogenetic destructive processes that occur on the cement. Also, when performing different therapeutic procedures, whether conventional or laser-assisted therapy, different amounts of cement are removed.
Based on these facts, the main goal of this research was to determine the thickness of the remaining cement after performing different types of periodontal therapy procedures (ultrasound instrumentation, conventional therapy and laser-assisted periodontal therapy)

2. MATERIAL AND METHOD

For the realization of the main goal, adeqaute research was conducted within the laboratory for dental scientific-research work at the Faculty of Medical Sciences and the department for electron microscopy from the AMBICON laboratory at the University "Goce Delchev" -Stip and at the Center for Dental Health Eterna LHC- Skopje. The research covered a one-year period from March 2020 to March 2021. The examined sample included a total number of 100 teeth that had an indication for extraction. The patients from whom the examined sample originated - extracted teeth - were older than 35 years. All extracted teeth that are part of the sample was with the diagnosis - stage III and IV of periodontal disease according to the New classification framework of periodontal diseases from 2018. (Caton et al, 2018) This means that for a tooth to be part of the examined sample it is necessary to be detect clinical attachment loss of at least 5 mm, where the radiograph-determined bone loss extends apically from the middle third of the tooth root, in patients who already have lost at least 4 teeth as a result of periodontal disease, where there is a vertical bone loss of at least 3 mm. In addition to the aforementioned criteria for the intensity and complexity of periodontal disease, the extent and distribution of periodontal disease in patients was determined. In order for one tooth to be included as part of the patient sample, the disease extension that is required should be more than 30% of the remaining teeth. This is a randomized controlled in vitro study.
Before extracting the teeth, the surface of the teeth is marked with a circular ring, making a linear groove at the location of the gingival margin to mark the supra-gingival area and to mark the part of the tooth that is located subgingival and to determine the distances between the enamel-cement junction and the marked groove- which in turn indicates the present gingival recession. The second linear groove is noted up to the level of the attached epithelium after the extraction of the teeth. The distance between the two grooves represents the clinical loss of attachment.
All research samples were divided into five groups of 20 teeth, according to which of the performed therapeutic procedures was applied. The basic division included the following groups:

- Group I: Samples treated with ultrasound instruments;
- Group II: Samples treted with ultrasound instruments and Gracey's curettes or conventional periodontal therapy;
- Group III: Consisted of teeth samples in which the ultrasound instrumentation was followed by laser-assisted treatment using LiteTouch Er: YAG laser (manufacturer Sineron, Joknem-Nellit, Israel).
- Group IV: Samples from periodontal diseassed teeth
- Control group: Impacted teeth that have an indication for extraction or teeth that are for extraction for non-periodontal cause (occlusal trauma, orthodontic therapy or prosthetic cause).

The ultrasonic instrumentation was performed using a Cavitron unit with adequate water cooling and medium power. The ultrasonic instrument uses an operating frequency of 25 Hz with an average duration of 30 seconds. During the treatment, moderate pressure was applied with sliding movements on the top and lateral side of the ultrasound extension.
The manual instrumentation was performed using area-specific Gracey curretes, pair instruments 1/2, 3/4 and 5/6, (manufacturer - Hu Friedy Co., Chicago, USA), with a total number of 30 traction movements in the direction from apical to cervical. Working angle of 60-70 ° was formed and appropriate pressure was applied during the working movements. (Kishida et al, 2004)

For laser asisted periodontal therpay LiteTouch Er: YAG (Erbium-yttrium-aluminum-garnet) laser (manufactured by Sineron, Yoknem-Nellit, Israel) was used. This laser is with a wavelength of 2.94 micrometers and pulses with energy up to 0.7 Joules per pulse and power up to 8.4 watts. The laser device has a direct laser beam delivery system. The inclination of the laser tip was 10-15º in relation to the vertical axis of the tooth, which is intended to simulate the positioning of the laser tip when performing the therapeutic procedure in vivo. The instrumentation was performed in coronary to apical direction along parallel paths. The settings for the laser were as follows: hard tissue operation, chisel tip, induction irrigation level-6, power-100mJ, 15 Hz, energy density around 256 mJ / mm^2, power density about 3.85 w / mm^2, pulse width about 170 ms.
After disinfection and sterilisation, each of the teeth was crowned with high-speed carbide disk. Thus, all teeth that have been previously treated according to the therapeutic groups, samples with dimensions of 5 mm × 5 mm × 2mm were prepared from the cement of the tooth root in the subgingival area. These specimens were cut off and separated from the rest of the tooth using a high-speed carbide disk.
All examined surfaces obtained from the extracted teeth were analyzed with VEGA3 LMU Scanning Electron Microscope within the Department for scaning electron microscopy at the University "Goce Delchev" in Stip. With the SEM analysis of each of the examined surfaces, the thickness of cement was determined. Before the analysis of the samples with the help of SEM, an efficient procedure for dehydration and drying was performed in order to avoid the formation of artifacts that could distort the quality of the obtained microphotographs.

3. RESULTS

After the analysis, it was noticed that the average thickness of the remaining cement after the performed therapy only with ultrasonic instrumentation was 146.0324 ± 13.42917 micrometers with Confidence interval from 141.6319 to 150.4329 (Fig. No. 1). The average thickness of the remaining cement after conventional periodontal therapy was the lowest and was 103.3144 ± 13.52161 micrometers with Confidence interval from 98.7514 to 107.8774 (Fig. No. 2). Finally, the thickness of the remaining cement after laser-assisted periodontal therapy in this study was 123.0332 ± 15.83445 micrometers with Confidence interval from 117.058 to 128.3156(Fig. No. 3).

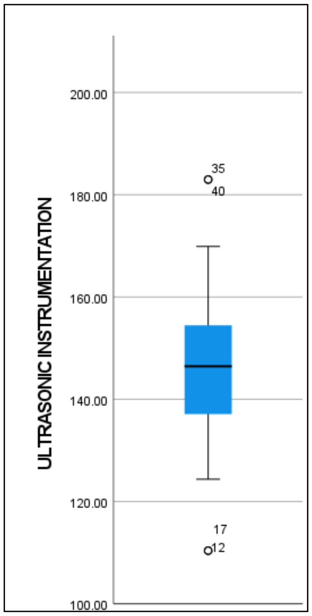

Fig. No. 1. Cementum thickness after ultrasound instrumentation

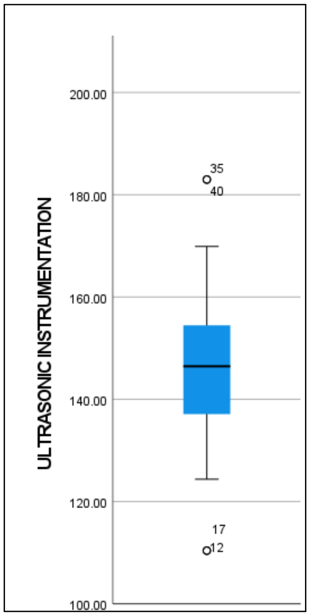

Fig. No. 2. Cementum thickness after conventional therapy

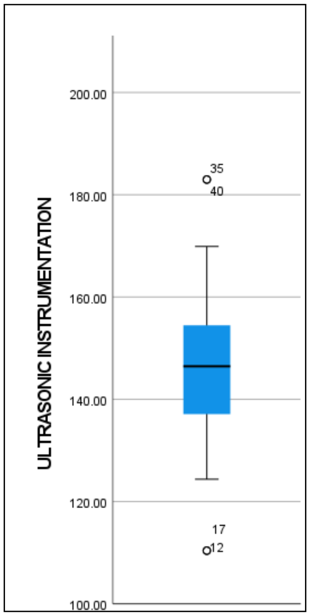

Fig. No. 3. Cementum thickness after laser assisted therapy

The result of SEM evaluation revealed a significant (P < 0.001) decrease in the thickness of cementum layer on the diseased root surfaces compared to the healthy surfaces.

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAR00004 - VAR00005	21.92640	22.67504	3.20674	15.48222	28.37058	6.838	49	.000

Fig. No. 4. Correlation of cementum thickness of heathy and periodontal disseased teeth

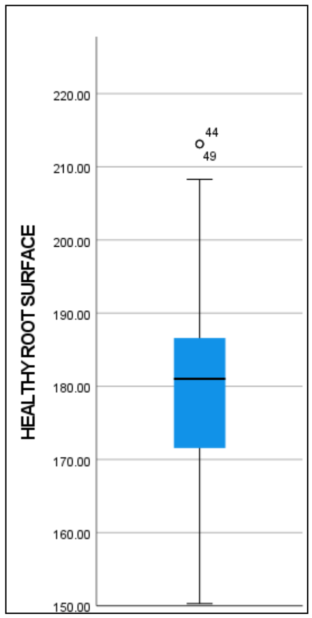

Fig. No. 5. Health cementum thickness

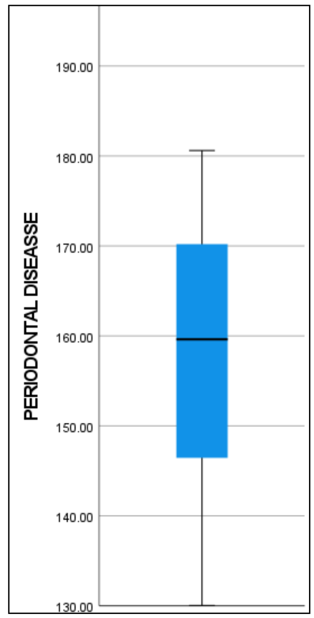

Fig. No. 6. Cementum thickness in periodontitis

4. DISCUSION

As mentioned, removal of dental plaque and calculus is an important part of the systemic treatment of periodontal disease. Only in this way the effects of microorganisms and their products on the tissues of the host can be avoided. Hence the main goal of periodontal therapy is to create a biologically acceptable root surface.

The question that inevitably arises is what does it mean to create a new biologically acceptable surface area? There is consensus about that a biologically acceptable smooth and firm root surface is a prerequisite for maintaining periodontal health in the long term. (Arora et al, 2016) Biologically acceptable root surface is the surface that will be created after the performance of therapeutic procedures and it should be basis for the re-creation of the soft-tissue attachment. This from a histological point of view means that during the periodontal treatment should be created adequate quantum of a new cellular external fibrous cement on the previously exposed root surface.

In modern dental science, a standard method for determining the aggressiveness of root calculus removal and for determining the quantity of cement that has been removed from the root surface has not yet been presented, which is why we have encountered some problems in comparing our data with various literature data. In humans, the rather thin (20 to 250 pm), densely mineralized acellular extrisic fibrillar cement shows parallel incremental lines and is found primarily on the cervical and middle root regions, but it may extend further apically. Cementum is thinner near the tooth neck, and it is about 20 to 50 microns thick, and about 150 to 200 microns thick at the root apex. (Shen & Kosmač, 2014) Acellular extrinsic fiber cementum is mainly found on cervical and middle root portions, covering 40% to 70% of the root surface.

The thickness of the cellular cementum, which may be over 100 μm, increases throughout life and may increase in response to passive eruption of the tooth due to functional attrition of its crown height.(Hughes, 2015). According to Stamfelj et al (2008) , midpoint cementum thickness ranged between 5 and 800 microns in maxillary molars and between 5 and 700 microns in mandibular molars. Maximal cementum thickness ranged between 25 and 1140 microm in maxillary molars and between 20 and 700 microm in mandibular molars.
Due to the anatomical dependency of cementum width on root location, the respective thicknees ranges from 5 to 200 μm for primary cement and from 400 μm–1 mm for secondary cement.(Jang et al, 2014) Our results is simmular to those published by Caraanza et al (2013) and to those published by Nanci and Bosshardt (2006). According to Gupta et al (2013) the cementum thickness in healthy areas was 105.38 ± 41.34 μm (55.95-133.72 μm) and in diseased areas was 104.11 ± 38.18 μm (50.58-168.50 μm).(Gupta et al, 2013) These published data is simular to our results.
As expected, when performing various therapeutic modalities in periodontology, whether performing ultrasound instrumentation, conventional or laser assisted therapy, there is a loss of cementum at the root of the tooth. The biggest loss based on the presented data is when performing conventional therapy. Ultrasonic instrumentation is characterized by the minor loss, yet the minimal amount of cement removed can cause retention of exotoxins.

5. CONCLUSSION

Based on the results of this study, we can conclude that during periodontal disease there is a significant reduction in the thickness of the cement in relation to the healthy tooth. Regarding the therapeutic modalities, it can be concluded that in conventional periodontal therapy there is a greatest loss of tooth cement. Also, it can be noted that the most appropriate therapeutic modality for periodontal disease is laser-assisted therapy in which there is no significant loss of cement.

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