Abfractions: A New Classification of Hard Tissue Lesions of Teeth

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Due to the stresses resulting from biomechanical loading forces exerted on the teeth (static, as in swallowing and clenching or cyclic, as in chewing), both enamel and dentin can chip or break away. This loss of tooth substance, which shall be termed *Abfraction*, is dependent on the magnitude, duration, direction, frequency, and location of the forces. These abfractive lesions are caused by flexure and ultimate material fatigue of susceptible teeth at locations away from the point of loading. Clinical observation of a variety of enamel and dentin lesions due to the shapes, sizes, loci, and frequency warrants a new and distinct classification.

The loss of tooth substance (both coronal and radicular), other than through accidental fracture, anomalies, or caries, can occur in a variety of ways related to function, wear, and longevity. Many bioengineering forces involving biomechanical, biochemical, and bioelectric principles come into play in this process. Because of the complexity, diverse activities, and consequent effects that take place in the oral environs, it is difficult to have each lesion classed in one category as several factors may sometimes be involved in their development. The composition, arch position, and shape of a tooth are most important considerations; however, the quantity and pH of the saliva, as well as the composition of the diet, affect teeth. The development and activity of the muscles of mastication, coupled with the emotional status of the individual, can also be contributing factors in the degree of tooth material loss.

Most textbooks in oral pathology and occlusion list attrition, abrasion, and erosion as the common forms of tooth substance loss.[1] In light of current and accepted scientific principles, a fourth classification of lesions attributed primarily to biomechanical loading is being presented. This classification is called "abfraction" from the Latin words, ab – "away," plus fractio – "breaking." The new and expanded classification of the lesions are defined as follows:

Attrition — the physiologic wearing away of tooth substance as a result of *tooth-to-tooth* contact, as in mastication. Attrition is most noticeable on occlusal and incisal surfaces. It may also occur at the interproximal contact points as a result of the anterior component of force, where small horizontal and vertical movements of teeth occur during function, thus causing frictional wear.[2] The overall effect of this physiologic wear is a reduction of 0.5 cm in length of the dental arch from the third molars to the midline by the age of 40 years.[3] Attrition involves biomechanical principles.

Abrasion — pathologic wear of tooth substance through (abnormal) *biomechanical frictional* processes. Examples are improper or excessive tooth brushing (mainly affecting root surfaces) and noxious oral habits such as biting a pipe stem, biting fingernails, holding nails between the teeth, and opening bobby pins. Bruxism is the most destructive manifestation of abrasion.

Erosion — chemically induced loss of tooth substance, mainly through *acid dissolution*. Erosive acids may have an extrinsic or intrinsic origin: the former through diet, e.g., citrus fruits or juices, carbonated soft drinks, baby bottle syndrome, or air (in some industrial chemical plants); the latter through regurgitation of gastric acids (habitual vomiting, as in bulimia, pregnancy morning sickness, or hiatal hernia).

Abfraction — pathologic loss of hard tissue tooth substance caused by *biomechanical loading* forces. These lesions are due to flexure and ultimate fatigue of enamel and dentin at a location away from the point of loading.

The effects of these forces, during static or cyclic activity, which are governed by the direction, magnitude, frequency, duration, and location, are ever present and unavoidable whenever teeth come in contact. It is estimated that during normal function, the average length of tooth contact per 24-hour period is 9.0 minutes for chewing and 17.5 minutes for swal-

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lowing.[4] Maximum human biting forces of 500 newtons (1N = .225 lb) in the molar region and 100–200 N in the incisor region have been measured.[5] According to Shore, the physiologic act of swallowing takes place 1,500 times a day, resulting in tooth contact each time. Occlusal loading forces of mastication occur for approximately 1 hour a day.[6]

The main principle involved in all dynamic tooth contacts, whether it be during mastication, swallowing, or parafunction (e.g., clenching), is that of column loading. Leonhard Euler (1707–1783), a Swiss mathematician, stated that when a column is loaded, it will flex, bend, buckle at a critical point, fatigue, and ultimately break.

In 1982, Dr. Gene McCoy first reported the significance of stresses on teeth. When occlusal forces are applied to a tooth, stresses are propagated throughout its structure. If the tooth is loaded eccentrically, bending or flexing stresses will occur (tensile on one side and compressive on the opposite). Should the stress level be of sufficient magnitude, whether a static load as in clenching or cyclically as in chewing, then abfractions can occur.[7-9] This breaking and chipping of tooth substance occur in both the enamel and dentin, which have a fatigue life, as do all materials and structures. These abfractive lesions progress to deep notches in the dentin and, ultimately, reach a fatigue limit that can result in complete tooth fracture. Clinically, Dr. McCoy noted a variety of shapes, sizes, and loci of lesions in both the dentin and enamel, thus suggesting a need for designation and a separate classification.

Due to the longevity of dentate humans and the frequency of these hard tissue lesions, a new classification is presented. It must be noted that in all lesions the concomitant effects of biochemical (salivary ion exchange), which is, in some instances, enhanced by stress corrosion, and bioelectric activity (piezoelectricity) are evident and unavoidable.[10] However, it is important to note that the initial force is the biomechanical loading of teeth, which results in the following abfractions:

Enamel

1. **Hairline cracks**—visible minute cracks; accentuated with transmitted light (Fig. 1).
2. **Striations**—irregular horizontal bands of enamel that have abfracted due to molecular breakdown, termed "molecular slip planes," or Lines of Luder (Fig. 2).
3. **Saucer-shaped**—an abfraction entirely within enamel (Fig. 3).
4. **Semilunar-shaped**—a crescent-shaped lesion entirely within enamel (Fig. 3).
5. **Cusp tip invagination**—a depression seen on the occlusal of molars and bicuspids that occurs on one or more cusps. The enamel becomes abfracted leaving an invagination in the dentin (Fig. 4).

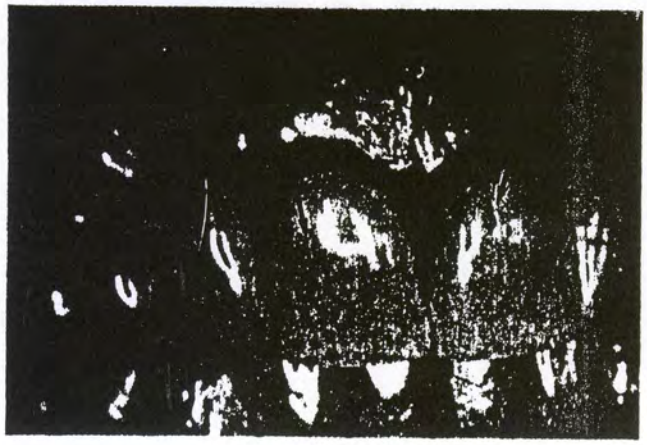

Figure 1. Hairline cracks—micro-abfractions in the enamel that are accentuated with transmitted light.

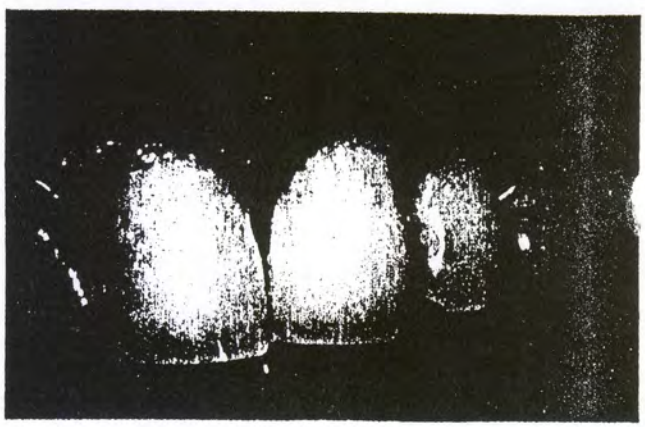

Figure 2. Striations—irregular horizontal bands of enamel that have abfracted due to molecular breakdown, termed "molecular slip planes."

Figure 3. Saucer-shaped—an abfraction entirely within the enamel (20). Semilunar—a crescent-shaped abfraction entirely within the enamel (21).

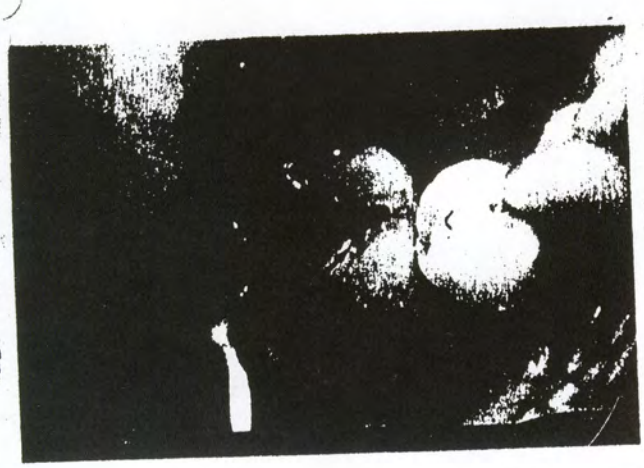

Figure 4. Cusp tip invagination—a depression that occurs on one or more cusp tips. The enamel is abfracted leaving an invagination in the dentin.

Dentin

1. **Gingival**—deep, sharply angular notches occurring at the gingival margin on the facial surfaces. Referred to as "McCoy notches" (Fig. 5).
2. **Circumferential**—abfractions completely around the cervical portion of the tooth (Fig. 6 [far right]).
3. **Multiple**—two or more grooves usually on one surface (Fig. 7).

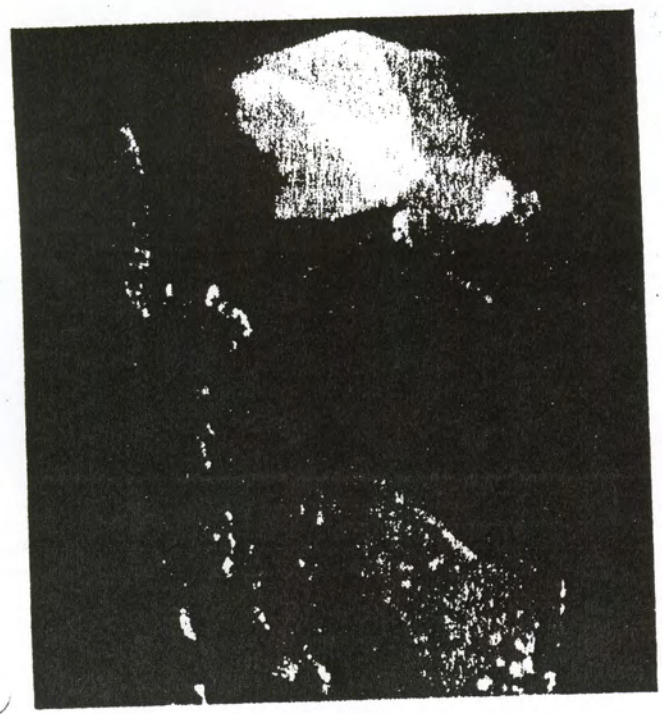

Figure 5. Gingival—sharply angular, deep notches occurring at the gingival margin on the facial surfaces. Referred to as "McCoy notches."

Figure 6. Circumferential—abfractions that are completely around the cervical portion of the tooth (far right).

Figure 7. Multiple — 2 or more grooves usually on one surface.

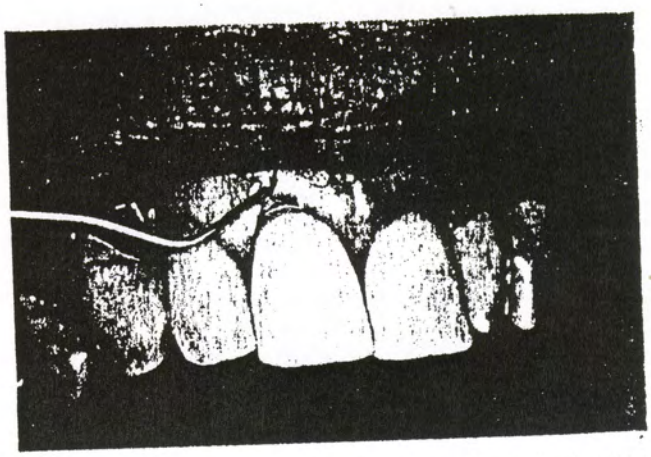

Figure 8. Subgingival—grooves or notches that extend beneath the gingiva, which can be single or multiple.

Figure 9. Lingual — abfractions on the lingual surface, either horizontal or angular, at the cementoenamel junction.

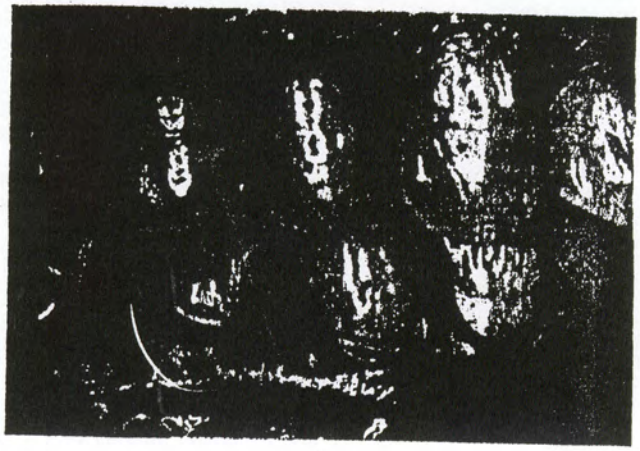

Figure 12. Angular — abfractive lesions that are at angles, usually 45 degrees.

Figure 10. Interproximal—abfractive groove or notch seen on teeth that are rotated out of the normal arch position.

Figure 13. Crown margin — an abfraction extending beneath the finishing lines of prosthetic crowns that are caries-free.

Figure 11. Alternate — an abfraction that occurs on a tooth, but the adjacent one is unaffected.

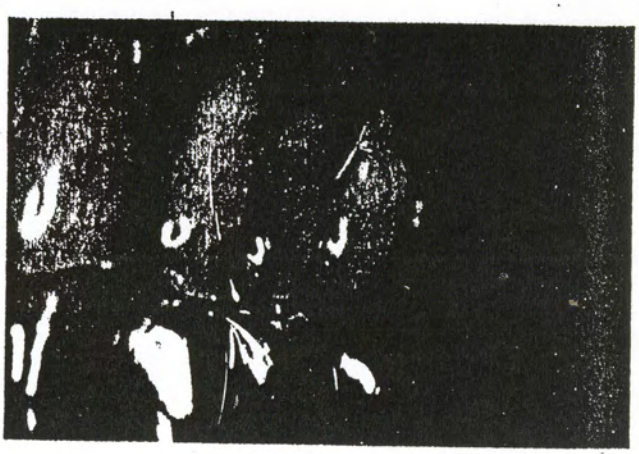

Figure 14. Restoration margin—a caries-free abfraction occurring gingival to all types of restorations (foil, amalgam, or composite) with no signs of toothbrush abrasion in the restorative material. Depicted restorations have been in place for 18 years.

4. **Sub-gingival**—an abfractive groove or notch that extends beneath the gingival margin, which can be single or multiple (Fig. 8).
5. **Lingual**—an abfraction on the lingual surface, either horizontal or angular, occurring at the cementoenamel junction (Fig. 9).
6. **Interproximal**—abfractive grooves seen on teeth that are rotated out of normal arch position (Fig. 10).
7. **Alternate**—an abfraction that occurs on a tooth but the adjacent one is unaffected (Fig. 11).
8. **Angular**—an abfractive lesion that is at a 45-degree angle (Fig. 12).
9. **Crown margin**—a caries-free lesion extending beneath the finishing lines of prosthetic crowns (Fig. 13).
10. **Restoration margin**—a caries-free abfraction occurring gingival to all types of restorations (composites, amalgam, foil) with no signs of toothbrush abrasion (Fig. 14).

This new classification explains a phenomenon that previously was attributed to toothbrush abrasion. The aforementioned lesions, such as all of those in enamel and dentinal margins (circumferential, multiple, subgingival, interproximal, alternate, angular, crown, and restoration) would negate the toothbrush as being the sole culprit.

SUMMARY

Clinical observation of a variety of enamel and dentin lesions are due to the stresses resulting from biomechanical, static, and cyclical loading forces. Their unusual shapes, sizes, loci, and frequency warrant a new and distinct classification that is being designated as areas of "Abfraction."

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