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Sarcopenia and hip osteoarthritis: possible role for targeted electrical and biophysical muscle stimulation applications

Abstract

Background: Hip osteoarthritis- a painful oftentimes longstanding progressively disabling condition that occurs predominantly among sizeable numbers of older adults may be detrimentally impacted by an atrophic muscle condition known as sarcopenia.

Aim: This mini review examines the possible utility of electrical or magnetic muscle stimulation for mitigating sarcopenic muscle mass declines that may be age or disease associated or both among older adults diagnosed as having early or late stage hip osteoarthritis.

Methods: Peer reviewed literature on hip osteoarthritis discussing sarcopenia, as well as any evidence that electrical or magnetic muscle stimulation as applied to foster muscle mass increments are relevant to ameliorating this condition were sought and examined.

Results: Many reports show hip osteoarthritis remains a highly debilitating disease to counteract and is a condition where the surrounding muscles may be atrophic. While most point to exercise and nutrition as suitable muscle interventions for countering sarcopenia, a favorable role for electrical stimulation cannot be ruled out.

Conclusions: There is a possible missed opportunity that implies muscle preservation at the hip through electrical stimulation will be beneficial for fostering function at all stages of hip joint osteoarthritis progression, even if surgery is forthcoming, and should be studied further.

Keywords: electrical muscle stimulation, hip osteoarthritis, muscle, pain, older adults, prevention, pulsed electromagnetic fields, sarcopenia, total hip arthroplasty

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Introduction

Hip osteoarthritis, a widespread disabling condition wherein very few methods of reversing or averting the disease progression have been put forth as of 2023 despite more than 100 years of study, with over 22,000 publications, remains a condition of high concern in all aging societies whose citizens are most impacted. Even when the need for surgery arises, often in the later disease stages, results are not always immediate or optimal, and may be influenced by multiple factors including the presence of muscle mass deficiencies or sarcopenic manifestations associated with aging as well as osteoarthritis and obesity that raises the chances of muscle fat content being higher than desirable and that can impact functional and cellular attributes of joint as well as bone homeostasis.[1,2]

In particular, the idea that sarcopenia, an umbrella term applied to describe the oftentimes observed age-related decline of muscle strength, muscle quality, and muscle mass found to foster or contribute to physical dysfunction in older populations[3] and that may induce or exacerbate frailty, and disability[4-6] is increasingly thought to be a possible consequence or outcome or both of hip joint osteoarthritis as well as other joints.[7-9] Its careful examination and consideration as a key pathogenic contributor to the generally negative health outcomes of hip osteoarthritis may yet be highly relevant to consider, even though available data do not permit any firm conclusions on this possibility.[10] Linked to the presence of pain and falls risk,[4] persistent obesity derived inflammatory responses and possible subnormal muscle serum biomarkers[8] that may lead to decrements in muscle strength and performance losses, may also foster a propensity towards dysregulated tissue repair and regulatory processes as well as muscle fiber type II losses, motor unit disruptions, and associated musculoskeletal damage.[3,11] As such, vulnerable older adults who are often offered few positive osteoarthritis treatment options other than medication or surgery, as well as sarcopenic osteoarthritis cases undergoing hip replacement surgery may yet benefit from interventions that are specifically designed to address or counteract any prevailing or possible emergent sarcopenic state, using established approaches. Among these may be one or more forms of externally applied muscle stimulation, even if possibly disputed by Papalia et al.[12]

Indeed, exploring this topic, especially in light of the increases seen in the sarcopenic obesity phenotype alone that is characterized by varying degrees of muscle fat mass encroachment and a lower than desirable skeletal muscle mass and is found to be associated with higher infection rates, poorer function, and slower recovery after surgery in other clinical populations, may be an important, yet commonly overlooked hip osteoarthritis correlate[1,9] that is worthy of attention. There is also evidence of the possibility of there being a form of cross talk between muscle and cartilage cells that may influence joint status[13] that may be amenable to selective electrically oriented externally applied electric type currents. The ability to keep an older adult who is in severe pain or has health comprises mobile-a remedy advocated for averting the development and presence of sarcopenia[3] as well as its functional implications[11] may likewise be favorably impacted by the careful application of electrical stimulation devices, in the case where the older adult cannot exercise safely or effectively and could otherwise be subject to both excessive rates of osteoarthritis progression and its multiple disabling impacts. In addition, even

though not mentioned to any degree in a recent osteoarthritis treatment review stressing the magnitude of the hip osteoarthritis burden,[14] the topic seems noteworthy because increasing data reveal sarcopenia, which may be detectable as well as modifiable, is associated with increased risk for complications after hip replacement surgery if untreated or ignored,[15,16] as well as having a low walking speed.[17] Many older adults who suffer from excess body mass and are at risk for osteoarthritis or are diagnosed as having this chronic condition may also incur a progressive sarcopenic state where muscle mass is impacted by fatty tissue rather than contractile tissue. Since this negative state can consequently interfere with overall muscle function and their joint protection mechanisms, the application of carefully construed muscle stimulation that reduces pain, and fosters mobility and muscle mass improvements, may also be helpful in mitigating possible decrements in muscle contractility due to excess fat cell mass.[1,18] In addition, hip osteoarthritis cases who are frail rather than overweight and who may benefit from direct exercise but could be at risk doing so, as well as those hip osteoarthritis cases with excess pain or suffering from balance or joint stability issues may similarly benefit.[19]

In this respect, and although the treatment or mitigation of both sarcopenia and osteoarthritis is accordingly based largely on physical exercise and nutritional interventions with the aim of improving cartilage, bone and muscle health,[20] this mini review aimed to examine if a possible additional form of intervention, namely some form of electrical muscle stimulation that might be expected to impact the structural properties of the stimulated muscle favorably could be valuable to consider in efforts to offset any unwanted albeit possibly modifiable sarcopenic-osteoarthritis pathology interactions that may involve placing stress on joint support structures such as ligaments.

Methods

The papers reviewed in this work were selected from an extensive computerized PUBMED and GOOGLE SCHOLAR database search for the years 1966 2023, using the key words: electro acupuncture, electrical muscle stimulation, hip osteoarthritis, magnetic stimulation, muscle remodeling, and sarcopenia. Google, PubMed Central and Scopus data bases were also searched. In addition, relevant citations from selected identified papers were searched. The most recent literature search was conducted on March 10, 2023.

To be included in this review, articles selected had to be published in English and detail pertinent facts on hip osteoarthritis and sarcopenia, plus the application of some form of electrical muscle stimulation that could be applied non-invasively to possibly ameliorate hip osteoarthritis. All forms of study and disease stages were deemed relevant, regardless of year of publication. The term sarcopenia was used to denote the presence of a possible age or disease associated muscle mass decline that has implications for clinical outcomes and physical function challenges in the case of the older osteoarthritis sufferer. The review is limited however, to the application of electrical stimulation in the context of hip osteoarthritis, often less well studied than knee osteoarthritis, and discusses no other non invasive muscle building intervention approach. In addition, no effort was made to examine mechanisms of joint disease other than sarcopenia or muscle atrophy. The causes of sarcopenia are also not addressed. Rather than addressing all forms of osteoarthritis, the article focuses on hip joint osteoarthritis as it occurs in the older adult, a topic less well studied than knee osteoarthritis.

In failing to uncover any body of literature that could be systematically analyzed, no formal analysis was attempted. As this topic appeared more emergent or theoretical rather than an established one, the limited findings are discussed in a narrative mode and in the context of intersecting publication themes and public health current and future economic and age associated population challenges. Electrical stimulation modes examined included those associated with direct or indirect forms of muscle stimulation.

Results

Current, as well as past data show that while the topic of osteoarthritis has been studied for more than one hundred years, this body of research, while promising, has not yielded any clear understanding of its origins, or any universally efficacious disease modifying strategy. Since a high percent of adults have been reported to be affected by osteoarthritis, that invariably induces the progressive onset of multiple primary functional challenges, the disease remains one of the most serious and costly health concerns facing aging nations, and stresses the need to employ all strategies available to prevent and intervene upon its occurrence and progression. This is additionally imperative because even though a variety of pain relieving medications and various exercise regimens are currently touted to be of key import in this regard, very few forms of intervention currently alleviate the condition to any meaningful degree and some may be more harmful than helpful.

As a result, many reports show older adults with excess hip osteoarthritis pain, along with difficulties in walking, getting up from a chair, dressing, toileting and bathing, are commonly referred for hip arthroplasty or joint replacement surgery, an intervention that is not without both complications as well as social costs, especially if waiting lists prevail in many countries post COVID-19, and sarcopenia is either long standing or emergent or impacts hip arthroplasty outcomes and therapeutic applications and a sense of whether the joint replacement seems artificial or not.[15,21] At the same time, even though some recent data do point to a role for examining and improving upon muscle composition at the hip joint at all stages of the disease process, and that a reduced presence of muscle atrophy in this regard may foster better bone health, a significant osteoarthritis correlate,[22] sufficient data show not all older adults may be able to exercise safely or are motivated to do so in the face of unrelenting pain.

However, a small, but promising array of various publications that embrace opportunities for one or more forms of neuromuscular stimulation show this modality can be used as a passive substitute for active exercise with some observable beneficial impacts in the context of various musculoskeletal and neurological conditions. As such, it may not only be useful for fostering mobility in general, but especially useful in cases where the person is already too debilitated to engage in exercise and where muscle atrophy is likely to further reduce their optimal wellbeing. Its examination in the specific context of older adults in general, and hip osteoarthritis in particular, is surprisingly limited, however, for example if compared to studies that have focused on associated interventions for preserving or stimulating knee muscle structural properties[23] or those that address age associated muscle mass and fiber property declines.[24] At the same time a reasonably sound basis for continuing to examine the role of age-associated as well as pathological-associated changes in muscle composition and muscle integrity including sarcopenic muscle wasting that can surely compromise muscle function in the context of the hip joint and others is being increasingly discussed. As has been found at the knee joint affected by osteoarthritis, a considerable body of evidence points to an associated high rate of knee extensor muscle atrophy that can be favorably attenuated by insightfully applied quadriceps electrical stimulation procedures and others.

There is hence a precedent for supporting the possibility of mitigating the rate of osteoarthritis disease progression and severity at the hip joint through carefully applied extrinsic modes of muscle stimulation alone or as an adjunctive approach in the face of any prevailing or pending state of disease provoking muscle atrophy.[19,25] As well, it may be possible to enhance muscle fiber composition preferentially and in a targeted manner by manipulating various electrical stimulation parameters, electrode placements, and treatment schedules, for example using electrical stimuli to increase either muscle type I or II fiber types and their associated important but differential functional impacts.[26–28] Moreover, obesity, leading to an increase of muscle fat content, muscle atrophy, inflammatory pain, and a probable decrease in motivation for activity participation[1] may be a condition that can be impacted both directly as well as indirectly by efforts to stimulate affected muscle non-invasively.

In this regard, one study has shown that the application of low frequency electrical muscle stimulation combined with physical therapy did appear to improve the outcomes of older cases undergoing hip joint arthroplasty surgery quite significantly.[29] However, in that study no treatment was reportedly applied directly to the hip muscles anthat may not yield the same biomechanical impacts as those in other parts of leg[30] and no mention was made of any sarcopenic improvement that explained the observed benefits.[29] Mikami et al.[31] also noted similar post-operative benefits with the addition of knee extensor neuromuscular stimulation, but did not discuss its influence on muscle mass at any joint. Zhao et al.[32] similarly applied neuromuscular stimulation to the nerves around the knee joint after patients had undergone hip arthroplasty with lower limb functional improvements, but the role of the hip muscles in this respect was not assessed or discussed. Stimulation of the hip abductor muscles is however found to be feasible, as well as acceptable, even if knee extensor stimulation is preferred by hip osteoarthritis cases.[33] There may also be a strong rationale for quadriceps muscle stimulation in hip osteoarthritis as outlined by Fukumoto et al.[34] and Ikutoma et al.[35]

Other forms of biophysical stimulation that can enhance muscle composition such as pulsed electromagnetic field therapy may also prove effective for minimizing osteoarthritis disability, or for slowing any associated adverse muscular impacts on the diseased joint,[36–38] as well as favorably impacting nerve damage that may underpin atrophic muscle states that are found to limit physical activity participation in older hip osteoarthritis cases with weak hip abductors or signs of accelerated muscle aging.[39-41] Some of these benefits may be due to the ability of certain forms of electrical stimuli to selectively target and strengthen certain muscles, improve muscle function, and to carefully modify the behaviors of intrinsic muscle fibers by increasing the contraction load per day.[41]

More recently, Leon-Salas et al.[42] developed a stimulator that was said to generate pulsing electric and magnetic fields at programmable rates and intensities to target bone and muscle tissue simultaneously with the aim of improving the therapeutic treatment of osteoporosis-a condition that might be implicated in some cases of hip osteoarthritis-and sarcopenia - or both conditions. The device which was fully programmable, portable and easy to use, and generated magnetic fields of up to 1.6mT and output voltages of +/- 40 V accelerated myogenic differentiation of myoblasts into myotubes as evidenced by morphometric, gene expression, and protein content analyses when the substrate was exposed to the stimulation.

Moritani et al.[43] argue that contrary to the orderly recruitment of motor units that ensues during low intensity voluntary exercise, electrical muscle stimulation can be designed so as to activate large fast-twitch motor units preferentially that could have benefits for the prevention and treatment of chronic diseases associated with muscle atrophy. As per Paillard et al.[44] for populations too frail/fragile or unable to exercise safely due to sarcopenic or pathological restrictions, electrical muscle stimulation applications may help to avert a loss of mobility and the risk of falling that can lead to fractures, or an increase in the handicap experienced by older adults with disabling hip joint osteoarthritis. It can also be applied to heighten or augment the impact of muscle strength training approaches where these can be performed,[45] and although poorly studied in hip osteoarthritis cases, has been shown to yield considerable advantages in knee osteoarthritis muscle contexts,[46] even though not recommended post hip joint arthroplasty by some.[47] It may also be of special significance if older adults are unable or reluctant to exercise[48] and the muscle stimulation is carefully applied and targeted to build hip abductor muscle strength.[49]

Accordingly, Carraro et al. suggest[41] it should be possible to defer the muscle decline that occurs in aging people and in those who have become unable to participate in physical activities, such as the hip osteoarthritis sufferer. Its application should hence be strongly considered, rather than overlooked in rehabilitation centers, nursing facilities and critical care units, especially when patients are rendered inactive even for short periods of time. It can also possibly be applied in efforts to minimize the widely observed limping gait exhibited by many older adults with hip joint osteoarthritis of one or both joints. In addition, its insightful application may help avert possible joint overloading and aberrant movement adaptations that can impact the limb opposite to the index side in unilateral cases and with this load-mediated pain and a diminished quality of life.[50-53]

Carrying out exercise or muscle stimulation interventions or both before surgery may further foster functional outcomes as indicated by Maezawa et al.[54] In particular, older patients with hip osteoarthritis are likely to benefit from continuous efforts to specifically preserve or increase their hip flexor and abductor muscle strength at all disease stages so as to maintain adequate motor function and favorable muscle physiological adaptations.[55] This applies especially to older adults who must undergo extensive hospital stays, those who have to use braces that could encourage muscle wasting, and older cases undergoing hip replacement surgery who have no signs of sarcopenia, but can yet develop this post surgery.[16]

Discussion

As of 2023, ample research including a multitude of epidemiological and clinical as well as preclinical studies over the past two to three decades has shown little progress in understanding the causes of hip osteoarthritis and how to ameliorate this widespread age associated debilitating condition. At the same time, the numbers of cases with this disease has grown and has continued to place an immense economic as well as an incalculable social burden on most aging societies in the absence of any sound intervention to alleviate hip osteoarthritis pain and enhance mobility, other than surgery. Even then, an increasing volume of emergent evidence indicates surgery in itself may yield less than optimal life affirming outcomes, or can actually create possible complications that are hard to remediate in the older adult population for many reasons.

There is however, a possible atrophic muscle linked pathway in the context of osteoarthritis disease progression, including that at the hip joint, that has not been fully explored, and based on studies in other realms is an attribute that can be measured accurately and may be reversible.[56,57] Moreover, even though poorly researched to date,[57] one

finding that appears promising is this regard is the possible association of age and/or disease associated muscle mass declines at the hip that may yet be amenable to intervention,[6,58] for example through nutrition and exercise. At the same time, there has been considerable interest in the clinical application of percutaneous modes of electrical muscle stimulation in different rehabilitation situations over the years that have been applied with some increasing success and that may enhance the outcomes of volitional exercise as well as helping to strengthen muscle or increase its cross-sectional area and desired muscle fiber content favorably in instances where exercise is challenging or impossible to undertake safely by a debilitated hip osteoarthritis older case.

As such, and in the absence of any specific therapy that can be shown to halt the progression of hip osteoarthritis effectively, treatments that employ electrical stimulation to reduce or avert sarcopenia at the hip or knee may:

1. Relieve the patient's pain and stiffness and tendency to muscle atrophy.
2. Indirectly reduce their anxiety about the disease.
3. Minimize their prevailing joint dysfunction, disability, and handicap.
4. Reduce the rate of disease progression and joint laxity.
5. Restore patients to optimal levels of physical and social function.
6. Improve surgical outcomes and costs.

This present review thus strove to first identify if there is some possible pathogenic linkage between the presence of any prevailing or emergent local or general muscle mass declines in the realm of improving the outlook for the older adult with varying degrees of hip osteoarthritis pathology and muscle weakness. With some support for this neuromuscular disease association, it then strove to specifically examine the possible value of applying one or more forms of extrinsic muscle stimulation among cases deemed sarcopenic, a common debilitating disorder in which associated weakness of the muscles surrounding the hip joint may contribute quite markedly to its associated pathogenesis and accompanying disability, particularly in those afflicted individuals-who may not be able to exercise effectively due to comorbidities and/or other arthritic manifestations such as pain and joint instability.

This review is thus unique in this regard, because although some work has been done previously to evaluate trials of non pharmacologic non-invasive therapies for hip osteoarthritis, very few examined, or even mentioned the modality of electrical muscle stimulation in any form, or discounted this as being a viable adjunctive approach. This is surprising because ample data that have examined this topic with respect to knee osteoarthritis have yielded some important insights and evidence of its considerable clinical potential. Laboratory studies too strongly show various extrinsic stimuli applied to muscle can be manipulated to yield favorable effects muscle morphological effects and others. It may also be beneficial for fostering improved surgical outcomes among older hip osteoarthritis cases or suitable for maintaining muscle composition during any lengthy wait period for surgery.

However, at present, there is a general consensus that the above ideas must remain conjectural at best pending future interest in pursuing this field of endeavor through dedicated research and doing this insightfully. It is a call that should be heeded though by those charged with fostering the wellbeing of the older hip osteoarthritis sufferer in our view as a failure to do this is likely to limit their opportunities for achieving a high life quality, as well as a high level of function, notwithstanding their osteoarthritis diagnosis. In the meantime, we hypothesize that the presence of localized sarcopenia at the hip joint, as well as a sarcopenic state in general, can impact the extent of several well documented manifestations of hip joint osteoarthritis, such as declines in muscle power, excess fast fiber composition deficits, and muscle fatigue, among others. Other research shows the application of one or more forms of neuromuscular electrical stimulation, which may adjusted so as to substitute for voluntary muscle contractions, can reduce atrophic muscle mass declines as well as functional declines.[59] This is promising because both those older adults who are obese as well as those who are extremely underweight and who are likely to be at highest risk for sarcopenia and possible primary or secondary hip osteoarthritis may yet achieve satisfactory management outcomes with fewer complications.

While it is acknowledged that this review is clearly limited in multiple respects, it may likewise be of considerable benefit to routinely apply some form of muscle stimulation to individuals requiring prolonged periods of immobilization or those who incur too much discomfort with active strengthening and endurance exercises. It may be beneficial as well for improving muscle strength recovery, torque and function and improved muscle endurance among those older adults for whom surgery is contraindicated. Finally, even if it is not possible to stimulate the hip muscles directly, several authors show that applying electrical stimulation selectively to the knee muscles of an individual with hip osteoarthritis may prove effective in alleviating their functional disability in its own right. It also seems plausible to suggest that if muscles and joint tissue cells do 'talk' to one another that its insightful study and improved ability to carefully select an optimal mode of application may yet be paramount in efforts to not only maintain or enhance muscle properties during periods of inactivity or arthritis flare ups, but to enhance muscle-cell interactions that underpin both muscle composition as well as possible inherent cartilage reparative or anabolic chondroprotective mechanisms, bone synthesis, joint function and anti-inflammatory processes.[60]

However, as with any form of intervention, and pending future study, the application of electrical stimulation to the osteoarthritic hip should be based on careful evaluation and appropriate graded applications of the modality. The positioning of the patient and electrodes as well as instructions that stress joint protection and sound nutrition and weight management are features that must however be carefully construed.[60,61] Care should be taken in the case of any prohibitive dermatologic or cardiac condition, as well as possible bone fragility, while hip osteoarthritis cases exhibiting leg length discrepancies may benefit from simultaneous attention to appropriate footwear.

In addition to attempting to examine where sarcopenia prevails and to reverse this where it prevails, the prophylactic usage of electrical stimulation in its varied formats and modes of delivery should be thoroughly explored. In this regard, whether used in a preventative sense or a therapeutic sense, researchers and clinicians are urged to begin to conduct rigorously designed prospective studies wherein both basic as well as clinical observations are embraced, including biomarkers of cartilage and muscle structure and function, as well as physical wellbeing. As a prelude to implementing any large-sized, robust, clinical trial, case studies in the clinical setting of older hip osteoarthritis and healthy adults may be helpful. As more societies age and their health services become scarce and expensive, and adults in the highest age ranges have few options for pain relief, it is increasingly evident that some form of physical activity or its analogue be pursued

so as to maintain optimal muscle function and the possibility of attaining an optimal functional capacity, regardless of joint status. On the contrary, sufficient data indicate that not only is poorly treated sarcopenia a factor that could undermine muscle morphology and joint protection, while poorly treated or untreated osteoarthritis may be expected to exacerbate sarcopenic manifestations locally as well as generally, as well as impacting the outcomes of any needed surgical or other non operative intervention negatively and significantly.

Since it is shown that one or more of the hip muscles around an osteoarthritis joint may indeed exhibit some degree of sarcopenia, external strategies, including one or more modes of neuromuscular stimulation[62,63] can be expected to lead to visible and progressive improvements in muscle morphology and function without any signs of visible muscle damage,[19,64,65] and possible greater weight bearing confidence and ability,[63] even if disputed by Suetta et al.[66] or not really mentioned.[67] Applied appropriately in terms of optimal electrode size and placement[68] and in a targeted manner, electrical stimulation may also be found in the future to offer an effective alternate or complementary and safe strategy that can help speed up rehabilitation and offset the immense costs of providing outpatient therapy services, drug overdose centers, and surgical care to the growing number of older hip osteoarthritis cases who may be too impaired to exercise. With its potential to impact pain, muscle, and bone morphology[69,70] and to thereby possibly restore the function of multiple intrinsic osteoarthritic joint tissues, as well as their surrounding peri-articular structures, while potentially offsetting osteoarthritis severity attributable in part to sarcopenia, it appears safe to conclude this biophysical mode of intervention warrants attention and should be studied further and without delay.

Conclusion

This current review that involved an intense search for literature relevant to sarcopenia and hip joint osteoarthritis, and whether electrical muscle stimulation might be advantageous in this regard, while clearly very limited in terms of numbers of reports, and the use of small non random samples with varying degrees of pathology does appear to indicate:

i. Hip osteoarthritis, a chronic disabling condition of one or both hip joints, remains highly challenging to treat or control.

ii. Cases who may well suffer from sarcopenia or declines of muscle mass may suffer more than those with optimal muscle composition.

iii. Those who suffer from muscle mass losses may on the other hand be favorably impacted by concerted efforts to exercise, and to follow sound diets, if possible.

iv. This muscle deficient group may also be benefited by carefully tailored applications of extrinsic muscle stimulation at all disease stages, whether surgery is indicated or not.

v. To advance the options for sarcopenic older adults who have persistent hip osteoarthritis pain, a failure to examine the state of their musculature and to consider how extrinsic forms of muscle stimulation might be favorably employed will likely limit surgical outcomes, as well as their day to day independence goals, while fostering frailty and possible dependence.

vi. Anticipated benefits of well designed electrical muscle stimulation include improvements in pain, bone mass, function, stability, and mobility, possible disease progression slowing, and decreased need for narcotics and surgery, and should be examined further.

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Conflicts of interest

Author declares there are no conflicts of interest towards this manuscript.

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