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ABSTRACT-

The teeth are the body part that is toughest. The anatomical and chemical makeup of teeth is quite distinctive. The scientific field of tribology examines lubrication, friction, and wear. It is desirable to assess the material qualities, chemical compositions of various materials, and tooth structure in order to comprehend the wear behaviour of human teeth. Human teeth erode quite gradually. Tooth wear is a multifactorial phenomenon that combines physical, chemical, and mechanical processes, in addition to being a complicated process. The tribological behaviour of teeth is greatly influenced and determined by the oral environment in which we live. The wear processes of artificial materials used in dentistry are rather sophisticated given the intricate biomechanics and intraoral environment. Abrasion, attrition, fretting wear, corrosion, and fatigue are some of the main wear mechanisms in our mouth cavity. Various combinations of these activities result in the slow surface deterioration of materials in the oral cavity. Excessive wear may cause early failure, necessitating the replacement of dental implants and restorations. Even though we have achieved incredible progress in the area of dental wear, there is still more research and analysis that needs to be done. This will enable us to develop a bionic design, a tribological design-based therapeutic therapy against dental wear, and a systematic correlation between the tribological behaviour and structure of human teeth. Eventually, more and more study trajectories will point us in the direction of a better treatment prognosis. So maybe these talks will shed some light and offer more information about what has previously been discovered about human teeth.

Keywords –implant, restoration, saliva, tribology

BIOTRIBOLOGY

Sharov defines a tooth as an open-ended, vital, innervated, calcified box (dentin and enamel) filled with soft, normal tissue (pulp chamber), and covered on the outside with a comparatively non-vital, non-innervated hard tissue (enamel).
The word "tribology" was first used by Jost Report in 1966. "The study and technology of interacting surfaces in relative motion and the practises thereto" is how tribology is defined.

The study of interacting surfaces in relative motion that deals with wear, lubrication, and friction is known as tribology. This includes a variety of fundamental fields, including physics, chemistry, material science, and mechanics. In essence, biotribology is the study of wear, lubrication, and friction in biological systems. In dentistry, tribology focuses on studies employing special materials on the tooth. The function and biomechanics of human teeth are very complex, despite the fact that they appear to be extremely basic. Human teeth hold a lot of interest for materials scientists and engineers. The toughest organ in the human body is the tooth. Teeth often last for a few decades. But teeth do wear down over time, and there are several ways in which this happens under the influence of different local environmental conditions. Scientists have been motivated to investigate the anatomical, chemical, and materialistic features and their impact on tribological behaviour by the tribological response of human teeth to diverse environmental factors. In the end, it will aid the scientists in simulating these characteristics. Our ability to offer solutions to decrease system wear will be aided by this. Additionally, a deeper understanding of how teeth wear will result in the creation and use of improved materials and methods for restorative dentistry, prosthodontics, and even dental implants.

The strongest compressive organ is a human tooth. Its anatomical and chemical composition are quite distinctive. However, it is preferable to examine the qualities of materials and structures in order to comprehend the wear behaviour of human teeth. Numerous quantitative and qualitative techniques of measurement are available to assess these qualities.

The ordinal dental attrition score method, which uses a quadrant approach for human molars, was initially presented to us by Scott, a scientist [1].

A few years after Scott's grading system was devised, Eccles created a categorization system for erosion that identified the location and degree of lesions on individual teeth [2].

The deterioration of human teeth happens relatively slowly. It takes months or years to measure tooth wear. Teaford and Tylenda claimed that minute variations in human tooth wear patterns could be quickly detected and used to estimate wear rates [3].

Similar diagnostic standards were put up by Millward et al. to assess tooth erosion in [4].
Mastication causes the tooth surface to deteriorate physiologically. Mastication causes surface erosion, which causes the convex architecture of human tooth cusps to gradually and purposefully disappear.
In humans, this loss of convexity shows up as a flattening of the incisal margins on the anterior teeth as well as the cusp tips on the premolars and molars [5,6,7].
Attempts to simulate the oral environment in vitro have been made before. The majority of in vitro research, however, has been done on several test rigs with various contact geometries, weights, sliding speeds, lubricants, etc. This makes comparing wear results from several machines challenging. In addition, a suitable wear-testing tool has not yet been discovered. As a result, linking in vitro results to in vivo tooth wear requires a lot of work.

In daily life, mastication is done by the human teeth. The tribological behaviour of human teeth is often influenced by oral biomechanical functions [8, 9, 10].

Therefore, tooth ageing is a cumulative process that lasts for the whole of our lives. Most of the time, this procedure is irreversible.

The tribological behaviour of human teeth is influenced by frictional force, age, and even tooth cleaning. The following summarises the tribolocal behaviour of human teeth:

1. In a permanent tooth, the microhardness and tribological behaviour change significantly between layers. The micro hardness is higher and the friction coefficient is lower than in the dentin zone in the enamel zone. Additionally, the enamel zone has greater wear resistance than the dentin. Both the occlusal portion and the axial section show the same result. Furthermore, the microstructural orientations have a significant impact on the friction and wear behaviour of a single tooth. The orientation of the enamel rods and dentinal tubules explains why the occlusal section has better wear resistance than the axial region.
2. During the wearing process, plastic delamination occurs on the enamel surface. As a result, human tooth enamel now experiences three layers of wear instead of just two. The wear rate decreases as the number of cycles rises. Enamel wear eventually reaches a steady state. Microscopic analyses show that the mechanical removal of components, without visible changes in the compositions and crystal structures of the enamel controls enamel wear. After the interrod enamel, the enamel rods begin to deteriorate.
3. The length of time a human tooth is present in the oral cavity has a significant impact on its tribological behaviour. Young permanent teeth exhibit friction and wear behaviour similar to that of middle-aged permanent teeth, and the worn surfaces are mostly distinguished by minor ploughs and delamination traces, which have superior wear resistance.

However, for primary teeth and older permanent teeth, substantial ploughs and severe delamination predominate, together with a sharp variation in the evolution of the friction coefficient.

Pathological causes are frequently linked to tooth wear. These conditions can cause excessive tooth wear, such as xerostomia, bruxism, and erosion. Normal tooth brushing appears to have little to no impact on dentin and no noticeable impact on enamel. It should be remembered that cleaning your teeth right after an erosive challenge can significantly accelerate the wear on your enamel and dentin.

Tooth wear is a complex phenomenon that depends on many different things. These comprise several oral cavity chemicals, physical, and mechanical processes [11].

The tribological behaviour of both human teeth and the artificial restorative materials used in dentistry is greatly influenced by the oral environment.

The most crucial element that supports the stability of the oral environment is saliva. All surfaces that are exposed to the oral environment, including mucosa membranes, are coated with an acquired pellicle, which is made up of proteins that are absorbed from saliva. Any solid surface that is exposed to the intraoral environment immediately starts to develop acquired pellicle [12].

Saliva serves several different purposes in the human mouth cavity. As a lubricant between hard (enamel) and soft (mucosal) tissues, saliva serves a vital purpose [13].

This aids in reducing frictional forces inside the oral mucosa and on the surfaces of the tongue, as well as wear on human teeth. This aids our ability to swallow. Saliva is also essential in order to sustain other critical processes, including mastication, deglutition, and speaking. The pH of saliva is typically 7 (neutral) [14].

The intraoral environment benefits from the function of saliva as a buffer. Saliva is also considered to shield tooth surfaces from acid damage and aid in maintaining the integrity of the teeth [15, 16].

Saliva gives the enamel calcium and phosphate ions, aiding in the remineralization of the enamel. In addition to saliva, occlusal load from food particles also affects the tribological behaviour of human teeth. Mass used compression experiments to identify the tiny wear characteristics brought on by various food particles on the occlusal surfaces of teeth. Mass discovered that compared to the relative smaller tiny particles, huge particles created fewer, greater wear patterns. [17] Additionally, it was observed that when particle size rose, so did the overall wear area. It's interesting to note that load did not appear to affect wear.

Similar tests were conducted by Eisenburger and Addy, who discovered that load greatly influenced enamel wear by attrition regardless of the environment's chemical composition [18].

Even so, these investigations tended to focus more on the wear loss than on the mechanisms that were at play during the wear phenomena.

Human teeth were subjected to in vitro wear experiments under various environmental conditions. Citric acid solution, food slurry, and artificial saliva are some of the various circumstances. These experiments were carried out to determine the impact of the oral environment on the tribological behaviour of the teeth. The natural wear pattern of enamel was represented in the citric acid solution. Mineralization occurred when acid-eroded enamel was exposed to synthetic saliva. These two phenomena were also investigated. According to the test circumstances provided, it may be said that:

1. During the wearing process, artificial saliva has a cooling and lubricating effect. Artificial saliva use lessens the possibility of drying up the texture of the teeth.
2. Human teeth had greater wear resistance in a food slurry medium than in an artificial saliva medium due to the lubrication and stress distribution of food slurry on the contact surface. As a result, a food slurry medium showed both a low friction coefficient and a low wear depth. Additionally, increasing the load could cause teeth to wear down more quickly, and an artificial saliva medium showed that the effects of the regular load were more pronounced than those in a medium containing a slurry of food.
3. In the citric acid solution, enamel wear was caused by both mechanical and chemical activity. The wear behaviour of enamel was significantly influenced by the surface softness brought on by erosion dissolving under low normal loading levels, and adhesion delamination was the primary mechanism for enamel wear. As a result, enamel erosion is much less in artificial saliva than in citric acid solution. Due to the intrinsic fragility of enamel, wear was increasingly characterised by mechanical removal as the load increased, intensifying brittle fracture by loading force. The artificial saliva solution's enamel loss and wear morphology matched those of the citric acid solution.

4. Early enamel erosion was primarily characterised by partial demineralization and reduced micro hardness without evident substance loss, which were the key characteristics of the surface lesion of enamel. The enamel surface developed a honeycomb-like structure as the erosion period lengthened due to the enamel rods' extreme disintegration. Then there was a significant loss of erosive material. With the passage of time during erosion, the loss grew approximately linearly. Enamel's ability to resist erosion was also strongly related to where it was found. From the outside to the inside of the enamel, more erosive material was lost. Its friction and wear behaviours were also significantly impacted by enamel degradation. The erosion period strongly influenced the friction coefficient and wear loss of degraded enamel.

The inside enamel appears to have a greater impact from erosion on future friction and wear behaviour than the exterior enamel.

5. The antiwear qualities of acid-eroded enamel could be improved by remineralization in synthetic saliva. After in vitro remineralization, a layer of mineral deposits developed on the enamel surface that had been damaged by acid. This layer was chemically comparable to the original enamel surface, but its crystal orientation was very different. Remineralization greatly improved the nanomechanical and microtribological characteristics of the enamel surface that had been damaged by acid.

However, even after in vitro remineralization, the enamel surface's acid-induced loss of hardness and Young's modulus could not be fully regained. Acid-eroded enamel's wear volume is reduced after remineralization. It was still significantly higher than the original enamel, though.

A unique natural compound with exceptional mechanical and tribological properties is enamel. There is no artificial restoration substance that can replace enamel yet. The peculiar "prism-shaped" rods that make up enamel are aligned and range in diameter from 4 to 8 m. They go from the dentin-enamel junction (DEJ) toward the tooth surface at roughly an angle [19].

On the longitudinally sectioned enamel surface, scratching tests were conducted in directions parallel and vertical to the enamel rods, respectively, and recovery after scratching enamel was also explored. The following is a summary of the key conclusions based on the test conditions:

1.The enamel rod's nanomechanical characteristics were superior to those of the interrod enamel. Over its occlusal cross section, they varied. However, when a single enamel rod was taken into account, the hardness and Young's modulus tended to be higher in the centre head area and lower in the edge area, particularly in the tail area.

2. The anisotropic damage caused by the scrape on the tooth enamel's longitudinal section means the crystallite alignment of hydroxyapatite in enamel is special. However, when scraped in a direction parallel to the axis of the enamel rod, the interrod enamel's buffer capacity offered good wear resistance for the tooth enamel.

3. The hardness of the interrod enamel is lower. Thus, it was found that the interrod enamel had less wear resistance than the enamel rods despite the fact that it had a significant buffering effect on the teeth's ability to masticate food.

4.The enamel scratching was discovered to break up hydroxyapatite crystals into smaller ones. Such actions could assist to in relieving stress-related tension. Additionally, this stops teeth from cracking when being chewed on. However, it can significantly increase the teeth's capacity for wear resistance.

5. It was discovered that the size of the particles on the surface of the remineralized tooth samples grew to 200 nm. It was also mentioned that the chipped tooth enamel surface can be partially restored.

Metals, alloys, ceramics, and composites are often used materials in restorative dentistry.

The biomechanics and complex intraoral environment make it difficult to predict how prosthetic dental materials will deteriorate over time. Abrasion, attrition, corrosion, fretting wear, and fatigue are examples of the wear processes that are frequently used. [20, 21]

Surface loss of materials in the mouth results from the different combinations of these processes. Excessive wear might result in early failure and the need to repair implants and dental restorations. Clinically significant for clinical lifespan, attractiveness, and resistance to dental plaque for a better treatment outcome is the wear resistance of artificial dental materials [22].

A poor understanding of the tribological properties of restorative materials may cause teeth to wear down visibly when chewing, which will eventually threaten the integrity of the stomatognathic system. Therefore, in addition to cost and aesthetics, it is important to consider the biomechanics of dental materials, biocompatibility, and corrosion resistance.

Missing teeth are a common issue that affects people in every nation on earth. Every year, more people have missing teeth. An artificial tooth root, known as a dental implant, is a dental device that supports restorations and eventually replaces lost teeth. In 2011, the market for dental implants and prostheses was worth $6,781.7 million globally. In the decades to come, this value is anticipated to increase quickly. In implantology, the tooth-jawbone interaction should resemble the normal tooth-bone interface. This is bioactive, and there isn't any mechanical damage either. Thus, we may conclude that the surface treatment of implant materials requires our attention.

In order to ensure the success of the implant over the long term, the design of the dental implant screw must also be taken into account and analysed.

Numerous studies have been conducted not only on the wear and friction of real teeth but also on the interaction between artificial dental implants and bone. Important recommendations for the difficult future challenges involving both engineering and dental medical streams may be produced by combining the various findings with literature reviews.

In contrast to other tribology professions, dentistry has its own categorization and definition of wear. In general, wear in dentistry is more or less derived from clinical reasons or aspects of surface degradation. Human tooth wear is a topic that is the subject of an increasing amount of research nowadays. Thus, from a mechanical standpoint, conceptual ambiguity may result in some contradictions.

The majority of dental wear studies take an interdisciplinary approach. Therefore, it is crucial that scientists and researchers work together effectively and correlate their findings, and that they enhance their collaboration with oral surgeons and tribologists.

Dental implants can fail for a variety of reasons, including poor osseointegration or bone resorption. However, the occlusal surfaces of teeth are frequently loaded during chewing. Fretting can happen at the interfaces of the screw joint as well as where implant materials connect with alveolar bone. Failure to loosen can obviously result from this. As a result, it is undeniably true that biomechanics plays a critical role in reducing wear-related damage to the surface of dental implants. The dental implant-bone interaction, however, cannot ever be compared to the equivalent in the tooth's bone [23].

The development of tissue engineering, however, might provide us with fresh insight, and it suggests that we might be able to address the problem of fretting damage at the interface by creating a new periodontal ligament between the dental implant and gum tissue.

Therefore, for dental surgeons to develop a dental implant with a longer service life and greater patient compliance, collaboration studies with other experts are essential.

Even though we have made incredible progress in the study of dental wear, there is still much work and evaluation to be done in order to develop a bionic design for engineering wear systems, a clinical treatment against dental wear based on the idea of tribological design, and a systematic correlation between the tribological behaviour and structure of human teeth. Eventually, more and more study trajectories will point us in the direction of a better treatment prognosis. So maybe these talks will shed some light and offer more information about what has previously been discovered about human teeth.

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