

## Clinical assessment of stainless steel brackets failure rate after reduction of phosphoric acid concentration and etching time

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### ABSTRACT

The purpose of this study was to evaluate clinically the effect of reduction of phosphoric acid concentration and etching time during bonding procedure of stainless steel brackets. As (240) metal mesh-backed brackets were bonded by using no-mix adhesive orthodontic composite, they were divided into (3) equal groups, each of (80) bracket (10 patients), the labial and buccal surfaces of the first group was conditioned with (37%) phosphoric acid for (45) seconds, the second with (20%) for (10) seconds, and the third group was conditioned with (5%) for (15) seconds, all patients were received the orthodontic treatment by the same operator, the study period was (1) year of, the results indicate that the percentage of failure rate for the second and third groups did not significantly differ from the first group, this was calculated by using the Z- test of two proportions at ( $p < 0.05$ ). However, the evaluation of the adhesive remnant index (ARI) after bracket failure, revealed that the application of (37%) acid for (45) second resulted in higher amount residual adhesive left on the teeth. The present study demonstrated that phosphoric acid concentration of (5%) for (15) seconds could be sufficient for bracket bonding on anterior or premolar teeth.

**Key words:** Acid etching, phosphoric acid, etching time.

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## الخلاصة

هدفت هذه الدراسة إلى تقييم معدل إخفاق حاصرات تقويم الأسنان الفولاذية وذلك بعد تقايرس الوقت والتركيز اللازمين لمعاملة طبقة الميناء الخاصة بالسطوح الخدية لمرضى تقويم الأسنان بحامض الفسفوريك أثناء خطوات إصاق الحاصرات التقويمية باستخدام اللاصق غير المعتمد على المزج على تلك السطوح.

لقد تم استخدام (٢٤٠) حاصرة قسمت إلى ثلاث مجموعات, كل مجموعة من (٨٠) حاصرة (١٠ مرضى), في المجموعة الأولى استخدم حامض الفسفوريك بتركيز (٣٧%) لمدة (٤٥) ثانية أم في المجموعة الثانية فقد استخدم نفس الحامض بتركيز (٢٠%) لمدة (١٠) ثواني وفي المجموعة الثالثة استخدم بتركيز (٥%) لمدة (١٥) ثانية, لقد كانت فترة الدراسة لمدة عام كامل حيث تمت عملية الإصاق والعلاج من قبل طبيب أسنان واحد. لقد أظهرت النتائج الإحصائية والتي تمت باستخدام اختبار (Z) عدم وجود فرق معنوي بين معدل إخفاق حاصرات التقويم للمجموعة الأولى عن تلك التي في المجموعة الثانية والثالثة. تم كذلك استخدام مؤشر أثار اللواصق من خلال علاماته الأربعة والذي اظهر وجود نسبة عالية من العلامة (٢) للحاصرات المخففة في المجموعة الأولى بينما كانت العلامة (١) ذات النسب الأعلى في كلتا المجموعتين الثانية والثالثة.

أظهرت هذه الدراسة إمكانية استخدام حامض الفسفوريك بتركيز (٢٠%) لمدة (١٠) ثواني أو (٥%) ولمدة (١٥) ثانية بأنه وافي للغرض أثناء خطوات إصاق الحاصرات الفولاذية لمرضى تقويم الأسنان.

## INTRODUCTION

Since the introduction of the enamel etching within phosphoric acid by Buonocore<sup>(1)</sup>, the use of direct bonding of acrylic resins to enamel was significantly increase both by dental practitioners and specialist. One of the clinical applications for Buonocore's concept is the direct bonding of orthodontic brackets and attachments to the enamel surface<sup>(2)</sup>.

Any orthodontic attachment that bonded to the tooth surface must be placing in such a manner that to be able to withstand the orthodontic forces. Beside that, the simplicity of debonding and cleanup of residual composite

must be taken in consideration to avoid any loss of enamel layers which result in subsequent decalcification and caries<sup>(3)</sup>.

For many years, the recommended bonding technique was the application of ether phosphoric acid solution or gel that have (30-35%) concentration for (60) seconds<sup>(4)</sup>. Evermore, several laboratory reports indicates that a reduction of phosphoric acid concentration and etching time have not any adverse effects on orthodontic bonding force<sup>(4-6)</sup>.

As Barkmeirer *et al.*<sup>(5)</sup>, Legler *et al.*<sup>(6)</sup>, Wang and Lu<sup>(7)</sup>, and Carstensen<sup>(8-10)</sup> were used in their laboratory works different concentrations that range between (2%) till (37%) with an etching times ranged between (15) to (120) seconds, all were found that the different measured force that recorded at small concentrations and short times were comparable to the higher one. In spite of that, Johnston *et al.*<sup>(11)</sup>, indicated that (15) seconds in (37%) concentration of phosphoric acid was inadequate to bond the orthodontic attachments mainly in molars, but it could be used for the anterior and premolar teeth.

Beside these investigations, Carstensen<sup>(9)</sup> in his clinical practice compared the failure rate of the anterior and premolar stainless steel brackets after conditioning the enamel with (2%) and (5%) of phosphoric acid concentration for (30) seconds to both of them, and found no significant difference in failure rate between them, also he found a similar result in comparison to (37%) at (30) second concentration and etching time.

Once more, this study is aimed to evaluate the failure rate of stainless steel brackets attached to anterior and premolar teeth of orthodontic patient by using (20%) and (5%) phosphoric acid etchant solution for (10) and (15) seconds etching times respectively by comparing their failure rates with (37%) phosphoric acid concentration of (45) seconds etching time.

## MATERIALS AND METHODS

### Materials

1. Master-Dent<sup>R</sup> orthodontic brackets adhesive. No-Mix system. The kite contain a single paste container, liquid primer, and minibrushes for liquid application.
2. Stainless steel, twin standard edgewise, pretorque, preangulation, "0.018" slot (Ultratrim<sup>R</sup>, Dentaurm Co.).

3. Phosphoric acid solution (85%), (Sigma Chemical Co.).
4. Non – fluoridated pumice.
5. Rubber cup (Produits Dentaires SA).
6. Dental probe (Dentaarm Co.).
7. Dental tweezer (Dentaarm Co.).
8. Hand scaler (Dentaarm Co.).
9. Dental unit (Qualye Dental Co, Castellini Co.).
10. Light microscope at 40X magnification, and magnifying lens 5X.

## Methods

In this study, (30) patients who were seek orthodontic treatment were participate on it, their ages were range between (11 – 17) years, any patient who have a massive anterior restorations were excluded, this investigation was limited to the anterior and premolar maxillary teeth either the first or the second depending on the extraction for orthodontic reasons. A total (240) metal mesh – brackets were involved in this work, they were directly bonded by the same operator, this investigation was limited to anterior and premolars because the molars were routinely banded.

The teeth to be bonded were cleaned and polished with a rubber cup and slurry of fluoride free pumice and water. The first group represented the quality control one as the labial and buccal surfaces were etched within (37%) of phosphoric acid for (45) seconds, while in the second group, the area of brackets attachment were etched by (20%) of phosphoric acid for (10) seconds and the third received (5%) for (15) seconds. The previously maintained concentrations were prepared from (85%)  $H_3PO_4$  by weight as done by Carstensen<sup>(9)</sup>.

The acid etchant solution was applied with a minibrush just to the area of brackets attachment, each tooth was rinsed with air – water syringe for (10) seconds and dried by air for (20) seconds until the chalky appearance was occurred, after that, a single primer layer was applied on the etched surface and to the base of the brackets, then the adhesive was applied on the mesh surface and the bracket was bonded, any composite excess around the bracket was removed immediately within dental probe.

The acid concentration and etching time for each case was recorded separately, the test period was (1) year, if any participant come with a loosened bracket, tooth, date and adhesive remnant index (ARI) were recorded, the remaining composite was removed and a new bracket was

bonded using (37%) phosphoric acid for (30) seconds according to Carstensen<sup>(9)</sup>.

The adhesive remnant index (ARI) of Artun and Bergland<sup>(12)</sup> was a four – points scale. 0 = no adhesive left on the tooth; 1= less than half of the adhesive left on the tooth; 2= more than half of the adhesive left on the tooth; 3= all adhesive left on the tooth. Each brackets were examined under light microscope at (40x) magnification to assess the adhesive remnants on the failure sites, while in the tooth it was assessed within magnifying lens (5x). The statistical analysis was done by using Z- test of two proportions between the groups ( $p < 0.05$ ).

## RESULTS

The number of brackets that involved in the study are shown in table (1); while those which have been failed within the (1) years are shown in table (2). The statistical analysis by Z- test of two proportions was showed a non significant difference between the group that use the (37%) phosphoric acid concentration with (45) seconds of etching time and the group that use (20%) for (10) seconds ( $Z = 0.085$ ) or that which evaluated (5%) for (15) seconds of concentration and etching time ( $Z = 0.250$ ). Also, there was no significant difference between the second and third groups ( $Z = 0.107$ ).

Table (1): Phosphoric acid concentration and etching time with number of bonded brackets for each group of the study

Groups	Phosphoric Acid Concentration	Etching Time in Seconds	No. Bonded Brackets
First	37%	45	80
Second	20%	10	80
Third	5%	15	80

Table (2): Number and localization of failed brackets after (1) year follow -up

Groups	NO. Bonded Brackets	No. Failed Brackets				Total
		Central Incisor	Lateral Incisor	Canine	Premolar	
First	80	0	1	3	4	8
Second	80	0	3	2	4	9
Third	80	1	3	2	5	11
Total	240	1	7	7	13	28

The values of adhesive remnant index (ARI) was shown in table (3) which revealed that the score (2) was the highest one for the first group (37% for 45 seconds), as a considerable amount of adhesive was left on teeth surfaces. While score (1) was the predominant one in relation to the second and third groups respectively. The frequency distribution for the groups were shown in figure (1), which indicate a high percentages for the score (1) at the second and third groups in comparison within the first one.

Table (3): The adhesive remnant index values for the groups of the study

Groups	No. Failed Brackets	Adhesive Remnant Index			
		Score 0	Score 1	Score 2	Score 3
First	8	0	3	5	0
Second	9	0	6	3	0
Third	11	1	8	1	0

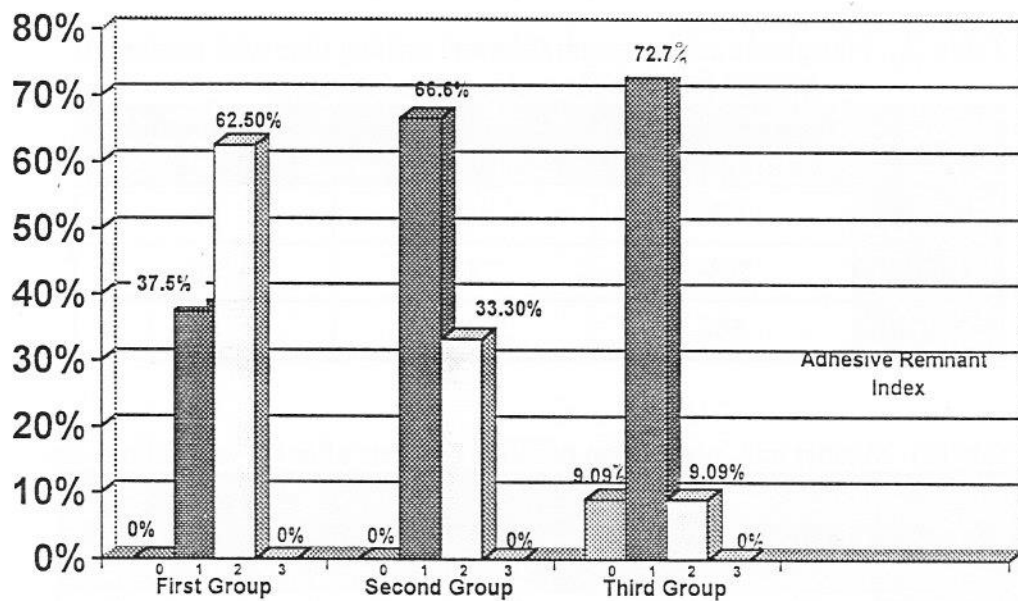


Figure (1): Frequency distribution of ARI values for the groups of the study

## DISCUSSION

During orthodontic procedures, it is impossible to confine the conditioning agents just to the site at which the brackets will be seated. So that, the enamel under and adjacent to those attachments is removed with subsequent caries<sup>(13)</sup>. Many attempts were carried out to reduce this condition to its minimal, either by topical fluoride application<sup>(14)</sup> or by reducing in phosphoric acid concentration or etching time taken in consideration not to effect the retention of orthodontic attachments<sup>(9, 15)</sup>.

The rule of phosphoric acid concentration and the etching time have been studied by several investigators. Some reports, indicated that, the use of high phosphoric acid concentrations have no significant interference within the retention of orthodontic attachments<sup>(8,9)</sup>. While others, try to assess the etching time and stated that the decrease on it do not reduce significantly the degree of brackets retention<sup>(7,10,15)</sup>.

This research is an attempt to evaluate again, but clinically the effects of concentration and etching time reduction in a sample of orthodontic patients, the procedure will carried out by reducing both concentration and etching time form (37%) for (45) seconds in first group to (20%) for (10) seconds in the second one and (5%) for (15) seconds for the third group. The period of study was (1) year.

Clearly, no direct statistical comparisons could be carried out within the available in vivo or the in vitro – studies, this is due to the differences between the laboratory circumstances and the clinical one, and because of the difference in either sample size, type of adhesive, quality of attachments in comparison to those who carried out on patients.

In spite of that, there is a general agreement with may investigators, as there was no significant difference between the failure rate of stainless steel brackets for the group that use the (37%) for (45) seconds on one hand and those of (20%) for (10) seconds or (5%) for (15) seconds on the other one. As the present study demonstrates that (5%) at (15) seconds of phosphoric acid application was sufficient for the direct bonding of metal brackets mainly to the anterior teeth and premolars. These results are mainly accordance with Wang and Lu<sup>(7)</sup>, Carstenson<sup>(9)</sup>, and Johnston<sup>(11)</sup> which they all recommended the use of the smaller concentration and etching time in bonding procedure so as to save the chair time, reduce the amount of enamel

loss in debonding procedure and to preserve the tooth from the decalcification and subsequent dental caries.

The brackets which failed down from the enamel surfaces that etched with either (20%) for (10) or (5%) for (15) seconds are predominantly in (ARI) score (1), these small amount of adhesive that left on enamel could be scraped off with a scaler, followed by polishing of teeth with rubber cup and paste of pumice and water. This cleanup procedure was thus much easier than in (37%) for (45) seconds group as the adhesive amount was removed within diamond bur under water cooling.

These finding are in accordance within Carstenson <sup>(9,15)</sup>, but this investigator recorded the (ARI) index for all teeth after debonding them. Usually the type of pliers, the applied force, and the interface of peak application, all of these could influence the amount of the adhesive that left either on tooth surface or bracket base, so they effects on the (ARI) scores that could be show a remarkable differences <sup>(16)</sup>.

However, the etching within (5%) for (15) seconds seems to reduce the total loss of enamel layers mainly the superficial one. Also, the depth of acid penetration seems to be reduced at this low concentration.

## CONCLUSIONS AND RECOMMENDATIONS

It was concluded that the failure rate of stainless brackets that bonded after conditioning the enamel surface with (37%) phosphoric acid for (45) seconds has no statistical significant difference from that failure rate for the brackets that attached after using (20%) for (10) seconds or (5%) for (15) seconds phosphoric acid concentration and etching time. In accompanied to that the (ARI) scores (2) have the larger numbers of failed brackets for the first group score and (1) for the seconds and third one have the larger values, which indicated that the amount of adhesive remnant was reduced on the tooth surface after using low concentrations and etching times. Due to the limited extend of this investigation, a more investigations are recommended either in laboratory fields or in clinical work so as to asses



the actions of similar concentrations and etching times, either by measuring the strength of attachments (tensile or shear) or by evaluating the failure rate of them. This should be carried out for a different qualities of bracket like the ceramic, titanium and in a different types of adhesive either the self or the light cure or the dowel one.

## REFERENCES

1. Buonocore MG. A Simple method of increasing the adhesion of acrylic filling materials to enamel surface. *J Dent Res.* 1955; 34: 849 – 853.
2. Retief DH, Dreyer CJ, Gavron G. The direct bonding of orthodontic attachments to teeth by means of an epoxy adhesive. *Am J Orthod.* 1970; 58: 21-40.
3. Zachrisson BU, Zachrisson S. Caries incidence and oral hygiene during orthodontic treatment. *Scand J Dent Res.* 1971; 79: 394 – 401.
4. Gattlib EL, Nelso AH, Vagels DS. Study of Orthodontic diagnosis and treatment procedures, part I: Results and trends. *J Clin Orthod.* 1991; 25: 145 – 156.
5. Burkmeier WW, Gwinnett AJ, Shaffer SE. Effects of reduced acid concentration and etching time on bond strength and enamel morphology. *J Clin Orthod.* 1987; 21: 395 – 398.
6. Legler LR, Retief DH, Bradley EL. Effects of phosphoric acid concentration and etch duration on enamel depth. *Am J Orthod Dentofacial Orthop.* 1990; 98:154-160.
7. Wang NW, Lu CT. Bond strength with various etching times on young permanent teeth. *Am J Orthod Dentofacial Orthop.* 1991; 100: 72 – 79.
8. Carstensen W. Direct bonding with reduce acid etchant concentration. *J Clin Orthod.* 1993; 27: 23 – 25.
9. Carstensen W. Clinical effects of reduction of acid concentration on direct bonding of brackets. *Angle Orthod.* 1993; 63: 221 – 224.
10. Carstensen W. Effect of reduction of phosphoric acid concentration on the shear bond strength of brackets. *Am J Orthod Dentofacial Orthop.* 1995; 108: 274 – 277.

11. Johnson CD, Burden DJ, Hussey DL. Bonding to molars – the effect of etch time: an in vitro study. *Eur J Orthod.* 1998; 20: 195-199.
12. Artun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid – etch enamel pretreatment. *Am J Orthod.* 1984; 85: 333 – 340.
13. Benett CG, Shen C, Waldron JM. The effect of debonding on the enamel surface. *J Clin Orthod.* 1984; 18: 330 – 334.
14. Meng LC, Wang NW, Yeh SI. Fluoridated etching on orthodontic bonding. *Am J Orthod Dentofacial Orthop.* 1997; 112: 259 – 262.
15. Carstensen W. Clinical results after direct bonding of brackets using shorter etching time. *Am J Orthod Dentofacial Orthop.* 1986; 89: 70 – 72.
16. Oliver RG. The effect of different methods of brackets removal on the amount of residual adhesive. *Am J Orthod Dentofacial Orthop.* 1988; 93: 196 – 200.