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

Ali R AL-KHATIB*

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 حاصلات تقويم الأسنان الفولاذية وذلك بتحديد تقلص الوقت والتركيزات اللازمة لمعالجة طبقات السطوح الخالية بالمضخات الخفية لمرضى تقويم الأسنان بحامض الفسفوريك أثناء خطوات إصلاح الحاصلات التقويمية باستخدام الألمنيوم غير المعتمد على المزج على تلك السطوح.

لقد تم استخدام (204) حاصلات قسمت إلى ثلاث مجموعات: كل مجموعة من (83) حاصله (10 مرضى) في المجموعة الأولى استخدام حامض الفسفوريك بتركيز (37%) لعدة (5) ثوانى، في المجموعة الثانية فقد استخدم نفس الحامض بتركيز (62%) لعدة (10) ثوانى، وفي المجموعة الثالثة استخدم بتركيز (62%) لعدة (15) ثانية، وجدت فترة الدراسة لعدة عامل كامل حيث تم عملية الإصلاح والعلاج من قبل طبيب أسنان واحد. لقد أظهرت النتائج الإحصائية التي تم استخدام اختبار (Z) عدم وجود فرق معنوي بين معدل إخفاق حاصلات التقويم للمجموعة الأولى عن تلك التي في المجموعة الثانية والثالثة. تم كذلك استخدام مؤشر آثار اللاعصاب من خلال علاماته الأربعة والذي اظهر وجود نسبة عالية من العلامات (2) لحاصلات المختارة في المجموعة الأولى بينما كانت العلامات (1) ذات النسبة الأعلى في كلتا المجموعتين الثلاثة.

أظهرت هذه الدراسة إمكانية استخدام حامض الفسفوريك بتركيز (20%) لعدة (5) ثانية أو (5) ثانية وافقت العلاج أثناء خطوات إصلاح الحاصلات الفولاذية لمرضى تقويم الأسنان.

INTRODUCTION

Since the introduction of the enamel etching within phosphoric acid by Buonocore (1), 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 (2).

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 (3).

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 (4). Evermore, several laboratory reports indicates that a reduction of phosphoric acid concentration and etching time have not any adverse effects on orthodontic bonding force (4-6).

As Barkmeier et al. (5), Legler et al. (6), Wang and Lu (7), and Carstensen (8-10) 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 (11), 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 (9) 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 R orthodontic brackets adhesive. No-Mix system. The kit contain a single paste container, liquid primer, and minibrushes for liquid application.
2. Stainless steel, twin standard edgewise, pretorque, preangulation, "0.018" slot (Ultratrim R, Dentaurm Co.).

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3. Phosphoric acid solution (85%), (Sigma Chemical Co.).
5. Rubber cup (Produits Dentairs SA).
6. Dental probe (Dentaurm Co.).
7. Dental tweezer (Dentaurm Co.).
8. Hand scaler (Dentaurm 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%) H₃PO₄ by weight as done by Carstensen (9).

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 an 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(9).

The adhesive remnant index (ARI) of Artun and Bergland(12) 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

<table>
<thead>
<tr>
<th>Groups</th>
<th>Phosphoric Acid Concentration</th>
<th>Etching Time in Seconds</th>
<th>No. Bonded Brackets</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>37%</td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>Second</td>
<td>20%</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>Third</td>
<td>5%</td>
<td>15</td>
<td>80</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Groups</th>
<th>No. Bonded Brackets</th>
<th>No. Failed Brackets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Central Incisor</td>
<td>Lateral Incisor</td>
</tr>
<tr>
<td>First</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>Second</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>Third</td>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>240</td>
<td>1</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Groups</th>
<th>No. Failed Brackets</th>
<th>Adhesive Remnant Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Score 0</td>
</tr>
<tr>
<td>First</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Second</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Third</td>
<td>11</td>
<td>1</td>
</tr>
</tbody>
</table>

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 (13). Many attempts were carried out to reduce this condition to its minimal, either by topical fluoride application (14) or by reducing in phosphoric acid concentration or etching time taken in consideration not to effect the retention of orthodontic attachments (9,15).

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 (8,9). While others, try to assess the etching time and stated that the decrease on it do not reduce significantly the degree of brackets retention (7,10,15).

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 (7), Carstenson (9), and Johnston (11) 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 (9,15), 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 affects on the (ARI) scores
that could be show a remarkable differences (16).

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