Biologically Effective Units of Force

ROBERT M. RUBIN

When the 18th Century German Scientist Kant said "Eine Wissenschaft aber nicht Wissenschaft" (A Science, but not really science), he was reflecting on the inability to relate the chemistry of that time to mathematics, which is regarded as an essential part of a true science. In *Number, the Language of Science,* Tobias Danzig argued that unless mathematics can describe it, it is not scientific.

In D'arcy Thompson's classic essay *On Growth and Form,* he commented; "How far even then mathematics will suffice to describe, and physics to explain, the fabric of the body, no man can foresee. It may be that all the laws of energy, and all the properties of matter, and all the chemistry of all the colloids are as powerless to explain the body as they are impotent to comprehend the soul. For my part, I think it is not so."

Orthodontists have been tireless and undaunted in their attempts to quantify diagnostic and treatment criteria. The agreement to adopt the Frankfort Plane as a craniometric reference plane in 1928 and the introduction of cephalometrics in 1931 helped to spawn the endless stream of numbers used since then in attempts to mathematically describe craniofacial morphology.

The arguments 50 years ago about continuous versus intermittent forces were also aimed at making treatment less empirical and more scientific. Storey and Smith's work on differential forces is a more recent attempt at using linear mathematics to describe biological phenomena.

Even more recently, Brader has sought to define the mathematical parameters of dental arch form in homo sapiens. He concluded that an innovative trifocal ellipse fits most consistently, although some would argue that even this represents an oversimplification.

Several researchers have been unsuccessful in their efforts to explain the stability found in the untreated dentition by a mathematical relationship between lip and tongue forces as measured with pressure transducers. The existence of an equilibrium is obvious. Although teeth move continually throughout life, their rate of movement is slow enough to regard them as stable at any given time.

One problem in attempting to use Newtonian physics to describe such a complex long-term equilibrium may be that we are using the wrong measuring units. A force of 600 grams for 1 hour is 600 gram-hours. A force of 30 grams for 20 hours is also 600

Dr. Rubin practices orthodontics in Norfolk, VA and serves as Director of the Eastern Virginia Orofacial anomalies team. He is a dental graduate of Tufts University, and holds an M.S. degree in Orthodontics from Temple University.

Dr. Robert M. Rubin
300 East Little Creek Road
Norfolk, VA 23505

gram-hours. But will living cells respond equally to either? Lifting 6 pounds 100 times in an hour is 600 pound-hours. Lifting 600 pounds once in an hour is also 600 pound-hours. Do those represent equal challenges?

Biological equivalence is far more complex than such simplistic units. A force of 3 lbs. on a cervical traction appliance under one application schedule may be the biological equivalent of a 5 lb. force on another schedule. Is it not possible that the inability to establish a mathematical equilibrium for the tongue reflects the inadequacy of measurement of force alone to describe this biological phenomenon?

Norton has suggested that there may be a six-hour threshold before a cellular "cascade effect" occurs, signalling the beginning of tooth movement. We are all familiar with the demonstration in which a large number of mousetraps are loaded with ping pong balls and one trap is fired. The chain reaction that follows may resemble the action of osteoclasts when an effective force is applied to a tooth.

A tooth cannot move until an entire layer of cells is resorbed. Since the biological process is time-linked, nothing measurable happens until the force has been applied for an effective length of time.

There must be an elusive Biological Effect Unit (B.E.U.) that may be composed of such factors as a threshold force, operating over a threshold time, possibly interrupted by a series of threshold intervals.

The development of quantum physics was the solution to a similar problem in the field of atomic physics. Ingeniously devised by Max Planck, quantum mechanics explained phenomena for which Newtonian Laws had proven inadequate.

This essay does not include a definition of the proposed Biologically Effective Unit. It presents a concept in the hope that it will contribute to a broader appreciation of the nature of biological processes, and a challenge to future researchers to progressively refine the definition of such a unit.

Orthodontics differs from most clinical sciences in the very special way in which its milieu is linked with force, space and time. We must develop a concept and a vocabulary of measurement that reflect that uniqueness. The term Biologically Effective Unit is proposed as a goal along the path to a better understanding of the essential processes underlying orthodontic tooth movement.