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*Research Article*

# Acid Etching Before Chemical and Laser Bleaching: Effects on Enamel Microhardness

**Amenah M. Younis[1*], Abduladheem R. Sulaiman[2]**

[1] *Specialized Dental Center, Nineveh Health Directorate, Mosul, Iraq*

[2] *College of Dentistry, Al-Noor University, Mosul, Iraq*

Corresponding author: amenah.21dep51@student.uomosul.edu.iq

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## Abstract

**Aims:** The present study aimed to compare the microhardness of enamel bleached with two different bleaching solutions (chemical and laser activated), preceded or not with acid etching.

**Materials and Methods**: Thirty bovine teeth were prepared and haphazardly assigned into two groups (n=15) depending on the bleaching technique. Each group was subdivided into three subgroups (n=5) consistent with acid etching by 37% phosphoric acid. A digital Vickers microhardness tester (VHN) was used to measure enamel microhardness. Three readings were conducted on each sample to quantify microhardness. The samples were held in artificial saliva for five days. The microhardness was measured immediately and five days after bleaching. Paired-samples t-test and independent samples t-test were employed for statistical analysis.

**Results**: The paired-sample t-tests used to evaluate enamel microhardness in the conventional and laser-assisted bleached groups before and immediately after bleaching revealed a significant decrease in both groups. However, the microhardness after five days increased significantly in all groups compared with that immediately after bleaching. The results of the independent samples *t*-test employed to assess enamel microhardness between conventional and laser bleaching of the same group type showed no significant differences between any of the groups, except the C2-L2 groups immediately after bleaching.

**Conclusion**: Acid etching of enamel followed by chemical or laser-assisted bleaching resulted in significant microhardness reduction with no effect of etching time (5 or 10 sec.). Storage of samples in artificial saliva for 5 days after bleaching increased the microhardness but wasn't able to restore them to the levels before acid etching and bleaching. As a clinical implication, and for cases requiring enamel etching before bleaching, five seconds of etching time may be preferred over ten seconds.

**Keywords**: Acid etch, Bleaching, Microhardness.

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## INTRODUCTION

The growing desire for whiter teeth has led to a surge in popularity for non-invasive dental procedures like teeth bleaching (1). Bleaching is the chemical technique used to whiten teeth with chemical products that include hydrogen peroxide ($H_2O_2$). Two main types of bleaching are present: vital and non-vital tooth bleaching. There are three fundamental approaches for bleaching vital teeth: in-office or power bleaching, at-home or dentist-supervised night-guard bleaching, and bleaching with over-the-counter (OTC) products. Numerous non-vital bleaching techniques are used today, for example, walking bleach, modified walking bleach, non-vital power bleaching, and inside/outside bleaching (2).

The precise process of tooth whitening is not entirely understood; it has been suggested that free radicals produced by hydrogen peroxide during whichever reduction or oxidation reactions alter the chemical structures of teeth (3). Because these free radicals possess one or more unpaired electrons in the outer orbit of their atoms, they are regarded as extremely unstable agents. They often function as oxidative agents, absorbing electrons from nearby substances to maintain their chemical structure. Because of this, oxidation of the color particles in the tooth structure causes them to break down and reduce or completely remove tooth discoloration (4).

In dentistry, the application of phosphoric acid etching for numerous purposes is quite accepted. Nevertheless, loss of mineral content and alteration in the hardness and surface roughness of the tooth surface may result from this application. These effects vary depending on the duration of application and will affect the hard dental tissues at a structural level that will cast its effects on clinical applications (5). Acid etching increases enamel permeability by removing a portion of the superficial mineralized layer, which speeds up the bleaching process (6,7). For patients who are resistant to bleaching and/or have more pigmented teeth (such as adults, the elderly, teeth colored by tetracycline, dystrophic calcification of the pulp, and teeth with shades darker than A3, B3, and C2), this may be an alternative (6,7). In these circumstances, prior etching might encourage quicker outcomes in a single session.

Etching should not be recommended for retreatments or when a second session is required since patients' teeth in these clinical circumstances would have a higher enamel permeability. Despite in vitro studies attesting to its safety through evaluation of pulpal cellular metabolism and morphology as well as the hydrogen peroxide penetration through dental tissues, clinical trials evaluating the influence of enamel acid etching prior to in-office bleaching are lacking (8).

In the context of in-office dental bleaching procedures, the use of laser light to activate bleaching material is a common procedure that needs certain chromophores incorporated in the bleaching gel for each wavelength of the laser energy for it to be absorbed (9). While the effectiveness of dental bleaching in improving tooth color is undeniable, opinions on the safety of this process in terms of enamel microhardness vary widely, and the experimental results are very contentious. According to a scientist (Mushashe *et al*., 2018) (10), dental bleaching did not affect the microhardness of enamel; however, according to Grazioli *et al*. (11), microhardness actually decreased. Determining the safest bleaching method to achieve the best bleaching effects while preserving the greatest number of dental tissues requires an understanding of how bleaching agents affect dental enamel, particularly microhardness. Therefore, the purpose of this study was to assess the microhardness of bovine dental enamel after the application of acid etching and bleaching either chemically or by laser activation.

## MATERIALS AND METHODS

### Specimens' collection and preparation

Thirty bovine teeth were collected from a slaughterhouse in Mosul city, which were extracted from cows of about two to three years old. A dental scaler was used to carefully and gently remove any remaining soft tissues from the teeth after the teeth were gathered (12).

A stereomicroscope and visual inspection of the specimen were used to make sure they were cavity-free. Sterilization of the teeth was done by immersing them in a

container containing 0.1% thymol solution, tightly sealing the container and placing it inside an incubator at room temperature (20-25°C) (13).

Non-fluoridated pumice (Pd / Switzerland) was used to polish the teeth. After that, the roots were cut at the cemento-enamel junction. After that, the roots were discarded, and a barbed broach was used to extirpate the pulpal tissue of the crown portion. After using deionized water to clean it, an absorbent cotton pellet was used to dry the pulp chamber, and finally composite (Nexobio, Korea) was used to close the aperture.

After being mixed in accordance with the manufacturer's instructions, cold-cure acrylic resin (Shanghai New Century Dental Materials Co. / Ltd., China) was poured into 50 mm-diameter, 7 mm-height PVC rings that have been built especially for this purpose. The specimens were then placed in the acrylic dough with the labial surface pointing upwards (3). The samples were maintained in sealed jars containing deionized water (Intravenous solutions manufacturer / Iraq) at room temperature (20–25°C) (13).

Twenty-four hours after they were fixed in acrylic resin, the specimens were wet sanded by means of escalating grit, water-proof, silicon carbide papers (King spor / Germany) starting from #400, then #600, #800, #1000, up to #1,200, under running water for a whole 25 seconds (5 seconds/grit). Next, a stereomicroscope was used to inspect the specimens in order to rule out any sample that had exposed dentin (14). The central third of the labial surface was chosen as the treatment region's location (15).

**Study design and specimens grouping**

Thirty bovine teeth were arbitrarily assigned into two different groups (n=15) based on the bleaching method used:

**Chemical bleaching (CB) group**: It was further subdivided into three subdivisions (n=5) as follows: C1: Acid-etched (Spident, Korea) for five seconds followed by chemical bleaching; C2: Acid-etched for ten seconds followed by chemical bleaching; and C3: Standard bleaching without acid etching.

After being taken out of their storage solution, the teeth were dried using cotton pellets. As directed by the manufacturer, the chemical whitening gel ($H_2O_2$, 35%) (Claridient X ,Tedequim, Argentina) was prepared by unstrapping the factor B syringe, fitting the connector snugly, and then unstrapping the factor A syringe and attaching it to the connector. The solution from the (A) syringe was pressed into the (B) syringe and then back again to the (A) syringe, and this passage was repeated eight times until homogenized. After that, the connector and the empty syringe were removed, and the applicator tip was attached. A thick coating (2–3 mm) of the produced bleaching gel was applied to the treatment area. The specimens were exposed to the gel for forty minutes, after which deionized water was used to rinse the gel. To avoid dehydration, the specimens were held in a deionized water reservoir.

**Laser bleaching (LB) group**: It was also subdivided into three subgroups (n=5):

L1: Acid-etched (Spident, Korea) for five seconds followed by laser bleaching; L2: Acid-etched for ten seconds followed by laser bleaching, and L3: Laser-assisted bleaching without acid etching.

A Biolase EPIC laser (Waterlase iPlus, USA) with a wavelength of 940nm was used in this investigation.

A customized dental whitening gel (LaserWhite20, Biolase/USA) was used in combination with Biolase diode laser equipment.

The active component of the basic gel is 45% concentrated hydrogen peroxide. The LaserWhite20 whitening gel produces a 35% hydrogen peroxide mixture when prepared. The preparation of LaserWhite20 was performed according to the manufacturer's instructions. According to manufacture as follows: the caps of both the base and the whitening gel activator syringes were removed. A connection between the two syringes was established by twisting one syringe against the other until fully tightened. The contents of the base syringe (clear contents) were transferred into the activator syringe (purple contents). The activator syringe was depressed until all gel was transferred into the base syringe. This action was done 25 times. All mixed gel was

finally pressed into the whitening gel base syringe. The two syringes were separated by unwinding them. The applicator tip was then attached to the base syringe.

Four specimens were arranged to imitate the four quadrants of the patient's mouth to follow the instructions of the manufacturer as accurately as possible. After that, an approximately 1 mm thick layer of bleaching gel was placed on the specimens. The bleaching tip was placed, and the diode laser (940nm) was applied in continuous wave mode: 7W for 30 seconds (16), at a distance of 2 mm from the sample. The four specimens were subjected individually to laser light for exactly 30 seconds. A total of 1.5 minutes of resting time, which is the time needed to apply the laser to the other three samples, was gained for each specimen. This practice was repeated according to the manufacturer's instructions and resulted in a total of one minute of laser exposure and three minutes of rest per specimen. Following the second laser irradiation, the bleaching gel was left on the specimens for five minutes. Finally, the gel was removed by suction and the specimens were rinsed with deionized water. For both CB and LB groups, the samples were stored after bleaching in artificial saliva prepared as follow: Sodium Cloride (NaCl) (0.4g), Potassium Cloride (KCl) (0.4g), Calcium Chloride dehydrate ($CaCl_2.2H_2O$) (0.79g), Sodium dihydrogen phosphate dehydrate ($NaH_2PO_4.2H_2O$) (0.78g), Hydrated Sodium Sulfide ($NaS_9.H_2O$) (0.005g), CO $(NH_2)_2$ Urea 1g, in 1L of Distilled water, at pH (7) (17).

**Microhardness test**

A digital Vickers microhardness tester (VHN) (Figure 1) was used to measure enamel microhardness. Each specimen was placed on the stage of the test machine. Indentations were made by the indenter on each sample surface, followed by observation using the built-in microscope. The hardness was computed digitally using the diagonal lengths. The specimens were subjected to a load of (500) grams for ten seconds of dwell time (18,15). Three equally spaced indentations were placed on each specimen; the first was placed in the center of the evaluation area, another was placed 1mm to the right, and the last one was placed 1mm to the left of the central one. The mean of the three values gained was used to determine the specimen's VHN (19).

Three read-outs were conducted on each sample to quantify microhardness. The samples were held in reserve in artificial saliva for five days. The microhardness was measured immediately and after five days from bleaching.


**Figure (1):** A digital Vickers microhardness machine

**Statistical Analysis**

The normality test (Shapiro-Wilk) was used to confirm that the data had a normal distribution. Every data point revealed a normal distribution. To compare the pre and post-treatment results and the results between groups, paired samples *t*-test and independent samples *t*-test were used, respectively

**RESULTS**

The results of the *t*-tests used to evaluate enamel microhardness of the conventional and laser-assisted bleached groups before and immediately after bleaching revealed a significant decrease caused by both methods of bleaching procedures in all groups (Table 1).

Table (1): Paired samples *t*-test for VHN of conventional and laser-assisted bleached groups before and immediately after bleaching

| | | Mean | *t*-value | Sig. | N | Std. Deviatio | Std. Error |
|---|---|---|---|---|---|---|---|
| Group C1 | Before Bleaching | 282.28 | 40.414 | .000 | 5 | 5.55862 | 2.48589 |
| | Immediately bleaching | 219.18 | | | 5 | 8.36829 | 3.74241 |
| Group C2 | Before Bleaching | 284.93 | 25.263 | .000 | 5 | 3.45192 | 1.54375 |
| | Immediately bleaching | 222.62 | | | 5 | 8.02867 | 3.59053 |
| Group C3 | Before Bleaching | 284.20 | 284.301 | .000 | 5 | 5.14454 | 2.30071 |
| | Immediately bleaching | 223.49 | | | 5 | 5.14454 | 2.42262 |
| Group L1 | Before Bleaching | 273.77 | 21.515 | .000 | 5 | 8.24542 | 3.68747 |
| | Immediately bleaching | 220.95 | | | 5 | 11.98749 | 5.36097 |
| Group L2 | Before Bleaching | 267.88 | 19.197 | .000 | 5 | 10.15995 | 4.54367 |
| | Immediately bleaching | 208.22 | | | 5 | 5.08338 | 2.27336 |
| Group L3 | Before Bleaching | 272.02 | 14.177 | .000 | 5 | 5.89625 | 2.63688 |
| | Immediately bleaching | 215.30 | | | 5 | 5.96448 | 2.66740 |

However, the microhardness after five days increased significantly in all groups when it was compared to that immediately after bleaching, as evident in Table 2.

Table (2): Paired samples *t*-test for VHN of conventional and laser-assisted bleached groups immediately and after 5 days from bleaching

| | | Mean | *t*-value | Sig. | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|---|---|
| Group C1 | Immediately after bleaching | 219.18 | 14.934 | 0.00 | 5 | 8.36829 | 3.74241 |
| | After 5 days from bleaching | 246.79 | | | 5 | 5.54700 | 2.48070 |
| Group C2 | Immediately after bleaching | 222.62 | 3.082 | 0.037 | 5 | 8.02867 | 3.59053 |
| | After 5 days from bleaching | 243.00 | | | 5 | 14.10062 | 6.30599 |
| Group C3 | Immediately after bleaching | 223.49 | 9.189 | .000 | 5 | 5.41715 | 2.42262 |
| | After 5 days from bleaching | 251.50 | | | 5 | 10.23816 | 4.57865 |
| Group L1 | Immediately after bleaching | 220.95 | 10.641 | .000 | 5 | 11.98749 | 5.36097 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | After 5 days from bleaching | 243.21 | | | 5 | 11.61445 | 5.19414 |
| Group L2 | Immediately after bleaching | 208.22 | 7.969 | .001 | 5 | 5.08338 | 2.27336 |
| | After 5 days from bleaching | 234.43 | | | 5 | 10.11123 | 4.52188 |
| Group L3 | Immediately after bleaching | 215.30 | 4.916 | .008 | 5 | 5.96448 | 2.66740 |
| | After 5 days from bleaching | 240.23 | | | 5 | 11.39526 | 5.09612 |

Although there was an increase in microhardness values after 5 days compared to that obtained immediately after bleaching, it was significantly less than those before bleaching for all groups (Table 3).

Table (3): Paired samples *t*-test for VHN of conventional and laser-assisted bleached groups before and after 5 days from bleaching

| | | Mean | *t*-value | Sig. | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|---|---|
| Group C1 | Before Bleaching | 282.28 | 28.619 | .000 | 5 | 5.55862 | 2.48589 |
| | After 5 days from bleaching | 246.79 | | | 5 | 5.54700 | 2.48070 |
| Group C2 | Before Bleaching | 284.93 | 6.953 | .002 | 5 | 3.45192 | 1.54375 |
| | After 5 days from bleaching | 243.00 | | | 5 | 14.10062 | 6.30599. |
| Group C3 | Before Bleaching | 284.20 | 10.746 | .001 | 5 | 5.14454 | 2.30071 |
| | After 5 days from bleaching | 251.50 | | | 5 | 10.23816 | 4.57865 |
| Group L1 | Before Bleaching | 273.77 | 15.939 | .000 | 5 | 8.24542 | 3.68747 |
| | After 5 days from bleaching | 243.21 | | | 5 | 11.61445 | 5.19414 |
| Group L2 | Before Bleaching | 267.88 | 43.521 | .000 | 5 | 10.15995 | 4.54367 |
| | After 5 days from bleaching | 234.43 | | | 5 | 10.11123 | 4.52188 |
| Group L3 | Before Bleaching | 272.02 | 4.387 | .012 | 5 | 5.89625 | 2.63688 |
| | After 5 days from bleaching | 240.23 | | | 5 | 11.39526 | 5.09612 |

The results of the independent samples *t*-test employed to assess enamel microhardness between conventional and laser bleaching of the same group type

(5sec.; 10sec. acid etch or no acid etch) showed no significant differences between any of the groups, except the C2-L2 groups immediately after bleaching (Table 4).

Table (4): Independent samples *t*-test for VHN of conventional and laser-assisted bleaching of the same group type

| | | N | Mean | t-value | Sig. | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|---|---|
| Immediately after bleaching | group C1 | 5 | 219.18 | .271 | .793 | 8.36829 | 3.74241 |
| | group L1 | 5 | 220.95 | | | 11.98749 | 5.36097 |
| Immediately after bleaching | group C2 | 5 | 222.62 | 3.388 | .012 | 8.02867 | 3.59053 |
| | group L2 | 5 | 208.22 | | | 5.08338 | 2.27336 |
| Immediately after bleaching | 1group C3 | 5 | 223.49 | 2.273 | .053 | 5.41715 | 2.42262 |
| | group L3 | 5 | 215.30 | | | 5.96448 | 2.66740 |
| After 5 days from bleaching | group C1 | 5 | 246.79 | .622 | .551 | 5.54700 | 2.48070 |
| | group L1 | 5 | 243.21 | | | 11.61445 | 5.19414 |
| After 5 days from bleaching | group C2 | 5 | 243.00 | 1.104 | .302 | 14.10062 | 6.30599 |
| | group L2 | 5 | 234.43 | | | 10.11123 | 4.52188 |
| After 5 days from bleaching | group C3 | 5 | 251.50 | 1.645 | .139 | 10.23816 | 4.57865 |
| | group L3 | 5 | 240.23 | | | 11.39526 | 5.09612 |

**DISCUSSION**

Vickers and Knoop hardness tests are two alternative indentation techniques that can be used to quantify microhardness (20).

An investigation carried out by Gutierrez-Salazar and Reyes-Gasga (2003) (21) found that enamel's typical microhardness ranges from 250 to 360 kg/mm$^2$. The enamel's microhardness in the current study fell between 256 to 292 kg/mm$^2$, which is within the range of microhardness found in the previously stated study.

According to the current study, when enamel was examined immediately after bleaching with 35% $H_2O_2$, the microhardness of the enamel significantly decreased. This result is consistent with other researchers' findings (Lia *et al*., 2015; Scribante *et al*., 2020; Vieira *et al*., 2020) (22,23,14) that traditional in-office dental whitening, using the same concentration, had a detrimental effect on enamel concerning microhardness.

Additionally, Jurema *et al*. (2018) (24) examined the impact of 35% $H_2O_2$; this concentration considerably reduced microhardness. The current study's findings, however, conflict with those of Mushashe *et al*. (2018) (10), who found that 35% $H_2O_2$ did not significantly reduce the microhardness of enamel.

The precise process of dental bleaching remains unclear, but it is hypothesized that the free radicals generated during the oxidation-reduction reaction throughout the bleaching procedure are extremely reactive due to their unpaired electrons. Regrettably, this extreme reactivity may react with the enamel's organic matrix and may not be restricted to organic molecules that are pigmented. (25,26,27,28). Even though this organic matrix makes up no more than 1% of the enamel composition, it is engaged in a critical function, that is maintaining the integrity of the enamel (29,30). A layer of tightly bound water envelops the hydroxyapatite crystals in enamel, forming a hydration shell that gives the crystals an electrical charge that allows them to attract ions and take part in the demineralization reaction (31).

Microhardness was also notably reduced by laser-assisted in-office bleaching with 35% $H_2O_2$. Nematianaraki *et al*. (2015) (32) examined the effects of 35% $H_2O_2$ (Laser White 20 whitening gel kit, Biolase, USA) using a diode laser wavelength (810 nm) and found a significant reduction in enamel microhardness, which coincides with this study's finding. According to Saati *et al*. (2020) (33), when two distinct diode laser wavelengths, 810 nm and 980 nm, were used to activate 35% $H_2O_2$ for thirty seconds and then repeated three times with a one-minute break in between, the microhardness significantly decreased.

The mean VHN obtained from chemical and laser-assisted in-office bleaching techniques did not differ significantly in the current study, except that the microhardness measurement conducted immediately after bleaching for the chemical and laser groups, preceded by a 10-second acid etch, demonstrated lower microhardness values for the laser than for the chemical bleaching method. Ashnagar *et al*. (2017) (34) examined the effects of 40% $H_2O_2$ either unaided or in conjunction with two distinct laser activations (diode laser or Nd: YAG laser). They stated that laser-

assisted bleaching considerably reduced microhardness more than chemical bleaching, which is consistent with this study's finding. However, this result conflicts with that of Mondelli *et al*. (2015) (35), who found that when 35% $H_2O_2$ was employed with or without laser activation, traditional chemical bleaching resulted in a greater amount of microhardness reduction compared to laser-assisted in-office bleaching. The disparate methodologies used, such as different bleaching gel concentrations, contact times, and application techniques, and different microhardness tests (Knoop hardness tests) with various storage media, including saliva, may help to explain these contradictory findings.

Following the bleaching process, the samples were held in reserve in artificial saliva for a duration of five days. Every day, artificial saliva was replaced with freshly prepared artificial saliva. There was an increase in microhardness on the fifth day of artificial saliva preservation. However, despite this increase being significant compared to that immediately after bleaching, it was still significantly less than that before bleaching. Mondelli *et al*. (2015) (35) assessed the effects of bleaching treatments on the microhardness of bovine enamel using varying concentrations of hydrogen peroxide ($H_2O_2$) and light activation. After seven days of bleaching, all groups were preserved in artificial saliva, and the trial groups showed no discernible differences from the control group.

Additionally, several studies demonstrated that saliva's capacity for remineralization, which replenishes lost calcium and phosphate ions, can reverse demineralization of enamel microhardness caused by Hp (36).

Araujo *et al*. (37) found that because saliva contains calcium and phosphate, which are absorbed and precipitated, microhardness alterations are not substantial and can be regained 14 days after bleaching. According to Araujo *et al*. (38), all of the specimens that were bleached using an HP-based gel with a neutral pH were able to return to their initial microhardness after 15 days.

Due to the presence of phosphates and bicarbonates, saliva has a cleansing and buffering system (39). Microhardness is provisionally reduced by bleaching. This reduction is restored after storing in saliva for seven days (40).

Thus, the present study's results suggest that saliva plays a significant part in the restoration of enamel microhardness and that this process has an impact on the remineralizing process. Additionally, it is important to keep in mind that, from a clinical perspective, changes in enamel microhardness may not be significant (41). However, to lessen the demineralizing consequences, it is crucial to follow the manufacturer's instructions and apply fluoride and/or desensitizing mediators before, during, or after the bleaching procedure (42).

As a clinical implication, if acid etching was to be used before bleaching, then 5sec. acid is preferred to be used over 10 sec., since there was no significant difference in microhardness values.

Phosphoric acid, acid etching of the enamel was first suggested in the early 1970s for teeth with stains brought on by tetracycline. The clinical outcomes might theoretically be optimized by removing the aprismatic layer and increasing the surface porosities, which would increase the substrate's permeability when applying the bleaching chemical (43).

Acid etching increases enamel permeability by removing a portion of the superficial mineralized layer. Due to apatite crystallite orientation, enamel dissolution does not happen uniformly across all enamel surfaces with etching time. It starts in rod core/wall interfaces and develops anisotropically along the c-axis, decreasing the enamel microhardness (44).

Etching should not be recommended for retreatments or when a second session is required since patients' teeth in these clinical circumstances would have a higher enamel permeability. Despite in vitro studies attesting to its safety through evaluation of pulpal cellular metabolism and morphology as well as the hydrogen peroxide penetration through dental tissues, clinical trials evaluating the influence of the enamel acid etching prior to in-office bleaching are lacking (43).

Limitations of the study include: 1. using only a single concentration of bleaching agent. 2. Microhardness should be measured after longer time intervals.

## CONCLUSIONS

Within the limitations of this study:
Acid etching of enamel followed by chemical or laser-assisted bleaching resulted in significant microhardness reduction with no effect of etching time (5 or 10 sec.). Storage of samples in artificial saliva for 5 days after bleaching increased the microhardness but wasn't able to restore them to the levels before acid etching and bleaching. As a clinical implication, and for cases requiring enamel etching before bleaching, five seconds of etching time may be preferred over ten seconds.

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### Authors' Contribution

Conceptualization: Younis AM. , Sulaiman AR. Formal analysis: Younis AM. , Sulaiman AR. Funding acquisition: Younis AM. Investigation: Younis AM. , Sulaiman AR. Methodology: Younis AM. , Sulaiman AR. Project administration: Sulaiman AR. Resources: Younis AM. , Sulaiman AR. Software: Younis AM. Supervision: Sulaiman AR. Visualization: Younis AM. , Sulaiman AR. Writing–original draft: Younis AM. Writing–review and editing: Sulaiman AR. All authors have read and approved the final manuscript

### Ethical statement

This research was conducted in compliance with ethical standards and received approval from the Research Ethics Committee and Scientific Committee of the College of Dentistry, University of Mosul.

### Conflict of interest

The author declares that there are no conflicts of interest regarding the publication of this manuscript.

**Availability of data and materials**: All data generated or analyzed during this study are included in this published article and its supplementary information files.

**Declaration of Generative AI and AI-assisted technologies**

During the preparation of this work, the authors used Grammarly software to edit and proofread the text. The authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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## التخريش الحمضي قبل التبييض الكيميائي والليزري: تأثيراته على الصلابة المجهرية للمينا

**أمنة مأمون يونس[1]*، عبد العظيم رؤوف سليمان[2]**

دائرة الصحة في نينوى، الموصل، العراق
كلية طب الأسنان، جامعة النور، الموصل، العراق

**الملخص**

**الأهداف**: تهدف الدراسة الى مقارنة الصلادة للمينا المبيضة بمحاليل تبييض مختلفة (كيميائية ومنشطة بالليزر)، مسبوقة أو غير مسبوقة بالتخريش الحمضي. **المواد وطرائق العمل**: تم تحضير ثلاثون سن بقري وتقسيمها عشوائياً الى مجموعتين (العدد =15) اعتماداً على تقنية التبييض. تم تقسيم كل مجموعة الى ثلاث مجموعات فرعية (ن =5) متوافقة مع التخريش الحمضي بنسبة 37% من حمض الفوسفوريك. تم استخدام جهاز الصلادة الرقمي فيكرز لقياس الصلادة لمينا الاسنان. تم إجراء ثلاث قراءات لكل عينة لقياس الصلادة. تم حفظ العينات في اللعاب الاصطناعي لمدة خمسة أيام. تم قياس الصلابة الدقيقة فورًا وبعد خمسة أيام من التبييض. تم استخدام اختبار t للعينات المرتبطة واختبار t للعينات المستقلة للتحليل الإحصائي. **النتائج**: كشفت نتائج اختبارات t للعينات المرتبطة المستخدمة لتقييم الصلادة للمينا للمجموعات المبيضة التقليدية والمدعومة بالليزر قبل وبعد التبييض مباشرة عن انخفاض كبير في كلتا الطريقتين في جميع المجموعات. ومع ذلك، زادت الصلابة الدقيقة بعد خمسة أيام بشكل ملحوظ في جميع المجموعات عند مقارنتها بتلك التي حدثت مباشرة بعد التبييض. أظهرت نتائج اختبار t للعينات المستقلة المستخدمة لتقييم الصلابة الدقيقة للمينا بين التبييض التقليدي والتبييض بالليزر من نفس نوع المجموعة عدم وجود فروق ذات دلالة إحصائية بين أي من المجموعات، باستثناء مجموعات C2-L2 مباشرة بعد التبييض. **الاستنتاجات**: أدى التخريش الحمضي للمينا متبوعًا بالتبييض بمساعدة كيميائية أو ليزر إلى تقليل الصلابة الدقيقة بشكل كبير دون أي تأثير لوقت التخريش (5 أو 10 ثوانٍ). أدى تخزين العينات في اللعاب الاصطناعي لمدة 5 أيام بعد التبييض إلى زيادة الصلادة ولكن لم يكن قادرًا على استعادتها إلى المستويات التي كانت عليها قبل التبييض والتخريش. كنتيجة سريرية، وبالنسبة للحالات التي تتطلب تخريش المينا قبل التبييض، قد يكون وقت التخريش لمدة خمس ثوانٍ مفضلاً على عشر ثوانٍ.

**الكلمات المفتاحية:** التبييض، الحفر الحامضي، والصلابة الدقيقة.