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Weight Bearing Synovial Joints and Bioelectrical Impedance Plethysmography: A Perceptive Concerning Knee Joint

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Abstract

Osteoarthritis of weight-bearing synovial joints is the most common disabling disorder and affects the normal active life enormously. It also consumes a major amount of financial resources for its diagnosis and relief. Also, two-third of the world population belongs to an economically weaker section of society. Medical facilities in these developing and poor countries are almost negligible or absent. Modern joint assessment tools are very sophisticated and very costly. Onset, progress and growth of disease can be contained if it is diagnosed at the early stages of development. Several detection and diagnostic technologies are available, but fail to provide a clear picture/state for correct judgement for the status of the disease. The review discusses the benefits and disadvantages of various joints diagnostic and investigative methodologies for the most crippling ailment i.e. osteoarthritis.

Keywords: Diagnostic; Crepitus noises; Triphasic; Hyaluronan

Introduction

Osteoarthritis of joints is common in disabling disease adults affecting millions of people worldwide [1]. Osteoarthritis (OA) patients most commonly complained of load-bearing articulating joints for pain during joint motion, swelling, stiffness, restriction and cracking or crepitus noises within the joints structures and immobility [2]. Stability with the motion of the joint depends on musculoskeletal structures (ligament, tendon, articular cartilage and synovial fluid). However, 3-4 mm thick avascular and aneutronic hyaline articular cartilage which covers the extremities of long bone provides frictionless free locomotion to the joints. It is believed that hyaline AC provides ice to ice motion during various events. Hyaline Articular Cartilage (HAC) is tough, resilient tissue of locomotors joints and is a triphasic structure and composed of collagen, ionic proteoglycans aggregans and cations of salts bathing the extracellular and intracellular of cartilage matrix and scantly dispersed chondrocytes cells. The elasticity of articular cartilage helps to bear variation of pressure and impact of loadings. Viscous synovial fluid flowing inside the joint cavity provides resilient interphase for frictionless free movement. Repair and regeneration of articular tissues have limited ability after injuries etc., hence damage in the cartilage matrix is irreversible.

Literature Review

Morph physiology of weight-bearing joints

Physiologically, movable joints are created for bearing weight and are required to provide smooth motion in a human lifetime. Stability with the motion of the joint depends on musculoskeletal structures (ligament, tendon, articular cartilage and synovial fluid). However, 3-4 mm thick avascular and aneutronic hyaline articular cartilage which covers the extremities of long bone provides frictionless free locomotion to the joints. It is believed that hyaline AC provides ice to ice motion during various events. Hyaline Articular Cartilage (HAC) is tough, resilient tissue of locomotory joints and is a triphasic structure and composed of collagen, ionic proteoglycans aggregans and cations of salts bathing the extracellular and intracellular of cartilage matrix and scantly dispersed chondrocytes cells [3]. It has extracellular matrix meshwork of collagen type II fibres in which proteoglycans aggregates are densely entrapped and packed. Hyaline Articular Cartilage (HAC) has a high proportion of water (60%-70%) and due to this; it is a highly spongy compressible tissue structure. The Extracellular Matrix (ECM) of the Hyaline Articular Cartilage (HAC) contains Proteoglycan aggregate (PG) macromolecule and forms as a major structural component, composed of hyaluronan and link protein. The Proteoglycan (PG) has a great affinity for water due to its structural properties; it can bind 200% to its body weight. The Proteoglycan (PG) aggregates provide in cartilage a unique gel-like property and can resist the forces of deformation with water association. Proteoglycans provide much-needed elasticity to cartilage, however, collagen meshwork restrict excess binding with water and provides tensile strength and serve as an anchoring factor in the matrix [4,5]. Articular cartilage contains relatively few cells i.e. chondrocytes, hence it needs less oxygen and nutrients for its health. It receives most of its nourishment from the circulating viscous synovial fluid and is accomplished by diffusion process /pumping action i.e. during compression and decompression action in the movement phase. Chondrocytes

cells of AC has limited mitotic ability, hence AC tissue has very restrictive regeneration/ repair properties [6]. Hyaline Articular Cartilage (HAC) is dynamically active tissue and plays important role in painless free movement of load-bearing joints and is developed to serve an individual lifetime. Load-bearing joints physiological functioning depends on the use or the loading of the cartilage [7]. The elasticity of articular cartilage helps to bear variation of pressure and impact of loadings. Viscous synovial fluid flowing inside the joint cavity provides resilient interphase for frictionless free movement. Repair and regeneration of articular tissues have limited ability after injuries etc., hence damage in the cartilage matrix is irreversible.

Etiological factors for the genesis and growth of osteoarthritis

Osteoarthritis develops when the cartilage covering the bone extremities get damaged due to various predisposing factors Age-related degeneration and inflammation of synovial structures are mainly responsible for pathological changes in joint articular cartilage (Also several other etiological factors can lead to the early onset and progress of Osteoarthritis (OA). Although osteoarthritis is more common with age, younger people can develop it, usually as the result of a joint injury, a joint malformation, or a genetic defect in joint cartilage. The onset of Osteoarthritis (OA) and can be divided into primary i.e. ageing leading to degradation/degeneration (middle-aged and older men and women population) and secondary may be due to trauma, infiltrative disease or connective tissue diseases mechanical stresses i.e. strenuous exercises, postures, pressures, impact loading, sports (golf, weightlifting, long-distance running etc.) physical inactivity, obesity, hormonal deficiencies and manual labour occupations etc.

Aging: Aging and related factors (locomotion, immobilization) of load-bearing joints lead to thinning articular cartilage matrix, in turn during motion it causes more stresses on joint structures leading to softening and disruption of the cartilage matrix. Abrasion, cleft and fissures followed by erosion and denudation and finally exposure of pain feeling bone cortex [8-10].

Mechanical stresses and postures: Mechanical stresses can lead to alteration functional configuration of osteoarthritic joints. The abnormal and excessive stresses cause loss of articular cartilage. Detection of mechanical facilitator of cartilage loss can help for the prevention and treatment of OA. Several mechanical stresses i.e. strenuous exercises, postures, pressures, impact loading and sports etc. [11]. Frequent kneeling and squatting are considered the main primary risk factors in correlation with knee disorders [12].

Gender, obesity, race, genetic disorders: Prevalence of knee Osteoarthritis (OA) in men is lower compared with women [13]. It is suggested that women are less exposed to various information media; obesity and poor muscular strength are associated with the genesis of Osteoarthritis (OA) disability [14]. African Americans had a slightly higher prevalence of knee symptoms and severity compared to Caucasians [15]. Genetic factors have a crucial role in the pathogenesis of disabling osteoarthritis [16].

Nutrition, metabolic disturbances, hormone: The role of nutrition and nutritional supplements in the development and progression of osteoarthritis have been found important factors for the development of osteoarthritis [17]. It is reported that Osteoarthritis (OA) is associated with above-average serum cholesterol in women and substantially higher blood glucose level compared to that in healthy individuals [18]. Vitamin D deficiency increases the risk of knee Osteoarthritis (OA) and BMI and Osteoarthritis (OA) showed a good correlation for OA [15]. The definite increase in Osteoarthritis (OA) in women around the time of menopause has led investigations to hypothesize that hormonal factors may play a role in the development of Osteoarthritis (OA) [19].

Sports and occupation: knee osteoarthritis as a result of sport participation has been found responsible for the early genesis and development of disease and it is important and critical for the prevention strategies. Participants in soccer, long-distance running, competitive weight lifting, and wrestling had an increased prevalence of knee Osteoarthritis (OA) [20]. Lower extremity knee disorders have been found major causes of musculoskeletal disorders. Occupational activities such as mining, construction, manufacturing, and custodial services where knee bending postural activities are common and efforts should be made to create an environment for the prevention of Osteoarthritis (OA) [21].

The financial burden due to osteoarthritis

It has been observed that two-third of the population of the world lives in developing and poor countries, where medical facilities are not commonly available and if available they are deficient in modern medical technologies. Epidemiological and other assessments showed that Joints disabilities are major health-related problems. Joint disorder/disabilities (JD) ruin the normal dynamic physiological life of human beings and make them immobilized and bedridden [22]. Alleviation of JO is a difficult problem and modern medical therapeutic and surgical procedure consumes a substantial amount of patient money resources; also immobilize the patient for the money-generating productive activities. Studies found that therapeutic treatment and surgical interventions for joint disabilities patients have to spend substantial amounts of money [23]. Also, the economic conditions of the burgeoning population of these countries are not the same as developed countries. Generally, people of these countries are employed in hard physical job activities (Building road construction etc., scavenging activities, packing and loading and other menial jobs. These manual jobs desire strenuous work and utilization of hands, legs and back for loadings, lifting, carrying etc. activities. Therefore, the massive population of third world countries suffers most from joint disorders. Also due to economically constrained and not commonly availability of medical facilities. Also, they cannot afford the high cost of diagnosis and treatment cost of joint arthritic ailments. In turn, they generally neglect and avoid the medical examination for the onset and progress of disease condition and remain working in these suffering situations [24]. This is because that they may lose jobs and go on working in adverse conditions. During this neglecting period disease process keeps on increasing and when the joints physiological functions completely fails. They either sit

in the home or hesitantly visit the Government Primary Medical Centre (GPMC). Most of the Government Primary Medical Centre (GPMC) is not equipped with diagnosing facilities and after physical symptomological assessment by a general physician, referred him to Bone and Joint Speciality Hospital. Osteoarthritis (OA) diagnosis, therapeutic and surgical interventions are quite expensive and do not provide permanent cure and remedy. Also, it is a disabling lifelong ailment that leads to economic inconvenience to society and the State. Knee joint disorder is the second most common disabling disorder of India (22%-39%) [25].

Pathological biology of hyaline articular cartilage and synovial fluid

Hyaline articular cartilage: Osteoarthritis is the most common disorder amongst all other articular disorders affecting humans. It is a type of arthritis caused by inflammation, breakdown, and eventual loss of cartilage in the joints. It is also called degenerative arthritis. Its genesis is characterized by an imbalance between the synthesis and wear of the articular cartilage. The surface of the cartilage shows areas of softening, fibrillations, or erosions. In the later stage, there may even be areas of cartilage loss. The onset of Osteoarthritis (OA) depends upon unhealthy lifestyle, obesity and traumatic injuries etc. can produce damage of the articular cartilage and can cause diseases such as osteoarthritis. Synovial joints hyaline cartilage and subchondral bone are the cause of deformities in osteoarthritic conditions [26]. Etiological factors aggravate the inflammatory progress of Osteoarthritis (OA) and gradual structural changes within the joint tissues [27]. Osteoarthritis (OA) occurs with a series of events that alters the balance of the interior milieu of cartilage matrix configuration. With the progress of Osteoarthritis (OA) disorder, there is severe degeneration of cartilage, narrowing of the joint space, subchondral bone thickening, formation of osteophytes or bone spurs, and inflammation in the joints accompanied by swelling and pain [28-30]. It is found that in proteoglycan aggregans content is decreased, while collagen content is increased [23]. This change in Extracellular Matrix (ECM) composition predisposes the tissue for mechanical fault resulting in significantly altered mechanical environments of the cells within the cartilage matrix. Early diagnosis Osteoarthritis (OA) is a major obstacle because change at early stages of cartilage does not cause any discomfort to a joint activity. Hence, patients do not show any signs or symptoms until disease progress until when significant and irreparable joint damage has not occurred in Extracellular Matrix (ECM) [31]. During the onset of Osteoarthritis (OA) chemokines and cytokines play an important role in the pathogenesis and progress of degenerative changes in articular cartilage, leading to erosive, fibrolytic, and cracking changes in the matrix of articular cartilage [32]. Several studies showed that that articulating joints hyaline cartilage wears with time (ageing process) [33-35]. At the beginning of Osteoarthritis (OA), articular cartilage loses its glistening appearance, later on surface layers flake off while deeper layers develop longitudinal fissures termed as fibrillation. Degeneration of avascular hyaline porous cartilage generates lesions in the articular matrix i.e. pits, crevices and micro cleft formation. Osteoarthritis is characterized by an imbalance between the synthesis and wear of the articular cartilage. The surface of the cartilage shows areas of softening, fibrillations, roughness and erosions and in the later stages, it may lead to partial/complete loss of cartilage and exposure of vascularized and neural subchondral bony structures [36]. Although osteoarthritis pathogenesis has been studied extensively (next to cardiovascular diseases), still it remains challenging for its etiopathogenesis in order to alter or halt disease progression.

Synovial fluid in osteoarthritis: Synovial Fluid (SF) properties get altered in osteoarthritic conditions. Normal Synovial Fluid (SF) is viscous, pale yellow, clear and transparent is a dialysate of plasma produced by type B cells of synovial membrane flows on the interface of the articular cartilage surface. It provides lubrication and nutrition to the avascular cartilage of movable joints. SF contains almost all types of inorganic ions such as sodium, calcium, chloride, and potassium in its fluid [37]. Under physiological conditions, joint SF exhibits an almost negligible coefficient of friction [38]. SF composition is a very important factor for the diagnosis of arthritis. In Osteoarthritis (OA) synovial fluid becomes highly viscous due to the increased amount of hyaluronic acid. It is also observed that ageing leads to thinning of articular cartilage and exposure of subchondral bony structures [39]. Also, injuries, obesity and mechanical stresses etc. can enhance the progress of Osteoarthritis (OA) [40]. It is known that chemokines and cytokines play a key role in the pathogenesis of arthritis [41]. Since articular cartilage has no blood supply, hence unable to get repaired and leads to exposure of subchondral long bones extremities. The Health and lubrication of hyaline articular cartilage solely depend on synovial fluid properties [42]. As the severity of Osteoarthritis (OA) increases, the rate of fluid transfer to the joint surpasses the synthetic capacity of the synovial lining cells, and hyaluronic acid concentration falls below normal. In these conditions, synovial fluid biochemical properties get altered and become less viscous and its biochemical properties are found to be changed [43].

Discussion

Diagnostic technologies for the detection of osteoarthritis

Symptomological evaluation of knee joint: Clinical assessment of patients with joint symptoms allows limited physical evaluation i.e. the range of movement, deformities and instability. For assessment of joint function, symptoms and disability the disease-specific and patient-related outcomes have been developed. Western Ontario and McMaster Universities osteoarthritis index for a Knee injury and Osteoarthritis are found to be very useful for symptom logical evaluation of osteoarthritic by using the Index scale of severity for osteoarthritis of the Knee and outcome have been used for assessing the pathological status of knee osteoarthritis [44,45]. The most common symptom of osteoarthritis is a pain in the affected joint(s) after repetitive use. Other symptoms include swelling of joint joints, joint stiffness [46]. When the affected area is touched shows tenderness, crepitus, enlargement of area

and deformity. It is found that pain gets after prolonged sitting or resting, later on, pain after onset gets worse with activity leading to joint creaking and loss of range of motion. Pain and other symptoms of OA may have a profound effect on the quality of life affecting both physical function and psychological parameters [47].

Radiographic examination of osteoarthritis: Radiographic (x-ray) assessment of joint disorders/osteoarthritis is a routine and common clinical technique used for the diagnosis and o assessment of the progress of the Osteoarthritis (OA) throughout the world. Kellgren and Lawrence developed a radiographical classification scheme and assessment detection methodology for the diagnosis of OA. However, radiological detection and analysis sometimes provide a misleading picture of joint synovial cavity abnormalities and are unable to provide a clear picture under the Kellgren and Lawrence system for the classification of osteoarthritis [48]. Even it has been found that radiological images provides confusing and misleading appearances for the narrowing of the joint spaces and are not effective and efficient to detect the onset and progress of osteoarthritis [49,50]. It is suggested that combined radiographic criteria and other diagnostic techniques may be able to provide a more reliable basis for the diagnosis of Osteoarthritis (OA) [51]. Also, reliability for the detection of Osteoarthritis (OA) by radiographical methodology provides little help in making an early and correct diagnosis for the different forms of osteoarthritis. Suggested that the symptoms of knee osteoarthritis (OA) are rather weakly associated with radiographic findings and vice versa [52].

Arthroscopy and arthrography: Arthrography/arthroscopy is a surgical technique and scanning is done by inserting a needle to view through a tube into the joint space. Abnormalities of and damage to the cartilage and ligaments can be detected and sometimes repaired through arthroscopy [53]. If successful, patients can recover from arthroscopic surgery much more quickly than from open joint surgery [54]. Due to the high cost, invasive nature and potential risk, albeit low, associated with intra-articular injection, arthrography examinations are rarely used in large scale clinical or epidemiological OA studies. Arthrography is a decades-old diagnostic technique to assess joint structures properties for their integrity and component substances [55]. Now, this invasive fluoroscopic technique has very little diagnostic value due to the use of ionizing radiation for intra-articular contrast scanning. However, it does provide information about the injury to intra-articular structures of joints [56]. It requires perforation of the joint cavity by needle and scanning is done by x-ray. It desires a contrast medium into the joint space and opacity. Arthrography diagnostic technique is not commonly used for the evaluation of joint pathophysiology due to allergic reactions by contrast dye [57]. Also, it exposes the subject to radiation. It may be infected or bleeding. X-ray scanning of joint structures may lead to some radiation. It should not be used during pregnancy and can harm the baby [58].

Ultrasound imaging: Ultrasound imaging enables real-time, multilane imaging at a relatively low cost and it provides reliable data of osteoarthritic pictures regarding inflammatory and structural abnormalities [59]. It works when an electric field is applied on piezoelectric crystals it generates high-intensity acoustic energy/ sound ultrasound waves and penetrating and hitting the tissue structure and generating electrical signals that are sent to the ultrasound scanner. In OA, the major advantage of ultrasound over conventional radiography is the ability to detect synovial pathology [60,61]. Current generation ultrasound technology can detect synovial hypertrophy. Ultrasound has also been used to evaluate features of knee Osteoarthritis (OA) and hip Osteoarthritis (OA). European studied painful knee Osteoarthritis (OA) in several hundred patients and found ultrasound-detected synovitis showing advanced radiographic Osteoarthritis (OA) and clinical symptoms [62]. Ultrasound-detected inflammatory features showed that knee pain in motion in patients correlated with radiographical findings of knee Osteoarthritis (OA), supporting the association between synovitis and knee pain, which has also been reported in MR imaging-based studies [63].

Magnetic resonance imaging: Magnetic Resonance Imaging (MRI) diagnostic technique is a major imaging tool for the assessment of Osteoarthritis (OA) pathobiology and has the ability to assess pathology in structures not visualized by radiography and does not have the distortions and magnification problems inherent in radiographic pictures i.e. articular cartilage, menisci, ligaments, synovium, capsular structures, fluid collections and bone marrow [64-66]. Joint morphological alterations can be evaluated by MRI as a whole organ and multiple tissues. Also, it can detect pain factors with bone marrow lesions, cartilage morphology, cartilage composition alteration and synovitis [67]. MRI may sometimes be affected by artefacts that mimic pathological findings and. can be misinterpreted as cartilage loss or meniscal tear [68]. MRI is clinically used for noncontract or contrast-enhanced cartilage imaging but has a limited spatial resolution, which often requires longer acquisition times. MRI imaging system is a high-cost diagnostic technology; hence it cannot be used routinely for clinical management of OA patients [69].

Optical coherence tomography: Optical Coherence Tomography (OCT) displays better spatial resolution compared with MRI and provides for detection of meniscal tears that are not visible with MRI, or in patients with contraindications for MRI. Optical imaging technology has made considerable progress towards a novel biomedical imaging modality that uses near-infrared (NIR) light for diffuse optical tomography for the diagnosis of osteoarthritis [70]. Thus, the challenge now lies in applying the rapidly improving Optical Coherence Tomography (OCT) technologies to relevant preclinical models of Osteoarthritis (OA) induction to evaluate its feasibility and identify potential dry biomarkers of early disease development and/or progression before reliably applying this novelty in clinical praxis [71]. Optical Coherence Tomography (OCT) is currently facing important technical challenges concerning normalization strategies and controlling light beam angles. At present, unequivocal image-based differentiation between healthy and early degenerative cartilage by Optical Coherence Tomography (OCT) still seems challenging [72,73]. Computed Tomography (CT) has also been employed in the diagnosis of Osteoarthritis (OA), it too is very expensive and provides only

qualitative structural information in severe Osteoarthritis (OA). As an emerging nonionizing technology CT, near-infrared optical imaging has received much attention because optical techniques offer unique advantages over the existing imaging methods [74]. Optical imaging is low in cost and non-invasive. Although joint space narrowing is an important indicator for Osteoarthritis (OA) diagnosis but cannot be judged until the patient is really affected by this disease. Only structural information can only confirm natural variations exist between different individuals. Hence, we must employ both structural (space narrowing) and functional information (optical properties) to diagnose Osteoarthritis (OA) [75].

Bioelectrical impedance plethysmography: Bioelectrical Impedance Plethysmography (BIP) is a noninvasive measurement technique developed during 1940/1950 for peripheral blood flow, cardiac output, thoracic fluid accumulation, peripheral blood flow, cerebral blood flow, muscle contraction, eye movement, and uterine contraction [76-78]. It is a versatile, simple, safe and low cost economical diagnostic methodology. Bioelectrical Impedance Plethysmography (BIP0 is a method that determines the variation of low-intensity excitation alternating electrical current to the tissue by surface electrodes; it generates a complex bioelectrical impedance (resistance) depending on tissue composition [79]. Bioimpedance technologies are depending on the principle that biological mediums behave as conductors, dielectrics, or insulators of electrical current, depending on their composition. Bera suggested that electrical impedance plethysmography can be used in almost all physiopathological assessments of living beings along with certain non-living substances [80]. Nowadays BIP is used for the pathophysiological status of organs and cells i.e. body composition regarding nutritional and hydration status and obesity, obstetrics and pregnancy and lactation, critical care and postoperative monitoring, gastroenterology and chronic inflammation and sports science and can be used as an efficient and effective technique for the medical research tool for liquid flow assessment of tissues and organs due to its non-invasive, low cost and of easy operation [81-84].

Studies of knee joint plethysmography

The genesis of Osteoarthritis (OA) of weight-bearing joints is a very common crippling disorder. It is the second-largest disabling disease after cardiovascular disease [85,86]. Also, it has no safe and permanent therapeutic methodology [87,88]. However, its onset and progress can be reduced if its early onset is diagnosed at early stages of development. Even, Osteoarthritis (OA) etiopathology is not very well understood [89,90]. Epidemiological surveys showed that knee joint osteoarthritis is more prevalent in Asian and African countries due to occupation limitations, religious postures, way of life (toilets/bathrooms/ kitchen's, etc. [91,92]. Several diagnostic technologies have been developed at various research centres throughout the world [93,94]. Clinical evaluations of these diagnostic technologies showed that most assessment methodologies are unable to diagnose the disease process at the early stages of development or are very expensive or have a cumbersome complicated operating methodology. However, these clinical diagnostic techniques do not provide correct, safe, and cost-effective detection methodology [95-98]. As mentioned earlier, two-thirds of the population lives in Asian and African countries and random analyses found that these burgeoning human lives in poor hygienic conditions, under illiteracy and in poverty. In these countries, the medical system is rudimentary and cannot afford expensive diagnostic tools for the assessment of disease. Hence, there is a need for a reliable, non-invasive low-cost assessment methodology for the assessment of the pathological status of osteoarthritis. It is felt that the detection/monitoring methodology system should be simple, economical and safe to record and analyse the genesis of disease and growth process and must not require a specialist/expert for the operation and diagnosis of the disease process.

Studied knee joint pathophysiology of knee joints of normal and osteoarthritic 14 subjects by applying an alternating current of 3 mA at 20 kHz by four bands of braided silver wire mesh electrodes. Kelvin Double Bridge Plethysmograph was used for the measurement of Impedance by balancing the resistive and responsive components and recorded on a rectilinear recorder [99]. To understand synovial cavity changes two types of loadings were applied i.e. tractive loading of 3 Kg and compressive loading of 10 Kg. Effects of loadings were monitored and it is found that the osteoarthritis group showed almost twice in comparison to normal subjects. Also, similar pictures were seen during compressive loading of the knee joint. To ascertain that changes in impedance observed are due to synovial cavity interior milieu alterations, the author has performed animal work in studies on freshly amputated bull joints and albino rats under similar conditions and observed a significant difference in altered conditions. No changes in the knee impedance consistent for different types of loadings Kelvin's double bridge-type Impedance Plethysmograph [100]. Authors have published their substantiated research work of knee joint OA and Bioelectrical Impedance Plethysmography (BIP) in Journal of Institution of Engineers (India) 1999 [101]. Studied bone fracture healing by bioelectrical impedance plethysmography and Responses obtained from normal and fractured were analysed and results of the study suggest that the electrical impedance plethysmographic technique can be used as a diagnostic tool for the management of bone fracture healing [102].

Later on have done a comprehensive study of osteoarthritis on human subjects to record bidirectional DZ (change in impedance) analogue data in the range of +6 V corresponding to +6 O (1 V O by electrical impedance plethysmograph (Bionics Ltd., New Delhi, India) and analogue output was digitized by ICPDAS PCI digitizer card (ICPDAS Ltd., Hsinchu, Taiwan), which was interfaced to a standard PC using a LAB VIEW (National Instruments, Austin, TX, USA) interface specially designed for the data acquisition. The results indicate that there is a significant difference in amplitudes of signals. The difference in mean of variances of the two groups was significant ($p<0.05$). The difference in the mean values was also significant ($p<0.05$) for KS and WN. Impedance changes suggest that EIP signals around the knee have the potential for a non-invasive diagnosis of knee Osteoarthritis (OA) [103,104].

Alvarenga and Souza studied 14 subjects knee joints for the bioelectrical impedance measurements and observed intracellular resistance 281 ± 82.6 Ù in osteoarthritic subjects compared to 143 ± 33.9 Ù ($p<0.01$) in the knee of normal healthy subjects and suggested that bioelectrical impedance can be diagnosed determine the inflammatory pathological conditions of knee joint [105]. Later on, studied 32 volunteers (Healthy and osteoarthritis (OA) knees) by Bioelectric Impedance Spectroscopy (BIS) and showed that bioimpedance is a sensitive technique to assess the physiological changes associated with Osteoarthritis (OA) [106-108].

Non-invasive detection and diagnosis technology Bioelectrical Impedance Plethysmography (BIP) developed in 1940, since then it has been used for the measurements and diagnosis of various physiological as well as pathological conditions. Now, it is suggested that electrical plethysmography can be used in almost all living as well as non-living identities. Bioelectrical Impedance Plethysmography (BIP) procedure has certain constraints and limitations, but the technique is simple, non-invasive, safe, and economical diagnostic methodology and beneficial for the two-third populations of Asia and Africa, where medical facilities are elementary or not available.

Conclusion

Assessment of electrical impedance detection diagnostic technique with its beginning, its scientific efficacy and sensitivity in comparison to other sophisticated diagnostic technologies is presented. It is suggested that Bioelectrical Impedance Plethysmography (BIP) can be used along with other diagnostic technologies for the detection and diagnosis of various ailments.

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