Hardness testing of five brands of acrylic artificial teeth

[1,2]Daisy Wulansari, [2]Rasmi Rikmasari, [2]Seto Pramudita
[1]Resident of Prosthodontic
[2]Department of Prosthodontic
Faculty of Dentistry, Padjadjaran University
Bandung, Indonesia
Corresponding author: **Daisy Wulansari**, e-mail: daisy.wulansari@fkg.unpad.ac.id

ABSTRACT
Acrylic artificial teeth are still widely used in denture fabrication. Several brands marketed in Bandung claimed that their product has met the standard but all the brands do not give the mechanical properties data including hardness. The ADA specification standard no. 15 requires a hardness of minimum 15.00 KHN for acrylic artificial teeth. This study is aimed to find out which acrylic artificial teeth have a standardized hardness value. The study is an analytic descriptive study performed on five brands of acrylic artificial teeth marketed in Bandung. The samples were given 10 indentation spots on the upper and lower surfaces. The results of the study were analysed using Anova test and Dunnet test. The analysis showed that the hardness value of the upper and lower surfaces was as followed, respectively: A, 17.95 KHN and 17.46 KHN; B, 17.01 KHN and 17.49 KHN; C, 18.24 KHN and 17.41 KHN; D 17.61 KHN and 17.01 KHN; E 17.01 KHN and 16.59 KHN. The two-ways Anova showed that the hardness value of both surfaces does not differ significantly. It was concluded that the five brands have met ADA specification standard no. 15 and there were differences in hardness values among the brands.
Keywords: acrylic artificial teeth, ADA specification standard no.15, hardness

INTODUCTION

In dentistry, since 1930 until now acrylic artificial teeth are still widely used, especially in the manufacture of removable dentures. Some of the advantages of acrylic artificial teeth are light weight, easy to grind and polish, self-adjusting and self-balancing. While the disadvantages are that it is less strong and has low abrasion resistance so that it can change occlusion and vertical dimension.[1-4]

Acrylic artificial teeth (AAT) on the market must meet standards, one of which must comply with the American Dental Association (ADA) standard specification no.15. The AAT that meet this standard are made of polyacrylic, polyacrylic fillers, polyvinyl ester copolymers or mixtures of these plastics. In addition, chemical bond between the AAT and the base (bond strength) is 315 kg/cm2 (31 MPa), hardness is not less than 15.00 kg/mm2 (KHN), does not change color or shape when heated in hot water at 100°C for 3 hours.[4,5]

Hardness is one of the important properties in dentistry, so the hardness test is included in the requirements for obtaining specifications from the ADA.[6] Hardness is the resistance of a material to indentation or penetration on a permanent surface. Hardness gives an idea of the possible abrasion of the denture material. The surface properties of acrylic resin can be affected by hardness, which is a characteristic of the material's ease of finishing because it is resistant to scratches during cleaning.[7-9]

Some commercial brands marketed in Bandung claimed that their product has met the standar but all the brands do not give the mechanical properties data including hardness. In addition, dentists also often find patients with acrylic artificial teeth whose wear and tear on the surface of the artificial teeth have even been accompanied by a decrease in vertical dimensions.

METHOD

This research is descriptive analytic research. The samples of this study were five brands of AAT circulating at the dental depot in Bandung, each brand taken 4 dentures as samples. The sample was ground flat with a thickness of 2.5 ± 0.5 mm and buried in clear resin, this is in accordance with the ADA standard AAT hardness test.[5,10]

Samples were tested using the Knoop hardness tester. The results of the Knoop indenter shape a diamond pyramid with a diagonal of 280.8-

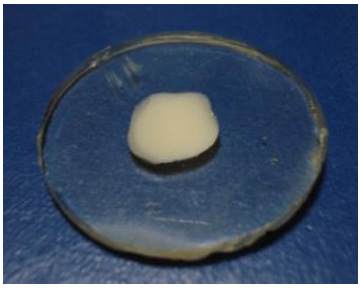

Figure 1 Sample

Table 1 Mean hardness of AAT on upper surface (KHN)

Sample	Acrylic Artificial Teeth Brand				
	A	B	C	D	E
I	16.80	16.57	19.05	17.58	18.00
II	17.48	17.12	18.44	17.53	17.10
III	17.82	17.52	17.87	17.48	16.96
IV	19.71	16.81	17.58	17.86	15.92

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Table 2 One-way anova for the hardness value of AAT on the upper surface

Source of variations	Degree of freedom	Sum of square	Mean square	Fvalue	$F_{0.05}$	
Between group	5	26.80	5.36	11.10	2.77	Sign
Within group	18	8.70	0.48			
Total	23	35.50				

311.1 m. The smaller the diagonal, the greater the hardness value and the larger the diagonal, the smaller the hardness value. Each sample was stressed 10 times using a load of 100 g for 20 seconds. Pressure is placed on the top and bottom surfaces. The results of each surface test are calculated on average, so that one hardness value is obtained from one AAT.

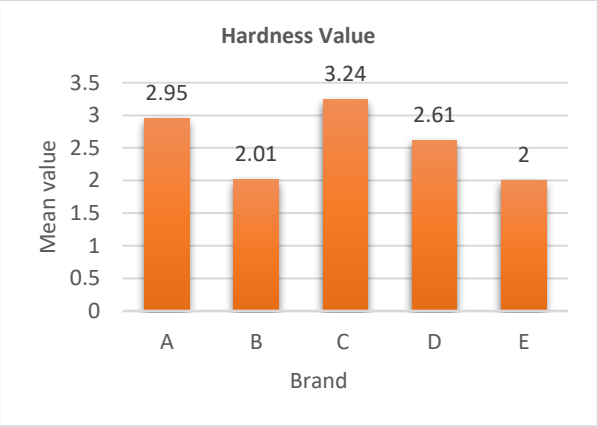

Diagram 1 Mean difference in the hardness values of the upper surface AAT in five brands with the standard values

Table 3 Dunnett test comparison of hardness values of upper surface AAT on five brands

(I) Brand	(J) Acrylic artificial teeth Standard	Mean difference (I-J)	Sig.	
A	Standard	2.95	0.00	Sign
B	Standard	2.01	0.00	Sign
C	Standard	3.24	0.00	Sign
D	Standard	2.61	0.00	Sign
E	Standard	2.00	0.00	Sign

RESULT

The results of the study will be analyzed using one-way Anova F test statistics to see if there is a difference in the average hardness value of AAT on various brands of AAT against the ADA standard specification no.15. If there are differences, further analysis will be carried out using Dunnett's test. Furthermore, to see the difference in hardness values between the upper and lower surfaces of five AAT brands, a two-way analysis of variance was performed.

DISCUSSION

Based on table 2, it is known that the calculated F 11.10 is greater than F0.05;5;18 2.77, this means that there is a significant difference in mean AAT hardness value on the upper surface between the five brands of AAT with a value of standard. To see which brand of AAT has a different surface hardness value from the ADA standard no.15, it was followed by Dunnett's test after analysis of variance.

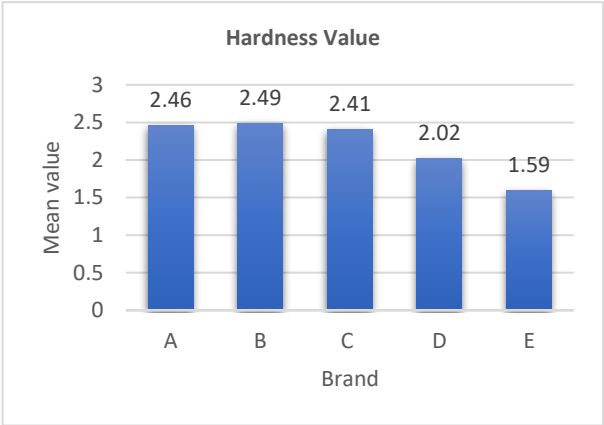

Diagram 2 Mean difference in the hardness values of the lower surface AAT in five brands with the standard values

Table 4 Mean hardness of AAT on the bottom surface (KHN)

Sample	Acrylic Artificial Teeth Brand				
	A	B	C	D	E
I	17.36	18.04	16.34	16.79	16.61
II	17.61	16.86	16.97	17.48	17.04
III	17.62	17.34	17.48	16.33	17.08
IV	17.25	17.72	18.83	17.48	15.63

From table 3, Dunnett's test compares the hardness values of the upper surface acrylic artificial teeth on brands A, B, C, D, and E to the ADA standard. Mean hardness value of the lowest upper surface acrylic artificial teeth is brand E with an average difference of 2.00 compared to the standard, while the highest is brand C with an average difference of 3.24 compared to the standard.

Table 5, it is known that F count 10.12 is greater than F0.05; 5; 18 2.77, this means that there is a significant difference in the value of artificial teeth hardness on the lower surface between the five brands of dentures with standard.

Table 6 Dunnett test comparison of the hardness values of undersurface acrylic artificial teeth on brands A, B, C, D, and E against the standard, the result is that the hardness values for AAT on the five brands have a higher mean hardness value compared to the ADA standard. The lowest mean hardness value for AAT undersurface is the brand with a mean difference of 1.59 compared to the

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Table 5 One-way Anova for hardness value of acrylic denture on bottom surface

Source of variations	Degree of freedom	Sum of square	Mean square	Fvalue	$F_{0,05}$	
Between group	5	18.42	3.68	10.12	2.77	Sign
Within group	18	6.55	0.36			
Total	23	24.98				

Table 6 Dunnett test comparison of hardness values of lower surface AAT on five brands

(I) Brand	(J) Acrylic artificial teeth Standard	Mean difference (I-J)	Sig.	
A	Standard	2.46	0.00	Sign
B	Standard	2.49	0.00	Sign
C	Standard	2.41	0.00	Sign
D	Standard	2.02	0.00	Sign
E	Standard	1.59	0.00	Sign

Table 7 Two-way Anova hardness value in AAT

Source	Degree of freedom	Sum of square	Mean square	Fvalue	F Table	
Mean	1	12077,71	12077,71			
Factor A (Surface)	1	1,35	1,35	2,65	4,17	Non-Sign
Factor B (Brand)	4	5,33	1,33	2,62	2,69	Non-Sign
Interaction AB	4	2,02	0,50	0,99	2,69	Non-Sign
Error	30	15,25	0,51			
Total	40	12101,66				

standard, while the highest is brand B with a mean difference of 2.49 compared to the standard.

Table 7 shows that the upper and lower surfaces of each brand of acrylic artificial teeth gave results that were not significantly different from mean hardness value of AAT.

These five brands of AAT have complied with the ADA standard specification no.15, namely values above 15.00 KHN. According to Craig[4] the hardness value of AAT is about 18-20 kg/mm2, in this case, only brand C is met.

One of the most important physical properties of artificial teeth used is hardness. The hardness of AAT plays a crucial impact on comfort and superior quality of mastication by aiding in the maintenance of stable occlusal relationship over time. Failure to maintain the same causes loss of masticatory efficiency, faulty tooth relationship and increased horizontal stresses and their associated sequelae. The mechanism of wear in occlusal contact areas of dental restorations is not completely understood. Three basic types of wear have been suggested: frictional wear or the interaction of microscopic irregularities, adhesive wear produced during the shearing of surface irregularities between the two occluding surfaces, and abrasive wear that occurs whenever hard foreign particles are present between the two occluding surfaces.[1] Wear depends on many factors such as neuromuscular forces and movements, lubricants associated with salivary flow and pH, foreign objects, exposure to an abrasive or corrosive atmosphere, patient's habit, diet, poor or excessive hygiene, and the type of restorative material used.[3,8]

One of the disadvantages of AAT is wear and tear, because the hardness value of acrylic is quite low compared to enamel and porcelain dentures. The AAT have been modified to overcome the disadvantage of wear by using cross-linking agents, different monomers, and the addition of fillers.[4,8]

New types of AAT using modified acrylic resin that incorporate cross-linking agents and composite resin containing filler have become increasingly common. A profoundly crosslinked system has the following advantages: color stability, plaque resistance, wear resistance, tissue compatibility, high grinding strength and excellent polishing properties (due to increased thermal resistance). Cross-linking agents also improve strength and crazing resistance. Double cross-linking procedure, eliminates the weak points of conventional polymethacrylate teeth, such as the exposure of uncross-linked polymer beads that detach during grinding. Simultaneously, the double cross-linking process leads to a considerably enhanced resistance to the mechanical wear caused by food, contact with the opposing dentition as well as tooth brushing.[8]

However, cross-linked AAT have been reported to demonstrate lower bond strength to denture base resin when compared to conventional AAT. Therefore, the ridge lap portion of the teeth is expected to be the least cross-linked so as to facilitate bonding to the denture base resin.[8,11,12]

It is concluded that all brands meet the ADA standard specification no.15. There are differences in the hardness values of the five brands of AAT. It is suggested that It is necessary to conduct further research on various factors that can

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affect the hardness of AAT as well as testing on other brands of AAT. There is a need for a testing agency tasked with testing the quality of dental materials in Indonesia.

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