Dental Biotribology

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Foreword

The word “tribology” was introduced in 1966 to embrace the separate subjects of friction, wear, lubrication, and bearing design. Most machinery involves interacting surfaces in relative motion, and a sound understanding of the fundamental nature of these interactions is essential for future progress.

Human bodies illustrate many fine examples of tribology, from load-bearing synovial joints to teeth and the oral environment. Interest in these examples of biological and medical tribology precipitated the introduction of the term “biotribology” in 1973. The latter, fascinating field has represented one of the most active areas in tribology research in the past half-century.

Recent interest in biotribology is evident in the vast growth in published journal papers, chapters in tribology books, and sessions carrying the title in international conferences. The present text by Professor Zhong-Rong Zhou and his colleagues in China, devoted entirely to teeth, is a natural and welcome extension of these rapid and important developments.

The authors emphasise the multidisciplinary nature of their subject, which embraces dental and medical concepts and well-defined aspects of tribology. Terminology has long been a problem. For example, the word *attrition* is widely used and understood in dentistry, yet in tribology it is the five distinct forms of wear defined as abrasion, adhesion, corrosion, erosion, and fatigue that are adopted and investigated. *Erosion* is defined differently in the dental and tribological fields, and the differences between *erosion* and *corrosion* are rarely recognised in dentistry. These examples immediately draw attention to one of the difficulties in this multidisciplinary field, which relies upon contributions from engineering, physics, chemistry, materials science, biology, dentistry, and medicine.

The authors remind us that concern for dental health has a long history. Tooth-cleaning procedures developed over thousands of years, while dental implants have been used for over a thousand years. Attempts to link age to tooth wear have been of interest for many years in medical, dental, and forensic fields.

The interesting structure of the hardest organs in the body is outlined and the basic mechanical properties of the natural materials quantified, while those for restorations and fillings are also introduced. These well-illustrated features of teeth will be of particular interest to tribologists and material scientists. While fracture of enamel and dentin inevitably calls for the introduction of alternative materials, the evaluation of wear is difficult. In vivo estimates necessarily extend over long periods of time, and difficulties arise in the measurements over relocation. Laboratory methods, based upon many familiar tribological test procedures, have to be undertaken in meaningful environmental conditions and under realistic dynamic loads and speeds.

An impressive range of reciprocating friction and wear tests between a titanium alloy ball and specimens of teeth in artificial saliva are reported for subjects of various ages. The role of microstructure in friction and wear processes is clearly evident. Tests were carried out at different depths of wear through the enamel and beyond the enamel-dentin interface. Initially, the coefficients of friction were about 0.1, but as penetration increased, the values rose to about 0.85. Surface analysis instruments revealed the microstructure and wear interface, with the enamel rods being clearly evident.

An in-depth account of the role of environment upon friction and wear demonstrates in impressive style the severity of acidic environments associated with soft drinks, fruit juices, and sports drinks. The value of micro- and nano-hardness tests in tribological studies of enamel is well illustrated. The current range of restorative materials is presented and comparisons made with natural materials such as dentin and enamel. Ideally, restorative materials should exhibit similar wear to normal enamel under the wide range of loading conditions, motion, temperature, and environment encountered in the mouth, but this goal has yet to be fully achieved. Current restorative materials include metals and their alloys, composites, and porcelains.

Human teeth are subjected to many very small movements in normal functioning in the mouth, and the phenomenon of fretting, particularly at the implant-interface, attracts particular attention. While fretting cannot be avoided during mastication, greater understanding of its nature and extent could benefit the drive towards reliable osseointegration.

Many factors contribute to dental caries, and the authors discuss the role of diet, sealants and restoratives, remineralization and demineralization, fluoride, amorphous calcium phosphate, Galla Chinensis, hydroxyapatite, and laser irradiation. Biomechanical, tribological, physiological, and pathological factors in the process are also discussed, once again emphasising the need to integrate many separate disciplines in further studies.

The authors are complimented on bringing together accounts of dental, tribological, and materials science studies of natural teeth, together with their assessments of the performance of revision and replacement materials. The considerable number of

experiments already undertaken is recognized, but it is noted that the field would benefit from a systematic approach to research. This is one of several fields in biotribology which would certainly benefit from more holistic approaches. It represents a challenging task, but the present text will do much to further promote collaborative research and benefit patients.

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Duncan Dowson

Preface

I turned my attention to dental friction and wear when I chatted with a dentist in 1998. In fact, human teeth are the masticatory organ and therefore subjected to friction and wear functionally every day under a complex oral environment and loading condition. What makes human teeth adequate to serve for a lifetime in the mouth with complex physical and chemical processes has been a puzzle, which initially motivated us to get through the work presented in this book focusing on dental wear. Dental wear is one of the most important parts of and also on the leading edge of biotribology. However, the benefit of its achievements is far beyond the recent studies. The accumulation of the scientific knowledge about human teeth can provide invaluable insights into the developments of advanced dental materials, oral practices, archaeology and also stimulate the bionic design by transferring the antiwear properties of human teeth into engineering antiwear systems. I believe in next decades that more researchers will be involved and will usher in significant progress in dental wear research.

The present book is a research snapshot of my group in the last a few decades together with a summary of the literature. I am grateful to the contribution to the work from my postdoctorate, Dr. Hong Li. Additionally, I would like to express my appreciation for the valuable help from some graduate students: Dan Yang, Mao-Yu Shi, Ming Wen, and Shan-Shan Gao, in collecting documents and preparing the figures. In addition, this book is deeply indebted to the National Natural Science Foundation of China for its financial aid.

I hope that the information presented in the book will be of interest to clinical dentists, engineering tribologists, and materials researchers. I also hope that readers of this book may, if they are not doing so already, be stimulated to work in this fascinating field.

Chengdu, People's Republic of China

Zhong-Rong Zhou

Contents

1	Introduction to Teeth	1
1.1	Biotribology	1
1.2	Classifications and Definitions	2
1.3	Anatomy and Function of Human Teeth	4
1.4	Biomechanics of Human Teeth	6
1.5	A Brief History on Dental Wear	8
1.5.1	Dental Erosion	8
1.5.2	Dental Caries	10
1.5.3	Two-Body Contact (Attrition and Abrasion)	11
1.5.4	Wear Rate	14
1.5.5	Archaeological Analysis	16
1.6	Saliva	16
1.7	Early Methods of Cleaning Teeth	17
1.7.1	Toothpaste	17
1.7.2	Toothbrush	18
1.7.3	Oral Hygiene in China	19
1.8	Wear of Animal Teeth	19
1.9	Research Significance	22
1.9.1	Clinical Implications	22
1.9.2	Development of Dental Materials and Design of Implant Teeth	23
1.9.3	Bionic Design	23
1.9.4	Identification	24
1.10	Summary	24
	References	25
2	Clinical Evaluation and Laboratory Wear-Testing Methods	31
2.1	Clinical Evaluation Methods and Diagnosis	31
2.2	Wear Modes and Location	34
2.2.1	Wear Modes	34
2.2.2	Wear Location	36

2.3	Wear-Testing Methods	37
2.3.1	In Vivo Observation and Measurement.....	37
2.3.2	In Situ Testing	38
2.3.3	In Vitro Laboratory Simulation	38
	References.....	41
3	Friction and Wear Behavior of Human Teeth	43
3.1	Introduction.....	43
3.2	Effect of Tooth Microstructure on Its Friction and Wear Behavior.....	44
3.3	Process and Mechanism of Human Tooth Enamel Wear	52
3.4	Effect of Age on the Friction and Wear Behavior of Human Teeth...	61
3.5	Pathological Factors.....	68
3.6	Effect of Toothbrushing	69
3.7	Concluding Remarks.....	70
	References.....	71
4	Effect of the Oral Environment on the Tribological Behavior of Human Teeth	75
4.1	Introduction.....	75
4.2	Effect of Saliva on the Friction and Wear Behavior of Human Teeth.....	77
4.3	Effect of Food Particles and Occlusal Load on the Friction and Wear Behavior of Human Teeth	79
4.4	Wear Behavior of Human Tooth Enamel in Citric Acid Solution.....	85
4.5	Erosion and Remineralization of Human Tooth Enamel	92
4.5.1	Effect of Erosion Time on the Tribo-Erosive Properties of Enamel.....	93
4.5.2	Effect of Erosion Location on the Tribo-Erosive Properties of Enamel	99
4.5.3	Effect of Remineralization on Nanomechanical Properties and Microtribological Behavior of Acid-Eroded Human Tooth Enamel	105
4.6	Concluding Remarks.....	111
	References.....	113
5	Microtribology of Human Teeth	117
5.1	Introduction.....	117
5.2	Nanohardness and Elastic Modulus at Different Locations of a Rod of Human Teeth	120
5.3	Nanoscratch Along the Vertical and Parallel Directions to the Enamel Rod Axis	126
5.4	Comparison of the Wear Behavior of Enamel Rod and Interrod Enamel.....	131
5.5	Variation in the Size of Enamel HA Crystallites During Scratching.....	133

5.6	Recovery of the Scratch in Remineralization	136
5.7	Summary	138
	References	138
6	Tribological Behavior of Dental Restorative Materials.....	141
6.1	Wear Behavior of Resin-Based Restorative Materials.....	141
6.2	Wear Behavior of Dental Alloys	146
6.3	Wear Behavior of Porcelains.....	148
	References	151
7	Fretting Failure of Dental Implant–Bone Interface.....	155
7.1	Dental Implant System.....	155
7.2	Fretting Wear of the Dental Implant–Bone Interface.....	156
7.2.1	Tangential Fretting Behavior.....	157
7.2.2	Radial Fretting Behavior	158
7.3	Remarks	162
	References	162
8	Inspiration from the Wear of Human Teeth.....	165
8.1	Wear-Resistant Elements of Human Teeth.....	165
8.1.1	Ingenious Systemic Structure.....	165
8.1.2	Surface Engineering	166
8.1.3	Compact and Orderly Microstructure	167
8.1.4	Bioactive Self-Protection and Repair Capacity.....	168
8.1.5	Unique Lubrication System.....	169
8.2	Inspiration from Human Teeth to Engineering Antiwear Systems	169
8.3	Further Directions for Research.....	170
	References	171
	Index.....	173