

## Abrasivity of dentrifices: An update

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### ABSTRACT

Tooth abrasion is a leading dental problem in common population. The main culprit of this is toothpaste abrasives. Hence, measurement and standardization of toothpaste is required. Various recommended methods were described previously. However, radioactive dentin abrasion (RDA) is the mostly followed method. In this article, we presented the basic need of toothpaste abrasivity testing, brief description of the recommended methods, different etiologies of tooth wasting other than caries, and RDA values of different tooth pastes.

**Key words:** Radioactive dentin abrasion, tooth abrasion, tooth paste

### INTRODUCTION

Abrasion can be defined as the removal of material from the bulk of the substrate, during relative movement of the abrasive and substrate and as such the term can be used to include the removal of tooth surface films, such as pellicle.<sup>[1]</sup> Soft microbial layers in the oral cavity can be removed by brushing alone. That may be plaque, debris, which is adhered to tooth surface by chemical and physical attachment. Dentrifices have been used for many years and have been proven to be an important tool for improving both oral health and esthetics. The primary purpose of brushing the teeth with a dentrifice (dens-tooth, fricare-to rub) is to clean the accessible tooth surfaces of immature dental plaque which, if not removed, matures in 24 h. Besides chemically active agents, abrasives are essential compound of dentrifices as the major cleaning effects of toothpastes are still due to mechanical action (abrasivity).<sup>[1,2]</sup> Various wasting disorders can be seen externally such as toothpaste abrasion, erosion, attrition as shown in Chart 1.

Typical formulation of toothpaste is abrasive 10–40%, humectants 20–70%, water 5–30%, binder 1–2%, detergent 1–3%, flavor 1–2%, preservative 0.05–0.5%, and therapeutic agent 0.1–0.5%. There are various types of abrasive materials used in toothpaste. These may include the use of one or more of, for example, hydrated silica, calcium carbonate, dicalcium phosphate dihydrate, calcium pyrophosphate, alumina, Perlite, and sodium bicarbonate.<sup>[3]</sup> Various key parameters that have been demonstrated to influence the abrasion process along with material used and its properties which include particle hardness, shape, size, size distribution, and concentration. Various methods for measuring abrasivity of toothpaste has been described in this article and along with that diagnosis of wasting disorder has briefly discussed. Aim of this article can be considered to be spreading knowledge of abrasivity of toothpaste; so that dental surgeon will well aware about when and why to prescribe different formulation of dentrifice.

### METHODE OF SELECTION OF ARTICLES

We searched in Google scholar, PubMed, IndMED with the phrase “abrasivity of toothpaste” and found 112 article of

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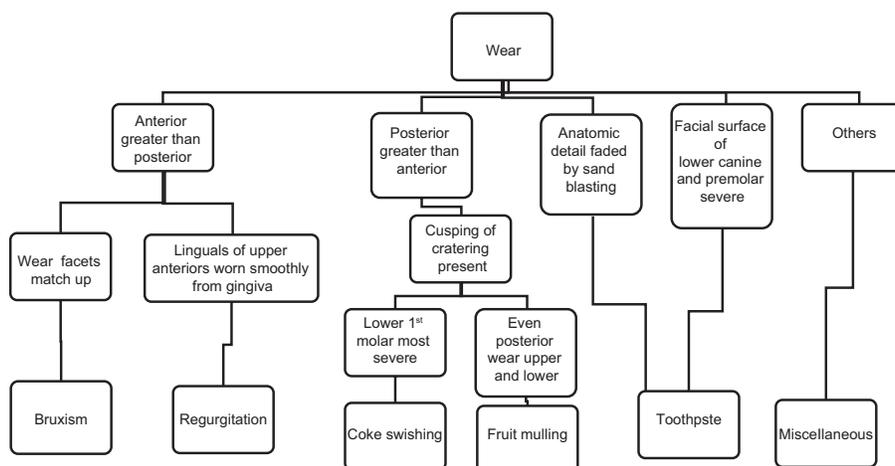


Chart 1: Dental wasting disorders

choice. After the 1<sup>st</sup> step of scrutiny, we selected 21 articles on the method of abrasivity measurement and 2 articles of dental wasting disorder and a review of those article and information gathered were presented in this following way.

### VARIOUS METHODS TO TEST ABRASIVITY OF DENTIFRICES

Various qualitative and quantitative methods are used to measure toothpaste abrasivity. Quantitative methods are radioactive dentin abrasion (RDA) method, weight, and volume loss. Qualitative methods are profilometry, light reflection techniques, microscopy, etc.

Different methods to test abrasivity are as follows in chronological order:

#### Predictive term selection - 1907

Miller described the wasting of tooth tissue as abrasion, chemical abrasion, denudation.<sup>[3]</sup>

#### Contamination - 1937-1942

Scratch tests for particulates:

- 1937 – Glass scratch test<sup>[4]</sup>
- 1942 – Silver scratch test.

#### Abrasion methods

1. Using rotating plate application of abrasive to substrate  
1933 – Silver as substrate.<sup>[5]</sup>
2. Using tooth brushing machine:  
1942 – Antimony and brass as substrates  
1942 – Electrolytic copper as substrate  
1971 – *In vivo* method with acrylic substrate on veneer crowns<sup>[6]</sup>  
1982 – Acrylic as a substrate for abrasion of power toothbrushes.<sup>[7,8]</sup>

#### Measurement methods

- Radiotracer measuring method and protocols
- Profilometry collaborative study comparing radioactive dentin and profilometry methods
- International collaborative study of abrasion methods.

#### Toothpaste specifications and related methods

- 1937 – US Government toothpaste purchasing guidelines that included glass scratch test for grit as a qualitative abrasion test method<sup>[4]</sup>
- 1976 – American Diabetes Association (ADA) used RDA method for tooth paste
- 1981 – British Standards Institute (BSI) Toothpaste Specification BS 5137 that included radiotracer and profilometry abrasion measuring methods
- 1995 – ISO toothpaste specification 11,609 includes radioactive dentin abrasivity and profilometry methods
- 1995 – Chinese specification includes glass scratch test.

#### Gravimetric methods using metals as abrasion substrates

In 1933, Hodge and McKay<sup>[5]</sup> reported in the on the rotating plate method for tooth brushing. The method used silver metal as the brushing substrate that was abraded with a mixture of abrasive, glycerin, and water. Silver was chosen because of its comparable hardness to human enamel based on 2.7 Mohr and 96 Bierbalm units, two methods using the relative ability to scratch a surface as a hardness measurement value. Other metals have also been used as abrasion substrates with the rotating plate concept. Peerless used antimony and silver with hardness of 231 and 200 Bierbalm units, respectively. The silver used by Peerless was thus twice as hard as the silver of Hodge and McKay. Antimony and brass were also used as abrasion substrates.<sup>[6]</sup>

In 1942, Monsanto used of electrolytic copper (2.6–2.8 Mohr's scale, 74 Bierbahn units) as an abrasion substrate which was comparable in hardness to silver in Mohr's scale, and <96 Bierbahn units of the silver used by Monsanto and McKay.<sup>[7]</sup>

In 1982, Harrington *et al.* at general electric used acrylic strips as abrasion substrates for power toothbrushes and toothpastes.<sup>[8]</sup>

### Profilometry

In 1972, Ashmore *et al.*<sup>[9]</sup> described an abrasion method using profilometry.

### Procedure

At least six enamel and six dentine specimens should be allocated to each product and the reference dentifrice. Prior to the abrasion test; each specimen should be taped with two pieces of PVC adhesive tape, placed parallel to each other to expose a window of enamel or dentine approximately 2 mm wide. After dentifrice slurry brushing, remove the tape from specimens and re-measure using the operating method for the particular profilometer. For two-dimensional contact profilometer, the profile should be taken from just inside the previously taped zone of the specimen across the exposed zone and just into the opposite previously taped zone. For three-dimensional contact and noncontact profilometer, a length in the x-axis of the exposed window, such as 1 mm, can be taken and the instrument provides scans at several microns along this zone, again from the edge of the previously taped zone across the treated zone to the edge of the other previously taped zone. Depending on the number of specimens of enamel and dentine allocated to each reference and test dentifrice, a mean abrasive depth across the respective specimen group is calculated.

### Radioactive dentin abrasion

RDA method is currently recommended by ADA. ISO standardization number 11609 also recommends this method. The method is based on the methodology described by Grabenstetter, *et al.*<sup>[10]</sup> and Hefferren.<sup>[11]</sup>

ISO recommendation for toothpaste should not have more than 250 RDA, i.e., 2.5 times more than dentine.<sup>[12]</sup>

### The reason behind radioactive dentin abrasion development

The most common dentifrice abrasives are calcium phosphates. Calcium or phosphate analysis of the toothpaste slurry used to brush the teeth is not possible (for one could not differentiate between the calcium and phosphate in the brushing slurry coming from the loss of tooth structure, and that coming from the toothpaste abrasive system).

This situation led to the use of irradiated teeth and the measurement of the isotopic forms of the elements coming

from the tooth. The amount of calcium and phosphate coming from irradiated teeth was variable between teeth and between sequential layers of the same tooth. This measure is RDA.

A specific lot of calcium pyrophosphate was set aside by the Monsanto Company (St. Louis, MO, USA) as the first abrasive method reference for the dental research community the abrasivity of this lot was assigned an RDA value of 250, and later changed to an AI (Abrasivity Index) of 100. Various toothpaste described having RDA values [Table 1].

### INTERNATIONAL COLLABORATION

In 1984, an international collaborative study compared the ADA RDA and the BSI radioactive and profilometry methods.<sup>[9,13-15]</sup>

Five laboratories used the ADA method, two laboratories used the profilometry method, three laboratories used the BSI modified RDA method,<sup>[15]</sup> with sequential dilution of the toothpaste slurry to mimic the salivary dilution occurring when brushing in the mouth.

The test toothpaste included two calcium phosphate and two chalk blends to achieve lower and higher dentin abrasivity. The ADA method had a somewhat narrower range for both the phosphate and chalk pastes. The BSI profilometry method was somewhat more variable and tended to rank some abrasives differently than the radiotracer methods.

### SODIUM BICARBONATE AS A CLEANSING AGENT

Sodium bicarbonate in various crystalline sizes has very low dentin abrasivity. Mean abrasivity of seven grades of sodium bicarbonate particles was one-ninth that of the abrasivity reference, calcium pyrophosphate. The mean ratio of abrasion to cleaning power (abrasion cleaning power) for the seven grades of sodium bicarbonate was 10.2, compared to 1.7 for calcium pyrophosphate. The cleaning function of sodium bicarbonate is achieved by a combination of mechanical and chemical cleaning; thus sodium bicarbonate cleans with less abrasion.<sup>[16-18]</sup>

### Clinical implication

Tooth abrasion during brushing, have multi-factorial etiology. This also includes physical properties of the toothpaste and toothbrush used with patient-related factors such as tooth brushing frequency and force of brushing. Tooth brushing abrasion is mainly related to the abrasivity of the toothpaste, while the toothbrush acts as a carrier, with addendum effects of the toothpaste. Acid impacted tooth has more material loss in enamel as compared to dentin.

All these factors should be considered when a patient confirmed with tooth brushing erosion comes to dental

**Table 1: Updated values of common toothpaste**

Toothpaste name	RDA
Toothbrush with plain water	4
Plain baking soda	7
Arm and Hammer Dental Care Tooth Powder	8
Weleda Salt Toothpaste	15
Elmex Sensitive Plus	30
Weleda Plant Tooth Gel	30
Sensodyne ProNamel - Isoactive - Daily Protection	32±15%
Sensodyne ProNamel - Mint Essence	37±15%
Sensodyne ProNamel - Fresh Wave	37±15%
Weleda Children's Tooth Gel	40
ARM and Hammer PeroxiCare Toothpaste	42
Arm and Hammer Advance White Baking Soda and Peroxide	42
Sensodyne Iso-active - Multi Action	44±15%
Squiggle Enamel Saver	45-55
Weleda Calendula Toothpaste	45
Weleda Pink Toothpaste with Ratanhia	45
Oxyfresh	45
Arm and Hammer Dental Care Advanced Cleaning Toothpaste	49
Tom's of Maine Sensitive	49-100
Crest Plus Scope Flavor (green gel)	51
Sensodyne Cool Gel-Fresh	51±15%
Sensodyne Fresh Impact	51±15%
Sensodyne Fresh Mint	51±15%
Rembrandt Original	53
Arm and Hammer Dental Care Icy Mint Whitening Toothpaste	55
Tom's of Maine Childrens	57-100
Mentadent Advanced Whitening	60
Supersmile	62
Rembrandt Mint	63
Arm and Hammer Complete Care Enamel Strengthening	65
Crest plus Scope Flavor Whitening (white gel)	68
Colgate Regular	68
Colgate Total	70
Arm and Hammer Advance White for Sensitive Teeth	70
Colgate 2-in-1 Fresh Mint	70
Sensodyne Isoactive - Whitening	75±15%
Tooth Builder - Squigle	70-80
Biotene 78 Pepsodent® Complete Care Original Flavor	80
Close-Up	80
Arm and Hammer Complete Care Extra Whitening	81
Under the Gum	82
Colgate Sensitive Max Strength	83
Arm and Hammer Complete Care Intense Freshening	83
Sensodyne ProNamel - Gentle Whitening Alpine Breeze	83±15%
Nature's Gate	87
Mentadent Advanced Breath Freshening	88
Aquafresh Sensitive	91
Tom's of Maine	93-100
Rembrandt Plus	94
Oxyfresh with Fluoride	95
Aim Cavity Protection Toothpaste	96
Oxyfresh Powder	97
Arm and Hammer Advanced White Brilliant Sparkle Gel	100
Close-Up Cinnamon Red Gel with Mouthwash	100
Natural White	101
SENSODYNE ProNamel Iso-active Gentle Whitening	100±15%
Crest Whitening Expressions (liquid gel)	105
Colgate Platinum	106
Crest Baking Soda and Peroxide Whitening	107
Crest Kid's	108
Crest Cavity Protection	108
Crest Advanced Cleaning	109
Colgate Herbal	110
Amway Glistar	110

Contd...

**Table 1: Contd...**

Toothpaste name	RDA
Aquafresh Whitening	113
Crest Extra Whitening	118
Crest Multicare Whitening	118
Colgate Total Whitening	120-150
Crest Plus Scope Whitening (paste)	125
Crest Tartar Protection	125
SENSODYNE Extra Whitening	125±15%
SENSODYNE Full Protection Plus Whitening	125±15%
SENSODYNE Tartar Control Plus Whitening	125±15%
Crest Sensitivity Protection	126
Crest Whitening Expressions (paste)	132
Ultra Brite	133
Crest Pro-health night	140
Ultra brite Advanced Whitening formula	145
Pepsodent	150
Crest Pro-Health	160-180
Colgate Total Gum Defense	165-185
Colgate Tartar Control	165
Arm and Hammer Dental Care PM Fresh Mint	178
Colgate Total Advanced Whitening	180-200
Crest Vivid White	187
FDA recommended upper limit	200
ADA recommended upper limit	250

ADA: American Dental Association, FDA: Food and Drug Administration

clinics. The brand name of the patient's dentrifice should be asked and the RDA value should be checked.

In general, dentin loses more material so if already abraded enamel condition came, the doctor should go for the pH test of morning and random saliva. Then, the toothpaste with minimum RDA value can be prescribed along with a soft bristle brush.<sup>[19]</sup>

On the contrary, if no abrasion of enamel noted then the acidity to be controlled with importance, to protect the un eroded enamel. There are not many publication regarding the molecule 'Novamin', which considered as the remineralizing property. However, some article compared the sensitivity testing and proved good molecule.<sup>[20,21]</sup>

The chart shown in this article can be regarded as the clinical diagnostic flow chart and helps you to get arrive at a conclusion.

**Recent study review**

RDA-profilometry equivalent is an up graded method that checks the depth through contact profilometry had a guideline for testing abrasivity of dentrifices.<sup>[22]</sup> In a clinical study, some paste produce tooth sensitivity, taste discomfort, and texture discomfort; patients also reported rougher teeth, soft tissue peeling, dry mouth, thrush, tingling, and taste changes in response the paste with lower pH. Hence, toothpaste's properties should be well known for the indication to patient therefore minimizing discomfort reports.<sup>[23]</sup> The flexibility (soft, medium, hard) of bristles considered secondary to abrasion process and abrasivity of dentrifice is more important in abrading tooth.<sup>[24]</sup>

## CONCLUSION

Wasting of tooth material is a common disease regarding to-days population. Various causes may cause abrasion; one of these is abrasivity of toothpaste. Proper clinical diagnosis can help us to recommend various treatment and preventive measures. Preventive measure includes the testing of any marketed toothpaste before clinical trials. Various methods were described and RDA is most frequently followed and recommended by ADA and Foreign Direct Investment authorities. Mechanical along with chemical method should be employed for cleaning of tooth. It is difficult to distinguish the effect of the toothbrush on the abrasivity from that of the toothpaste and it is probably dependent on the interaction between the two elements.

A secondary problem from the abrasiveness of the paste is notching of the tooth at the gum line causing a structural compromise. Often, a filling is necessary to protect the future integrity of the tooth. Again, selecting a paste with a low RDA can prevent both sensitivity and structural compromises that can cause the need for future restorative dentistry. The importance of *in vivo* study must be taken into concern and abrasibility (roughness value) of that material must be tested.

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## Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Wülknitz P. Cleaning power and abrasivity of European toothpastes. *Adv Dent Res* 1997;11:576-9.
2. Joiner A. The cleaning of teeth. In: Johansson I, Somasundaran P, editors. *Handbook for Cleaning/Decontamination of Surfaces*. 1<sup>st</sup> ed., Vol. 1. Amsterdam: Elsevier; 2007. p. 371-405.
3. Miller WD. The wasting of tooth tissue variously designated as erosion, abrasion, chemical abrasion, denudation. *Dent Cosm* 1907;49:1-23, 109-24, 225-47.
4. Hefferren J. Abrasivity of dentrifices from a laboratory (*in vitro*) perspective. *J Clin Dent* 2010;XXI:S5.
5. Hodge H, McKay H. Microhardness of teeth. *J Am Dent Assoc* 1933;22:227.
6. American Dental Association. Antimony and brass as substrates. *Accepted Dental Remedies*. 8<sup>th</sup> ed. New York: Greenberg Publisher, Inc.; 1942. p. 87-115.
7. Monsanto Chemical Co. Electrolytic copper as substrate, Monsanto Chemical Co. Method. *Accepted Dental Remedies*. 8<sup>th</sup> ed. Chicago: Council on Dental Therapeutics; 1942. p. 99.
8. Harrington E, Jones PA, Fisher SE, Wilson HJ. Toothbrush-dentifrice abrasion. A suggested standard method. *Br Dent J* 1982;153:135-8.
9. Ashmore H, Van Abbé NJ, Wilson SJ. The measurement *in vitro* of dentine abrasion by toothpaste. *Br Dent J* 1972;133:60-6.
10. Grabenstetter RJ, Broge RW, Jackson FL, Radike AW. The measurement of the abrasion of human teeth by dentifrice abrasives: A test utilizing radioactive teeth. *J Dent Res* 1958;37:1060-8.
11. Hefferren JJ. A laboratory method for assessment of dentifrice abrasivity. *J Dent Res* 1976;55:563-73.
12. ISO 11609. Dentistry – Toothpastes – Requirement, Test Methods and Marking. Online Material: <https://www.iso.org/obp/ui/#iso:std:iso:11609:ed-2:v1:en>.
13. Hefferren JJ, Kingman A, Stookey GK, Lehnhoff R, Muller T. An international collaborative study of laboratory methods for assessing abrasivity to dentin. *J Dent Res* 1984;63:1176-9.
14. Chinese Standardization Association. Chinese toothpaste specification. 1995.
15. British Standards Institute (BSI). Radioactive dentinal profilometry methods. BSI 4137. 1981.
16. Hefferman J. Abrasivity of dentrifices from laboratory (*in vitro*) perspective. *J Clin Dent* 2010;21:s5.
17. Winer RA, Tsamtsouris A. Effects of an experimental sodium bicarbonate dentifrice on gingivitis and plaque formation: II. In teenaged students. *Clin Prev Dent* 1979;1:17-8.
18. Legier-Vargas K, Mundorff-Shrestha SA, Featherstone JD, Gwinner LM. Effects of sodium bicarbonate dentrifices on the levels of cariogenic bacteria in human saliva. *Caries Res* 1995;29:143-7.
19. Lussi A, Ganss C. Erosive tooth wear. *Monogr Oral Sci* 2014;25:215-9.
20. Burwell A, Jennings D, Muscle D, Greenspan DC. NovaMin and dentin hypersensitivity – *In vitro* evidence of efficacy. *J Clin Dent* 2010;21:66-71.
21. Du Min Q, Bian Z, Jiang H, Greenspan DC, Burwell AK, Zhong J, et al. Clinical evaluation of a dentifrice containing calcium sodium phosphosilicate (novamin) for the treatment of dentin hypersensitivity. *Am J Dent* 2008;21:210-4.
22. White DJ, Schneiderman E, Colón E, St John S. A profilometry-based dentifrice abrasion method for V8 brushing machines. Part I: Introduction to RDA-PE. *J Clin Dent* 2015;26:1-6.
23. Bruno M, Taddeo F, Medeiros IS, Boaro LC, Moreira MS, Marques MM, et al. Relationship between toothpastes properties and patient-reported discomfort: Crossover study. *Clin Oral Investig* 2015; [Epub ahead of print].
24. Kumar S, Kumar Singh S, Gupta A, Roy S, Sareen M, Khajuria S. A profilometric study to assess the role of toothbrush and toothpaste in abrasion process. *J Dent (Shiraz)* 2015;16 3 Suppl: 267-73.