AN EXPERIMENTAL STUDY OF THE WEAR CHARACTERISTICS OF HUMAN ENAMEL DURING TOOTH GRINDING

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PREFACE

Many of the difficulties faced by dental clinicians in diagnosing and treating the increasing number of people with tooth wear arise from a lack of detailed understanding of this biological process. Past anthropological studies, though valuable and extensive, have often tended to focus on tooth wear at a population level, attributing observed overall patterns to combinations of diet and cultural practices. Recently, researchers have begun to turn their attention to the specific causes of wear in individuals, including the effects of attrition, abrasion and erosion. These terms fall collectively under the broad umbrella of "tooth wear", "tooth reduction" or "tooth surface loss".

This study examines tooth-to-tooth contact under controlled experimental conditions that simulate bruxism. Though bruxism may affect both enamel and dentine, the investigation focuses on the wear characteristics of enamel. The stimulus for the project is described in the Introduction where it is argued that attrition, resulting from bruxism, can be considered a common physiological entity that contributes significantly to the process of tooth wear.

An *in vitro* investigation of the mechanical properties of human tooth wear may not appear initially to have direct clinical application. However, the results of this type of research provide basic knowledge that is important in explaining why variation in the extent and pattern of tooth wear is observed both within and between populations. By applying knowledge of how the oral environment influences tooth wear, dental clinicians may be able to control aetiological factors and hence the wear process itself.

This thesis provides new information about factors influencing the nature and extent of human enamel wear, and should provide a basis for future experimental and clinical research.

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SUMMARY

The processes of attrition, abrasion, erosion and fracture act on the dentition to produce various degrees and patterns of tooth wear. Attrition results from grinding of teeth without the presence of food, abrasion from solid foreign material being forced over tooth surfaces, erosion from chemical dissolution of dental structure, and fracture from trauma of varying degrees.

The objective of this research was to study enamel attrition using an electro-mechanical machine that was specifically designed and constructed to grind opposing tooth surfaces while controlling for load, speed, duration of contact, direction of movement, number of cycles, and quantity and quality of lubricant. The wear rate of enamel was quantified under various conditions and replicas of experimental wear facets were examined using scanning electron microscopy to assess surface features qualitatively.

The wear rate of human enamel was found to be bi-phasic for any given load. The primary wear phase was relatively rapid but, after reaching a threshold, a secondary wear phase progressed at a reduced rate. The relationship between wear rate and load under non-lubricated and lubricated conditions was assessed by experiments performed during the secondary wear phase. Qualitative assessment of all facets supported the quantitative results.

Enamel wear rates without a liquid lubricant displayed a linear relationship with loads ranging from 0-16.2 kg. Qualitative

assessment of facet surfaces indicated the presence of fine enamel powder resulting from enamel breakdown at the wear interface. This powder acted as a dry lubricant. The addition of water as a liquid lubricant (pH=7) reduced enamel wear. However above about 6kg the wear rate gradually increased until a threshold of 11-13kg was reached, above which the rate of wear increased dramatically. It is postulated that the liquid acted as a lubricant at light loads but was displaced from the facet surfaces at the heavier loads. The effects of this lack of lubrication were exacerbated as the liquid lubricant also washed away any dry enamel powder which would otherwise act as a dry lubricant. The resulting wear rate at loads above this threshold was therefore very high. Qualitative assessment of facet surfaces confirmed the absence of dry enamel powder, while the enamel surface consisted of craters that progressively enlarged due to fracture of enamel fragments from the edges. These fragments were responsible for the parallel striations commonly observed within facet borders.

When a liquid lubricant of pH=3 (acetic acid) was used, the wear rate was further reduced to that of the non-lubricated rate for loads up to 11-13 kg, after which the rate increased substantially. Facet surface appearance was generally smooth due to the build-up of an amorphous material with little evidence of cratering. At high loads, however, the frequency of cratering increased and the smooth amorphous layer disappeared.

At pH=1.2, the wear rate was considerably more than all the other lubricants. At low loads, surface breakdown due to erosion occurred producing an undulating smooth surface. This appearance changed to a flat, rougher surface as the load increased. When saliva (pH=7) was used as a lubricant, the wear rates compared with those of pH=3 below the 11-13kg threshold, and increased dramatically thereafter. Craters of various sizes and parallel striations were produced, similar to those observed with water at pH=7.

This study has not only quantified the behaviour of human enamel under dry and liquid-lubricated conditions, but has also provided qualitative assessments of facet appearance to support the quantitative findings. Clinical reports of a bi-phasic pattern of enamel wear have been confirmed experimentally. It has also been shown that the wear characteristics of enamel are independent of the speed at which opposing teeth are rubbed and their direction of movement, but dependent on load and the quality of lubricant.

Although the model used in this study could only simulate the dynamic biological processes occurring in the human oral cavity, new information has been gained about how dental enamel behaves within a tribochemical environment. Many areas requiring further investigation have been identified and it is planned to extend and refine the tooth wear machine to enable complete dental arches to be worn under controlled conditions in a computer-based system.