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The Future of Diamond Toothpastes

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Quintessence for the Dental Office

Toothpaste using diamond powder as a cleaning agent is suitable for all types of patients with various conditions. Diamond toothpaste has been shown to have low abrasive values on dentine and enamel. The cleaning action is comparable to conventional toothpastes with higher abrasive values, and it averts the formation of tartar. Diamond toothpastes have been shown to restrict the formation of wedge-shaped defects, provide prolonged smoothness on dentine and enamel and deliver ultimate fine polishing of all dental surfaces.

Summary

Diamond toothpastes achieve enhanced cleaning action compared to conventional toothpastes, while preserving the tooth substance. Using fine particles of diamond powder as an abrasive is biologically and toxicologically safe. The loss of dentine is reduced by three quarters when compared to traditional brands of toothpastes.

When using the finely graded diamond powder, the highly polished tooth surface feels and appears shiny even when dry. Benefits such as inhibition of Tartar formation can be observed as well as decreased hypersensitivity, conceivably contributed to obstruction of dental tubules by diamond particles.

The analyses not only show excellent acceptance of diamond toothpastes by the consumers, they also contribute to a prolonged feeling of smoothness and freshness.

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The Future of Diamond Toothpastes

Diamond toothpastes achieve a superior cleaning action than conventional toothpastes, while preserving the tooth substance with low abrasion, and low RDA values.

Introduction

Many commercially available toothpastes provoke damage to exposed dentine over a lifetime of regular tooth brushing, known as “excessive abrasion” (Imfeld et al. 1998). This is due to the use of regular abrasives such as silica etc., which do not harm the enamel but attack the softer dentine around the tooth necks and roots.

As the population ages, gums recede and more dentin and root surfaces can be exposed, creating more sensitive tooth surfaces. Many people have this problem yet just “live with” it and try to ignore the pain. Also, conventional toothpastes have become rather more aggressive in the past years, as a recent study has demonstrated (1).

The objective was to develop a toothpaste with a low RDA, which could clean and remove plaque from the tooth surfaces, retard new plaque formation and provide smoothness and a fine polished feel. The diamond powder selected for the purpose is much smaller and about 100 times less concentrated than the abrasives present in today’s regular toothpastes. Therefore, damage to the tooth surface is reduced.

Nonetheless, when substituting abrasives in toothpastes, the overall chemistry of the toothpastes should remain unchanged due to the scientific validation of fluorides, antimicrobial substances, anionic tensides and the like. Since diamond is bio-inert it does not change the chemical benefits of the proven pastes, and it reduces the abrasivity and enhances the polished clean effects.

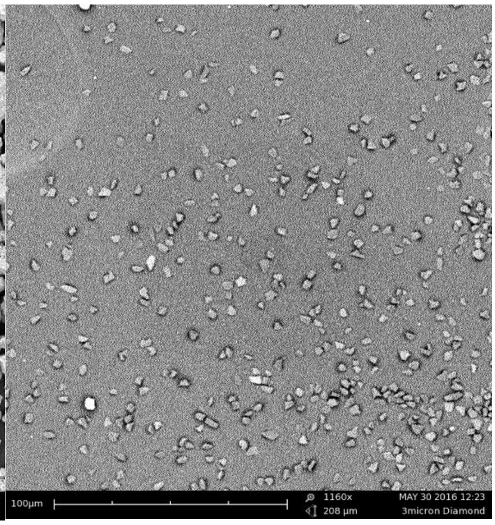
Diamond to substitute Silica

Diamond is the hardest material known. For many years, finely graded diamond powder has been used in various industries, for polishing materials in industrial production processes, for example, in optics, for the polishing of gems, sapphire glasses or electronic components. Diamond powder used in toothpastes can be selected so that it has very little abrasivity, yet still cleans and polishes well.

The use of precisely micronized diamond powder instead of silica, carbonates or the like, spares the tooth substance from unnecessary abrasion. Several products from AMC Abrasives Marketing & Consulting LLP, London, which contain diamond powder as sole abrasive have been tested in specialized laboratories and universities and their effects characterized. Below are SEM micrographs of different abrasives at equal magnifications (Fig. 1, 2 and 3).

Fig. 1: SEM Micrograph of a Conventional Abrasive (Silica) Particle Size Distribution = 1 to 100µm.

Fig. 2: Diamond Powder Size 3µm at Equal Magnification, with very narrow Particle Size Distribution.



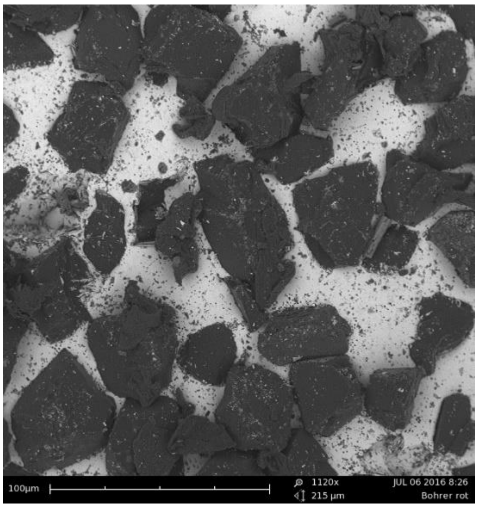


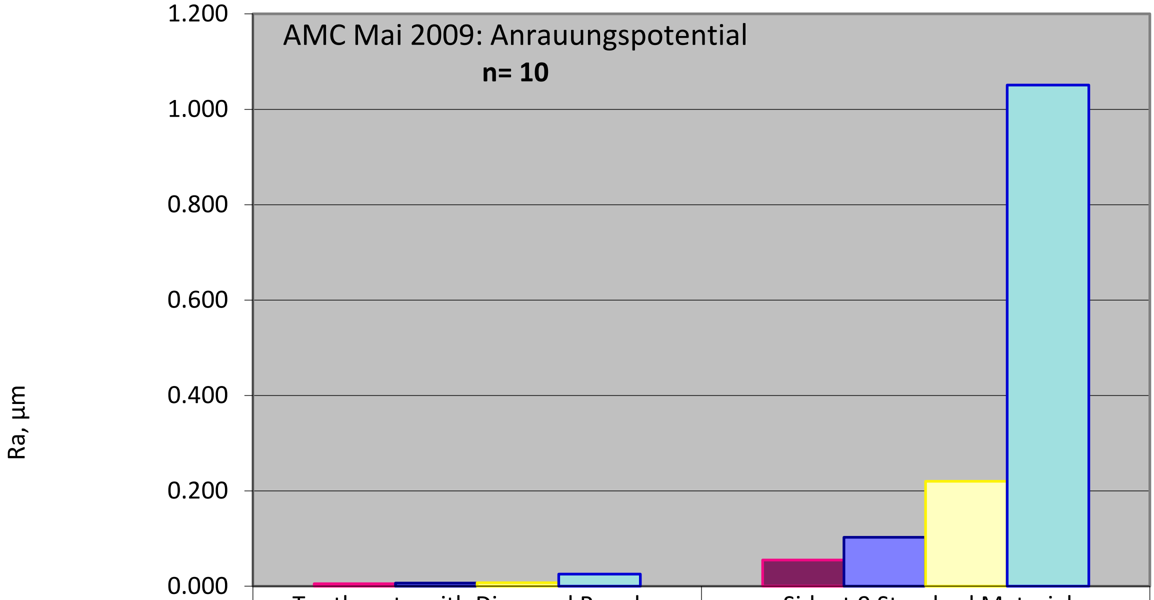
Fig. 3: SEM Micrograph of a Diamond Drill (red), used for the Machining of Tooth Hard Tissue. (Picture: AMC).

Abrasion mainly depends on material, particle size, distribution, and concentration of the abrasive. Diamond powder can be used for sawing and grinding, but also for polishing. It can be selected so the abrasion is measured at almost zero, so the loss of substance is not an issue anymore. The question whether diamond powder of a certain particle size can be used for the cleaning and polishing of teeth can be answered positively, based on the recently available research data below (1, 2).

Extensive Research

A study at the University of Zürich (2) assessed the roughening potential of a toothpaste containing 1 Micron diamond powder (AMC 1000*2) in comparison with a standard abrasive, Sident 9. The roughening potential is the difference between the initial roughness value of a surface and the roughness after treatment with an abrasive, in µm.

Test materials were 10 polished extracted human root specimens which were exposed to the test slurries in a brushing machine at 1 back and forth movement per s, during 2, 5, 10 and 25 min respectively, with a toothbrush pressure of 250g. Fig. 4 explains the difference:



	Toothpaste with Diamond Powder	Sident 9 Standard Material
after 2 min	0.005	0.055
after 5 min	0.007	0.102
after 10 min	0.008	0.220
after 25 min	0.025	1.051

Fig. 4 Roughening Potential of Dentine at different Durations. 1µm Diamond compared with Sident 9. (T. Imfeld 2009).

Basic requisitions for a toothpaste encompass thorough and tooth-conserving cleaning action, and protection from caries and periodontitis. Abrasion and roughness must remain minimal even for high PCR levels (3). The tightrope walk between a good stain removal and a minimal abrasion depends on the selection of the abrasive and its properties.

Abrasion

The abrasivity of toothpastes is expressed with their RDA (Relative Dentin Abrasion) value (4). The higher the number, the more abrasive and damaging the product is for dental materials and teeth. The RDA depends on material, size, surface and concentration of an abrasive.

Sensitive teeth and the neck of the tooth require a toothpaste with a low RDA. But, removal of tartar has so far only been possible with products with a high RDA. Hence, there is a multitude of different toothpastes on the market with different ingredients, but also very different RDA values, ranging from 30 to nearly 200. There seems to be agreement that RDA's over 80 are considered too aggressive for everyday use (5). For many years, the Laboratory of Indiana University, and particularly a group of people working with Dr. Bruce Schemehorn (4) have been concerned with research in this field.

This laboratory was assigned to measure dentin abrasion (RDA), enamel abrasion (REA) and the cleansing efficacy (PCR) of a few diamond toothpastes from AMC company containing various particle sizes in comparison to a whitening toothpaste and to the standard abrasive of the American Dental Association (ADA).

The Pellicle Cleaning Ratio (PCR) procedure is used to evaluate the stain removal performance of a toothpaste. Specimens made from extracted bovine incisors are exposed to a staining broth of coffee, tea, red wine and other substances. The stained samples are first measured spectrometrically and then measured again after brushing with toothpaste slurry to determine the color change using a standardized procedure (6). Table 1 shows the RDA and REA values and the PCR of various toothpastes.

Tab. 1: Test Results of five AMC Diamond Toothpastes with Sizes of 2.8µm, 3.5µm und 4.4 µm respectively, versus a 'Whitening' TP and the ADA-Standard Toothpaste (6) (Indiana University, B. Schemehorn, 2012)

Sample	Designation	Diamond (µm)	Conc. g/kg	RDA	REA	PCR
1	AMC 2800*1.6	2.8	1.6	14.9 ± 0.8	45.2 ± 3.9	n/A
2	AMC 3500*1.2	3.5	1.2	15.1 ± 1.3	38.2 ± 1.1	76.5 ± 11.1
3	AMC 3500*1.6	3.5	1.6	18.3 ± 1.4	33.7 ± 2.3	85.8 ± 7.9
4	AMC 3500*2	3.5	2.0	19.4 ± 0.5	32.4 ± 0.9	112.8 ± 7.7
5	AMC 4400*1.6	4.4	1.6	22.1 ± 1.3	31.2 ± 1.0	n/A
6	Whitening Toothpaste			95.0 ± 1.4	6.8 ± 0.5	97.9 ± 3.5
7	**ADA Control**			**100**	**10**	**100.0** ± 3.0

During the abrasion measurements according to Hefferren (7) with diamond toothpastes it was found that the method used did return results which were inconsistent with other methods used. The Hefferren method, when used for a comparison of very fine diamond samples with a much coarser ADA reference abrasive, was not directly applicable.

Indication 1: The samples 1, 3 and 5 in Table 1 show an increase of RDA, but a decrease of REA values with the increase of diamond size and equal concentration. However, Fig. 5 shows an increase of both RDA and REA if the diamond size increases. Those results are based on absolute abrasion measurements by profilometry (8a, 9) and seem to be more reliable.

Indication 2: For the samples 2, 3 and 4 the diamond size is equal but the concentration increases. Here too, RDA increases and REA decreases which runs against logic. A comparison with absolute abrasion measurements (8a, 9) shows an increase of both RDA and REA with an increase of concentration.

Abrasion Measurements by Profilometry

For the reason explained above measurements by profilometry (8a) which return absolute values in micrometers (µm) were effectuated. This method was better suited for the generation of reliable abrasion results. Therefore, University of Zurich tested the absolute abrasion of three diamond toothpastes on enamel and dentine of extracted bovine teeth in comparison with a commercially available control toothpaste. Table 2 shows the abrasion in micrometers.

Table 2	N		M	SD	VC%
AMC 1.5 µm on Dentine	12	3600 BS	0.40	0.18	45
AMC 1.5 µm on Dentine	12	7200 BS	0.67	0.24	36
AMC 1.5 µm on Enamel	12	21600 BS	0.36	0.14	39
AMC 1.5 µm on Enamel	12	43200 BS	0.57	0.18	32
AMC 2.5 µm on Dentine	12	3600 BS	0.97	0.44	46
AMC 2.5 µm on Dentine	12	7200 BS	2.40	0.62	26
AMC 2.5 µm on Enamel	11	21600 BS	0.92	0.22	24
AMC 2.5 µm on Enamel	12	43200 BS	1.36	0.33	24
AMC 4.0 µm on Dentine	12	3600 BS	1.91	0.87	45
AMC 4.0 µm on Dentine	12	7200 BS	3.06	1.16	38
AMC 4.0 µm on Enamel	12	21600 BS	1.47	0.68	46
AMC 4.0 µm on Enamel	12	43200 BS	2.49	1.06	42
Colgate Total on Dentine	12	3600 BS	5.04	1.23	24
Colgate Total on Dentine	12	7200 BS	10.21	1.54	15
Colgate Total on Enamel	10	21600 BS	0.13	0.08	62
Colgate Total on Enamel	9	43200 BS	0.22	0.11	49

Tab. 2: Mean (M), Standard Deviation (SD) and Variation Coefficient (VC%) of the Absolute Abrasion [µm] in the various Experimental Groups (n=12).
Abrasion [µm] in Relation to Initial Base Measurement after Number of Brush Strokes (BS).
N = Number of Samples included in the Analysis.

On dentine 7,200 brush strokes were effectuated, corresponding to about one year of teeth brushing. On Enamel 43,200 brush strokes were needed to show a measurable amount of wear. The brush pressure was 200 grams for all tests. The measured abrasion was then graduated into 70 years of teeth brushing and presented in Figure 5.

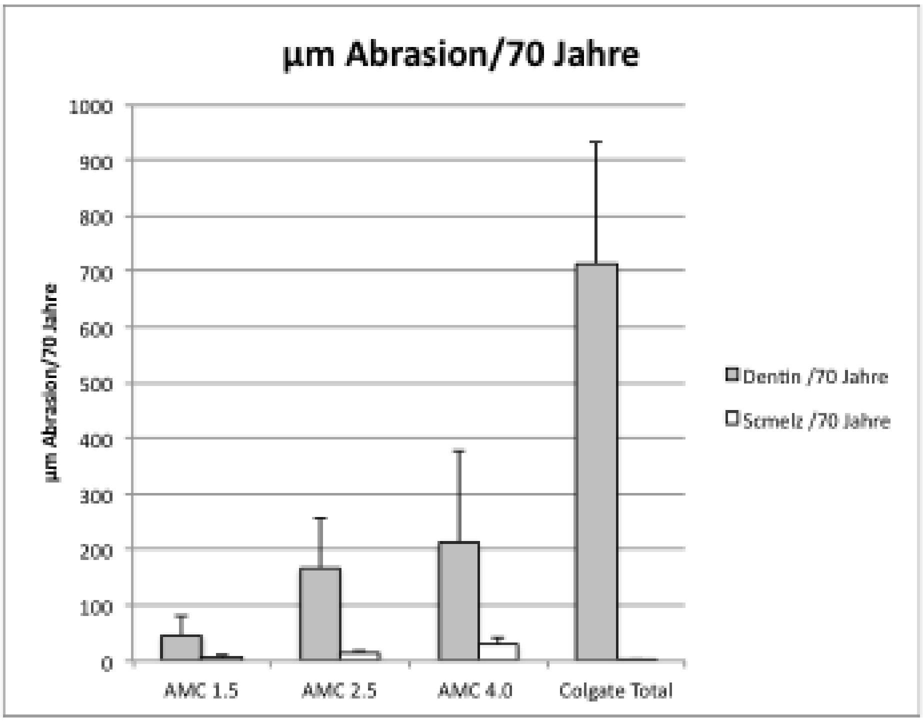


Fig. 5 shows the Abrasion in µm of three AMC Diamond Toothpastes with Particle Sizes of 1.5µm, 2.5µm und 4µm and a popular commercial Toothpaste, projected to 70 Years of use (8a).

The results show clearly that all diamond toothpastes reduced the abrasion of dentine significantly while the abrasion increase on enamel is comparatively low, depending on diamond size. This in comparison to one of the most popular toothpastes on the market.

Fig. 5 shows for 4µm diamond an enamel abrasion of 29µm in 70 years of use. But, the dentine abrasion is reduced by 70% or 500µm in 70 years of use, compared to the regular toothpaste.

For 2.5µm diamond the enamel abrasion is about 16µm, dentine abrasion is reduced by 555µm.

For 1.5 µm diamond the enamel abrasion is down to 7µm, but dentine abrasion is reduced by 670µm, all data pertaining to 70 years of use.

The abrasion values of dentine and enamel from Fig. 5 are presented in different form in Fig. 6, showing the abrasions for a 4µm diamond toothpaste and one of the most popular toothpastes on the market.

Dentin- und Schmelzverlust in Mikrometern

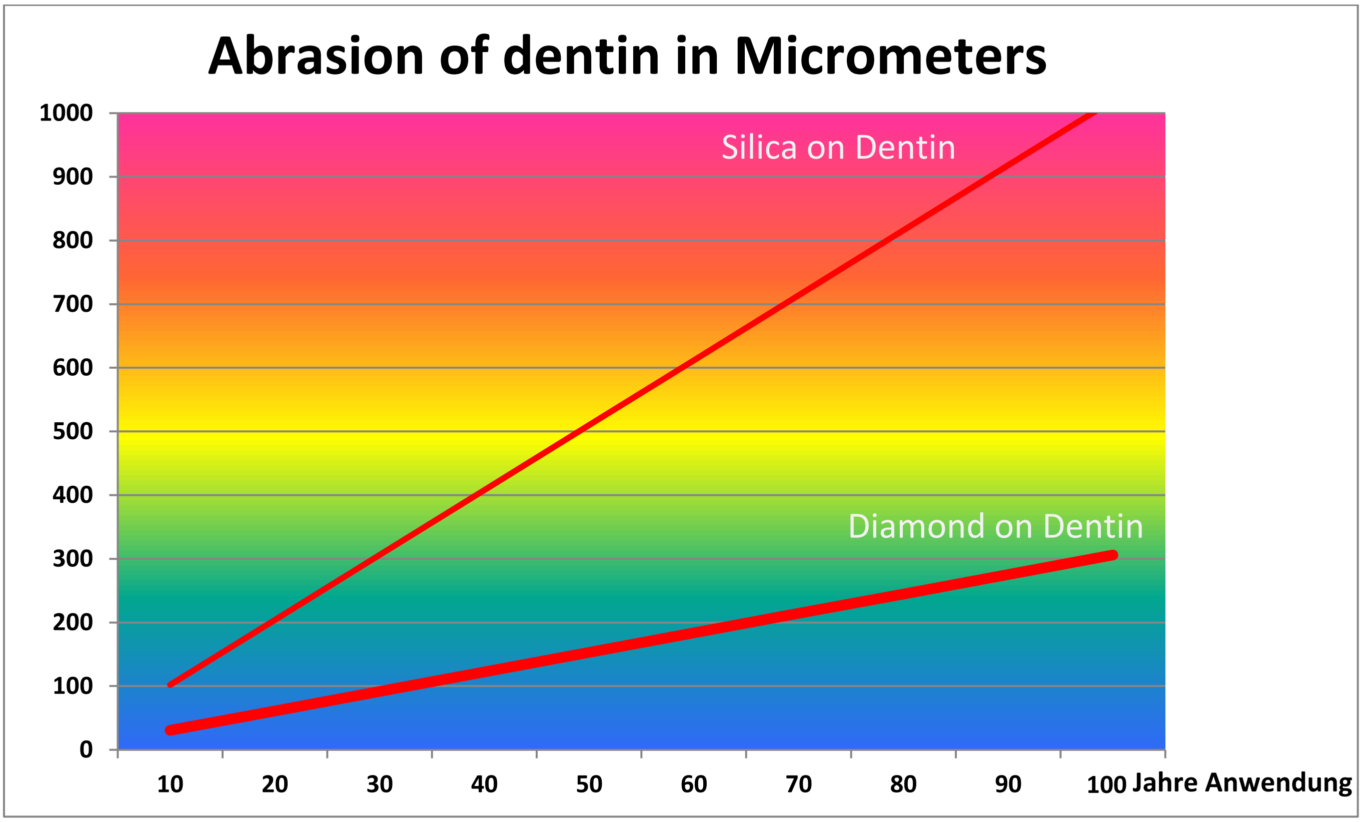


Fig. 6: Dentin and Enamel Abrasion of Diamond and Silica based Toothpastes over Time in µm. Interpretation and Extrapolation of Data from Fig. 5, compiled for 4µm Diamond.

Wedge-shaped Defects

Scientists agree that wedge-shape defects and recessions are owed to multifactorial reasons (10, 11). There is a consensus, however, that the frequency of teeth brushing and its duration and the technique employed play a role, as well as the changing of the tooth brush, the pressure applied for brushing and the acidity of previous intake.

A study of Lussi et al. (12) indicates a relation between wedge-shaped defects and hypersensitivity. An average of 34.8% of all participants were suffering from hypersensitivity, whereas the ratio of participants with wedge-shaped defects was higher at 84.6%.

Wedge-shaped defects at the tooth necks, caused by the use of conventional abrasive toothpastes and manual toothbrushes in combination with a unsuitable (scrubbing) brushing method, can be significantly reduced when using the new diamond abrasive instead of conventional silica or carbonates etc. (Fig. 6).

Fig. 7: Right hand side of buccal teeth of a 54-year-old male who brushed his teeth twice daily for 20 years with a hand brush and a toothpaste of medium abrasivity (Photo Prophylaxe Zentrum Zurich).

Discussion

Diamond toothpastes both protect the tooth substance and provide better tooth cleaning than conventional toothpastes. Diamond powder used as an abrasive is biologically and toxicologically safe (13,14). The reduction of tooth roughness from Ra = 1µm to approx. 0.05µm provides shiny teeth even when they are dry, and generates a reduced surface area.

Diamond powder reduces the abrasion of dentine by three quarters, when compared to one of the most popular dentifrices on the market. Wedge-shaped defects can also be reduced, even for 'scrubbers'. Tartar formation is inhibited at its formation stage by the action of the diamonds.

Experience shows good acceptance of diamond toothpastes by the public. The prolonged feeling of smoothness and freshness and the brilliance of the teeth surface is easily felt even after a few days.

A reduction of hypersensitivity has been confirmed by clinical tests. An obstruction of dentine tubules by the diamond powder may be the reason (15). These studies will be published in a separate article.

10. 3. 17

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