An In Vitro Comparison of Air-abrasion and Drill Influence on Dentin Surface

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***Abstract*— Objectives: A water - air abrasion is one of the dentine preparation method and provides an alternative to the classic drill preparation. The examined null hypothesis was: there are no differences in geometric structure and wettability of dentin surface after water-air-abrasion and drill preparation.**

Material and methods: Twenty, for orthodontic reasons, extracted molars were selected for the study. The residual half of the same tooth were qualified into two groups: A - elaborated with the water-air sandblaster Aquacut Quattro; D – elaborated with drill. These prepared 20 sets of corresponding teeth half were subject of profilometric and wettability tests. The prepared dentin surface ware scanned with with FE SEM ULTRA plus (field emission scanning electron microscope, Carl Zeiss NTS GmbH, Germany). Obtained values of profilometric parameters Ra, Rq, Rp, Rq, Rsk, Rt, Rv and surface development were analyzed. Dentine surface wettability measuring was performed with the System See E (Advex Instruments, Czech Republic). Statistical analysis was carried out using ANOVA for repeated measures.

Results: Between group A and D we observed statistically significant differences in Rsk (skewness) parameter indicating that the valleys dominate in samples from group A, and peaks in samples from group D. The degree of development of the surface was statistically significant higher for dentin prepared with sandblasting. Samples from group D showed trend of lower wettability than samples of group A.

Conclusion: The surface of dentin after sandblasting is more-developed and this feature can positively influence the greater capacity to maintain the liquid on the surface.

***Index Terms*— air abrasion, dentine, profilometry, SEM, wettability**

I. INTRODUCTION

Air abrasion is a therapeutic method, which has the advantage of precise and largely painless preparation of cavities. Currently, air abrasion is widely used in general dentistry, orthodontics, periodontics, prosthodontics and implantology. This method is consistent with the principles of minimally invasive dentistry. It has an impact on filling retention, and gives the patient comfort by reducing the sensation of pain treatment [1],[2]. The principle of the air abrasion method is kinetic elaboration of the tooth tissue. The kinetic energy of the abrasive being carried by compressed air is used to remove the decayed tissue, the old filling, or even cleaning and surface development of non-carries lesions [3]-[5]. It seams that this method of preparation may be especially useful in preparation of cervical cavities, which usually needs precise preparation and may be painful. It should be noted that filling maintaining is difficult after preparation of such cavities with standard methods [6],[7]. Type of elaboration of any surface correspond with adhesion of the filling material [8]. It was demonstrated that the adhesion of the material to the samples prepared with methods permitting more developed surface area have superior characteristics [9]. There are large number of factors affecting the quality of the connection between the dentine and the material for the targeted reconstruction and one of them is preparation method [10]. Each of the elaboration methods leaves a surface of different structural properties. Most of the studies in this field were focused on the evaluation of one of the selected preparation techniques e.g. CMCR (chemo-mechanical caries removal), laser, air abrasion or water-air-abrasion, drill or comparison between them [11]-[16]. However there are no literature comparative study on the geometric structure of the dentine surface by setting detailed parameters as R_{ku}, R_p, R_{sk}, R_v or degree of the surface development (3D/2D). In this paper we compare average and detailed structure geometric parameters as R_a, R_q, R_t, R_{ku}, R_p, R_{sk}, R_v and degree of development of the surface (3D/2D) as well as the wettability of the dentin surface after preparation with water-air- sandblaster Aquacut Quattro versus drill. The study was carried out on samples from the same, corresponding tooth dentin.

II. MATERIAL AND METHODS

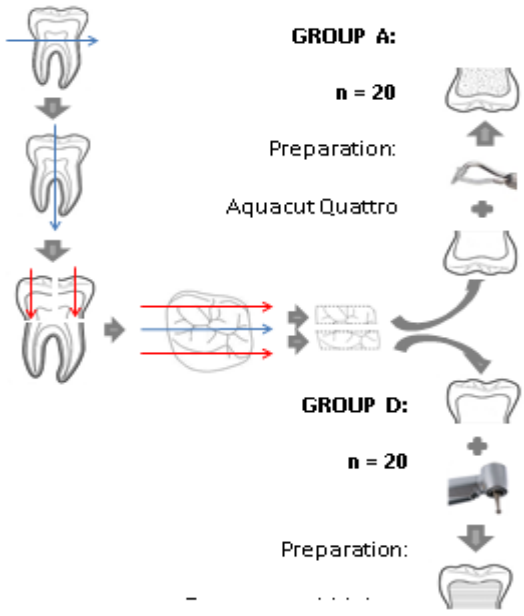

Fig. 1- Diagram of sample preparation.

The study included forty teeth, healthy permanent third human molars, extracted from patients in the age 18-25 years for orthodontic reasons. The material was analyzed by the DIAGNOdent and the twenty teeth of the same mineralization were qualified for further study. Each tooth was cut in a horizontal plane, two millimeters below the neck and subsequently cleaved mesial-distal along the long axis, so that

the resulting two samples of the same tooth. Another cut along the long axis of the tooth helped expose the dentin in the central part on the surface of the cheek and language (Fig. 1). Such residual half of the same tooth were separated into two research groups (i) A (prepared with the water-air sandblaster Aquacut Quattro) and (ii) D (prepared with drill). Thus prepared 20 samples for group A and D - 15 samples assigned for profilometric tests and 5 samples assigned for wettability tests. In order to limit the effect of histologic heterogeneity of dentin surface on profilometric measurements, studies were performed in two different dentin surface locations in each sample. Two hours before the wettability test the samples were placed in 0,9% NaCl at room temperature. Liquid droplets were applied sequentially in three different areas of the sample so as not to contact with one another. The measurements for each sample were averaged.

The prepared dentin surface ware scanned with FE SEM ULTRA plus (field emission scanning electron microscope, Carl Zeiss NTS GmbH, Germany). It gives the opportunity of three-dimensional reconstruction of the surface of the sample (3D), which was used to select the proper orientation for profilometric testing. The measurements retained constant distance of the profile and field. Profilometric measurements were performed always on the basis of images from FE SEM magnification of 500x. Samples were no mounting in resin or sputtered with gold (Au). The image analysis system was used operating Smart SEM® V05.05.

The following profilometric parameters Ra, Rq, Rp, Rq, Rsk, Rt, Rv as well as surface development (the ratio 3D/2D) were analyzed with non-parametric post hoc test for each combination of the dependent variable and independent for paired data (Wilcoxon Signed Rank Sum), adjusted for multiple testing using the patch on inflation error type I (Bonferroni adjustment) using statistical software: R for Statistical Computing (version 3.2.1). In the analysis of results, significance was pre-determined at $p < 0.05$.

The dentine surface wettability measuring of the samples prepared with drill and sandblasting were performed using a -portable computing device for measuring the contact angle and software compatible with ISO 27448: 2009 (System See E, Advex Instruments, Czech Republic). The contact angle for the dentin samples were obtained by measuring the angle between the tangent to the surface of the liquid drop (water) and the surface of the dentin sample. Statistical analysis was carried out using ANOVA (analysis of variance) for repeated measures.

III. Results

A. Profilometric measurements

Results of profilometric measurements are shown in Fig. 2. The ratio Ra (arithmetic mean elevation of the profile), Rq (root mean square elevation profile) and Rt (total height of the profile) for both tested methods of preparation were similar (p=0.8904; p=0.9780; p= 0.5995, respectively). However, significantly more spread of results in the case of the samples prepared with drill indicates that the technique is less predictable, and sandblasting leaves a more uniform surface of the predictable nature.

Information on the profile nature provide Rp parameter (height of the highest peak of the profile) and Rv (the lowest depth of the recess profile). A higher value for Rp dentin prepared with a drill shows the profiles with sharp spines. However, all previously discussed differences were not statistically significant (p=0.1876). In turn, the dentine Rv higher subjected to sandblasting shows greater capacity to hold the liquid on such surface. The difference in this parameter was statistically significant before use Bonferroni correction (p=0.0301), but after adjustment lost statistical significance (p=0.2408).

Parameter Rsk (skewness) announces the surface topography on the occurrence of valleys and highlands. Its negative value for the samples of group A indicates that the topography of dentin subjected to sandblasting dominate the valley, which is associated with a greater capacity to maintain the liquid on the surface. A positive value for the samples of group D indicates that the topography dentin crafted drill predominant peaks, pointed shape, which results in less predisposed to retain the liquid on the surface. The dependence of the skewness of the method of preparation is statistically significant (p=0.0003) even after adjustment multiple testing (p=0.0024). Predisposition to maintain liquid on the surface is of significance for example in the application of the binding, while setting fillings or restorations deposition.

Analysis of the surface development (3D/2D) showed the higher ratio for dentin prepared with sandblasting, and the difference remained statistically significant (p=0.0034) also after adjustment multiple testing (p=0.0272). The development of the surface gives the possibility of a much larger contact area of prepared dentin with a complex bonding-system-composite and to create a more extensive hybrid zone which may favorably affect the adhesion strength.

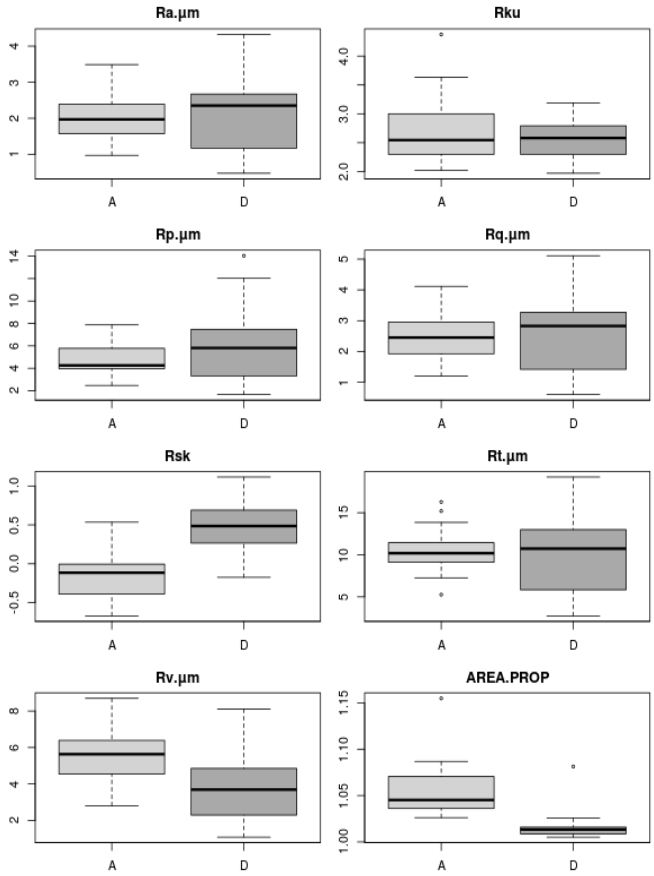

Fig. 2. Comparison of profilometric factors in group A and D- graphical analysis.

B. Contact angles measurements

The results of the statistical analysis of contact angles are presented in Fig. 3. The boxplots show graphically the observed differences. The results of samples elaborated with drill (group D) tended possibly a lower wettability (greater contact angle) comparing to samples elaborated with sandblaster (group A). Differences did not reach statistical significance (p=0.119).

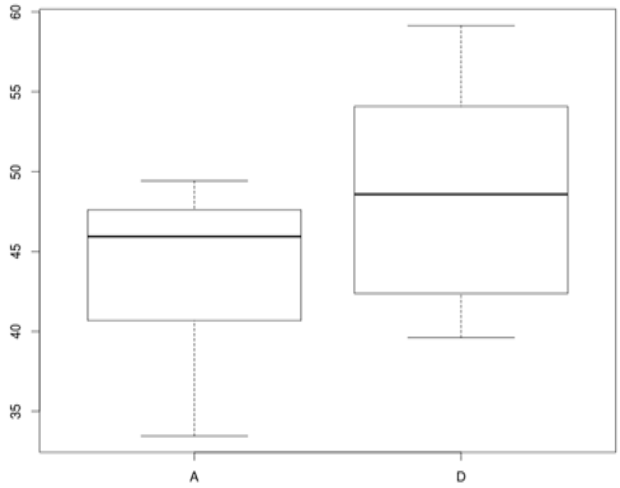

Fig. 3. Results the statistical analysis of contact angles (in degrees).

IV. Discussion

The quality of the connection between the dentine and the material is important factor influencing maintenance of the filling and therefore is target of intensive research. Recently, air abrasion has become therapeutic method, which in some extent may replace more traditional method of dentine elaboration. Herein we compared the surface of dentine prepared with water-air abrasion and drill. We have not observed significant differences in average parameters of geometric structure of dentine surface. It is with concordance with study of other authors [17],[18]. These parameters are of limited value regarding to characteristics of the surface. Field et al. proved that surfaces with the same coefficient of Ra parameter, differ significant [19]. In example the surfaces with the same Ra may show larger number of valleys, but second one larger number of peaks. Such differences may influence the stability of bonding system-composite complex. These differences reflect detailed parameters as Rv-the lowest depth of the recess profile and Rp-the highest peak of the profile. The parameter Rsk-skewness take into account surface topography details on the occurrence of valleys and peaks. Predomination of valleys is associated with greater capacity to maintain the liquid comparing to surfaces with predomination of peaks. In our study we observed significant differences in parameter Rsk between surfaces elaborated with water-air abrasion and drill indicating that predisposition to maintain liquid on the surface is greater on surfaces elaborated with water-air abrasion. Comparison of other detailed parameters – Rv and Rp showed tendency also indicating possible greater predisposition to maintain liquid on surfaces elaborated with water-air abrasion.

In our study the development of dentine surface also showed significant differences between surface prepared with sandblaster comparing to the drill. The ratio was higher for dentin prepared with sandblasting and it is associated with larger contact area of dentin with a bonding-system. The larger contact area make a more extensive hybrid zone which may favorably affect the adhesion strength. We have not found studies which used the development of dentine surface for comparison of different elaboration methods. It should be taken into account that development of the surface has some limits. Albrektsson et al. observed in studies performed on sandblasted titanium implants, that if preparation exceed roughness critical, the removal torque is reduced. It means that extremely large surface development may decrease ability to maintain the liquid [20]. In our study wettability and roughness showed tendency indicating higher parameters after sandblasting.

There are several limits of our study. The quality of the sandblasted surface depends on several operating parameters as the shape and size of the abrasive, the pressure, the tip design and working angle, preparation time end or the distance from the surface. These factors may influence the differences between studies. We used relatively small number of studied samples. However, to overcome this problem we performed profilometry measurements in two fields and wettability in three fields of each sample increasing the total number of measurements.

In this study to evaluate the degree of roughness and surface development the optical profiler was applied. Some researches find superior analyses performed with use of contact profilers [17],[23]. They indicated that results obtained with optical profilometry on dental hard tissues can be affected by color and transparency [24]. However, such problems caused by this phenomenon are more probable in studies with in transparent tissues as enamel but not dentine which is opaque. On the other hand, evaluation of biological samples with the blade contact profiler may cause deformation of delicate surfaces and influence the measurement results. The contact profilers find use in studies of metals and composites subjected to grinding or polishing. To analyze the biological samples with contact profiler it is necessary to perform replica sample surface of a material resistant to damage, for example metal, silicon or vinyl polysiloxane [25]. This method unfortunately is time consuming and expensive.

Another methodological problem is histological tissue heterogeneity, which is considered important reason for damming the difficulties to obtain reliable results. Dentin samples of different teeth randomly assigned to different preparation methods bring a lot of variables that are difficult to control [10]. In our study to minimize these difficulties we decided to perform the comparison of both techniques using two parts of the same tooth.

V. Conclusion

Taking together, evaluating Rsk parameter we observed statistically significant differences between surfaces elaborated with sandblaster and drill. Similarly, the degree of development of the surface prepared with sandblasting was higher. Roughness increase did not correspond with decrease of wettability in samples elaborated with sandblaster. These indicate that the surface of dentin after sandblasting is more-developed and this feature can positively influence the greater capacity to maintain the liquid on the surface.

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