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Research Article

AN IN VITRO ATOMIC FORCE MICROSCOPIC STUDY: COMPARATIVE EVALUATION OF ENAMEL SURFACE DAMAGE DURING CLEAN UP PROCEDURES AFTER DEBONDING WITH AND WITHOUT DENTAL LOUPES UNDER VARYING LIGHT INTENSITIES

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A B S T R A C T

Introduction: A smooth enamel surface after the removal of bracket from a tooth is essential for both aesthetic demands and the prevention of plaque accumulation. The significance of preserving the parent structure has revolutionized the treatment protocols towards the use of magnified fields like loupes, microscopes. Presently, dental chairs are supplied with lights of varying intensities ranging from 20,000 lux to 40,000 lux units. So, it's worthy a point to note as to what light intensity gives us the best visual experience and minutest detail of the adhesive resin on the tooth surface after debonding so as to minimize the enamel loss.

Aims & objectives: To compare and evaluate enamel surface damage during clean up procedures after debonding using different light intensities with & without dental loupes observed under atomic force microscope (AFM).

Methodology: A total of sixty freshly extracted pre molar teeth were randomly divided into two groups with Group 1 being the control group with 12 sample teeth and the other was test group with 48 sample teeth. All the sample teeth in the test group were bonded with MBT pre-molar brackets and were debonded using a debonding plier. After the debonding procedure was done, the samples were divided equally into 4 groups namely, Group 2, Group 3, Group 4, Group 5. Clean up procedure for the residual resin of all the samples in Group 2 and Group 3 was done under halogen chair light of 20,000 lux without & with magnification respectively and for Group 4 & Group 5 clean up procedure for the residual resin of all the samples was done under LED chair light of 40,000 lux without & with magnification respectively. After the clean up procedure, the buccal surfaces of all the sample teeth in Group 1,2,3,4,5 were scanned by Atomic Force Microscope and the parameters Average Roughness (Ra) & Root Mean Square Roughness (Rq) were duly recorded and sent for statistical analysis.

Results: Descriptive statistics for average roughness value (Ra) and root mean square roughness (Rq) showed least roughness in control group followed by group 5, 4, 3, 2 respectively.

Conclusion: From our study it was concluded that due to better visualization under increased light intensity and magnification, the ability to remove the adhesive remnant with least damage to the enamel surface was achieved.

INTRODUCTION

The significance of preserving the parent structure has revolutionized the treatment protocols towards the use of magnified fields like loupes, microscopes. Off late the use of dental loupes to enhance the vision is being practiced in various fields of dentistry such as the potential to aid the clinician in distinguishing the adhesive remnants and enamel surface[1]. The intensity of the light being used may also influence the surface morphology during clean up procedures. Presently, dental chairs are supplied with lights of varying intensities ranging from 20,000 lux to 40,000 lux units. So, it's worthy a point to note as to what light intensity gives us the best visual experience and minutest detail of the adhesive resin on the tooth surface after debonding so as to minimize the enamel loss[2].

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MATERIALS AND METHODS

Sixty freshly extracted premolar teeth for orthodontic purpose were collected from the Department of Oral Surgery, Navodaya Dental College and Hospital, Raichur. Teeth were taken separately and cleaned to remove blood, debris and periodontal fibres from the root portion and washed with distilled water. After the cleaning procedure was done properly, teeth were stored in a container containing distilled water. Teeth that were freshly extracted for orthodontic purpose, intact buccal surface enamel, no pre treatment with chemical agents such as derivatives of peroxide, acid, alcohol or any other form of bleaching were included in the study. Teeth with caries, Fracture, Hyper/Hypoplastic teeth, malformed teeth, restored teeth, teeth with fluorosis, enamel cracks, crazing were excluded from the study. The sample teeth were rinsed and washed with distilled water initially, thereafter the root portion of each sample tooth was resected at the cervical region with the help of carborudum disk. Once disking was done, the resected surface of the tooth was placed on a flat surface and ensured both were parallel. The crown portion of each of the prepared sample teeth was embedded in dental stone block with buccal surface facing uppermost. Dental stone was made in the form of small block with the sample placed in the middle of the block. Blocks were trimmed and polished to maintain uniformity. Concomitantly, the mounted teeth surfaces were cleaned and pumiced with a rubber cup for 15 seconds, rinsed with water and then air dried for 10 seconds. Once all the sixty sample teeth underwent the mounting procedure accordingly, they were divided into 2 groups, of which one was control group (Group 1) consisting of 12 sample teeth and the remaining 48 sample teeth were included under test group.

The mounted sample teeth which were kept separately as test group were etched by using AnabondOrthofix Etchant gel (37% Phosphoric acid) for 30 seconds and were thoroughly rinsed with water and completely air dried for 15 seconds. AnabondOrthofix Light Cure Primer was then applied to the etched enamel surfaces of the teeth and light cured for 10 seconds, then AnabondOrthofix-Light Cure Adhesive was applied to MBT 0.022 slot stainless steel brackets (Libral) and excess adhesive was removed and light cured for 20 seconds. The bonded samples were stored in distilled water at room temperature for 24 hours after which the brackets were debonded by using debonding plier.

The test group was divided into 4 groups (Group 2, Group 3, Group 4, Group 5) and along with the control group they were color coded after the debonding procedure. Decorative adhesive tape was stuck on the dental stone blocks. The colors included were black for Group 1 (control), yellow for Group 2, green for Group 3, red for Group 4, silver for Group 5. The residual resin removal for group 2 was done under dental chair halogen operating lamp of 20,000 lux light intensity without magnification and for group 3 the residual resin removal was done under the same light intensity but with magnification. The residual resin removal for group 4 was done under dental chair led operating light of 40,000 lux light intensity without magnification and for group 5 the residual resin removal was done under the same light intensity but with magnification. The residual resin removal procedure was done by using fibre reinforced composite bur (SHOFU GERMANY) using a low speed hand piece (10,000 rpm) and water coolant respectively. The magnification of 3.5x was provided by binocular loupes (Zumax Medical and Co Ltd) during the residual resin removal of samples of group 3, group 5. After the residual resin clean up procedure was completed, the control group along with the test group samples were stored in distilled water and were transported to Centre for Nanotechnology, University of Agricultural Sciences, Raichur in order to facilitate the scanning of buccal surface of the teeth under atomic force microscope and the final measurements were duly recorded.

Atomic force microscope (JPK ULTRA VIZARD NANO METER 2) was operated in the contact mode first to obtain topographic images over selected areas on the surface. The instrument was supported with a scanner with maximum range of 125µmx125µmx5µm in x, y, z directions respectively[5]. To measure roughness values, the tip was moved across the surface and three different points were measured on the same surface. For stastical analysis, the average of these three measurements was used. Images were acquired with a scan rate of 2.03 hz and 5µm scan sizes. A no platform (NP) type silicon nitride probe at 12 to 40khz with a normal bending of 0.06 to 0.058N/m was used. The force applied to the surface was 10N. The measurements involved two roughness parameters expressed in nanometers: average roughness (ra) values: the arithmetic mean of the heights of peaks and depth of valleys from a mean line, root mean square roughness (Rq): the height distribution relative to the mean line. Each sample

Table 1 Distribution table for Groups vs Averge Roughness

Descriptive Statistics								
Average roughness	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Group1	12	39.67	5.123	1.479	36.41	42.92	32	47
Group 2	12	100.58	6.259	1.807	96.61	104.56	91	110
Group 3	12	89.67	5.694	1.644	86.05	93.28	81	99
Group 4	12	72.67	7.548	2.179	67.87	77.46	62	86

Table 2 Distribution table for Groups vs Root Mean Square Roughness

Descriptives								
Root mean square roughness	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**		
Group 1	12	49.00	7.616	2.198	44.16	53.84	38	59
Group 2	12	111.08	7.090	2.047	106.58	115.59	101	120
Group 3	12	100.92	5.680	1.640	97.31	104.53	92	109
Group 4	12	83.92	8.129	2.347	78.75	89.08	71	97
Group 5	12	71.75	7.412	2.140	67.04	76.46	60	82
Total	60	83.33	23.138	2.987	77.36	89.31	38	120

was analysed individually based on the group, under the atomic force microscope and the roughness parameters Ra, Rq were measured and taken into account. A line along the y-axis of each 50x50μm section was randomly selected, and measurements were plotted to produce a two-dimensional profile of the surface through that section.

RESULTS

After the clean up procedure, the buccal surfaces of all the sample teeth in Group 1, 2, 3, 4, 5 were scanned by Atomic Force Microscope and the parameters Average Roughness (Ra) & Root Mean Square Roughness (Rq) were duly recorded and sent for statistical analysis. One way ANOVA descriptive statistics showed that the mean value of average roughness value (Ra) for Group 1 was 39.67nm [SD: 5.123] and for Group 2, Group 3, Group 4, Group 5 was 100.58nm [SD: 6.259], 89.67nm [SD: 5.694], 72.67nm [SD: 7.548] , 64.83nm [SD: 6.978] respectively. The least surface roughness was in Group1 followed by Group 5,4,3,2 respectively. (Table 1). One way ANOVA descriptive statistics showed that the mean value of root mean square roughness value (Rq) for Group 1 was 49nm [SD: 7.616] and for Group 2, Group 3, Group 4, Group 5 was 111.08nm [SD: 7.090], 100.92nm [SD: 5.680], 83.92nm [SD: 8.129], 71.75nm [SD: 7.412] respectively. The least surface roughness was in Group1 followed by Group 5, 4, 3, 2 respectively. (Table 2). ANOVA for average roughness value (Ra) was done between and within groups. It was found out that surface mean roughness between the groups was statistically significant with P value 0.001 than to within the groups. (Table 3). ANOVA for root mean square roughness value (Rq) was done between and within groups. It was found out that surface mean roughness between the groups was statistically significant with P value 0.001 than to within the groups (Table 4).

Table 3 Anova Table for Average Roughness

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Average roughness	Between Groups	17153.504	1	17153.504	85.257	0.001
	Within Groups	11669.479	58	201.198		
	Total	28822.983	59			

Table 4 Anova Table for Root Mean Square Roughness

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Root mean square roughness	Between Groups	17681.667	1	17681.667	73.750	0.001
	Within Groups	13905.667	58	239.753		
	Total	31587.333	59			

DISCUSSION

Removal of attachments and residual resin from tooth surface is the final procedure required to return the enamel surface as closely as possible to the original pre treatment condition without iatrogenic damage. If remnants are not completely removed, tooth surfaces are likely to become unaesthetically discoloured and entrap plaque with time resulting in caries formation[6,7]. The ratio of 10:1:0.5 can be used for optimal lighting at a dental workplace[1]. This is the ratio between oral cavity illumination by a surgical lamp (20,000 lux for most dentist's lamps, newer surgical LED lights often reach even higher values up to 55,000 lux), the direct vicinity of the mouth (2,000 lux) and the luminance in the rest of the treatment room (800-1,000 lux). For common workplaces (offices) a guideline of 500 lux is applicable in the workplace. As a dentist works with an operating light with an average of 20,000-25,000 lux, the "tunnel effect" should be avoided by increasing the overall workplace lighting to at least 2000 lux. Especially since newer surgical lights often have an even higher light intensity (20,000-55,000 lux). A unit of light intensity is lux. The amount of lux indicates how much light (lumen) reaches a certain Guidelines in the lighting field are best expressed in terms of the amount of light in lux that is needed at a specific location. The amount of lux is important to be able to reach the desired light intensity for discerning tasks. For a given task, the available light intensity can suffice or not. Precision and detail work already requires a lot of light. Even more luminance is needed for dental work[4]. This is because the transition from the ambient light to the light beam of a surgical light which illuminates the mouth should not exceed a ratio of 10:1. This way the eyes have an acceptable transition when turning the head away from the light beam. With modern dental operating LED lights, the brightness can be set in a range from 8,000 to 55,000 lux[1].

In recent years, there have been dramatic developments in the technology and performance of light emitting diodes (LEDs), to the point that arrays of LEDs are now suitable for replacing conventional operating lights. The long life of high intensity LEDs, less power consumption and the corresponding reduction in maintenance costs explains why they are now used routinely. Quartz tungsten halogen (QTH) lamps are the standard lighting component found in a dental operating light. These lamps are driven by the low voltage (12 volt) circuit of the dental unit. The light is emitted from the single tungsten filament in the lamp in all directions and despite the action of a parabolic lens, the light is brighter in the middle and dimmer at the edges of the focused spot. QTH lamps generate a broad range of wavelengths, from ultraviolet through to infrared, requiring the use of expensive filters in the reflectors to prevent the long (infrared) wavelengths being shown onto the patient's face. These same wave lengths also cause heating and degradation of components in the operating light made of plastic and other materials. In practical terms, this means that much more of the energy is dissipated into the reflector and frame of the light and into the operatory environment as heat, than onto the patient's face. Conventional LEDs comprise a small semiconductor chip mounted into an epoxy package. The limited dissipation of heat from the LED chip in this design gives them a high thermal resistance and limits the intensity which can be gained. Multiple LEDs can be combined into arrays with individual optics or combining light-guides so that uniform lighting is achieved without central hot spots and peripheral glare. LEDs have a much higher conversion efficiency than incandescent and halogen light sources, typically 35% and above. They produce light in a directional fashion, meaning that losses from absorption of energy into the frame of the light are almost eliminated. Unlike a halogen lamp, the turn on time of an LED is in the microsecond range, meaning that the light is instant-on, without flickering or warm up. LEDs can be dimmed over more than a 500 fold range without altering the colour temperature of the light, by using the technique of pulse width modulation. This means that once the colour temperature is selected, the intensity can then be adjusted independently to suit the ambient lighting conditions and optimize the difference between ambient surgery lighting and the illuminated intra-oral area. High intensity LEDs last at least 10 times longer than other light sources. Because they have no glass or filaments, there is nothing to break or shatter. LEDs are not subject to sudden failure or burnout. A further interesting attribute is the shadow-free nature of the illumination, which is due to the accurate positioning of the LEDs. An object which blocks the light emitted by one LED does not cast a shadow onto the oral cavity, because each takes a slightly different optical path. By using high intensity LEDs, the system uses 60% less energy than a halogen operatory light[1]. In this study, halogen light of 20,000 lux and LED light of 40,000 lux was used for the clean up of residual resin.

The alteration of the enamel surface depends on the instruments used for bracket removal, armamentarium for resin removal and type of adhesive used. Newmann concluded that removal of brackets and adhesive followed by pumicing restored the tooth surface to its original state[8.] Several methods have been recommended in the literature for bracket removal and adhesive clean up such as squeezing the wings of bracket with debonding plier, electro-thermalde-bracketing, debonding the bracket with bracket removal pliers followed by ultrasonic removal of the residual composite, Nd:YAG laser radiation[9].

Dental magnification loupes may offer a means for improved ergonomic posture. Loupes are designed at a proper declination angle and working distance to reduce the need to lean forward at the head, neck and waist, to give a magnified view of oral structures[5,10,11]. In this study a magnification of 3.5x was used during the clean up procedure of residual resin. SEM uses an electron beam for imaging whereas AFM uses the method of feeling the surface using mechanical probing[12]. AFM can provide 3-dimensional information of the surface but SEM only gives a 2-dimensional image. There is no special treatments for the sample in AFM unlike in SEM where many pre treatments to be followed due to vacuum environment and electron beam. SEM can analyze a larger surface area compared to AFM and also a faster scan rate[12,13,14]. In this study surface parameters Ra &Rq were used to analyse the surface characteristics of the sample teeth. Descriptive statistics for average roughness value (Ra) and root mean square roughness (Rq) indicate least surface roughness in Group 1 followed by Group 5,4,3,2 respectively, suggesting that, better illumination from the high intensity (LED) light, better visual perception from loupes helps in better removal of adhesive and hence reducing the enamel surface damage, which in turn reduces the enamel surface roughness[15]. As the illumination used during the clean up procedure reduces from group 5 to group 2, the ability to efficiently reduce the enamel surface damage decreases.

CONCLUSION

From the study the following conclusions were drawn A)Due to better visualization under increased light intensity the ability to remove the adhesive remnant with least damage to the enamel surface was achieved. B) Enhanced light intensity combined with magnification helped to visualize the adhesive remnant on the enamel surface properly and thereby reducing the enamel damage during clean up procedure.

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