ENAMEL HARDNESS AND CARIES SUSCEPTIBILITY IN HUMAN TEETH

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Abstract.

This paper presents a comparative study of enamel hardness in teeth of human beings with different susceptibility to caries disease. Six orthodontic patients were classified as high or low caries risk, on the basis of caries experience. Then by taking transversal ground sections of premolar from classified patients hardness measurements were made. The hardness values found for sound enamel VHN 268 - 375 are in agreement with published data. The lower hardness values corresponded to high caries risk patients. The mean of VHN between the high and low caries risk groups differ significantly. The differences found in this study show a relationship of hardness enamel with high susceptibility to caries disease.

Keywords. Enamel, microhardness, caries susceptibility.

Resumen.

Se presentan los resultados de un estudio comparativo sobre la dureza del esmalte entre sujetos con diferente susceptibilidad a la caries dental. Se emplearon seis premolares, extraídos por razones ortodoncicas, de pacientes clasificados como de alto o bajo riesgo, en base a la experiencia de caries que presentaron. Las mediciones de dureza se hicieron sobre cortes transversales pulidos. Los valores de dureza Vickers para esmalte sano, obtenidos en este estudio, concuerdan con otros reportados en la literatura. Los sujetos clasificados como de alto riesgo a la caries presentaron los valores de dureza más bajos, comparados con los sujetos de bajo riesgo. Las diferencias en los valores de dureza fueron altamente significativas. Los resultados muestran una asociación de la dureza del esmalte con la mayor susceptibilidad a caries.

Palabras Clave: Enamel, microdureza, susceptibilidad a las caries.

1. Introduction.

Knowledge of the mechanical properties of dental tissue is important to understand how mastication strain is distributed throughout a tooth, and for predicting how stress and strain are altered by dental restorative procedures, age and mainly by caries disease.

Between the mechanical properties the hardness of enamel is the most widely studied and has greater theoretical support. The enamel hardness values have been reported either by Knoop hardness number (KHN) or Vicker hardness number (VHN), depending on the method used. However, the values obtained with both methods showed no important differences, according to Rige’s study [1]. In Craig’s study [2] enamel hardness values were KHN 292 – 390. Collys [3] reported a value of KHN 354.9, Stephen [4] found a value KHN 271. Graspersic [5], in occlusal enamel, found VHN 359.5 – 424.3. Ryge [111] VHN 254 – 348. Reyes-Gasga [6] reported a range of VHN 254 – 383.

Microhardness indentation provides a relatively simple, nondestructive and rapid method for classification of materials and for comparative studies of their properties. However the measurement can be affected by different factors. The large standard deviations in hardness value reported in early studies [2] show that very different values can be obtained in distinct sections of a tooth. In a recent enamel hardness study [6] it was found that factors as sample preparation, indenter position, and reading error in indentation length can influence the hardness measurements. Then it is important to control these factors to obtain reliably measurements. Other important factor is the selection of the area for hardness test. According to literature [6] in transversal
sections well shaped indentations are obtained more easily than along the length sections.

In dental research, microhardness indentation measurements have been employed in the study of remineralization phenomena [4]. Featherstone [8] reported a relationship of enamel hardness values with mineral content of the tissue in a weight basis. More recently, Attin [9] found a significant correlation between initial enamel hardness and abrasion degree. Moreover, the hardness can influence the caries susceptibility because of the exposition of enamel to environment oral factors.

Caries is a multifactorial disease and enamel represents an important factor in the caries risk condition.


The study selected six premolars extracted from six orthodontic patients who had been chosen on the basis of their caries experience as low or high caries forming. Four of the patients were 13 – 14 and two 24 years old. Caries experience was recorded and the magnitude of caries lesion was measured according to known criteria [11].

Premolars in younger patients of both groups presented no caries lesions. The teeth from adults patients in low and high caries risk groups were filled, but the hardness tests were made in healthy enamel on a transversal section of the buccal cusp.

The premolars were embedded in acrylic resin, then were sectioned parallel to the oclusal surface. The first cut just be low the buccal cusp was used for hardness tests. On transversal ground sections from each tooth fifteen hardness measurement were made. A Matuzuzawa microhardness tester MHT2 with a Vickers diamond at a load of 25 g, for 15 s. was used. The indentation was observed and analyzed using both a light microscope (LM) and scanning electron microscope (SEM). The criteria for accepting a correct indentation were sharpness of diagonal edges, uniformity of diagonal shape (geometry) and freedom of interference from irregularities in the testing area [1]. The indentations were never closer to the edges of the specimen or to another indentation of less than two times the length of the diagonal. The measurements, were done only by one observer. The reliability in reading indentation length was Kappa 0.90. Then indentation length (IL) and Vickers hardness number (VHN) were obtained.

The statistic analysis was done using the SPSS statistical program. One way analysis of variance ANOVA and Scheffe post hoc test were employed to test the
The structural features of tested surface were observed by SEM. Phosphoric acid was used during 60 seconds in order to develop the prism structure.

The chemical composition of enamel was analysed for patients 1 and 4, using the EDS method.

3. Results

In this study only well-shaped indentations were considered and special attention was given to sample preparation and reading error of the indentation length. Figure 1 shows a well-shaped indentation. Because of the structural features of the enamel tissue, no well-shaped indentations can be obtained. A no well-shaped indentation is showed in Figure 2. The indentation can be easily observed by SEM and immediately accepted or rejected according with the shape they showed.

Caries experience of selected patients is presented in table 1. Younger patients classified as low risk (patients 1, 2) do not show clinically carious lesions. The adult patient (patient 5) presented eight filled teeth, with no teeth loss or bigger fills. The fills only covered occlusal groove, because the caries lesions presented before the dental treatment must not have been extensive. Figure 3 shows the longitudinal section of tooth from this patient, the fill includes only enamel tissue. This patient did not have fast caries process. The oral condition is very different for the adult patient in the high caries risk group. She had loss the three first molars and had eight filled teeth.

The younger patients in this group (patients 3, 4) presented 9 and 12 affected teeth. For patient 3, three decay teeth and six teeth were filled, in two of these, the fill covered two thirds of the crown. Patient 4 presented 12 decayed teeth; all these affecting enamel and dentin, and four with extended lesions.

Table 2 presents the results of the hardness tests for six samples from patients. The mean and standard deviation for both indentation length and Vickers hardness number are indicated. The lower hardness values were for high caries risk patients, the mean of VHN between the groups differing significantly (p < .0001).

The hardness is a very sensitive scale. In table 2 for values of IL the standard deviations are < 1μ, and these are in the hardness value up to 34 units. The difference of IL for patients 1 and 5 is 0.80 μ, (11.93 – 11.13), and for hardness values the difference is so great (VHN 375.93, and 327.20 respectively) that it reaches statistic significance (p< 0.1).
Table 2. Hardness Enamel Values Indentation Length (IL) and Vickers Hardness Number (VHN) for the patient’s samples studied.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Mean IL (SD)</th>
<th>Mean VHN (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1MR</td>
<td>11.93 (0.56)</td>
<td>327.20 (29.77)</td>
</tr>
<tr>
<td>2DS</td>
<td>11.97 (0.40)</td>
<td>324.67 (21.24)</td>
</tr>
<tr>
<td>3MM</td>
<td>12.83 (0.72)</td>
<td>283.07 (33.09)</td>
</tr>
<tr>
<td>4 LP</td>
<td>13.03 (0.35)</td>
<td>273.27 (15.07)</td>
</tr>
<tr>
<td>5 DC</td>
<td>11.13 (0.52)</td>
<td>375.93 (34.36)</td>
</tr>
<tr>
<td>6 BB</td>
<td>13.18 (0.70)</td>
<td>268.07 (27.64)</td>
</tr>
</tbody>
</table>

Table 3 shows the homogeneous subset identified by the post hoc Scheffe test. The mean average for the three high caries risk patients is VHN 269.07, 273.27 and 285.40 and they do not differ significantly. On the other hand, the hardness values in the adult patient (patient 5) for the low risk group was specially high (VHN 375.93). It was significantly different than the hardness values for younger patients of the same group: VHN 324.67 and 327.20 respectively.

Table 3. Homogeneous subset for Vickers Hardness Values

<table>
<thead>
<tr>
<th>Patient</th>
<th>Subset for alpha = .05</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>269.07</td>
</tr>
<tr>
<td>4</td>
<td>273.27</td>
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<tr>
<td>3</td>
<td>285.40</td>
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<tr>
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<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Sig.</td>
<td>.762</td>
</tr>
</tbody>
</table>

Scheffe test

The SEM study of the structure of specimens surface showed differences in the demineralising patterns. The teeth from low risk patients presented preferential etching of the prism boundary while the specimens from high risk showed preferential etching of the prism core. The figures 4 and 5 show the pattern for low and high risk respectively.

The EDS analysis was done in patient 1 and 4, the chemical composition shows differences mainly in the sodium and magnesium content. The figure 6 present the values for these elements from enamel surface to amelo dentinal juncton (ADJ).

Fig. 4. Prisms pattern in low caries risk patient.

Fig. 5. SEM image of prisms pattern in high caries risk patients.

Fig. 6. Mean distribution of sodium and magnesium from enamel outer surface (1) to ADJ (3) in samples from patients 1 y 4.
4. Discussion

The hardness values found for sound enamel VHN 268 – 375, are in agreement with earlier published data [1 – 6]. Because the special features of the hardness scale, careful use of measurements, is necessary. So in this way realible hardness values were obtained and differences in hardness value reflect differences in the properties being studied.

In the younger patients, the comparison was made in sound, no filled teeth for high and low caries risk categories. The age of these patients were similar while the differences in their oral condition must be attributed to faster caries process in the high risk group. The results of this study showed consistently higher hardness values for low risk patients, classified on base of caries experience. The hardness values for these patients were significantly higher than those for high caries risk group (Table 2).

Hardness is a property of enamel that can influence caries susceptibility because the enamel is exposed to different factors.

Attin [9] used bovine enamel and found a significant correlation, within all experimental groups, between initial hardness and abrasion degree. He concluded that susceptibility of eroded enamel to toothbrushing abrasion may depend on the hardness of the enamel of the particular specimen, because abrasion increases with decreasing hardness value.

The main feature found in the high caries risk individuals is the faster process of caries lesions, and that many factors are involved in this more susceptible condition. A number of results on salivary, microbiological and behavioral factors have been obtained but less information on enamel properties regarding high caries risk condition was found.

The different reactions of the core prism and prism boundary to acid treatment, found in this study, favor the view that dissimilar physical and/or chemical properties can be present that affect the hardness value.

The differences in chemical composition may be also important factors. It is important that the distribution of sodium and magnesium were similar for both patients, but the values for these elements, were different for low and high caries risk patients.

Among the patients selected on the basis of caries experience, the more susceptible individuals showed consistently significantly lower hardness values (Table 2). The selection of homogeneous subset (Table 3) shows the relationship of hardness enamel with caries experience. The differences found in this study show an association of low enamel hardness with high susceptibility to caries disease.

The differences in hardness of enamel can be associated to the mineral content in enamel [8, 12, 13]. Kodaka [7] found that small amounts of organic substances at sites of similar mineral content can have a strong influence on the microhardness values. Then, the presence of organic substances is another possible factor.

More studies are necessary to know exactly the factors that determine the differences in enamel hardness.

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References