Evaluation of Colour Stability of Three Polycrystalline Ceramic Brackets in Three Commonly Consumed Beverages- An In-vitro Study

M.S. Kannan, Rachana Saboo, S. Kishore Kumar and R.V. Murali

Department of Orthodontics, Sree Balaji Dental College and Hospital, Chennai, India

Abstract: The introduction of ceramic brackets revolutionized the field of orthodontics. They were introduced as an esthetic appliance having the advantages of permanent translucency and greater strength. However, from the esthetic point of view, they do tend to discolor from food stains. Aim: The purpose of this study was to assess the colour stability of three polycrystalline ceramic brackets, by three commonly consumed beverages. Materials: 40 upper right central incisor ceramic brackets of 3 different companies were taken. The beverages selected were Tea, Coffee and Coca-Cola. The color testing was done using a Spectrophotometer. Methods: the brackets were immersed in the beverages for 1, 3 and 6 days and the color change was measured. Results: that All the bracket systems showed considerable color changes in tea and coffee. The color change in coca-cola was minimal.

Key words: Poly crystalline Ceramic Brackets • Colour stability • Food stains • Beverages

INTRODUCTION

Characteristics of an ideal orthodontic appliance include good esthetics and optimum technical performance. In recent years the esthetics of the orthodontic appliance has become a topic of great interest with increasing number of adult patients seeking orthodontic treatment.

This led to the development of various esthetically superior appliances. The superior esthetics of ceramic brackets compared to conventional stainless steel brackets is not only well accepted by the patient, particularly adults, but also are positively sought for.

Ceramic brackets were introduced in Orthodontics in the 1980’s and their characteristics were described in detail by Michael L. Swartz [1]. Joseph Ghafari [2] in his extensive review article, highlighted the problems associated with ceramic brackets. The problems included attrition of teeth occluding against ceramic brackets; increased friction; breakage of bracket wings while engaging a heavy archwire, limited rotation of teeth; staining of brackets due to individual diets-prolonged use of caffeine (Coffee, tea, colas), enamel fracture and flaking or fracture lines in enamel during debonding; increased pain or discomfort while debonding, operational risk for the patient due to accidental ingestion or aspiration of a bracket during bonding or debonding.

The purpose of this study was to take into consideration, the staining of the brackets due to individual diets and to evaluate the effect of three commonly consumed beverages; tea, coffee and coca-cola upon colour stability of ceramic brackets.

Aims and Objectives: The aims and objectives of the study were

- To assess the discolouration of three polycrystalline ceramic brackets, by three commonly consumed beverages.
- To identify the ceramic bracket showing maximum discoloration.
- To identify the beverage having the highest staining capacity.
- To find out the co-relation between surface roughness and extent of discoulouration.
MATERIALS AND METHODS

This in-vitro study was carried out on 120 upper right central incisor ceramic brackets of three different companies (40 each). Three commonly consumed beverages (Tea, coffee, coca cola) were selected for the study and distilled water was taken as control.

The brackets used in the study were Transcend 6000 (3M Unitek, Monrovia, CA), Intrigue (Lancer Orthodontics, Vista, CA) and 20/40 (American Orthodontics, Sheboygan, Wis) (Fig. 1).

The beverages used were Yellow Label Tea (Lipton, Hindustan Lever, Mumbai), Nescafe Classic Coffee (Nestle India Limited, New Delhi) and Coca-Cola (Hindustan Coca-Cola India, Gurgaon).

The color analysis was done using a hand held spectrophotometer (GretagMacbeth Spectrolino type, Regensdorf, Switzerland) (Fig. 2).

The standard solutions for the beverages were prepared [3]. The brackets were divided into 4 groups of 10 each and were immersed in their respective standard solutions.

Color readings of the brackets were taken before immersion in the solutions (Base reading) and then after immersion in the solutions at the end of days 1, 3 and 6. These corresponded with the total in-vivo exposure values of 1, 3 and 6 months respectively [4], not taking into the account the various other factors of an in-vivo study.

The color readings were recorded in a personal computer using Optiview Lite Software (GretagMacbeth, Regensdorf, Switzerland) [5]. The color changes were determined using the Standard Commission Internationale de L'Eclairage (CIE) calorimetric techniques [6]. The colour was expressed in terms of CIE $L*a*b*$ coordinates. The color change, $\Delta E*$, of the value 3.3 was considered to be visually perceptible [7].

The obtained data was analyzed statistically using SPSS for Windows (SPSS Inc, Chicago, IL). The analyses used were Mean and Standard deviation, along with ANOVA.

The brackets (1 each) were also evaluated for surface roughness by SEM (Hitachi, S-3400 N, Hitachi India Trading Pvt. Ltd., New Delhi), before and after the staining process to check for any co-relation between surface roughness and staining capacity.

RESULTS

All the ceramic brackets immersed in tea and coffee showed clinically perceptible discoloration (Fig. 3). The brackets immersed in coca-cola also showed staining, but only to a very minimal extent.
Table 1: $\Delta E^*$ Changes in Tea

<table>
<thead>
<tr>
<th>Day</th>
<th>Bracket</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transcend</td>
<td>3.083</td>
<td>0.46</td>
<td>3.592</td>
<td>0.77</td>
<td>5.055</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>Intrigue</td>
<td>3.255</td>
<td>0.39</td>
<td>4.160</td>
<td>0.34</td>
<td>4.984</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>20/40</td>
<td>4.311</td>
<td>1.03</td>
<td>4.657</td>
<td>0.47</td>
<td>5.088</td>
<td>0.58</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: $\Delta E^*$ changes in coffee

<table>
<thead>
<tr>
<th>Day</th>
<th>Bracket</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transcend</td>
<td>3.631</td>
<td>1.02</td>
<td>3.613</td>
<td>0.55</td>
<td>4.160</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Intrigue</td>
<td>4.312</td>
<td>0.72</td>
<td>5.272</td>
<td>0.59</td>
<td>5.353</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>20/40</td>
<td>2.689</td>
<td>0.78</td>
<td>4.015</td>
<td>0.39</td>
<td>4.879</td>
<td>0.85</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: $\Delta E^*$ changes in coca-cola

<table>
<thead>
<tr>
<th>Bracket</th>
<th>Day</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcend</td>
<td>2.462</td>
<td>0.87</td>
<td>1.980</td>
<td>0.43</td>
<td>2.216</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Intrigue</td>
<td>1.404</td>
<td>0.36</td>
<td>2.159</td>
<td>0.29</td>
<td>2.727</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>20/40</td>
<td>3.095</td>
<td>0.76</td>
<td>2.879</td>
<td>0.48</td>
<td>3.634</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At the end of day 1, tea caused color changes in 20/40 brackets only. Changes were seen in Transcend 6000 and Intrigue at the end of day 3, with further staining at the end of day 6 (TABLE 1). Coffee caused discoloration of Transcend 6000 and Intrigue brackets after 1 day and the 20/40 brackets after 3 days, with significant changes seen after 6 days (TABLE 2). Coca-cola only caused discoloration of 20/40 brackets at the end of day 6. No other brackets showed changes after immersion in coca-cola (TABLE 3).

The SEM studies done on the brackets showed subsurface staining of the samples, but no co-relation could be found between the surface roughness of the brackets and the staining values (Fig. 4).

DISCUSSION

The color changes of the ceramic brackets can compromise the esthetic needs of the patient over the duration of the treatment. The change occurring can be difficult to distinguish visually, but is very evident through colorimetric measurements [7].

Different authors have proposed different values for the interpretation of $\Delta E$. R. R. Seghi et al. [11] stated that two objects having a $\Delta E$ value of approximately one unit have been judged by human observation to be an acceptable colour match 50% of the time. Ruyter IE et al. [7] showed that 50% of the observers considered that sample pairs were unacceptable when the colour difference ($\Delta E$) was approximately 3.3. In this study, we used the value of 3.3.

In this in-vitro study, tea and coffee caused considerable color changes, when compared to coca-cola. All the three bracket systems were stained at the end of 6 days. Similar findings were reported by Stober et al. [8], Debra R. Haselton et al. [9], R. Nishiura et al. [10] and Susanne Wriedt et al. [11], in their studies.

The results of the study, however were contradictory with the findings of Hyo-Jin Kim et al. [12], Adriana Postiglione Buhrer Samra et al. [13], Temel Koksal et al. [14].

Yoshiaki Tanizawa et al. [15] dealt with the phenomena occurring on the surface of porcelain tiles immersed in tea infusion. They mentioned that tea contains two major groups of pigments, theaflavins (TFs) and thearubigins (TRs), which are produced by the oxidative polymerization in the fermentation processes. The unsightly coloured tea stain, however, is not simply caused by the adsorption of those pigments from the tea infusion, but also as a result of chemical reactions. The stains consist mainly of complexes of caffeine with the oxidative products of polyphenols and other inorganic compounds [16].
Erik Kissa [17] mentioned that coffee stains are mainly caused by the water-soluble and acidic coloured substances in coffee. The acidic nature of coffee stain has been shown by ultraviolet and visible spectroscopy of coffee as a function of pH; ion-pair formation with a cationic surfactant [18].

The microscopic observation of the stained samples showed that discoloration was mainly due to stain adsorption and sub-surface stain absorption taking place between the staining beverage and the ceramic brackets. This finding is in concurrence with the findings of Didier Dietschi et al. [19].

CONCLUSION

The color change (ΔE) of 3.3 was considered to be clinically unacceptable. In this study, even after a short immersion time of 6 days, all the samples showed undesirable color changes, in tea and coffee.

Nevertheless, it is important to emphasize the impossibility of establishing the exact correlation between in-vitro and in-vivo tests, since the oral environment cannot be reproduced in the laboratory and orthodontic appliances are never subjected constantly to staining media for such a long period of time. Moreover the cleansing mechanism of saliva and the mechanical cleaning by toothbrush cannot be considered in the in-vitro setting.

REFERENCES