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MINI REVIEW

Can Pulsed Electromagnetic Field Applications Help Ameliorate Chronic Osteoarthritis Degradation in Older Adults: A Brief 2025 Update of its Potential Restorative Role

Ray Marks

Department of Research, Osteoarthritis Research Center, Box 5B, Thornhill, ONT L3T 5H3, Canada

Corresponding Author: Dr. Ray Marks, OARC Clinical Research and Education Director, Ontario L3T 5H3, Canada. E-mail: doctorraymarks75@gmail.com; Dr. RayMarks@osteoarthritisresearchcenter.com

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Abstract

Osteoarthritis, a painful oftentimes disabling joint disorder is generally deemed incurable. Affecting more and more aging adults, here we examine the rationale for, and potential efficacy of applying pulsed electromagnetic fields clinically for purposes of reducing osteoarthritis pain and other related disease features, especially muscle. Based on selected English language literature published largely on PUBMED between January 2020 and September 2025, papers describing muscle specific observations and others and the impact of pulsed electrical stimuli are explored. These show efficacy trends that may facilitate function and decrease suffering and the need for narcotics and possible joint reparative processes among older adults with chronically disabling joint derangement and dysfunction.

Keywords: Aging adults, Muscle, Osteoarthritis, Pulsed Electromagnetic Fields, Pain, Treatment

Introduction

Osteoarthritis, a common disabling complex multifactorial joint disease and one implicating varying degree of focal joint structural and functional pathologies that predominantly affects the cartilage tissue lining one or more synovial or freely moving joints such as the knee, hip and shoulder of many older adults is an increasingly challenging prevalent global health concern. Not only are there varying degrees of: joint inflammation, tissue impingement, muscle weakness, muscle mass declines, active and passive movement limitations, neural dysfunction, joint instability and mal-alignment associated with the condition, but additional deficits limiting function include emergent degrees of joint swelling, tenderness, and stiffness, diminished muscle endurance, functional challenges and adverse local and central reactive neural responses that converge and contribute to the immense personal as well as societal disease burden.[1]

Unfortunately, despite years of study and some contrary findings, not only is the underlying cause of osteoarthritis unclear with the exception of age, genetics, and injury, but its biological, and biomechanical components are rarely acknowledged, and addressed in efforts to mitigate the condition along with a strong belief the disease is not only inevitable, but ultimately incurable. As such, efforts to apprehend the disease in its early stages or avert or effectively allay this condition in the older adult population are rare. In addition, treatments are often applied too late and this situation may reflect the fact that osteoarthritis manifestations are commonly emergent and often hard to detect and verify at their inception. Treatment efficacy is further impacted and challenged by a reliance on medications to quell pain that mask the disease process and possibly increase it rate of progression, plus conventional imaging techniques that can only detect quite advanced disease and where the relation between pain and structural degeneration is not well correlated or explanatory.[1] In addition, individual attributes of the disease that extend to all joint tissues including muscle are hard to treat as these are highly disparate, and may not respond to standardized treatments that are not holistic, carefully titrated or targeted, and fail to address its biomechanical underpinnings and biology that may prove remediable, thus salient to target.

Indeed, even if apprehended in a timely way, osteoarthritis treatments often fail to not only address a wide array of interacting possible multiple painful joint functional determinants and varied degrees of joint derangement and inflammation that may progress or wax and wane, but the role of muscle mass declines and weakness, plus neural sensibility changes that are increasingly of import here are poorly addressed at best, along with the potential value of non-invasive disease management strategies other than palliative medications.[1]

Affecting high numbers of aging adults who may already have multiple health challenges, and even if the disease is deemed 'inevitable' it has become clear that mitigating osteoarthritis warrants more, as well as immediate attention as its pain attributes alone commonly interact to disrupt the adult's ability to function physically as well as psychologically, along with the ability to act independently, decisively, socially and economically. Sleep quality and duration may be appreciably impaired, falls injuries and fractures, obesity and depression risk may be heightened, as well. Costs of the disease are also likely impacted in the situation where the older adult who incurs unrelenting pain may be subjected to an array of unsafe medications, injections, or surgical procedures that have no defining structural favourable impacts.

To overcome these concerns, other non-medical or non-invasive therapies applied in this regard including a wide array of electrotherapeutic modalities show some promise in improving one or more osteoarthritis signs and symptoms or structural features even though well-designed research in this field remains limited and non-conclusive or is consistently overlooked at best.[2]

In this respect, one modality constituted by low-frequency/energy pulsed electromagnetic fields or PEMF applied as a single or pulse burst quasi-rectangular or triangular waveform, has been increasingly found to have some promise in this respect,[3-6] especially in the case of early or inflammatory osteoarthritis.[7-9] The mode of stimulation is also observed to have the ability to accelerate or reinitiate healing,[10,11] and to relieve pain.[12] It has been used towards enhancing bone fracture healing and regeneration, showing its impact is not spurious, as well as for reducing tissue inflammation. More recently, its potential effectiveness in ameliorating articular cartilage degeneration and osteoarthritis severity has also been demonstrated.[2]

Its multiple benefits when observed as an application for ameliorating osteoarthritis disability have also included the mitigation of joint swelling, and associated bone damage, plus the possible 'healing' or regeneration of articular cartilage and soft tissue lesions found to varying degrees in osteoarthritic joint disease.

Aims

To gain current insights regarding how pulsed electromagnetic fields may benefit an aging osteoarthritis sufferer, we aimed to uncover:

(a) Findings regarding the use of pulsed electromagnetic fields for the treatment of painful osteoarthritis in general, and specifically from the viewpoint of its interaction with cartilage and muscle plus tendons and their influence on joint structural integrity and function.

(b) Existing evidence of the extent of its clinical potential and possible underlying mechanisms of action and their cellular impacts.

(c) A role for more routine pulsed electromagnetic field applications, specifically in the context of osteoarthritis in the older adult with diverse degrees of joint damage, and where surgery is often contraindicated.

Rationale

It is increasingly apparent that many osteoarthritis treatments currently fail to produce results commensurate with the many research efforts on the topic no matter what joint is studied. In terms of pain relief alone, the growing usage of narcotics and other medications plus invasive injections to quell pain implies a failure to address this universal complaint and feature of osteoarthritis.[13] On the other hand, even if osteoarthritis is continuously viewed through a degenerative lens, various forms of biophysical stimulation such as low energy, low frequency electromagnetic fields have been shown to trigger a variety of favorable verifiable biological responses via specific membranous and intracellular signaling pathways that can impact, articular cartilage cells, subchondral bone cells, synovial membrane physiology, muscle structure and function, connective tissue cells, nerve pathways, intervertebral disc degeneration, and a host of reparative metabolic and reconstructive mobility associated attributes.[7-14]

In sum, what has been shown quite convincingly over time and of late is that due to their differential abilities to stimulate or trigger selected cell based molecules that underlie various joint structural components, intermittent or low frequency externally applied electrophysiological applied fields may favorably influence multiple intrinsic joint structures such as cartilage cells, bone cells, possible muscle and tendon cells and others[11,15,16] as opposed to several mainstream current approaches that are helpful in decreasing pain, but neither stop the disease progression nor improve the highly disabling osteoarthritis condition or consider how to maximize its regenerative potential,[17] pain, stiffness, anti-inflammatory and functional effects.[15,18,19]

Another report[20] strongly implies there are potential ‘wound’ healing benefits and mechanisms as a result of electrical stimulation that might be extended fruitfully to an osteoarthritis joint. In particular, it is probable too that the insightful application of active PEMF can serve as a beneficial form of adjunctive therapy for reversing pain due to chronic cartilage defect processes, muscle sarcopenia and derangement and tendon lesions.[21] In addition, it can potentially improve the intrinsic healing potential of damaged nerves as well as rendering muscle tensile force capacity improvements along with protective motor functions.[22] Its application may also help avert neuropathic-like pain and its central sensitization, a risk factor for poor postoperative clinical outcomes[23] such as stiffness.[24] In addition its mechanism of action may enable activation of pathways that increase calcium - axis flow mechanisms and as such, muscle and mitochondria functions consistent with exercise induced metabolic and functional adaptations.[25] At the same time, inflammation may be reduced; bone and ligament health may improve, along with joint shock absorption and the processes of cartilage regeneration,[26] and its possible unrelenting impacts on an array of debilitating cognitive symptoms and widespread suffering and health costs.[27-30]

While largely ignored in the current orthopedic realm and literature in favor of medication or invasive therapies it appears pulsed electromagnetic field applications when applied alone or as a complementary modality may be especially helpful in efforts to curtail considerable suffering in later life. Impacting to varying degrees the extent of muscle and joint derangement and progressively painful chronic disabling osteoarthritis, its timely and judicious usage may also reduce the immense societal health burden involved in long term care.[30]

Most importantly, their application may conceivably help to reduce any attendant stress provoked cognitive state often found to increase progressively in those diagnosed as having osteoarthritis as well as soft tissue and support structure derangements that can significantly reduce confidence as well as daily living and coping functions and motivation to comply with health recommendations or control their health risks.

One application barrier in this regard is the persistent controversy regarding the degree of influence afforded by pulsed electromagnetic field applications to an affected osteoarthritis joint[s]. This dilemma persists despite evidence pulsed electromagnetic field stimulation, a non-invasive treatment that utilizes electromagnetic fields to reduce inflammation and promote tissue repair can engender pain benefits and others.[34,35] Indeed, even though not fully accepted as mainstream, or a topic avidly studied in the clinical realm, and especially in joints other than the knee, strong evidence of its varied mechanistic impacts not only appear insightful, but of high clinical salience. However, herein, even though the topic has been studied for decades we found it challenging to verify its benefits in the clinical realm in 2025 especially among older adults and within any long-term osteoarthritis trajectory. We thus deemed it best to rely largely on what we have learned from both multiple preclinical studies and others that are often insightful and well designed and offer a gateway that can be translated to the future bedside.

Methods and Procedures

After studying this topic for many years, we elected to garner some current and past information on this issue and others posted over time on **PUBMED**, **PubMed Central,** and **GOOGLE SCHOLAR** accepted as reliable medical literature sources. Key words used were: *Articular Cartilage, Older Adults, Osteoarthritis*; *Pulsed Electromagnetic Fields* All forms of study were accepted, but no systematic analysis or synthesis of either the preclinical or the clinical literature was attempted-given their diversity and limited numbers of recent clinically oriented studies. A focus was placed on selecting and reviewing preclinical data and their clinical implications for offering a path to pain relief, tissue repair, and functional gains in narrative form and actual recently published clinical findings. Protocols for future study, studies of adults younger than 60 years of age, conference proceedings, invasive studies, combination therapy studies, physical therapy studies and non-English or incomplete studies were excluded as were many early citations covered in the reference section of reference.[32] It was assumed most studies were acceptable to experts in the field and those published may not include all negative findings. However, it was assumed a general picture of the state of the art would be attained with relative confidence when assessed very carefully and across multiple perspectives and substrates. No other forms of intervention were examined. Readers interested in clinical and past analyses and observations may want to examine references.[31-33]

While unproved, we accepted that it is possible a pulsed electromagnetic field current can induce biological tissue impacts relevant to osteoarthritis mitigation such as enhancing muscle energy expenditure during heavy constant-load exercises along with muscular activation in[34] as well as inflammation.[35]

Results

Several past studies show the osteoarthritis joint topic presently studied is one that persists with over 100,000 related studies over time. Increasingly common among adults older than 65 years of age, it is health condition where pain is the predominant feature, and where most conservative therapies, including pharmaceuticals, injections, and physical therapy are only modestly successful in reducing pain or in reverting or attenuating the condition to any degree. As a result, many older adults may suffer unduly since not only are their individual needs poorly identified or understood but may hasten the need for joint replacements or surgeries often considered if conservative measures appear ineffective.

However, neither drugs nor surgery yield regenerative or reparative outcomes to any degree and their long-term gains must remain in question. Thus, other adjunctive forms of non-invasive therapy are being studied more intently to discern if any may prove both safe as well as clinically safe and effective.

Indeed, since the early 1970s when several researchers began to examine pulsed electromagnetic fields and their interactions with cartilage and bone cells, this topic has continued to be of interest and very informative in the context of its basic potential to mitigate the hallmark of osteoarthritis pathology, namely articular cartilage degeneration and thinning and fragmentation. Most, albeit not all, do in fact continue to largely lend support to using or studying this mode of physical energy as a form of osteoarthritis therapy in the future, regardless of methods of inquiry that includes an array of cell culture assays, animal models of osteoarthritis, animals with naturally occurring or age associated osteoarthritis, stem cell substrates and cartilage and bone explants.[32,33] Its anti-inflammatory and muscle morphology, histology, muscle activation, and contractile effects may especially help slow the rate of osteoarthritis progression.[25,34]

In addition, Zhou et al.[35] report pulsed electromagnetic field therapy applied to artificially deranged joints appears to inhibit the expression of pro-inflammatory factors that can induce cartilage matrix degradation.[16] Furthermore, their pre-clinical study showed pulsed electromagnetic field-treated osteoarthritis induced mice post stimulation joint structural enhancements and preserved joint structure.

As such, cartilage attrition and possible bone, and muscle degradation that can all occur in advanced osteoarthritis may be reduced, while joint motion and stability and the ability to withstand joint impacts may improve substantively post stimulation.[36] Ergan et al.[37] show PEMF and stretching exercise when combined may have a positive effect on muscle healing rates where applicable, as well as the prevention of fibrosis and inflammatory-induced muscle pain.[38]

Along with its pain-relieving potential, pulsed electromagnetic field applications may thus enable more desirable osteoarthritis outcomes than mot among untreated older adults who may face excess bouts of chronic daily stress as well as nightly degrees of suffering, but strongly seek independence. At the very least it appears pulsed electromagnetic field applications may play a key role in countering the potentially devastating impact of osteoarthritis generated by cascades of degrading joint enzymes, and for fostering more favorable repair processes in the joint as a whole as well as in specific tissues.[35] These possible benefits include, but are not limited to: probable improvements in tendon morphology,[39] inflammation,[35] the risk of developing adhesions or tendon ruptures, and a reduced degree of osteoarthritis progression and mobility improvements.[40]

In addition, Yang et al.[41] who examined a mouse model of osteoarthritis and others affirmed pulsed electromagnetic field applications were able to attenuate the degree of ensuing osteoarthritis and its progression due to its ability to inhibit inflammatory signaling processes at the artificial tendon injury site. Importantly, the stimulation appeared to significantly attenuate the structural and functional progression of osteoarthritis commonly found to emerge in this pre-clinical disease model. The pulsed fields appeared to attenuate the magnitude of verifiable cartilage chondrocyte death processes and were hence deemed protective and important to pursue.

Wang et al.[42] agree that pulsed electromagnetic stimuli can foster a state of cartilage chondrocyte proliferation, while exerting a protective effect on cartilage cell catabolic actions and their impact on the cellular environment, including placing excess strain in joint tissues such as its tendons. Cadossi et al.[43] propose these aforementioned results and others are not unexpected if one considers that cell membrane receptors at the stimulation site appear to induce signals that have dose-like response effects as far as the synthesis of structural and signaling extracellular matrix components of cartilage is concerned. Through these actions, the structural integrity of bone and cartilage cannot be deemed inert and may well have an inherent potential to undergo enhanced repair.

Furthermore, this form of stimulation may not only serve as anti-inflammatory role,[44] but may help stabilize or improve bone structure as well as muscle and tendon[14,45-52] by mediating improvements such as in muscle fiber alignment, force transmission capacity, contractile function, neuromotor response functions, muscle recovery and protection against progressive harmful degenerative joint loading impacts.[50-53]

Moreover, long lasting inflammatory signals that compromise joint homeostasis and promote tissue regeneration, may be attenuated following pulsed field stimulation therapy[44,54] alongside pain and function.[51]

Its application may yet improve the subject's strength and associated ability to perform activities of daily living,[50,55] decrease reliance on medication, health services and surgery as well as potentially generating beneficial immune system impacts[56] as well as anti-inflammatory effects that reduces cartilage damage and osteoarthritis symptoms,[57] while fostering function gains[58] and depressive symptom relief.[58]

In sum, most currently published preclinical and clinical studies examined in this overview favour some form of pulsed electromagnetic field stimulation as far as having beneficial cartilage cell, muscle, bone, and pain impacts. However, as in many current realms of inquiry, these consistently affirmative and promising data found largely in non-clinical studies must be extrapolated with some caution to the bedside. In this regard, these are very promising data if we consider at the very least, they reveal osteoarthritis derived cartilage cells are not inert and can respond to biophysical stimuli responsively and specifically and thereby offer hope for possible repair effort to unfold, as well as by their positive impacts on muscle structure and function and levels of suffering.

As such, we believe the above results and others when pooled show:

a) The careful application of pulsed electromagnetic field stimuli to an osteoarthritis joint can improve its functional and mechanical properties including its cartilage and bone tissues.
b) As per Masante et al.[2] results will depend on the applied biophysical stimulation dose, magnetic field intensity, stimulation waveform, site exposed, status of site, and exposure duration.
c) Its efficacy, which requires the modality be applied with due care and precision by physicians and patients has shown success in ameliorating joint pathology and improving function in early osteoarthritis and after knee surgery with the ability to limit the inflammation of periarticular tissues and is thus highly promising.[44]

d) The use of a comprehensive descriptor to enable the identification of common features across different studies could serve as a valuable tool for refining PEMF protocols and establishing standardized guidelines to support bone and cartilage repair.[2]

e) The failure of most clinical studies to employ advanced technologies that can detect cartilage and tendon cell transformations at the nano molecular level as well as functional mechanics weakens the chances for valid insights of high veracity to emerge despite this being quite a promising line of pursuit.

Wong et al.[59] further propose exposure to pulsed electromagnetic field therapy may represent a non-invasive and non-strenuous method of ameliorating metabolic disorders, while reducing inflammation or modulating it and fostering protection as well as tissue repair. In some clinical trials, pulsed electromagnetic field applications have yielded short-term symptom relief as well as functional improvements in early-stage osteoarthritis patients, arthroscopy patients, and anterior cruciate ligament reconstruction patients.[3,61] Among older adults, other benefits are pain relief, a reduction in neuro inflammatory mediators, extracellular matrix degrading enzymes, nerve damage, improvements in body composition, skeletal muscle mass, metabolic determinants, healing of meniscal tears, and mobility.[60-64]

Moreover, the idea that carefully considered integrated therapy efforts that proceed in the face of optimal exposure and stimulus dosage will prove efficacious[44] and appears promising should be specifically tested without delay, even if disputed by some.

Discussion

As societies age, a strong need exists to prevent and mitigate health conditions that may be disabling. In this regard, osteoarthritis is one of high social and economic relevance wherein one or more joints might be painful and inflamed as well as weak. Help that is therapeutic and safe using non-invasive non-toxic passive methods appears provide one avenue of relief, especially among aging adults where age and pain are correlated with radiographic osteoarthritis structural damage.[57] In this current overview that largely spanned a 10 year time period, it appears safe to say in vitro applications derived from simulations of osteoarthritis in animals and cell cultures that are exposed to pulsed electromagnetic sources show consistent promise in ameliorating osteoarthritis disability in multiple ways. These include cartilage and soft tissues and muscle repair plus pain relief in selected osteoarthritis cases[10] and post pulsed electromagnetic field applications that are found to exert a positive role in the tendon healing process, as well as fostering bone and nerve healing.[58-62] Moreover, several notable plausible evidence based mechanisms appear to support the impact of pulsed electromagnetic fields in reducing inflammation that greatly mars the ability to mitigate the osteoarthritis condition and is often ineffective or unsafe when treated solely by anti-inflammatory drugs.

To guide challenges faced by health providers in the realm of chronic osteoarthritis in the high aged adult, and its immense related personal and societal burden, a number of positive laboratories based preclinical study results clearly show the potential efficacy of pulsed electromagnetic field therapy for osteoarthritis mitigation that warrant consideration and comprehensive study in the future. Indeed, even if other interventions are helpful and take less time, the ability of most to directly impact the actual joint pathology is limited and/or can undoubtedly foster one or more disabling physical, social, or mental health disease correlates as a result.

In addition, it is possible its insightful application using thermal doses may yet relieve pain and muscle spasm that accompanies the disease. Third, its application may alleviate bone marrow lesion pain, as well as the degree of bone microfractures and bone damage known to hastens the progression of osteoarthritis to a high degree.

It also appears articular cartilage cells are indeed highly responsive to electrical, mechanical as well as chemical stimuli and can be manipulated accordingly by selected pulsed electromagnetic field effects, as can muscle, nerves, and supportive tissue structures and molecular pathways. Moreover, adequate data points to the fact joint degradation can be minimized post PEMF.[31-33]

These PEMF benefits are clinically important to acknowledge in our view, because it is likely their careful applications may obviate the need of a fair number of elderly adults with disabling osteoarthritis to resort to narcotic usage that may prove addictive. Its anti-inflammatory, effusion, and pain reducing properties, may prove equally valuable in helping the affected individual to exercise, especially important in early as well as late life osteoarthritis, or induce effects comparable to these via PEMF alone.

In addition, because pulsed electromagnetic fields can be applied safely plus alone or in combination with other treatments, possible functional benefits may emerge without any possible injury to joint neural structures that may be debased by nerve blocks, intra articular injections, or surgery. Unlike exercises, since these magnetic waves can be applied even in the absence of movements that are often hard to perform in the case of pain, benefits may extend to reductions in joint swelling and inflammation, better post-surgery healing effects, and cartilage preservation. Indeed, the active adjunctive application of PEMF could be a useful adjuvant treatment to exercise programs to further decrease pain and knee stiffness and improve function in individuals with knee joint disease in the medium term[36] and long term.[51]

These results seem plausible in light of evidence PEMF stimulation in the lab under controlled conditions yields pain relief, tangible joint morphology repair processes, and mobility benefits while reducing the rate of cartilage cell death, joint inflammation and destructive enzyme actions. The active waves can also be applied with the expectation of exerting stimuli that foster collagen production and muscle regeneration[8] and that can alleviate noxious symptoms arising from nerve damage, sleep problems, and declines in functions that limit life quality. Potentially too, carefully designed treatments can help to avert or postpone the need for invasive surgery. This may depend on the selection of carefully targeted and directed wave forms that are tailored insightfully based on the client's profile and what is known at both the cellular as well as the molecular realms about enabling key genetic operations and favourable uptake responses as well as desirable gene functions and expression to emerge post PEMF bio stimulation.

However, although promising, it remains essential to validate these above-mentioned ideas more effectively if we are to expand upon the promise of this understudied modality as a more standard form of osteoarthritis therapy. What is profound though are the numerous observations that detail salient intracellular mechanisms of PEMF response and often thereafter improvements in pain, inflammation extent, sensorimotor function and anabolic pathways of repair even in damaged joints and in those presenting with hyperalgesia or after surgery.

Conclusion

Although many older adults suffer with osteoarthritis without much relief, and despite favourable preclinical related observations of possible relief and even disease regression or repair post electromagnetic stimulation, the shortcomings of clinical studies, and especially those relying largely on aggregated data to guide clinical decisions in this sphere hampers the ability to decrease it destructive manifestations. This is not only due to an inconsistent array of studies that are inclusive of clinically meaningful well designed research reports, but their lack of power and short duration.

As such, and after studying this topic for many years, it is still worthwhile in our view to pursue in light of the increasing rates of worldwide suffering among the older population from potentially treatable osteoarthritis pain and success in advancing PEMF healing understandings. Here, we advocate with reasonable confidence that clinicians can still consider applying pulsed electromagnetic field treatments to quell osteoarthritis pain and to foster function, especially if applied sooner rather than later.

Indeed, while this broad-based overview may not have included all available studies, and the quality of those identified cannot be readily established in many cases, it appears safe to offer four key reflection points that encapsulate the state of the art in 2025

1. Low frequency pulsed electromagnetic fields provide a safe and well tolerated form of biophysical energy that can be harnessed and titrated to promote intrinsic tissue healing, cartilage viability, and attenuate joint pain and inflammation as found in osteoarthritis.

2. Older individuals with chronic osteoarthritis may benefit from the application of pulsed electromagnetic fields to their affected joint[s], especially if applied at the outset of the condition.

3. Validating and clarifying the potential of pulsed electromagnetic fields may offer a cost-effective means of reducing considerable suffering in older adult who experience severe osteoarthritis disability
.

4. Extending research efforts to embody the features of the whole joint and their interactions in the older adult population, if impaired, as well as with their reaction to pulsed electromagnetic field therapy plus its added impact on possible complementary interventions such as collagen intake maximization, joint protection approaches, and muscle strength training is also likely to prove highly promising.

Moreover, the fact transcriptional, cellular and sub-cellular molecular effects within damaged cartilage, muscle, and bony tissues have been quite well documented and replicated must surely keep the door open for those interested in undertaking and unravelling possible clinical applications to mitigate late life chronically disabling osteoarthritis or even arrest or reverse this disease especially among those who cannot undergo surgery or use medication

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