Surface hardness of Thai spherical amalgam product

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Abstract

Objective: The purpose of this study was to compare the surface hardness of Thai spherical amalgam product (N'SURE) with three commercial spherical amalgams (Tytin FC®, Amalcap® Plus, and GS-80 spherical).

Materials and methods: Ten specimens were prepared from each of four spherical amalgams and then stored at 37°C for 24 hours. The surface of each specimen was polished using SiC paper (P240 to P4,000) and finished using alumina particles (average particle size, 0.05 µm). Surface hardness was then measured using Vickers hardness test under 1 kgf load for 15 seconds. The data were statistically analyzed using One-way ANOVA and Tukey's multiple comparison test at 95% confidence interval.

Results: The surface hardness of all spherical amalgams ranged from 127.77 to 158.51 HV1. Significant differences in surface hardness were found among all spherical amalgams. The highest was GS-80 spherical followed by Tytin FC®, Thai amalgam, and the lowest was Amalcap® Plus.

Conclusion: The result of this study showed that surface hardness of Thai spherical amalgam product is comparable to commercially available spherical amalgams.

Key words: alumina particles, SiC paper, spherical amalgam, surface hardness, Thai amalgam, Vickers hardness test

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Introduction

Dental amalgam has been widely used in dental restoration for many years because of its ease of use, high longevity, sufficient strength, and low cost. Dental amalgam is formed by mixing mercury with particles of dental silver alloy and usually used to restore the posterior teeth because the color is silvery gray and sometime changes to dark, lacking of esthetics[1-3]. Dental silver alloy contains silver, tin, copper and possibly zinc or other metals in small quantities, and particles can be either lathe-cut or spherical or a mixture of the two[1-4]. In dental practice, the early mixed amalgam has a plasticity that permits it to be conveniently inserted or condensed into a prepared tooth cavity and then carved to shape like the anatomy of a natural tooth[1-3].

Recently, the production of dental amalgam spherical shape using gas atomization technique has been successfully achieved in Thailand by Suchatlampong et al[5]. According to ISO 1559-1995 (ISO 24234-2004[6]), the required physical and mechanical properties (dimensional change, compressive strength, and creep) were studied, and the results supported that the Thai produced spherical amalgam can be used effectively in dental practice[7]. Surface roughness is another physical property studied, and the result showed that the surface roughness of Thai spherical amalgam product is comparable to commercially available amalgams[8]. Moreover, the cytotoxicity was also studied, and the result of Thai spherical amalgam product showed comparable toxicity to commercial restorative dental materials[9]. Hardness is important property for resistance to wear and abrasion[10,11], which has not been studied.

The purpose of this study was to compare the surface hardness of Thai spherical amalgam product with three commercial spherical amalgams.

Materials and Methods

Thai spherical amalgam product and three commercial spherical amalgams used in this study are listed in Table 1. Particle shape and size of all spherical amalgams were examined using a scanning electron microscope (JSM-6610LV, JEOL Ltd., Tokyo, Japan).

Specimen preparation

Ten specimens were prepared from each of four spherical amalgams. Each spherical amalgam was mixed following the manufacturer's instructions, and inserted into a mold (diameter, 4 mm) as shown in Figure 1, following the schedule shown in Table 2[6] using a load transferring device (A-001, Seiki Co.,Ltd., Japan). After ejection, specimens were stored at 37°C for 24 hours. One surface of each specimen was polished with SiC paper (P240 to P4,000, Microcut disk 200 mm, Buehler, Lake Bluff, Illinois, USA) and finished with alumina particles (average particle size: 0.05 µm, Micropolish II, Buehler, Lake Bluff, Illinois, USA) and then

Table 1 Spherical amalgams used in this study

Amalgam	Composition (mass%)			Alloy : Mercury ratio	Lot #
	Ag	Sn	Cu		
Thai amalgam (N'SURE)[a]	60	27	13	1 : 0.80	—
Tytin FC®[b]	61	26	13	1 : 0.80	7-4059
Amalcap® Plus[c]	70	18	12	1 : 0.95	MT4045
GS-80 spherical[d]	56	29	15	1 : 0.74	090733519

[a]Faculty of Dentistry, Mahidol University, Bangkok, Thailand
[b]Kerr Corporation, Michigan, U.S.A.
[c]Ivoclar Vivadent AG, Schaan, Liechtenstein
[d]SDI Limited, Victoria, Australia

cleaned in an ultrasonic cleanser (Harvey Vibraclean 300, MDT Corporation, California, U.S.A.) for five minutes.

Measurement and data analysis

Surface hardness was measured using a Vickers hardness testing machine (FM-ARS 9000, Future-Tech Corp., Tokyo, Japan) under 1 kgf load for 15 seconds. The data were statistically analyzed using One-way ANOVA and Tukey's multiple comparison test at 95% confidence interval.

Results

The particle shape and size for each of four spherical amalgams are shown in Figure 2. Particle shapes were sphere, oval, and droplet, while particle sizes varied comprising of fine and large particles. The various amounts of particle sizes did not different among Thai amalgam, Amalcap® Plus and GS-80 spherical, while Tytin FC® had a greater amount of fine particles than the other spherical amalgams (Figure 2).

The mean surface hardness of four spherical amalgams and the statistical differences between the mean are shown in Table 3. The surface hardness of all spherical amalgams ranged from 127.77 to 158.51 HV1. The highest was GS-80 spherical followed by Tytin FC®, Thai amalgam and the lowest was Amalcap® Plus.

The statistical differences between the means showed that the surface hardness of Amalcap® Plus was significantly lower than the other spherical amalgams ($p<0.05$), and that of Thai amalgam was also significantly lower than Tytin FC® and GS-80 spherical ($p<0.05$), while GS-80 spherical had significantly higher surface hardness than the other spherical amalgams ($p<0.05$).

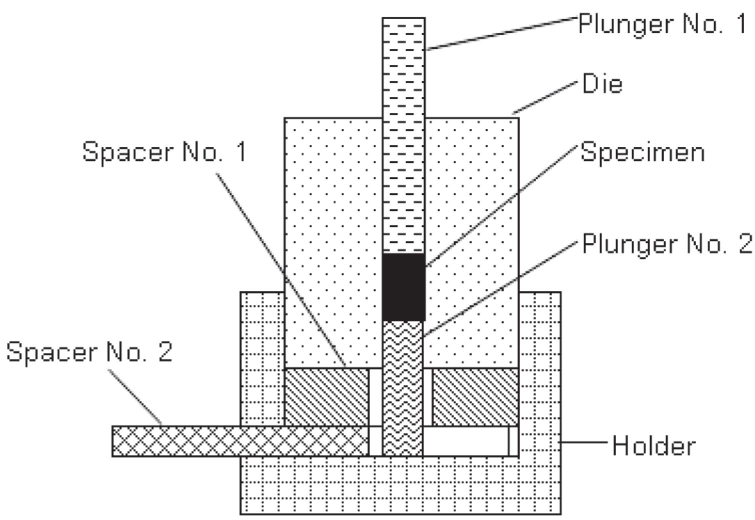

Figure 1 Diagram of mold for specimen preparation

Table 2 Schedule for preparation of specimens

Procedure	Time (sec)
1. End mixing	0
2. Place mixed mass in mold and apply a load to produce a pressure of 14±1 MPa	30
3. Release load and remove spacer No. 2 at	45
4. Replace load at	50
5. Release load at	90
6. Carefully remove excess mercury and eject specimen at	120

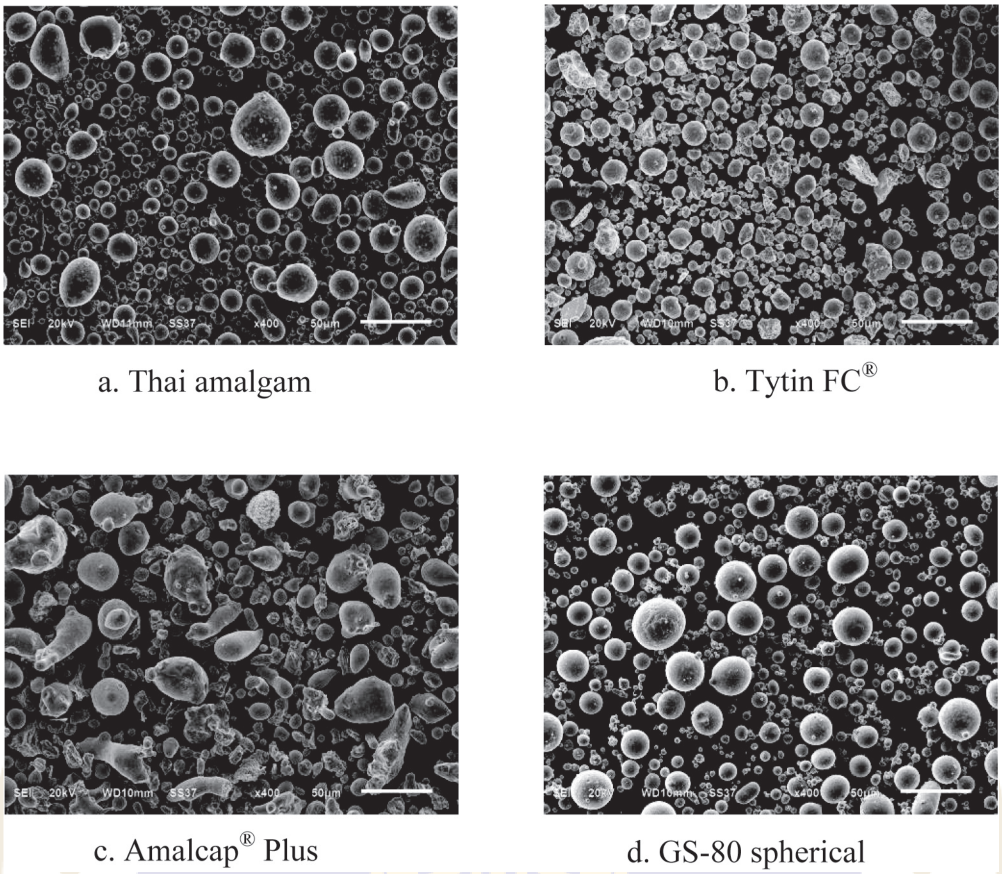

Figure 2 Particle sizes and shapes of four spherical amalgams

Table 3 Surface hardness (HV1) of four spherical amalgams

Amalgam	Surface hardness (HV1)
Thai amalgam	139.19 (2.02)
Tytin FC®	145.05 (3.53)
Amalcap® Plus	127.77 (2.15)
GS-80 spherical	158.51 (4.32)

Standard deviations in parentheses
Significant differences among four spherical amalgams ($p<0.05$)

Discussion

The present study investigated the surface hardness of spherical amalgam produced in Thailand and three spherical amalgams (Tytin FC®, Amalcap® Plus, and GS-80 spherical) imported from abroad, to determine whether the surface hardness of Thai-produced spherical amalgam was suitable for clinical use by comparing with commercial spherical amalgams. The data of surface hardness were used to consider the materials to be effective in dental practice because surface hardness is a property for resistance to wear and abrasion by chewing food and tooth brushing.

The result of this study showed that the surface hardness of all spherical amalgams ranged from 127.77 to 158.51 HV1. Significant differences in surface hardness were found among all spherical amalgams. The highest was GS-80 spherical followed by Tytin FC®, Thai amalgam, and Amalcap® Plus. Amalcap® Plus had the lowest surface hardness because the copper content was lower than the other spherical amalgams (Table 1). On the other hand, GS-80 spherical had the highest surface hardness because copper content was higher than the other spherical amalgams (Table 1). It has been reported by the literature for dental materials[12] that copper plays an important role to increase the strength and hardness of the dental amalgam, and a study by Hasheminezhad concluded that compressive strength and Hasheminezhad et al[13] hardness of dental amalgam increased with increased copper content.

Mercury/alloy ratio is one factor to control the quality of dental amalgam[4,14]. This factor may be related to the surface hardness, and the result of this study showed that GS-80 spherical had the highest surface hardness with the lowest mercury/alloy ratio, while Amalcap® Plus had lowest surface hardness with the highest mercury/alloy ratio. The higher mercury/alloy ratio showed more γ_1 (Ag_2Hg_3) and less the original unreacted γ (Ag_3Sn) particles, resulting in decreased mechanical properties because γ particles are the strongest and stiffest of dental amalgam[14,15].

The contents of the composition and mercury/alloy ratio in Thai amalgam were similar to those of Tytin FC® (Table 1), but the results showed that the surface hardness of Tytin FC® was higher than Thai amalgam because Tytin FC® had finer particles than Thai amalgam (Figure 2). The finer particles produced finer grain structure. It has been demonstrated by Wing et al[16] that the gain size of γ_1 in spherical amalgam reduced with reduced particles size. Metals with finer grain structure are generally harder and stronger than those with coarser grain structure[17].

Further studies including X-ray diffraction analysis and detailed microstructural observation are necessary to explore the setting reaction of Thai amalgam to clarify the formation of phases.

In conclusion, the result of this study showed significant differences in surface hardness among four spherical amalgams. The highest was GS-80 spherical followed by Tytin FC®, Thai amalgam, and the lowest was Amalcap® Plus. This result suggests that the surface hardness of Thai amalgam product is comparable to commercially available amalgams and acceptable for dental practice.

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