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The worn dentition – pathognomonic patterns of abrasion and erosion

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Historically, the dental literature has revealed various causes of tooth wear, yet it has failed to provide a conclusive method of differentiation and diagnosis of the condition. The categories of tooth wear encountered most commonly in dental practice are abrasion and erosion. The major causes of wear from abrasion are bruxism and toothpaste abuse, and the major causes of wear from erosion are regurgitation, coke-swishing and fruit-mulling. Through in-depth clinical study of these causes, this paper provides a diagnostic system that will enable dental professionals to determine and differentiate the exact aetiology of the worn dentition simply by the recognition of the pathognomonic wear patterns on diagnostic casts, which are based upon the position and quantity of the non-carious loss of tooth structure.

Key words: Attrition, abrasion, erosion, cupping, cratering, pathognomonic pattern, toothbrush recession, toothpaste abrasion

Since Hunter published his observations over 277 years ago, dentistry has expressed curiosity as to the specific causes of different types of tooth wear among patients' dentition[1]. Both a review of the literature and discussions with colleagues uncovered a sense of confusion about the subject of the worn dentition. One possible explanation is that all of the reviewed literature, while mentioning different causes, fails to give a conclusive method of differentiation and diagnosis of the worn dentition. This paper provides a diagnostic system developed through study and observation in clinical practice that will enable dental professionals to determine and differentiate the exact aetiology of the worn dentition simply by the recognition of the pathognomonic wear patterns on dental casts, which are based upon the position and quantity of the non-carious loss of tooth structure. Through the use of accurate casts poured from alginate impressions[2] and the addition of contrasting coloured wax to replace the worn dentition to normal in its entirety, these patterns can be recognised and quantified. After learning these patterns, most dentists, with practice, can do this visually, without wax, within minutes. It is not possible with oral examination because of the limited viewing perspective nor with photographs, because they are reduced to two dimensions. Hence, accurate study casts are the best and presently the only diagnostic tool to accomplish this.

Terminology

The classic dental texts[3] organise the subject of occlusal wear into three categories: attrition, abrasion and erosion. *Attrition* is defined as the normal physiological wear of teeth from mastication. *Abrasion* is defined as the pathologic wear of teeth from a mechanical/rubbing process. *Erosion* is defined as the pathologic wear of teeth from a chemical/dissolving process.

Closer examination of these definitions led to the first significant development in the understanding of the aetiology of the worn dentition. This occurred with the realisation that the definition of attrition typically cited in the literature is not appropriate nor particularly useful for the clinical assessment of how teeth wear. The amount of tooth wear resulting from mastication is insignificant due to the low abrasivity of food and the minute tooth-tooth contact during this function, and as such does not warrant a separate categorisation. The word attrition, which is a "gradual diminution of"[4] would be more accurately defined, in reference to the subject of the worn dentition, as the pathologic wear of teeth from abrasion and erosion. *Attrition,* then, simply is a word synonymous for wear, of which there are only two categories: abrasion and erosion. The non-carious loss of tooth structure can only happen by rubbing or dissolving.

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The second significant development relates to the clinical subject of cupping or cratering – the idiopathic invaginations that are commonly observed on the surfaces of teeth. As opposed to thinking it can only be caused by a chemical erosive process, clinical observation indicates that cupping or cratering can occur from both categories of wear, i.e. abrasion or erosion. Once the enamel is worn through to the dentine from abrasion (*Figure 1*) or erosion (*Figure 2*), the dentine, being softer and less mineralised, continues to wear at a more rapid rate than the peripheral enamel, creating morphologically what one would observe to be a cup or crater on the tooth surface.

Figure 1: Image of diagnostic cast demonstrating cupping or cratering from tooth wear from abrasion. The dentine, softer and less mineralised, wears at a faster rate than the peripheral enamel, creating morphologically what one would observe to be a cup or crater.

Figure 2: Another example of cupping and cratering. In this instance, the diagnostic cast features tooth wear from erosion, as opposed to abrasion.

Causes of wear from abrasion and erosion

Bruxism and toothpaste abuse are the two major causes of dental attrition/wear from abrasion; the three major causes from erosion are regurgitation, coke-swishing and fruit-mulling (*Table 1)*. It is important to note these causes rarely exist alone; combinations of causes are quite common. Consequently, the determination of the aetiology of the worn dentition can become complex. However, even though multiple patterns can overlay each other, the distinction still is clear. The following descriptions of wear patterns and corresponding images plus a description of the patient's behavioural profile are designed to assist dental professionals in differentiating the various causes and confirming the diagnosis.

Table 1 Causes of wear from abrasion and erosion

Abrasion	Erosion
Bruxism	Regurgitation
Toothpaste Abuse	Coke-Swishing
	Fruit-Mulling

Bruxism

Bruxism, the habit of grinding the teeth together (tooth to tooth contact when not eating), is the major cause of wear from abrasion. The quantity and positional wear pattern reveals the loss of tooth structure to be progressively greater towards the anterior teeth because of leverage changes created by eccentric posterior interferences. The posterior contact becomes the fulcrum point instead of the temporo-mandibular joint (TMJ), which alters the leverage system and increases the force applied to the anterior teeth. An exception to this would be the patient who exhibits an anterior open-bite. Cupping or cratering is quite commonly encountered in cases where the effects of bruxism are obvious but from another cause, which is most often toothpaste abuse. Patients who are heavy bruxers tend to brush their teeth with the same vigour that they brux.

A third significant development as a result of this study revealed that the signs of bruxism can be identified universally, which means that ALL human beings brux. This author's 33 year continuous study of the wear of teeth on dental casts from around the world has never produced a set of diagnostic casts that did not exhibit wear from bruxism. Therefore, it should be noted that wear from bruxism always will be present and can be in combination with any other cause.

Patients observed with bruxism are individuals who are stressed, as bruxism is a parafunctional activity controlled by the central nervous system and is likely to be the result of stress[5]. Confirming the diagnosis can be accomplished through the recognition of the pathognomonic wear pattern and observing that the worn surfaces (facets) of hand-articulated casts will coincide; not by asking the patient if they grind their teeth.

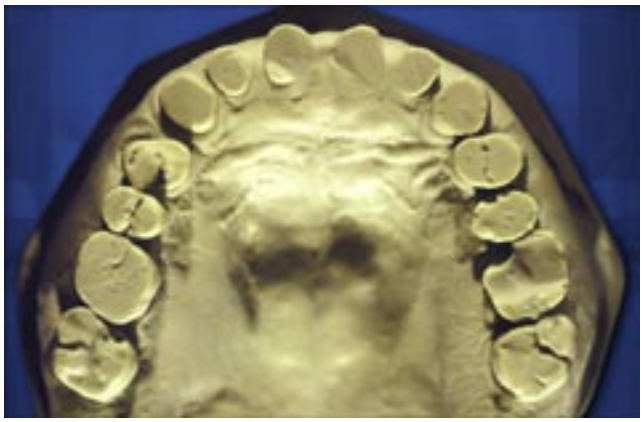


Figure 3

Figure 4

Two views of diagnostic casts of patient exhibiting severe tooth wear from bruxism. Examination indicates the wear is greater towards the anterior teeth. Note cupping or cratering is not present.

Figure 5

Figure 6

Another patient exhibiting tooth wear from bruxism, but to a lesser degree than patient featured in Figures 3-4. In this instance, cupping or cratering is caused by toothpaste abuse.

The patient detailed in *Figures 3* and *4* exhibits severe wear from bruxism. Examining the casts indicates that the wear is progressively greater towards the anterior teeth. Cupping or cratering is not present because the patient has no secondary wear factor. *Figures 5* and *6* detail another bruxism patient, but to a lesser degree and one with cupping or cratering caused by toothpaste abuse. In both featured patients, after hand-articulating the casts, the wear facets match-up and the diagnosis of bruxism is confirmed accordingly.

Toothpaste abuse

Toothpaste abuse, as evidenced by patients brushing over-zealously, is the second major cause of wear from abrasion and can often be viewed in combination with any of the other referenced causes. When toothpaste abuse is present, the anatomical detail of the affected surfaces is faded with a sandblasted appearance. The quantity and positional pathognomonic wear pattern reveals the facial surfaces of the mandibular canines and premolars to be affected the most, and when the enamel wears through to the dentine, cupping or cratering will form.

Patients who abuse toothpaste typically dislike the colour of their teeth. These individuals mistakenly believe that the more they brush their teeth, the whiter they will become. Actually, the opposite occurs; as the enamel becomes thinner, the dentine is closer to the surface, resulting in a darker overall appearance, which encourages more brushing. Confirming the diagnosis can be accomplished through observing the pathognomonic wear pattern and noticing that the worn surfaces of the hand-articulated casts will not coincide. It also is helpful to have patients demonstrate their tooth brushing style. It will be noticed that they very often 'scrub' with horizontal strokes. It will be useful to determine the frequency and nature of brushing, which should include the duration, number of occasions per day, and the velocity and pressure of their stroke. All toothpastes are

Figure 7

Figure 8

Images of diagnostic cast demonstrating tooth wear due to toothpaste abuse. Note anatomical detail is faded with a sandblasted appearance.

Figure 9

Figure 10

Closer view of the facial surfaces of cast detailed in Figures 7-8. Faded, sandblasted appearance is illustrated to a greater degree. Note the normal intricate facial anatomy is completely missing and there is no cervical recession of gingiva, although every surface of every tooth has been abraded.

abrasive[6]. An analogy to the potential harm can be seen in polishing an acrylic denture. It is the pumice that polishes the denture; not the ragwheel, and flour of pumice will wear the plastic just as much as coarse pumice; it is only a matter of time, speed and pressure.

Figures 7 and *8* exhibit wear from toothpaste abuse. Upon close examination, one can determine that the overall anatomical detail of the teeth is faded with a sandblasted appearance. A closer view of the facial surfaces (*Figures 9* and *10*) illustrates this to a greater degree and one can observe that the normal intricate facial anatomy is completely missing. It is interesting to note there is no cervical recession of the gingiva, even though every surface of every tooth has been abraded. This is because this patient has always used a soft, round-ended filament toothbrush[7].

So that the previous example is not misleading, the behavioural profile of the toothpaste abuser is not necessarily the caries-free immaculate oral hygiene patient, but can be almost anyone, as *Figures 11* and *12* detail a more advanced example of toothpaste abuse showing a patient with multiple restorations and some unkempt teeth. The anatomical details are faded with a sandblasted appearance and the silver alloy restorations are highly polished. The facial surfaces of the canines and premolars are affected the most, revealing the pathognomonic wear pattern. *Figures 13* and *14* are a close-up view of this area, illustrating a cupping or cratering effect as well. This particular individual does not like the colour of his teeth and spends an inordinate amount of time on these surfaces when brushing. Again, likewise due to the exclusive use of a soft, rounded-end bristle toothbrush, note there is no cervical gingival recession in this case either. When the featured casts

Figure 11

Figure 12

Another patient exhibiting a more advanced instance of tooth wear due to toothpaste abuse. Note again the anatomic details are faded with a sandblasted appearance; silver alloy restorations are highly polished. Facial surfaces of canines and premolars are affected the most, revealing the pathognomonic wear pattern.

Figure 13

Figure 14

Closer view of diagnostic cast detailed in Figures 11-12. Note the cupping or cratering effect. As with Figures 7-10, due to the patient's exclusive use of a soft, rounded-end bristle toothbrush, no cervical gingival recession is noted.

illustrating toothpaste abuse (*Figures 7-14*) are hand-articulated, the worn surfaces do not match-up and the diagnosis of toothpaste abuse is confirmed.

A distinction between the terms *toothbrush abrasion* and *toothpaste abuse* needs to be made, which will hopefully cause a paradigm shift in thinking and a better understanding about the pathological dynamics of the dento-gingivo-cervical junction: the non-rounded bristle toothbrush (typically firm) can damage gingiva (recession)[7,8]. Toothpaste can damage teeth (non-carious loss of tooth structure) regardless of the type of brush[9]. Because the deleterious effects of the toothbrush and toothpaste are two separate issues[10] (one can harm soft tissue and the other hard tissue), the all-inclusive term 'toothbrush abrasion' is clinically inadequate and misleading. Therefore, two new terms can be introduced: *toothbrush recession* and *toothpaste abrasion.*

Regurgitation

Regurgitation is the major cause of wear from erosion, with the quantity and positional wear pattern indicating that the wear is progressively greater towards the anterior teeth in the maxillary arch. This is caused by the action of the acidic projectile vomitus and position of the tongue when this occurs. With regurgitation, the acid dissolves tooth structure amorphously from the free margin of the gingiva on the lingual surface of the maxillary anterior teeth. The maxillary posterior teeth are affected more than the mandibular posterior teeth, particularly on the palatal surfaces. The mandibular anterior teeth are never affected as they are protected by the tongue. Cupping or cratering is quite common. If amalgam restorations are present, they will appear elevated.

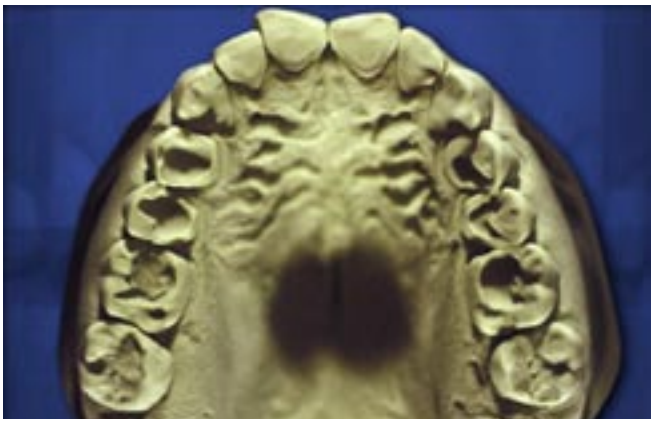


Figure 15

Figure 16

Images of diagnostic casts demonstrating tooth wear due to regurgitation. Note the amount of wear on the maxillary teeth is progressively greater towards the anterior.

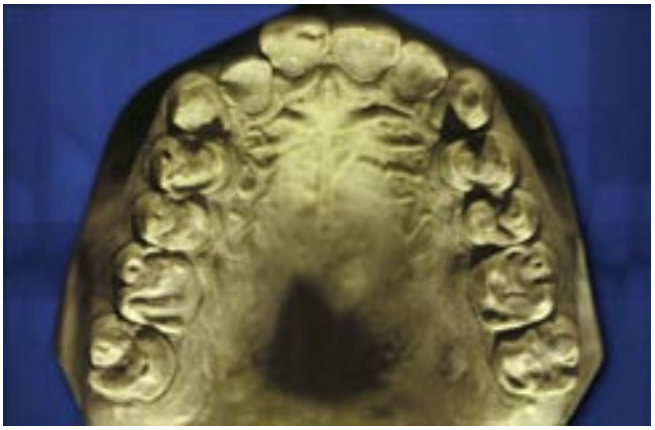


Figure 17

Figure 18

A more severe example of tooth wear due to regurgitation. Note the maxillary anterior teeth are worn smoothly from the free margin of the gingiva on the lingual surface.

The wear pattern from regurgitation is always found in the person who suffers from bulimia, a complex psychological disorder that is characterised by binge-eating and self-induced vomiting[11]. Regurgitation can be present in combination with other causes, with the exception of coke-swishing and fruit-mulling. The binging/vomiting process is done rapidly while coke-swishing and fruit-mulling take a long time. Diagnosis through discussion with the bulimic patient is very difficult because they characteristically deny their problem. Confirmation of the diagnosis is obtained through the recognition of the pathognomonic wear pattern and observing that the worn surfaces of the hand-articulated casts do not coincide. When a confession of the disorder is offered with a claim to be cured, but seems invalid, a small test amalgam restoration can be placed on the palatal surface of a maxillary anterior tooth; it should be carved flush and then observed six months later. If it appears elevated, further confirmation and current status is determined.

Figures 15 and *16* exhibit wear from regurgitation. When one visually compares abnormal to normal and positionally quantifies the loss of tooth structure, the pathognomonic wear pattern for regurgitation can be observed. The amount of wear on the maxillary teeth is progressively greater towards the anterior. The maxillary anterior teeth are worn smoothly from the free margin of the gingiva on the lingual surface. The maxillary posterior teeth are affected more than the mandibular posterior teeth, particularly the palatal surface. The mandibular anterior teeth are not affected. Cupping or cratering is present. When these study casts are hand-articulated, they do not match-up. *Figures 17* and *18* detail a more severe example demonstrating the same pattern,

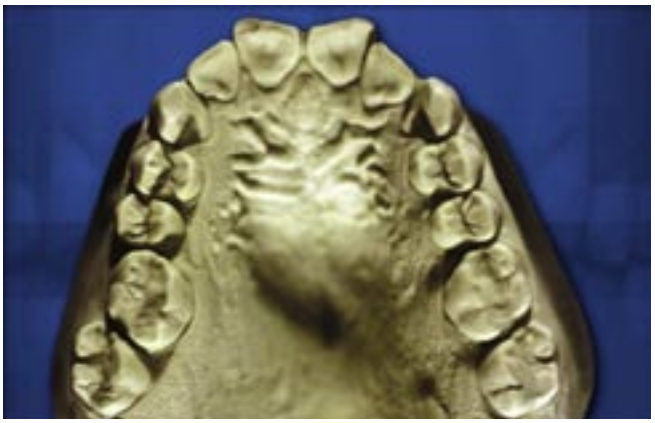


Figure 19

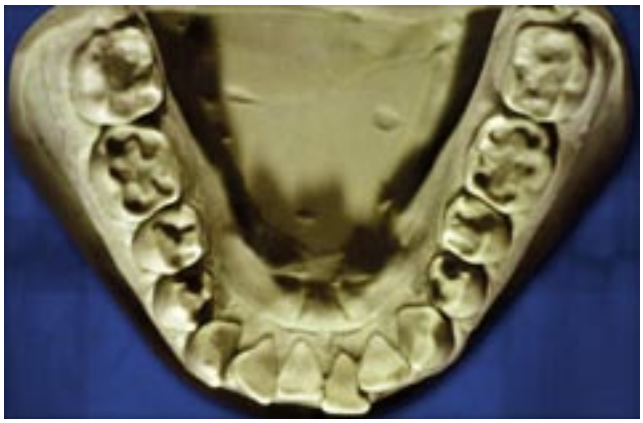


Figure 20

Images of diagnostic cast demonstrating tooth wear due to coke-swishing. Note posterior teeth are affected to a greater extent than the anterior teeth; mandibular first molar is affected the most. Cupping or cratering is present with sharp enamel edges.

Figure 21

Figure 22

A more advanced example of tooth wear due to coke-swishing. Note also that significant tooth wear from bruxism can be observed on the anterior teeth.

including restorations that appear elevated.

Coke-Swishing

Swishing with carbonated drinks, the rapid back and forth movement of soda in the mouth to reduce the carbonation and avoid the uncomfortable sensation of carbonation in the throat, is the second major cause of wear from erosion. The term 'coke' is used here generically; any brand of carbontated beverage will do, including sugar-free varieties. The quantity and positional wear pattern reveals the posterior teeth to be affected to a greater extent than the anterior because of the tongue's position when this habit occurs. The mandibular first molar, which typically erupts at age six, is affected the most because of gravity and the early childhood age this habit begins. Because of the positional protection from the tongue, the mandibular anterior teeth are never affected. Cupping or cratering with *sharp* enamel edges always is present. If there are any amalgam restorations present, they will appear elevated.

It should be noted that coke-swishers are not high-volume coke drinkers because coke-swishing takes a great deal of time; it often takes several hours to consume one can. Coke-swishing can be observed in combination with other causes except for regurgitation or fruit-mulling. Coke-swishing takes too much time for a person who regurgitates and fruit-mullers typically are too health-conscious to drink soda.

Confirmation of diagnosis occurs when the pathognomonic wear pattern is determined and the worn surfaces of the hand-articulated casts will not coincide. Unlike regurgitation, patients will freely admit to coke-swishing and usually a family member has complained about the habit.

Figures 19 and *20* exhibit wear from coke-swishing.

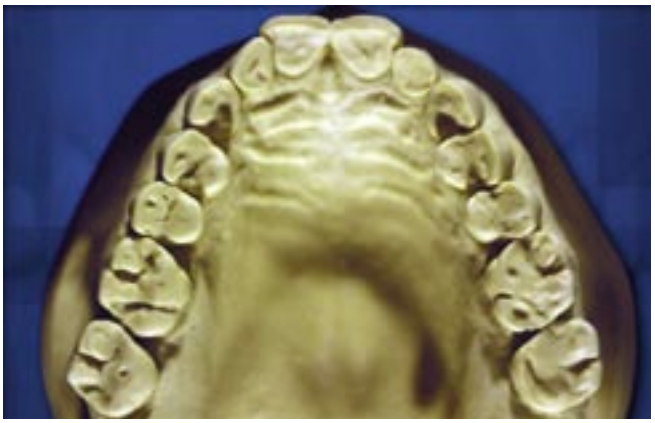


Figure 23

Figure 24

Images of diagnostic cast demonstrating tooth wear due to fruit-mulling. Note the posterior teeth are affected to a greater extent than the anteriors; maxillary and mandibular teeth are affected equally.

The posterior teeth are affected to a greater extent than the anterior teeth, with the mandibular first molar being affected the most. Cupping or cratering is present with sharp enamel edges. When these casts are hand-articulated, they do not match-up. The patient admitted the habit and the diagnosis of coke-swishing was confirmed.

Figures 21 and *22* detail a more advanced example with some significant wear from bruxism that can be observed on the anterior teeth. The posterior teeth are affected more than the anterior teeth. The mandibular first molar is affected the most. Cupping and cratering is evident with sharp enamel edges. The patient admitted the habit and again the pathognomonic wear pattern is recognised, the hand-articulated casts will not match-up, and the diagnosis of coke-swishing was confirmed.

Fruit-Mulling

Fruit-mulling, the third major cause of wear from erosion, is a habit often observed in health-conscious patients who consume fruit throughout the day with a delay in swallowing the pulp of the fruit so it can be mulled between the teeth, much like the chewing pattern of a cow. These patients are often vegetarians and heavy bruxers from a high level of stress. The quantity and positional wear pattern is similar to that caused by coke-swishing; the posteriors being affected more than the anteriors due to the position of the pulp of the citrus fruit the patient is mulling. During this mulling process, however, the acidic pulp is contacting the maxillary and mandibular posterior teeth simultaneously, thus causing an equal loss of tooth structure which distinguishes fruit-mulling from coke-swishing. Cupping or cratering is always present but with *abraded* enamel edges from the mulling/bruxing process. If amalgam restorations are present, they will appear elevated. Wear from fruit-mulling can be observed in combination with other causes with the exception of regurgitation and coke-swishing. To further diagnostically differentiate, fruit-mulling takes too much time for a regurgitator, and fruit-mullers typically do not drink soda.

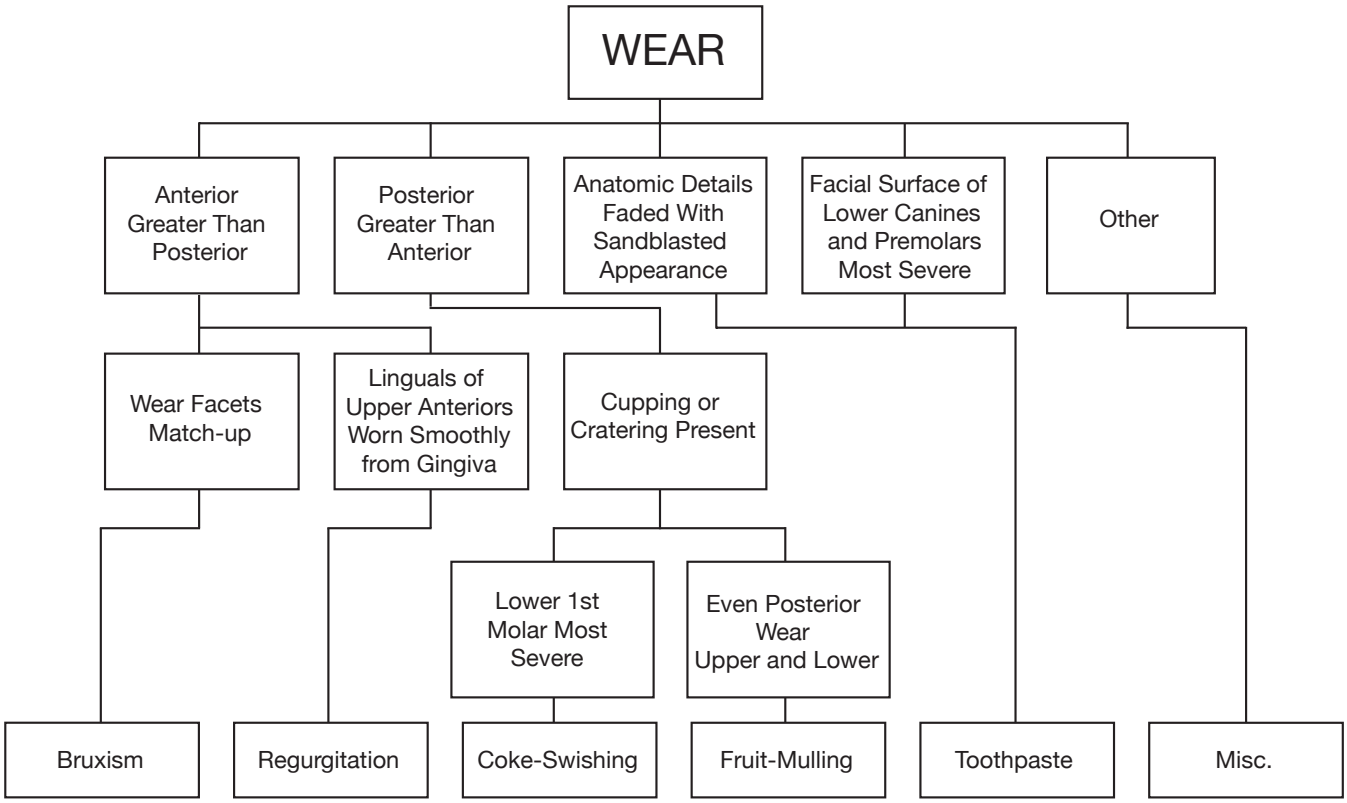
Confirmation of diagnosis can be made from the evidence of the pathognomonic wear pattern and by observing that the worn enamel surfaces (facets) of the hand-articulated casts will coincide. These patients will reluctantly admit their habit because they struggle with the concept that they are damaging their body by eating something healthy such as fruit.

Figures 23 and *24* exhibit wear from fruit-mulling. The posterior teeth are affected to a greater extent than the anteriors, with the maxillary and mandibular posterior teeth affected equally. Cupping or cratering is present with abraded enamel edges from the mulling action. The diagnosis was confirmed from the pathognomonic wear pattern along with the match-up of abraded enamel edges peripheral to the cups or craters and the admission of the habit by the patient.

Conclusion

By observing the quantity and positional wear pattern on casts which are pathognomonic to the cause, the dental practitioner will be able to accurately identify the various causes of the worn dentition. There are, of course, additional, miscellaneous causes of wear such as lemon-sucking, pipe-smoking, snuff-dipping, GERD, etc. The wear pattern will then be unique to the particular habit. These miscellaneous causes can occur in combination with the major causes presented, however, they comprise only a very small percentage of the patients we encounter with tooth wear. To discover the less common miscellaneous causes, the differntial diagnosis must be accurately determined by first elimi-

Table 2 Diagnosing causes of worn dentition due to abrasion and erosion



nating the pathognomonic patterns of the five major causes featured in this paper and then questioning the patient regarding their oral habits. The corresponding flowchart (*Table 2*) is designed to assist in making the diagnosis as simple as possible.

In order to be successful in the treatment of any disease or disorder we must be able to determine the cause before we can affect cure. The success of the restoration of the worn dentition, an increasing problem, is dependent on this axiom. The clinical value of this author's discoveries should be obvious.

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