Notes condensed from Oral Dynamics by Thomas Forde
typed by Edward Feinberg, DMD

I. FORCES IN NATURE

A. Basic Laws and Assumptions

1. In order to create a condition of equilibrium:
   a. The vector sum of all forces acting on a body must be zero
   b. The algebraic sum of the torques about any axis of the body must be zero.

2. "When the lever is in equilibrium, the applied force on one side multiplied by its distance from the fulcrum equals the resistance on the other side multiplied by its distance from tge fulcrum."

3. Newton's Third Law of Motion: When one body exerts a force on a second body, the second body reacts on the first with a force opposite indirection but equal in magnitude.

4. Principle of Arch Strength: "When noncrushing external pressure on an arch exceeds internal pressure, the segments of the arch tend to bond together and become stronger, because the vector components of the force are directed downward through the supports."

B. Biologic and Chemical Principles Involved in Nonsystemic Mouth Degeneration

1. Cellular reaction of tissue under stress
2. Percentage of bone loss sustained
3. Metabolic Indication of the progress of fatigue of bone tissue
4. Dental Deformities
5. Relationship of function to correct dentitional blood supply
6. Misuse of Masticatory muscles
7. Biomechanical requirements of dentitional wear
8. Hard dentition that resists necessary occlusal wear.

II. EVOLUTIONARY CONSIDERATIONS

A. Ten thousand primitive mouths were examined in museums from all continents and climates. The following observations were noted:

1. All ten throusand primitive mouths exhibit bite correction through natural wear.

2. Eight thousand skulls were dated in the period where only raw foods were eaten. 7840 skulls exhibited complete dentitions with less than .5% mouth degeneration.

3. Two thousand skulls were dated in the period where cooked foods were introduced in the diet. Of these, 1700 exhibited complete dentitions -- 15% of dentitional loss was attributed to accidents.

4. Both groups of skulls show that degeneration of dental structures was an insignificant factor in loss of dentition.

B. In the primitive period, raw food with its component of grit and sand particles allowed natural bite correction by reducing the cuspal planes which safeguarded the teeth against the deleterious effects of interlocking cusps. Bite correction progressed so that:

1. the crowns were shortened
2. interlocking cusps were removed
3. the mandible was free to move in mastication
4. the dentition and arches were preserved in health
5. there was a reduction of masticatory strain on the supporting structures.

C. In the early cooked food period, natural bite correction was greatly affected by the lack of raw foods. There is a considerable difference between the primitive and the contemporary mouth:

1. In the primitive mouth, deciduous teeth are flat by the time the permanent molars erupt. In modern man, the deciduous teeth retain sharp cusps which interdigitate with opposing cusps.

2. In the primitive mouth the 6 year molar has undergone some bite correction modification by the time the 12 year molars erupt. This does not occur in modern man.

3. In primitive mouths the strength of all secondary masticatory muscles are developed for lateral trituration. This does not occur in modern mouths.

4. By the end of the fifteenth year, primitive mouths exhibit bite correction which has modified the dentitional topography so that the posterior teeth do not interdigitate. The maxillary dental arch and alveolar process have ceased condensing. In modern man the upper arch and alveolar process continue to condense through lingual inclination at the end of the fifteenth year. The cusps interlock.

5. The mouths of primitive man exhibit perfect end to end bite for anterior teeth with all posterior teeth meeting simultaneously. Modern man exhibits mouths with malocclusions and dental abnormalities.

6. In primitive man the teeth are held for life in solid bone and have survived centuries after death. Modern man exhibits dentitional loss and degeneration of supporting structures throughout life.

D. These differences lead to the following conclusions:

1. "The masticatory apparatus is an essentially mechanical device intended to operate efficiently throughout the lifetime of the systemically healthy adult". Dentitional loss is not a consequence of the aging process.

2. The masticatory design does not have physiologic or structural limitations which preclude the lifetime retention of teeth.

3. Nonsystemic (force-induced) mouth degeneration and premature loss of teeth has increased through the ages as food preparation and sanitary practices depreived man of natural means of bite correction.

4. Mouth degeneration in the absence of systemic factors is induced by erroneous masticatory force patterns created by dentition denied the benefits of bite correction.

5. Full bite correction is essential to the development and retention of healthy dentition. Dentistry has an obligation to provide this correction once provided naturally.

III. DESIGN OF FORCE EQUILIBRIUM IN THE MOUTH

A. The masseter and temporalis muscles contribute 85% of the masticatory forces in the mouth. The entire masticatory apparatus is designed so that the greatest force output is distributed "more or less equally, between the posterior teeth and synovial membrane or meniscus on the head of the condyle".

B. The magnitude of occlusal load any tooth is required to bear is a function of its distance from the center of heaviest force application.

C. The heaviest force of mastication is on the first and second molars. The bicuspids take less force. The relative fragility of anterior teeth suggests that they were never intended to accomodate sustained pressure.

D. Cuspless teeth (primitive man) receive only vertical components of force and no ther thrusts are involved. The forces cancel each other out, as their vector sum is zero. Teeth with steep cusps (modern man) received buccal and lingual thrust components of force as well. These forces increase in effectiveness the farther they

are from the fulcrum. Physics can measure this effectiveness in terms of torgue. For equilibrium to occur, the clockwise torques must equal the counterclockwise torques. If more than one torque is applied to a tooth, the resultant torque is the algebraic sum of the two.

E. Unbalanced and unequal torques applied to teeth must result in their rotation. "By means of resolution of forces it has been found that masticatory impact must always be converted by cuspal planes into torques which act at right angles to the plane and it has also been found that dentitional rocking and inclination must always occur toward the side of heaviest orque application".

F. The teeth react as the lever does under force. The equilibrium of the lever is explained in the following equaltion:

$$Fw = Ds$$

F=force application (masticatory force)
w=distance along the working arm of the tooth from force application to fulcrum
D=dead weight resistance
s=distance along the supporting arm from deadweight (apex) to fulcrum

In other words: "When the lever is in equilibrium, applied force on one side multiplied by the distance from the fulcrum equals the resistance on the other side multiplied by its distance from the fulcrum".

Thus, since it is true that force increases in effectiveness the farther it is from the fulcrum, it is also true that very massive supporting dental bone structures can be replaced or degenerated. If the working arm is greater than the supporting arm, the resulting torque can lead lead to destruction and exfoliation in much the same way as a fence post that lacks enough foundation to prevent it from being torn from the ground by a farmer's livestock.

G. <u>DENTAL ARCH STRENGTH</u>

1. The dental arch is as integral to the structural design of the mouth as any tooth or supporting dental structure. If a tooth is pounded from normal axial alignment, so must that portion of the arch be unbalanced or weakened and exposed to destruction.

2. The dental arches are exposed to three forces in various combinations:

   a. occlusal
   b. external (labial)
   c. internal (lingual)

3. The dental arches are designed to easily withstand external pressure. Arches built in construction throughout the centuries exemplify this fact since the stones are often not connected with any cementing substance. The explanation lies in the resolution of forces by vector analysis. The weight of the load applied externally is converted through mutual pressure of individual blocks into lateral or diagonal thrust which bonds or strenghtens the arch. An exprrimental arch built of a material with the same tolerance as teeth easily withstood pressures in excess of masticatory forces. Even less than ideal arches were able to accomplish this. The resistance of individual segments to concentrated pressure was substantially stiffened by the arch as a whole.

4. The following conclusions can be made about the dental arches with regard to external pressures:

   a. The strength of the dental arch under external pressure is the collective strength of all arch segments with each other in the arch form.

   b. The strength of the tooth segment of the dental arch is its capacity to withstand concentrated external pressure and its resistance to rotation and other force-induced wear and tear are sub-substantially buttressed by the collective strength of all the tooth segments of the arch.

   c. The dental arch contribution is important to the development and retention of oral health by safeguarding individual teeth against the ravages of external pressure and therefore resists force-induced alterations of the structure and physiology of the masticatory apparatus.

5. Arches cannot withstand internal pressures, either in construction or in the mouth. The following observations about internal pressures are noted:

   a. The strength of the arch under internal pressure is not the collective strength of the arch segments. This is true for construction as well as dentistry.

   b. The strength of segments is not butressed by other segments under interal pressure.

c. Internal pressure can destroy an arch more readily than external pressure by pressures well within the masticatory forces.

d. The dental arch does not safeguard teeth against the ravages of internal pressure and leaves teeth and supporting dental structtures vulnerable to destruction.

e. As a segment is rotated by internal pressure, its resistance to external pressure decreases.

IV. PATTERN OF GROWTH AND DEVELOPMENT IN MODERN MAN

A. Steep cusps are required in immaturity for various formative and development purposes. When teeth erupt cusp function exhibitis a holding pressure which preserves occlusal contact and tends to resists rotation action. This plan of occlusal contact is referred to as bilateral balance.

B. In primitive man, cusps were reduced through natural bite correction until the teeth receive only vertical components of force. The plan of bilateral balance was thus changed to a two dimensional plan of balance. This does not occur in modern man and steep cusps remain in bilateral balance.

C. Bilateral balance, by preserving cusp function after normal mouth development has ended converts masticatory impacts into unbalanced torques. Whereas the two dimensional plan eliminated rotational components from masticatory force patterns.

D. The mouth seeks, through growth, to accomodate these force components but growth can't be continued indefinitely nor can abnorman growth occur without deleterious consequences to the masticatory apparatus. "Considering Newton's third law of motion, it is inevitable that mouth structures constrained to accept unaccomodable thrust must sooner or later degenerate under stress. The teeth, in other words, become levers, through which even relatively slight force application can degenerate the most massive dental structures. Masticatory forces are generally in the range of 35 to 150 lbs/sq./in."

E. The upper process and dental arch continue to expand and the lower process and arch widen posteriorly, through lingual inclination. Dentitional rotation also occurs.

F. As a result there is less masticatory force through the lines of the long axes. "When the interaction of force and dentitional topography is in conformance with the principles of torques and the principle of the lever, mastication creates the impulsive hydraulic pressure essential to full dentitional blooc supply. When each act of mastication causes teeth to rock and

rotate, a reduction of impulsive hydraulic pressure ensues reducing dentitional blood supply". This statement is based on the following biological principles:

1. Blood flow at the arteriole level is not attributable to systolic pressure. There is no apparant pulse at this level. The size of the arteriole and the specific gravity of blood make it possible to determine that it is physically impossible for a pump the size of the heart to exert pressure through the arterioles to complete the circulatory cycle.

2. At this level, blood is carried through the circulatory system by voluntary and involuntary muscular acttion as well as by osmotic pressure and chemotaxis. The masseter and temporalis are the primary originators of oral forces and they create the impulsive hydraulic pressures which complete dentitional blood circulation. As the muscles contract, blood is expelled. As they relax, blood freshly infuses.

3. The alveolus is designed as a hydraulic foundation so that the tooth can healthfully absorb all the masticatory pressures applied to it. With abnormal forces, not all parts of the tooth can receive forces equaally. One side of the tooth is overworked with stretched fibers and the other side has compressed fibers in a semistatic state. Not all arterioles and cells can get the benefit of full blood supply. Chronic fatique lowers the pH of the membrane and invites inflammation. Thus, through fatigue and reduced blood supply, inflammation and alveolar bone degeneration result.

4. As the upper process and arch expands and the lower arch inclines lingually, the bite closes and cuspal interlock makes the pressures on teeth progressively worse. The loss of vertical affects the anterior region profoundly, causing crowding on the lower anterior teeth or pushing the upper anteriors labially. Extreme overbite is also the inevitable corollary of vertical dimension shrinkage. It is interesting to note that therapeutic grinding to prevent pounding of the lower anterior teeth against the uppers accomplishes little because a few months later the anteriors are again pounding. Cuspal force patterns cause this to occur; the lower anteriors do not continuously erupt. In light of this fact it is also evident that third molars do not cause crowding of the lowers.

5. In the beginning, bone degeneration does not manifest itself in X-rays. The loss is first evident in the compensating bone (buccal surfaces) as the processes

thin and the arches expand. As bone is lost, the fulcrums of the teeth are eroded, hastening degeneration through the lever principle. Exfoliation and extraction are the inevitable result. Broken dental arches further hasten the degeneration of remaining teeth.

V. BILATERAL BALANCE VS. THE TWO DIMENSIONAL PLAN

A. Characteristics of Bilateral Balance

1. Bilateral balance is healthful for forming immature mouths. Steep cusps cause a holding pressure which preserves occlusal contact and tends to resist rotation. It is a disservice to reduce cusps before the processes have ceased growing (before the 12 year molares are in place).

2. Bilateral balance preserves cuspal functuon after the normal mouth development has ended.

3. It converts masticatory imbalance into unbalanced torques. When the algebraic sum of all torques is not zero, rocking and rotation result. Through the principle of the lever, the normally tolerable masticatory force can degenerate and displace the most massive structures. Bilateral balance is therefore a major cause of force-induced degeneration.

4. Unless the lever arms of the teeth are too short for the lever principle to apply, lateral movements of the mandible can rotate and destroy teeth.

4. In the bilateral balance plan, the abnormal expansion of the upper process and widening posteriorx of the lower process conform with Newton's third law of motion to the pressures and counter pressures resulting from cuspal topography.

B. Characteristics of the Two-Dimensional Plan

1. In a two-dimensional plan of balance, the cuspal causes of misdirected force are eliminated. Force is delivered and received in lines parallel with the long axes of the teeth. It safequards dental arch form.

2. There us no occlusal locking and the mandible can slide forward for end to end function without thrusting forces.

3. There is still a holding thrust permitted to exist since cusps are not completely reduced. This holding pressure actscondensively to prevent expansion of the upper teeth. The contacts are tightened and fatigue-free function can occur.

4. Bite correction should be performed whenever the

force pattern of the mouth poses a potential threat or a circect threat to the strength and continuity of the arch.