ORIGINAL RESEARCH PAPER
Volume - 9 | Issue - 9 | September - 2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

BIOPHYSICS MODERNIZING DENTISTRY

Dental Science

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ABSTRACT

Physics has proven helpful in physiology, biology, and medical research by providing deeper insights into the phenomena studied by these sciences. In some fields of investigation , physics studies produced major analytic and diagnostic tools. Modern medicine cannot be imagined without apparatuses and devices based on physical principles .

KEYWORDS

Medical physics, Laser, Magnifications.

INTRODUCTION

Biophysics attempts to describe the phenomenon of life using the conceptual framework of physics . The word "Biophysics" was used allegedly by *Karl Pearson* in his book *The Grammar of Science* 1892 . Medical physics appeared even earlier , in the middle of the 19th century , which is connected with the name of *Adolf Eugen Pick* ,the author of diffusion laws. The synthesis of biophysics and medical physics resulting in medical biophysics was a gradual process. The introduction of X-ray diagnostics and electrodiagnostics, investigation and utilisation of ionising radiation in therapy, understanding bioelectric phenomena and the imposing appearance of tomographic imaging are the main roots of modern medical biophysics .1

Physical laws or concepts such as mechanics ,hydrodynamics ,optics , electrodynamics and thermodynamics are used to explain physiological observations like muscle contraction, neural communication and vision. The fields of biological and medical physics is broad , multidisciplinary and dynamic. Diversity is a simple result of a multitude of possible combinations of a finite number of structural elements.The functioning of biological systems must also be derived from this complexity . The specific organizations of complex molecular systems provide specific functions but continue to be governed by fundamental physical laws .

Laws of physics apply to living organisms as much as they apply to inanimate matter. Attempts at applying physical laws to living systems can be traced to the early creators of modern science. *Galileo* analyzed the structures of animal bones using physical principles, *Newton* applied his optics to color perception, *Robert Mayer* was inspired by physiological studies to formulate the first law of thermodynamics. A particularly fruitful area of application of physics to physiology is hydrodynamics. *Poiseuille* analyzed blood flow by using physics principles. Air flow in the lungs has been described consistently via the laws of aerodynamics. The theory of action potential propagation was developed by *Huxley and Hodgkin,* who earned a Nobel Prize for their discovery. The discovery of the structure of DNA by *Crick and Watson* sparked creation of a new discipline called molecular biology, x ray crystallography revealed the double helix structure of DNA. Gel electrophoresis and fluorescent labeling are the crucial techniques perfected by physicists and biochemists for the studies of DNA sequences. Techniques that originated in physical laboratories have become standard equipment for most molecular biologists and chemists. Such devices usually start as probes of physical phenomena; they are later adapted for molecular biology and eventually transformed into common diagnostic and therapeutic tools. X - ray machines are used to detect abnormalities.

Nuclear magnetic resonance, now called magnetic resonance imaging, aids in detecting tumor growth; tumors in turn can be treated by radiation. Optical fibers are used for noninvasive examination of internal organs (*Tuszynski and Dixon*, 2002). Physics has made many conceptual and experimental contributions to biology. Experimental techniques that physics has devised; they include (Parsegian , 1997)-Light microscope, Electron microscope, Neutron scattering, X-ray crystallography, Nuclear magnetic resonance, magnetic resonance imaging, Fluorescence spectroscopy Microwave absorption and Laser light scattering.2

Optical fiber started with the creation of "optical transmit" by *French Chappe siblings* . In 1880, *Alexander Graham Bell* concocted his 'Photophone ', which transmitted a voice motion on a light emission. *Ringer* centered daylight with a mirror and after that talked into an instrument that vibrated the mirror. *William Wheeling*, in 1880 , protected a technique for light exchange called *funneling light* .3

Magnifications for microsurgery was introduced to medicine during the late 19th century. *Carl Nylen*, father of microsurgery, in 1921 first used a binocular microscope for ear surgery. The pioneers in dentistry were *Apotheker and Jako*, who first introduced the use of microscope in dental procedures in 1978.4

Applications in dentistry

Quantitative Light-Induced fluorescence. It is an optical technique which employs the principle that the carious process gives rise to changes in the auto-fluorescence of enamel. Green fluorescence is observed when blue light illuminates teeth and excites green intrinsic fluorophores in enamel, dentine the enamel - dentine junction. When a lesion is present, the light travels a shorter distance in the tooth and the passage of light to the junction is blocked resulting in a dark area of reduced fluorescence surrounded by bright green fluorescence. Red fluorescence results from the excitation of red fluorescent fluorophores from bacterial metabolites when illuminated with blue light. These fluorophores are thought to originate from porphyrins found in some bacterial species and are often those associated with gingivitis. Red fluorescence is often observed in advanced dental lesions and progressive white spots and may be of clinical significance and as a diagnostic aid to help in clinical decision making in relation to timing of restorations and restoration replacements.

Laser profilometry

Profilometry measures the bulk or mass of a surface. Non - contact optical profilometry permits the non - destructive study of surface detail. The measurement of the sample is made on a computer controlled traversing stage upon which the sample is systematically scanned by either a laser beam using triangulation of the captured image or white light using chromatic aberration. The wavelength of the light focused onto the surface measures distances between the sensor and the sample to depict surface detail in three dimensional form. Reproducibility has been found to be at the same level as confocal microscopy. The technique is useful as a method of measuring small changes in the surface topography of teeth in three dimensions. This allows the depth of the surface to be factored into assessments of surface change. It has been used in the measurement of erosion, abrasion, abfraction, early dental cavitation, wear of dental restorations, loss of dental enamel during orthodontic treatment as a result of biofilm demineralisation or enamel bonding techniques.5

Diode lasers have been shown to photobiomodulatory effects promoting wound healing and tissue regeneration. Diode lasers stimulate fibroblasts and osteoblasts, cause increased production of ribonucleic acid messengers , which leads to significant collagen production during tissue healing. The effect of a *magnetic field* on the surgical field also has an anti-inflammatory, analgesic, regenerating and accelerating tissue healing effect. *Magnetic-laser therapy* combines the therapeutic factors widely used in modern medicine: magnetic field, low laser radiation and

infrared light radiation.6

Transverse Microradiography

Transverse microradiography is a technique that allows the mineral content of the hard tissues to be quantified using x-rays. It is based on a concept that has been developed following the work of *Angmar et al*. and the use of densitometry. It is a valuable research tool as a method for directly measuring the mineral content of the dental hard tissues. It is recognised to be a practical and reliable technique appropriate for quantifying not only mineral change, but also mineral distribution in enamel, dentine and cementum .

Optics Transillumination is a method based on optic fibre technology. It is based on a *law of physics, namely that a beam of light will continue to penetrate through a substance until it meets a space, after which the light beam is reflected* . This results in a light and a dark area of the tooth separated by the fracture line.

Tissue with caries, being more porous than healthy tissue, absorbs far more light enabling us to observe that the surrounding tissue is whiter and more opaque, whereas the lesion appears darker because carious lesions disperse visible light . The light is propagated towards the tooth by way of optic fibres and has the sufficient intensity to pass through the dental structure to reach areas difficult to view with the naked eye , the light transmitted passes through the tooth and becomes a detectable signal read by a computer; it is then instantaneously displayed on a screen.7

Fiber optics (optical fiber) refers to flexible , thin cylindrical fibers of high-optical-quality glass or plastic . The theory of fiber optics is based on a single optical fiber that consists of glass or plastic material with an outer cladding of a lower index of refraction material . Since the fiber core has a higher refractive index, light rays are reflected back into the core. This phenomenon is based on *Snell's Law* and is called *Total Internal Reflection*. Individual fibers are grouped together to form a fiber optic bundle. Fiber optics have been used in dentistry for adjunctive illumination of other devices such as handpieces and ultrasonic scalers, are attached to magnifying loupes. 8

Magnification Systems

The concept of magnification - enhanced dentistry incorporates the use of two types of optical magnification systems : a) Loupes b) Surgical operating microscope.

They produce better magnification, larger fields of view, wider depths of field, and longer working distance. *Surgical operating microscope* in dentistry, are designed on *Galilean principles*. They incorporate the use of magnifying loupes in combination with a magnification changer and a binocular viewing system so that it employs parallel binoculars for protection against eye strain and fatigue. They also incorporate fully coated optics and achromatic lenses, with high resolution and good contrast stereoscopic vision. Surgical microscopes use *coaxial fiber - optic illumination*. This type of light produces an adjustable, bright, uniformly illuminated , circular spot of light that is parallel to the optical viewing axis, due to its shadow - free light, visualization of pathologies, documentation, motion videography, and management of all dental and surgical procedures can be effectively performed under unobstructed vision.4

The optical polarization imaging system for oral medicine is noninvasive and nonradioactive. In recent years advancements in physics has introduced digital devices for use as supplemental aids for diagnosis of dental pathologies enabling dentists to add to their diagnostic armamentarium .

Electronic Caries Monitor The principle is that of applying an electrical current through the tooth and determining the extent to which the current is conducted. Each of the component mineralised tissues of teeth displays differing conductivity; dentine, for example, is more conductive than enamel. Sound tooth surfaces have been described as having little or no conductivity, while in contrast, demineralisation of the tooth, as in the caries process, leads to an increase in conductance. Carious process leads to loss of mineral, which in turn is manifest as an increase in porosity of the carious tissue. The resulting pores contain ion rich fluid derived from the oral environment which results in increased conductivity or conversely a decrease in impedance.

X-ray Microtomography

Microtomography is a development of computed tomography, technology in medical diagnostics, which has much finer resolution (in the region of 5µm) allowing x - ray scanning of thin slices of small objects, the threshold of the detectability of the smallest detail is potentially between 1-2µm. Essentially a 360 degree radioscopic image is generated from an object placed on a sample table in the scanner. This is obtained by using an X - ray image intensifier while the irradiated object is rotating on the sample table. This data is used for reconstruction of a three dimensional image of the object which is generated via dedicated computer software and can be displayed on a computer screen.5

Magnetic resonance imaging

Magnetic resonance imaging was first introduced by *Lauterbur* . Magnetic fields and radiofrequencies, which are used by electromagnetic detectors to provide electronic images of body protons, are processed by a computer that generates them as digital images. Magnetic resonance imaging is considered a powerful diagnostic method which enables the visualization of soft tissue contrast without the use of ionizing radiation.9 Electromagnetic energy has also been shown to affect wound healing and to significantly shorten each phase of the process.

Summary

The fields of biological and medical physics and biomedical engineering are broad, multidisciplinary and dynamic. They lie at the crossroads of frontier research in physics, biology, chemistry and medicine. Development and application of biophysical technologies has allowed major advances to be made in dental research as well as in clinical dentistry. With continued developments these technologies will play an important role in the future management of dental disease .

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