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Cervical Joint Osteoarthritis and Position Sense: Overview of Selected Findings and their Implications

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Abstract

In man, the cervical spine composed of seven interlocking bony units and articulated via a series of associated freely moving synovial joints is highly vulnerable to injury and the development of the painful disabling joint disease termed osteoarthritis. Here we discuss the some findings that show there are clinically measureable alterations in the sensibility of cervical position detection that may prove detrimental in the control of neck movements and their possible clinical implications for the prevention and treatment of cervical osteoarthritis in the older adult population.

Keywords: Cervical Osteoarthritis; Chronic Neck Pain; neck Joint Position Sense; Older Adults

Introduction

The cervical spine comprising seven vertically oriented bone units or vertebrae, and their associated facet joint synovial articulations, vital to the ability of humans as well as other species to function optimally under static and dynamically changing conditions is often subjected to injury and progressive damage due to osteoarthritis joint disease at one or more of the seven cervical spine vertebral levels. This is unfortunate for the individual because of the proximity of the C1-C7 vertebral region to nerves located in the surrounding muscles, ligaments, tendons, vertebral discs, and joint capsules, as well as their vascular connections. Indeed, damage to any of these sites as well as impaired network stimuli due to a narrowing of the cervical body foramina or the impingement of the vertebral artery and cervical nerves or nerve roots, may have profound implications for these joints and function as a whole [1-4].

In addition, to a possible loss of vertebral disc height, painful nerve impingement, bone and ligament damage, ensuing bone and synovial tissue related bioactive substance production and a host of adverse local and central neural responses including muscle atrophy, or myopathy, as well as neuropathy may unfold, with possible long term negative implications for those cases where joint position sense is progressively degraded, or simply exists due to age [5,6].

Today, cervical osteoarthritis, a highly disabling widespread joint disease, remains a major health challenge and concern because commonly accompanied by the presence of persistent cervical pain, older affected adults may experience a marked reduction in their ability to function physically and confidently as time progresses with little hope of eliminating their disabling condition. At the same time, even if somewhat effective for short time periods, most non surgical intervention approaches may fail to attenuate the condition. Some approaches too, may inadvertently cause or exacerbate a state of disequilibrium between the anabolic and catabolic normal tissue interactions of the neck joint support tissues, such as cartilage, in favor of noxious catabolic processes as well as abnormal muscle responses and adaptations, for example consequent to narcotic medications and steroid and other focal injections that mask pain and

induce anesthesia. Moreover, as time advances, it is common to observe signs of possible increases in pain and numbness in the neck and arm as well as neck stiffness and neck muscle weakness, which can greatly affect function, joint integrity, and the ability to readily pursue a life of independence and high quality if joint protective strategies are not enacted at all or consistently [7,8].

Ozen, et al. [9] notes this above scenario is likely to occur quite frequently partly because the cervical spine serves as an essential region for housing proprioceptive receptors or sensors that can be impaired over time, but are vital for motor control and joint protection. Peng, et al. [10] concur that one of the main problems in patients with neck pain is the impairment of cervical proprioception, which may subsequently leads to one or more cervical sensorimotor control disturbances and that play a crucial role in the control posture and balance. This form of cervical proprioceptive impairment is found to be subnormal in multiple cases with symptomatic neck pain regardless of age, and can be detected via efforts to assess cervical joint position sense as this impacts head position, and can be degraded by multiple mechanisms including muscular fatigue [11]. However, if severe and unrelenting, those inherent motor control interactions that normally protect the individual from excess or adverse joint impacts may fail to display optimally efficient and timely well modulated degrees of muscle force generation, motor movements and posture, and may lead in some to an even more serious condition termed cervical myelopathy - the most common cause of spinal cord impairment among older people.

This is a highly disabling condition and one to avoid if possible because affected cases typically present with multiple signs of gait dysfunction as well as hand impairments, and/or the presence of long term adverse neural tract signs of dysfunction including: clonus, the Hoffman and Babinski signs, possible inverted radial reflexes and a high rate of neurological decline. Moreover, even if only mildly impacted, a degree of cervical-spine sensorimotor dyscontrol that becomes chronic is strongly associated with a recurrence or perpetuation of neck pain and possible heightened rates of joint dysfunction [12,13].

The ability to isolate the causative factor[s] underlying the presence of chronic neck pain and possible functionally undesirable preventable degrees of osteoarthritis pathology, is thus of considerable import and a study of what we know about the neck neural control determinants may advance this. Alternately, if possible sensorimotor impairments in particular are identified interventions implemented accordingly may help to attenuate otherwise unrecognized joint impacts that can foster or exacerbate a progressive breakdown of even a healthy joint[s]. based on the complex anatomy and nerve supply in the cervical region, and its multiple protective and functional sources of the neck sensory receptors located in the surrounding joint capsules, muscles, ligaments, and tendons that are all currently implicated in osteoarthritis-now deemed a disease of the 'whole joint' [5].

Indeed a study of 135 cases with neck pain recently revealed subnormal findings with respect to direction-specific repositioning tests generated during flexion, extension or rotations that implied the possible influence of subnormal central and peripheral sensorimotor adaptations [5] plus the presence of poorly integrated information from the surrounding neck joint and muscle receptors [14]. Findings may also have implicated suboptimal co-ordination of several key muscles in this regard and that can be altered by age, osteoarthritis or other joint diseases, trauma or some form of associated joint dysfunction such as abnormal side to side as well as rotary neck movements [5] plus subnormal manifestations of head posture. This view implies that changes in the integrity of periarticular tissues, including the ligaments and muscles that may arise in response to pain and disease could impact the ability to position the head and neck optimally and thus move without incurring excessive or inefficient load impacts [15].

In this respect, as discussed by Armstrong, et al. [15] ample neurophysiological studies point to the importance of the neck joint neural receptor pathways in providing proprioceptive information for the CNS, wherein the high densities and complex arrays of spindles found in cervical muscles suggest that these receptors play a key role in a pattern recognition system that is used to establish joint position and movement sense. Moreover, the sensory information from the neck proprioceptive receptors is specifically processed in tandem with information from the vestibular system. There are extensive anatomical connections between neck proprioceptive inputs and vestibular inputs, and thus if information from the joint and muscle receptors locally, plus the vestibular system is inaccurate or fails to be appropriately integrated in the CNS, errors in head position and the control of head position may be affected. The cerebellum and cortex also play a role in control of head position, providing feed-forward and modulatory influences depending on the task requirements, but can yet be jeopardized in the face of subnormal muscle response mechanisms. Joint receptors in the ligaments as well as tendons may also exhibit functioning deficiencies, while abnormally activated pain receptors may foster impairments in neck position sense often observed in individuals who have experienced whiplash-type injuries irrespective of age as well as individuals with chronic head and neck pain of non-traumatic origin, such as cervical spondylosis more readily without cessation and at a lower activation threshold [10,14].

In addition, Sung [16] proposes problems that occur in the ligaments or muscles of the upper cervical spine can cause a form of proprioception mediated confusion, and possible subsequent inaccuracy of information conveyed to the vestibular nucleus, resulting in abnormal motor reactions or adaptations that foster a state of cervicogenic dizziness. There may also be measureable instances of extreme hypersensitivity of the neck pain receptors that are evoked by even by the most modest movement and/or thermal stimuli rather than those associated directly associated with the disease specifically [17].

Indeed, despite years of research, how to reverse chronic neck pain or even attenuate this effectively has not been a simplistic task given the close proximity of the neck joints and the peripheral and central nervous system connections. It can also be conjectured that without very careful analysis and choice of intervention more harm than good could emerge.

This brief highlights the role of neck joint position sense as both a key function underpinning neck joint health, as well as a promising evaluative and explanatory tool in painful neck syndromes. The question was whether inroads could be made in understanding and intervening to ameliorate the perpetuation of chronic pain in the cervical region. The article assumes there are multiple sensorimotor pathways that may be implicated in heightening neck pain and cervical joint degeneration. It was thereby hoped the literature could possibly provide some form of guidance to more ably support a very cautious extended neural based therapeutic rationale that could be effectively applied to the prevention of excess cervical pain of biomechanical origin in cases such as the older cervical osteoarthritis sufferer.

Methods

To achieve some insights in the aforementioned regard, a broad based scoping literature overview and scan was conducted including historically based as well as contemporary observations regarding cervical pain and osteoarthritis as observed on the PUBMED, PubMed Central and Google Scholar database sites. Specifically sought were articles detailing cervical osteoarthritis, pain, and neck joint position sense, Methods of assessing position sense were not discussed or differentiation. Joint position refers to the sensibility to detect joint angles, usually measured as the degree of repositioning error. The article also does not discuss the role of osteoarthritis biology, pharmacologic and possible gene therapy, or any invasive forms of cervical spine intervention or the biochemistry of osteoarthritis degenerative processes. Moreover, while it does not differentiate between the differing modes of assessing neck position sense specifically, it recounts its observed importance as regards neck pain and injury prevention. All years of study were acceptable as were all forms of study and study substrates as long as there was a bearing on understanding the possible association between neck joint position sense, neck osteoarthritis and neck related pain. The term proprioception as applied by Ozen, et al. [9] refers to the awareness of body parts including joint position sense, kinesthesia, and the sense of muscle force is increasingly thought relevant to understanding the pathology of chronic pain and joint dysfunction. The term cervical osteoarthritis was used throughout although the term cervical spondylosis is used to similarly describe a wide range of progressive degenerative changes that affect all the components of the cervical spine of many adults after age 50 [18]. A detailed overview on neck position sense in the context of neck pain is that by Armstrong, et al. [15] and de Vries, et al. [18]. As per Mazaheri, et al. [19] it further appears cases with a whiplash type injury also show observed changes of joint position sense and standing balance that represent deficits in sensorimotor control especially in those with dizziness.

Selected Findings

Since the inception of efforts to understand neck motion and its dysfunction the role of the joint sensory receptors and their connections in this regard has steadily been identified as helping to explain or predict the oftentimes intractable nature of pain produced in the neck region through injury even of the most minor type and its possible advancement due to osteoarthritis associated damage. Based on many dedicated studies of the cervical nerves and their ramifications and functions initially largely conducted in isolation, and in animal models under anesthesia or on tissue samples of deceased animals or surgically removed human tissues it was clear there was a close interaction between osteoarticular damage and/or surrounding and intervening neural networks. Indeed, a role for intact sensory inputs in the ability to move safely and functionally and in a timely manner became hard to dispute. In this regard, the nature of cervical damage commonly affecting one or more cervical vertebrae in many older adults as well as younger adults is likely to injure or detrimentally impact one or more sensory nerve pathways and receptors in the neck joint region, often progressively and irreversibly.

At the same time, despite its flaws, emerging research has shown that as with findings at other joints, people with neck pain may shown a declining ability to reproduce joint positions accurately and without excess error [18]. This seems important to identify if we consider the possible impact of neck pain and a diminishing sense of joint position that may encompass associated signs of vertigo or dizziness, and nystagmus, as well as dynamic balance and locomotor performance disturbances that may be provoked readily in addition to falls and further injury and debility [20].

In this regard, even though the genetic, cellular, and molecular aspects of osteoarthritis are those topics most intently studied in 2024, a wealth of cumulative literature does point to a considerable role for a more inclusive focus, and one that accounts for possible one or more sensory alterations in the extensive sensorimotor receptor system surrounding the neck joints and bone surfaces of injured joints that could provoke pain and dysfunction as predicted to some degree by early studies performed by Wyke and Palacek [21]. This group repeatedly found as with all mammalian joints those of humans were supplied by four basic albeit differing functionally diverse joint receptor types that interacted to foster facilitatory or inhibitory reflex like influences on the ipsi- as well as the contralateral striated musculature of the neck, trunk, and limbs, as well as respiratory muscles in response to changing mechanical stresses on the joint tissues. These reflexes were considered of extreme importance in the control of posture, gait and respiration and were also found to influence the reactivity of the ocular as well as the mandibular muscles. They had further influences on upper extremity limb movement and cortical interactions. In addition, some cervical nerves supplying the surrounding muscles or running through muscle and their vertebral attachments were implicated in posture control. However, ms well, many nociceptors or pain nerve receptor endings were likewise located not only around the cervical joints, but in the adjacent connective tissue coverings of the cervical vertebrae and its ligaments, as well as the adventitia of its related blood vessels and while normally quiescent could be readily evoked in the face of inflammation and abnormal joint mechanics. Moreover, these evoked responses were consistently found to not only discharge for long time periods, but to have widespread effects on distant tissues and the kinematics of the normal sub adjacent vertebral segments with possible resultant larger than desirable translation displacement in the extension mode and high degrees of motor dysfunction [22-25].

Unsurprisingly, deviations in cervical joint position sense are more evident in the patient with chronic neck pain when compared with healthy controls. As well as subnormal joint position sense relative to various movement patterns static balance was worse in female patients with chronic idiopathic neck pain when compared with asymptomatic controls [20].

Due to similar observations, Peng, et al. [10,14,26] urge clinicians treating cases with neck pain to assess their clients carefully for any neural abnormalities and if so implement a management program to mitigate remediable cervical proprioceptive impairments and possible related sensorimotor control disturbances that may underpin or invoke pain as well as structural muscle, cartilage, and bone atrophy or damage [27,28].

Other research implies some neck pain sufferers may feel neck instability, even if joint position sense is not clinically evident. Indeed, it has been observed that neck pain cases tend to show an overall stiffer and more rigid neck motor control pattern compared to healthy controls and one that may implicate an effort to boost proprioception inputs to muscles despite a lower than desirable degree of neck flexibility that arises in turn. It may also implicate more energy expenditure to maintain a stable rigid head trajectory and head motion pattern that may inadvertently induce fatigue, a possible precursor to declines in psotion sense, even if initially reducing pain provocation [29].

According to Treleaven, et al. [30] the receptors in the cervical spine have important connections to the vestibular and visual apparatus as well as several areas of the central nervous system, thus dysfunction of these in some way can be expected to alter afferent inputs significantly, as far as changing the integration, timing and tuning of day to day sensorimotor control actions. Measurable changes in cervical joint position sense, eye movement control and postural stability and reports of dizziness and unsteadiness by patients with neck disorders can thus be related to such alterations to sensorimotor control.

Nobe [17] proposed that based on their research in specific neck pain patients, the activity of the cervical extensors and flexors associated with neck motion increased with an imbalance in activity between these muscles compared to their activity in healthy adults. In addition, the presence of fibromyalgia like muscle pain and impaired cervical proprioception especially in the face of muscle fatigue were cited as having a possible bearing on explaining an indirect neck related loss of balance control [31] and possibly positional sense. Injury to a cervical located joint also appears to have the possible effect on fostering dorsal root ganglion changes in inflammatory provoking chemicals that sensitize joint afferents to mechanical stimulation and spinal inflammation and may interfere with normal neural messaging inputs [32].

Reddy, et al. [33] also found neck extensor endurance a capacity somewhat vital for maintaining optimal cervical spine function was often defective along with position sense in those with chronic neck pain. Moreover, the direction and velocity receptors of joint movements believed of great import may be impaired and misinterpreted by the central nervous system on receipt thereof [14,34].

This above scenario concurs with observations from the clinic where patients even with minor neck injuries may voice concerns about their vision and balance as well as referred pain and headaches [35-37] and a possible reduced ability to render timely postural adjustments during certain neck

or limb movements [38-40] that may implicate the effects of neck pain on cervical joint position sense error [41-44].

Over time, there may also be associated changes in eye movement control and postural stability and control, reports of dizziness and unsteadiness along with pain regardless of originating site of dysfunction [9,45], thus a high degree of multi rather than singularly derived morbidity issues. These include but are not limited to muscle and joint receptor alterations, changes in joint position sense, heightened inflammatory responses, functional performance declines, and psychological distress.

Discussion

Among the many perspectives studied to explain and highlight the key determinants of cervical osteoarthritis, years of study devoted specifically to uncovering the intricacies of the articular neurology of the cervical spine in various invertebrate and vertebrate models plus efforts to tease out causes of neck pain other than age, have tended to point to a strong interaction between neural based impulses and joint biomechanics among other health related factors.

In this regard, mounting evidence points to a role for the disruption of normal sources of proprioceptive activity and their responses as these may affect head, limb, eye, and lower limb functions as well as cervical spine integrity and ability to position the head accurately over time. In particular, several sources discuss a key role for muscles around deranged neck joints that may react by exhibiting muscle spasm and various degrees of dysfunction, contractures, or alternately hypotonia, weakness, a reduced irritability threshold and pain and are thus likely sources of muscle afferent alterations as well as effective reflex entities. Sensory abnormalities arising in weak or atrophied muscles or deranged ligaments in turn may not only fail to provide positionally accurate data, but may fail to repeatedly exert timely and well modulated motor responses to perturbations that in turn lead to the gradual or acute attrition of one of more cervical spinal structural elements often with dire results.

As per Armstrong, et al. [15], Roh, et al. [41] and Wilder, et al. [42] since a one size all approach may duly fail to offer some degree of benefit, while researchers advocate comprehensive retraining protocols, which include eye and neck motion targeting tasks and coordination exercises, as well as co-contraction exercises to reduce such impairments, some studies show that more general exercises and manipulation may be of benefit. Alternately, overlooked or left untreated, and in the face of prolonged cervical muscle imbalances and forms of internal derangement, one can thus expect increasing bouts of uneven joint loading, increased stresses on some joints and soft tissues, additional pain and possible further alterations in muscle afferent inputs and afferent neural traffic patterns that may well engender periodic joint inflammation flares, and possible additive cervical proprioception disturbances [9]. Moreover, appropriate articular sensory feedback processes, reaction time as well as force generating reactions may be altered within the muscular system such that repetitive movements become distorted and less able to attenuate sudden or successive impulse loading during activity [43-47].

Based on biomechanical study observations [eg., 37], the repeated exposure of one or more vulnerable neck joints and tissues to perpetual and abnormal joint stresses may initiate as well as induce a rapid and more extensive degree of joint degenerative changes than desirable, and a degree of severe pathology and dysfunction where surgery is the only solution. Moreover, even then, it is conjectured that if either the joint or muscle positioning receptor pathways associated with the disease process are unrecognized, and if remediation or rehabilitation is suboptimal or not forthcoming or carefully construed and insightfully integrated in consideration of the diverse morphology, joint and muscle nerve supply of the diseased or painful neck joints their functionally beneficial relationship to head posture and movement control may wane, even if the local cervical pain relief is forthcoming [48,49].

Additional deterministic factors that may have an influence here include but are not limited to overall health status, body mass factors, age, and overall general prognosis. Moreover, outcomes are likely to be impacted according to the degree of disc degeneration commonly characterized by an elevation of inflammatory cytokines, which stimulates the mechanoreceptors in degenerated discs and others, with resultant degrees of peripheral sensitization, abnormal central nervous system inputs, possible sensory mismatches with vestibular and visual information and dizziness. In addition, neck pain caused by cervical disc degeneration can play a key role in cervical discogenic dizziness by increasing the sensitivity of muscle spindles, a key position sense neural attribute [49]. Hence, tailoring the remedy or remedies believed to offer promise to heightening the wellbeing of cervical spine osteoarthritis sufferers is clearly essential to efforts aimed to yield the best result. In addition, the same principle applies even if surgery is a last resort. In the interim, to reduce pain and dizziness and their adverse ramifications, non pharmacologic therapies that focus on enhancing position sense may prove helpful in controlling the disease as well as in providing substantive pain relief.

Manipulation and mobilization therapies conducted manually as well as massage and traction that are discussed in the literature in this regard [eg., 46,47] should proceed cautiously in our view however, as well as being very

accurately targeted and titrated especially if the case in point has had recent analgesic injections or is using narcotics, skeletal muscle relaxants, and exhibits frailty, osteoporosis and rheumatoid arthritis, joint inflammation, and signs of a significantly impaired positional sense. Even then, the affected adult should be cautioned to avoid excess muscle or capsular stretching or fatiguing movements that impact position sense and possible joint stability negatively and incrementally [50].

In sum, and in all instances, and until more research, including anatomical as well as radiological, neural, cellular and molecular aspects of clinical discomfort or cervical joint disease is forthcoming, it appears safe to say that very careful understandings and analyses of the possible sources of cervical pain and associated declines in joint position sense in any region are paramount to the rational selection of treatments and although likely to differ widely are expected to prove additive in benefits rather than not.

Moreover, based on what we know about the painless origins of most osteoarthritis forms, it appears that even if no observable or measurable evidence of any joint lesion prevails the adult's ability to reposition their head in different directions can be tested clinically and may predict a more proactive course of intervention to limit this. As well, cases complaining of persistent postural disturbances or dizziness should undergo intermittent observation to avert any possibility of developing a state of neuropathic type pain and joint damage.

At all stages, specific sensorimotor training and rehabilitation strategies including helping patients to manage pain, as well as their ability to improve afferent feedback in those with poor position sense may be helpful. Additionally, extensive diagnostic follow ups along with efforts towards mitigating any negative associated affect as much as possible may yield immense functional benefits even in the face of irreversible pathology. In addition, such strategies may be especially effective in limiting the spread of the disease and retarding the rate of osteoarthritis progression and reducing any perceived handicap.

Conclusion

Although this article provides but a snapshot of the topic of interest and is one that may have omitted salient research inadvertently, based on a 25 year study by the author of this topic, and many clinical years of practice, it appears safe to say:

When attempting to understand the nature of painful cervical osteoarthritis, the role of afferent signals arising from the joint and muscle receptors and their cortical and spinal regulatory influences and functional significance should not be overlooked.

- Only very carefully construed therapies that account for the need to restore an efficient and effectively integrated repertoire of neural reflex responses and joint sense applied over time are likely to succeed as opposed to any singular unidimensional generic approach implemented on a single occasion or sporadically.
- To avert a widespread potentially increasing threat to optimal health, longevity and life quality among many older as well as younger adults experiencing chronic cervical pain and degeneration determinants, researchers and clinicians are urged to examine and document their observations in this respect including measures of joint position sense and the ability to map these data with synovial fluid assays and cartilage biomechanical attributes.

Currently, it appears safe to predict less harm will emerge to aging adults as well as health systems and costs if all cases reporting persistent neck discomfort are subject to early sustained monitoring and screenings that include those measuring joint reposition sense and balance plus interventions that are enacted both insightfully and with fidelity thereafter so as to avert a multitude of cascading biochemical and biomechanical disturbances and their possible untold costs. In addition to lifting limits on access to therapies that may require prolonged therapeutic efforts and resource access, refraining from a reliance on technology to deliver therapy, public and local campaigns to promote safe driving, sports, workplace, and environmental safety, and general awareness and the importance of preventing "cervical spine locomotive syndromes" including chronic neck pain may be warranted.

In the interim, we agree with Ferreira and de Luca [50] that cervical osteoarthritis encompasses more than just pain, and has immense ramifications for the wellbeing and independence of older people within the community. At present though, despite its global burden, spinal pain in this group is often poorly managed, and knowledge of safe and effective treatment strategies are lacking perhaps because of the common exclusion of older people in the realm of clinical research. It is however, a potent disabler of older adults not simply just a burden of pain; and its physical and personal impact directly threatens efforts to support healthy ageing locally and globally, especially if the osteoarthritis is accelerated due to overlooked disruptions in afferent and efferent motor control.

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