Comparison of exposed dentinal surfaces resulting from abrasion and erosion

Emma Jane Bell*
John Kaidonis*
Grant Townsend*
Lindsay Richards*

Abstract

The aim of this study was to compare the shape of exposed dentinal surfaces caused by abrasion and erosion with a view to developing a diagnostic clinical test. The study material consisted of 80 natural teeth and 129 dental models obtained from Australian Aborigines known to display considerable dental abrasion due to their diet, and dental models of 37 Caucasians diagnosed with dental erosion through detailed history and dietary analysis. Polyvinyl siloxane impressions were obtained of all occlusal surfaces with dentinal scooping in both the 'abrasion' and 'erosion' groups. All impressions were sectioned buccolingually through the deepest point of the scooped dentine, and then the profiles were photocopied at × 2 magnification. The breadth and depth of dentinal profiles were measured to an accuracy of 0.1 mm, enabling ratios of depth:breadth to be determined, and the position of the deepest part of each scooped surface was recorded. The mean depth:breadth ratio of scooped dentine was significantly greater in the Aboriginal natural teeth (0.19±0.06, mean±SE) than in the Aboriginal dental models (0.15±0.04). Both Aboriginal natural teeth and models with abrasion showed significantly smaller ratios ($p<0.05$) than the Caucasian models showing erosion (0.33±0.07). Furthermore, in the abrasion samples, the deepest region of the scooped dentine tended to be lingually placed more often in maxillary teeth but buccally placed more often in mandibular teeth ($p<0.05$). These results indicate that scooped dentine on abraded occlusal surfaces of teeth displays significant differences in shape compared with that caused mainly by erosion.

Key words: Tooth wear, human populations, clinical diagnosis, abrasion, erosion, corrosion.

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Introduction

The wearing down of tooth crowns with increasing age has been observed in all human populations, whether by inspection of human skeletal remains or through clinical examination of living individuals. In the past, anthropologists viewed tooth wear as being mainly the result of abrasion, often associated with coarse unrefined diets, but researchers are now aware that attrition and erosion are important determinants of tooth wear that may occur at any age.

Abrasion is the physical wear of teeth resulting from mechanical grinding, rubbing, scraping or microcutting.[1,2] It may result from the friction of foreign objects, such as toothbrushes or coarse food-stuff repeatedly introduced into the mouth.[3,4] Pathological abrasion can occur when articles are habitually gripped by, levered against, or scrubbed over the teeth.[5] Dietary abrasion produces a blunting appearance on the tooth cusps. In enamel, abrasion generally exhibits an ill-defined, diffusely circumscribed pattern,[6] whereas it presents a scooped out appearance in exposed dentine. Often the affected surface has a pitted appearance, being a reflection of the abrasive food consumed.

Attrition also physically removes tooth substance and is caused by the interaction between opposing teeth, resulting in surface loss at locations of occlusal contact. Tooth contact occurs occasionally during mastication, during swallowing, or most commonly during tooth grinding. Clinically, attrition presents as flat facets on the incisal and occlusal surfaces of opposing teeth with clearly distinguishable circumscribed borders.[6]

Erosion is the chemical dissolution of enamel and dentine by acids not produced by oral bacteria. The acids can be extrinsic in nature, either dietary (for example, in carbonated soft drinks and citric fruit juice) or industrial airborne chemicals, or they may

*Department of Dentistry, The University of Adelaide, Australia.

be intrinsic such as hydrochloric acid via gastric regurgitation. Erosion has the ability to remove any detailed microanatomy, scooping dentine and presenting a glazed appearance on the tooth.[6] It is able to remove facet detail and evidence of abrasion and attrition.

It is worth pointing out that although the term erosion is in common dental usage, in the context of engineering and disciplines outside dentistry, the term corrosion is used more correctly to refer to chemical dissolution. Similarly, attrition is really a form of two- and three-bodied abrasion. It is appropriate that consideration be given to changing terms such as attrition, abrasion and erosion to endogenous abrasion, exogenous abrasion and corrosion respectively, although the more common dental terms are used in this paper.

Removal of the dental hard tissues, namely enamel, dentine and cementum, through wear processes, is of great significance because lost mineral will not regenerate.[2] Enamel wear on incisal edges and occlusal surfaces leads to morphological changes and a reduction in the crown height of teeth. It is followed by exposure and more rapid wear of the less densely mineralized dentine, which produces a concave wear pattern termed dentinal scooping or cupping. The dental pulp responds by stimulating odontoblasts to deposit reparative dentine.

Problems such as a reduction in occlusal vertical dimension, unfavourable masticatory function, undesirable aesthetics, and sometimes increased tooth sensitivity can result from excessive tooth wear. The consequences may involve complex restorative and prosthetic dental treatment that is costly both in terms of time and money.

Although each mechanism of tooth wear manifests itself quite differently, in reality they do not function in isolation. Over a lifetime, an individual will be exposed to different mechanisms of tooth wear of varying intensities, duration and time frames. Overall, this contributes to the multifactorial origin of tooth wear,[3] making its appearance variable and presenting difficulties in clinical diagnosis and treatment planning.

The aims of the present study were to quantify any differences in the form of dentinal scooping due to abrasion and erosion by comparing the ratio of depth:breadth for the two modes of tooth wear, and to evaluate whether any alterations occurred in this ratio for abrasion with increasing age. The investigation also

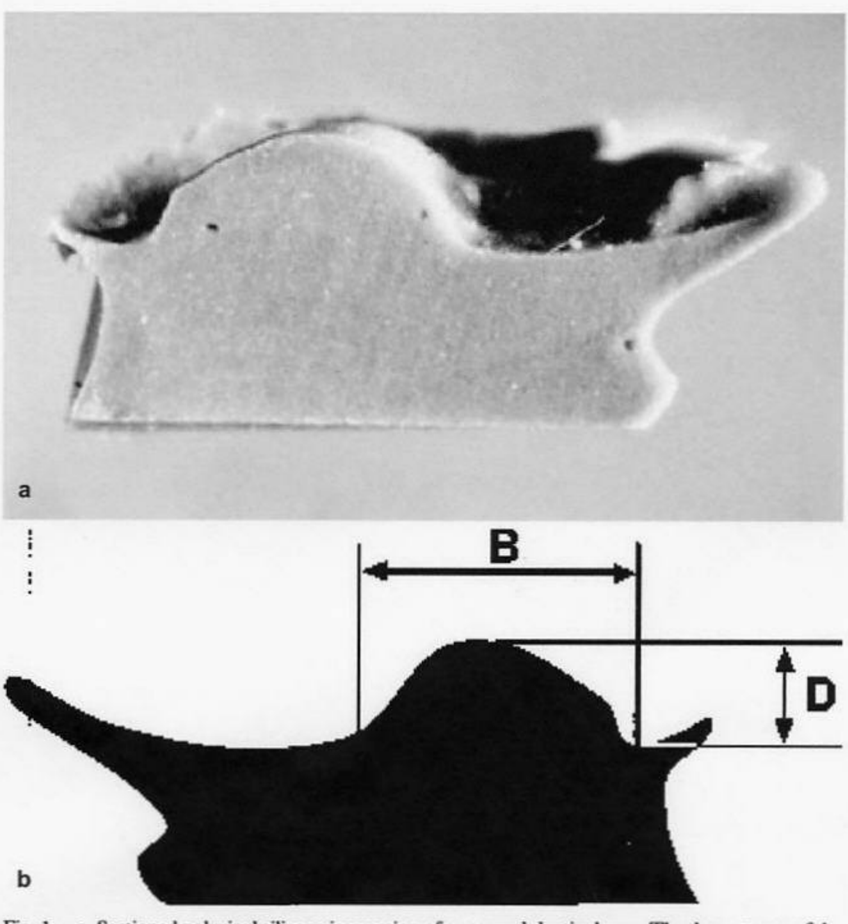


Fig. 1. – a, Sectioned polyvinyl silicone impression of a scooped dentinal area. The deepest part of the scoop is centrally positioned. b, Photocopy of impression indicating depth and breadth measurements.

aimed to qualify differences in the pattern of the dentinal wear between erosion and abrasion lesions by looking at the position of the deepest part of the scoop (that is, bucally, centrally or lingually placed).

Materials and methods

The samples chosen for the investigation represented individuals with either predominantly abrasion or erosion areas on the occlusal surfaces of their teeth.

The abrasion cases were selected from Australian Aboriginal populations since the teeth of these individuals are characterized by distinctive occlusal abrasion lesions due to their coarse diets. It can also be reasonably assumed that their non-industrial culture provided little exposure to strong erosive agents with potential to destroy tooth structure. Thus, it was postulated that the dentinal scooping examined in Aborigines was predominantly due to abrasion.

One sample displaying abrasion comprised 80 separate teeth belonging to Australian Aborigines who were living along the Murray River in South Australia before European settlement. The second group of 129 abrasion cases, with ages ranging from 8 to 77 years, was represented by dental casts obtained in the 1960s and 70s during a longitudinal growth study of Aborigines living at Yuendumu, a Commonwealth Government settlement in the Northern Territory of Australia.

The sample of 37 dental models showing erosion was obtained from patient cases in the Adelaide Dental Hospital. The occlusal surfaces of teeth had been diagnosed previously by dental specialists as displaying erosion on the basis of various clinical tests, and detailed history taking of habits and dietary analyses.

The natural teeth were placed in wax to secure them, and the dental study casts were positioned on a bench. The entire occlusal surface of each tooth in the sample groups was covered with polyvinyl siloxane impression material that was removed after setting. The impressions were orientated to define each tooth surface and sliced in a buccolingual direction through the deepest part of the dentinal scoop. The impressions were then photocopied at × 2 magnification to enable the margins of the scoop to be defined. Assessments of the shape of the scoops were obtained both metrically and non-metrically. The buccolingual breadth and the depth of the abrasion and erosion lesions were measured to an accuracy of 0.1 mm using a digital calliper (Fig. 1a, b).

The ratio of the depth:breadth of each lesion was calculated and mean values for the abrasion and erosion samples were compared using *t* tests. A qualitative evaluation of the lesions was attained by determining the position of the deepest part of the dentinal scooping by visual inspection. The position was scored as buccally placed, centrally placed and lingually placed with respect to the deepest part of the dentine scooping.

Table 1. Depth:breadth ratios of scooped dentine in abrasion and erosion samples

Sample		n	$\chi \pm SE$
Abrasion	Natural	80	0.19±0.06*†
	Models	129	0.15±0.04†
Erosion	Models	37	0.33±0.07

*Mean values differ significantly between Aboriginal natural teeth and models at $p<0.05$.
†Mean values for Aboriginal teeth differ from Caucasians at $p<0.05$.

Table 2. Location of deepest region of dentinal scoops in abrasion and erosion samples

	Abrasion		Erosion
	Natural	Models	Models
Maxilla			
Buccal	9 (14.8%)	10 (12.5%)	4 (33.3%)
Central	19 (31.1%)	23 (28.8%)	4 (33.3%)
Lingual	33 (54.1%)	47 (58.8%)	4 (33.3%)
Mandible			
Buccal	6 (31.6%)	25 (51.0%)	9 (36.0%)
Central	5 (26.3%)	15 (30.6%)	12 (48.0%)
Lingual	8 (42.1%)	9 (18.4%)	4 (16.0%)

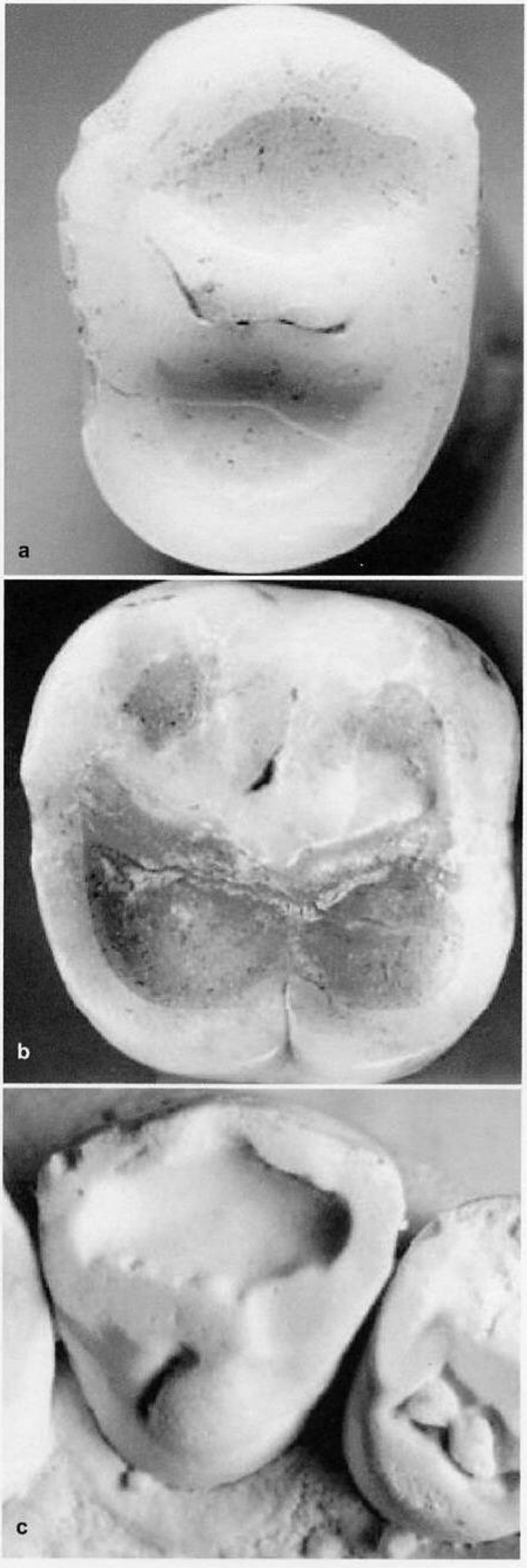
Significant association between location of deepest region and arch in pooled abrasion sample ($p<0.05$).

Replicate measures of 38 teeth confirmed that errors of the method were small and unlikely to bias results.

Associations between the type of wear and the position of the deepest part of the dentinal scoop were tested with chi-squared analyses, with statistical significance set at the 5 per cent probability level. Correlation coefficients were also computed to quantify the strength of the association between the dimensions of the dentine scooping in the Aboriginal dental casts and age.

Results

The mean depth:breadth ratio of scooped dentine was significantly greater in the Aboriginal natural teeth (0.19±0.06, mean±SE) than in the Aboriginal dental models (0.15±0.04). Both Aboriginal natural teeth and models with abrasion showed significantly smaller ratios ($p<0.05$) than the Caucasian models showing erosion (0.33±0.07). That is, scooped dentine was significantly shallower in the abrasion sample than in the erosion sample. Furthermore, in the abrasion sample, the deepest region of the scooped dentine tended to be lingually placed more often in the maxillary teeth but buccally placed more often in mandibular teeth ($p<0.05$). For the erosion cases, the maximum concavity of the dentinal scoop tended to be centrally placed in both arches. Tables 1 and 2 summarize the results for each of the study samples. Figures 2a, b, c show examples of typical



abrasion lesions observed in Aborigines and erosion lesions in Caucasians.

Correlation analysis (Fig. 3) indicated that there was only a weak association between the ratio of abrasion lesion dimensions and age ($r=-0.25$, $p<0.05$). Therefore, despite dimensional changes that occurred over time in the size of abrasion lesions, the depth:breadth ratio for the dentinal scooping remained relatively constant.

Discussion

Making a differential diagnosis between abrasion and erosion when dentine is scooped can be a complicated and difficult task.[6-10] Elderton[5] found that erosion lesions tend to be very deep. Similarly, Kaidonis and co-workers[6] have suggested that when dentine is severely scooped out, the causative agent is most likely to be of erosive origin. That is, once the dentine is exposed, acid more readily dissolves the dentine, leaving the enamel rim relatively intact. In contrast, although dietary abrasion may cause severe wear, the dentinal scooping tends to be shallower.

This difference has been confirmed by the results of this study which indicate that abraded dentine on occlusal tooth surfaces displays significant differences in the shape and depth of the scoop when compared with that caused mainly by erosion. The scooped dentine reflecting abrasion is relatively shallower and the deepest part of the scoop tends to be positioned lingually in maxillary teeth and buccally in mandibular teeth, the degree of which reflects the direction of force of the food during masticatory movement. The findings also indicated that the abrasion ratio did not alter over time. As the width of the scoop increased there was a proportional increase in depth.

Once the occlusal enamel wears during mastication, it exposes the softer underlying dentine. As the dentine progressively scoops, the surfaces come further and further 'out of occlusion', causing a progressive reduction in occlusal force and gradually limiting the depth of the wear, while the remaining, more durable enamel rim maintains occlusal 'contact'. Furthermore, as the height of the enamel rim decreases over time and the area of exposed dentine increases, there is a corresponding increase in scoop depth that maintains the abrasion ratio. The ratio may change slightly if the diet and hence the abrasiveness of the food changes. It is proposed that the difference in abrasion ratios observed between the Aboriginal natural teeth and the Aboriginal dental models reflects differing dietary and environmental conditions of the two populations.

In erosion, the deepest part of the scooped dentine is most commonly centrally positioned and

Fig. 2. – a, b, Aboriginal maxillary premolar and molar teeth with scooped dentine caused by abrasion. c, Caucasian model of maxillary canine with deep dentinal scooping caused by erosion.

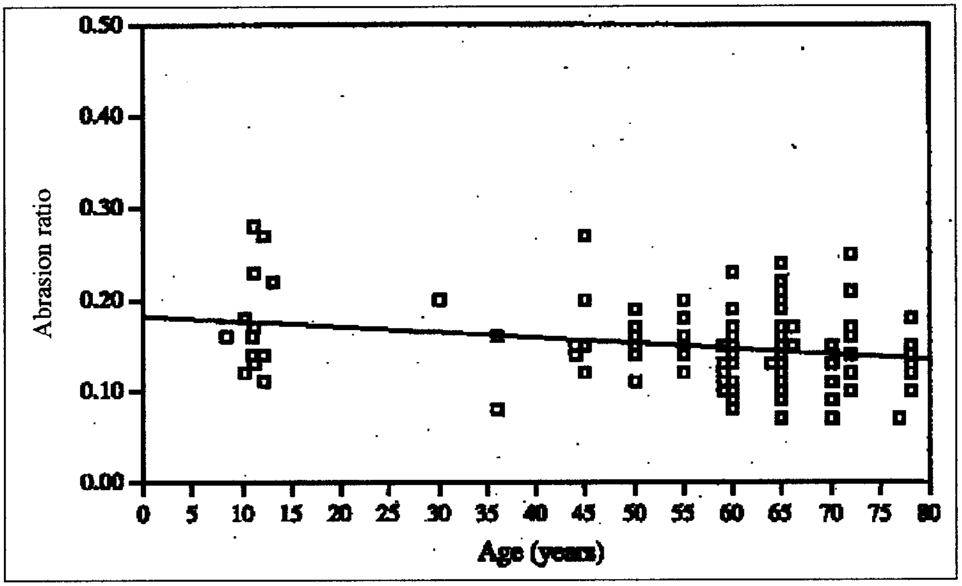


Fig. 3. – Scatter diagram of abrasion lesion ratio vs age in Aborigines.

there appears to be no difference in distribution between maxillary and mandibular teeth reflecting the chemical nature of the process.

When defining the margins of the scooping on photocopied images to measure the buccolingual diameter of the dentine lesions, it was observed that those for erosion were very clearly defined, whereas those for abrasion were poorly defined and more difficult to locate. This finding emphasizes the differential pattern of wear in enamel between abrasion and erosion. It illustrates one of the overlooked fundamental differences between these modes of tooth wear that is useful clinically.

From a clinical perspective, though very deeply scooped dentine is most likely to result from erosion, the authors believe that the quantitative diagnostic test described, calculating the depth:breadth ratio of dentinal scooping and assessing the position of the maximal concavity of the lesion using an impression, provides a relatively simple and more objective test that is feasible to use in clinical situations.

Further research, based on larger sample sizes and including different human populations, will show whether the patterns described in this paper are confined to specific groups or represent common effects among all humans. These fundamental differences may enable dentists to more appropriately diagnose and manage the different wear processes.

Conclusion

Clinically discriminating between dentinal scoop patterns of erosive or abrasive origin is difficult. However, measurable differences in the scoop depth and pattern noted in this study, in conjunction with supported theory, provide a better scientific basis for making this differentiation. The finding that the depth:breadth ratio for abrasion lesions does not seem to alter over time is worthy of further investigation.

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References

1. Dahl BL, Carlsson GE, Ekfeldt A. Occlusal wear of teeth and restorative materials. Acta Odontol Scand 1993;51:299-311.
2. Smith BGN. Some facets of tooth wear. Ann R Aust Coll Dent Surg 1991;11:37-57.
3. Imfeld T. Dental erosion. Definition, classification and links. Eur J Oral Sci 1996;104:151-5.
4. Every RG. A new terminology for mammalian teeth. Founded on the phenomenon of thegosis. Part 1 and 2. Christchurch: Pegasus Press, 1972.
5. Elderton RJ. The dentition and dental care. Oxford: Heinmann Medical Books, 1990.
6. Kaidonis JK, Townsend GC, Richards LC. Abrasion: an evolutionary and clinical view. Aust Prosthodont J 1992;6:9-16.
7. Smith BGN, Knight JK. A comparison of patterns of tooth wear with aetiological factors. Br Dent J 1984;157:16-9.
8. Eccles JD. Tooth surface loss from abrasion, attrition and erosion. Dent Update 1982;9:373-81.
9. Nunn JH. Prevalence of dental erosion and the implications for oral health. Eur J Oral Sci 1996;104:156-61.
10. Mair LH, Stolarski TA, Vowles RW, Lloyd LH. Wear: mechanisms, manifestations and management. A report of a workshop. J Dent 1996;24:141-8.

Address for correspondence/reprints:
Professor G. Townsend,
Faculty of Dentistry,
The University of Adelaide,
South Australia 5005.