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# JCCA
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***Imaging case review***

# Editorial Board

# JCCA April 2023 Chiropractic Sciences Special Issue: 4th Edition

Brynne E. Stainsby, BA, DC, FCCS(C)[1]
Assistant Editor

(JCCA. 2023; 67(1):6)

KEY WORDS: chiropractic, clinical

Éditorial
JCCA Avril 2023 – Numéro spécial des sciences chiropratiques : 4e édition

MOTS CLÉS : chiropratique, Clinique

It is my great honour and privilege to present this fourth Chiropractic Sciences issue of the JCCA. This issue includes practical case reports, an interesting pilot study, reviews, an imaging case review and important original research – whatever your practice area, I'm sure you'll find relevant learning in the pages that follow. I hope this content helps to inform clinical practice as well as future research endeavours for each of us as individuals and collectively as a profession.

The growth of research and scholarly activity in chiropractic in Canada has been fueled by dedicated researchers, Chiropractic Sciences Fellows, faculty members, residents, and students. I would like to thank Dr. Kent Stuber for his support of ongoing Chiropractic Sciences edition, and his leadership through the JCCA. I would also like to thank all of the contributing authors and peer reviewers who have helped make the JCCA Chiropractic Sciences issue possible. Lastly, I am so grateful to each of you for committing to read this important work and working so hard to advance health care for our patients and all Canadians. As Albert Einstein said, "Wisdom is not a product of schooling but of the lifelong attempt to acquire it". I hope this issue of the JCCA allows you to continue to learn and grow.

I encourage you all to get involved in research. Be inquisitive and ask questions. If you have an interesting case, set of data or research ideas or questions that you would like to further investigate and need any help, please do not hesitate to contact me, one of the JCCA's Editorial Board members, or a member of the College of Chiropractic Sciences (Canada) (https://ccs-canada.ca).

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# Should you adjust that herniated disc? Thoughts from a chiropractor/molecular scientist

W. Mark Erwin, DC, PhD[1-3]

*Low back pain accounts for the most years lost to disability of any malady worldwide but most cases of disc herniation (DH) and degenerative disc disease (DDD) resolve with conservative methods. Numerous tissue sources of pain affecting the degenerative/herniated disc have been identified, with changes secondary to the influence of inflammation figuring prominently among them. Due to the proven linkage of inflammation to the pain and progression of disc degeneration, anti-inflammatory/anti-catabolic and*

*Les douleurs lombaires sont responsables du plus grand nombre d'années perdues pour cause d'invalidité, toutes pathologies confondues, mais la plupart des cas de hernie discale (HD) et de discopathie dégénérative (DD) sont résolus par des méthodes conventionnelles. De nombreuses sources tissulaires de douleur affectant le disque dégénératif/herniaire ont été identifiées, les changements secondaires à l'influence de l'inflammation figurant en bonne place parmi elles. En raison du lien avéré entre l'inflammation et la douleur et la*

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*pro-anabolic repair strategies are gaining prominence for novel therapeutic approaches. Current treatments include conservative therapies such as modified rest, exercise, anti-inflammatory treatments, and analgesics. There is no accepted proposed mechanism of action to support the direct role of spinal manipulation for the treatment of the degenerative and/or herniated disc. However, there are published accounts of very serious adverse events accompanying such treatments leading to the question; 'should a patient with suspected painful IVD be treated with manipulation?*

(JCCA. 2023;67(1):7-18)

KEY WORDS: chiropractic, disc, herniation, safety

*progression de la dégénérescence discale, les stratégies de réparation anti-inflammatoires/anticataboliques et pro-anaboliques sont de plus en plus utilisées comme nouvelles approches thérapeutiques. Les traitements actuels comprennent des thérapies conventionnelles telles que le « repos modifié », l'exercice, les traitements anti-inflammatoires et les analgésiques. Il n'existe pas de mécanisme d'action proposé et accepté pour soutenir le rôle direct de la manipulation de la colonne vertébrale dans le traitement de la dégénérescence et/ou de la hernie discale. Toutefois, des comptes rendus publiés font état d'effets indésirables très graves liés à ces traitements, ce qui amène à se poser la question suivante : « Un patient soupçonné de souffrir d'une discopathie dégénérative douloureuse doit-il être traité par manipulation? »*

(JCCA. 2023;67(1):7-18)

MOTS CLÉS : chiropratique, hernie discale, sécurité

Back and/or neck pain associated with disorders of the intervertebral disc (IVD) are a well-recognized source of spinal pain with and without radicular symptoms and disabling spinal pain is the world's leading cause of years lost to disability.[1] The causes of pain and disability associated with disc disease (herniated and/or degenerative disc disease or 'DDD') are difficult to accurately diagnose even with sophisticated imaging including CT, MRI scanning and provocative testing such as discography. A thorough history, careful physical examination and appropriate imaging can lead to a presumptive diagnosis of 'discogenic pain' in each patient, however certainty of diagnosis unless reproduced such as through provocative discography, remains elusive. Most episodes of back and/or neck pain are self-limiting and respond to rest, modified activity, analgesics and/or anti-inflammatory interventions. Patients suffering from symptoms of axial and/or radicular pain commonly seek such treatment advice from their family physician, physical therapists, massage therapist, chiropractors, and acupuncturists. Treatments provided by these professionals predictably varies according to the unique perspective / skill set / bias of the respective provider. The chiropractor ought to consider a treatment plan to address pain of discogenic origin based upon a contemporary understanding of the pathobiology of the intervertebral disc and an appropriate risk / reward analysis. This review provides an updated overview of the pathobiology of degeneration of the intervertebral disc and mechanisms of pain with a view to treatment decision making with an emphasis upon the treatment of disc herniation.

## Pathology of disc degeneration

The anatomical aspects of the IVD are well known and many review papers that describe the molecular and cellular events integral to disc degeneration have been published previously.[2-6] There are numerous inter-related cellular and biological processes that summate to result in degeneration of the IVD and contribute to a loss in IVD integrity, impaired biomechanical properties, disability, pain, and the possible advent of a herniated disc. These processes include a loss of homeostatic regulation of the IVD whereby pro-inflammatory signaling within the IVD lead to progressive cell death, impaired extracellular matrix and cellular communication, all of which potentiates further degeneration.[6-10] It is impossible for the clinician to know the precise cellular/molecular signaling status of

a given patient's degenerative disc since the temporal aspects of these biological processes vary from person to person as well as with differing degrees of degeneration. However, what is a certainty, is that disc degeneration impairs loadbearing of the disc and is associated with osteoarthritis of the facet joints, varying degrees of hypertrophy of segmental ligamentous structures and disorders affecting the endplates; all of which may contribute to some degree to the patient's status and pain.[11-14] Impaired loadbearing may contribute to spinal pain of discogenic origin for several reasons including activated nociceptors within the outer annulus, facet joints and joint capsules, and paraspinal muscles and is one of the reasons why discogenic pain is often relieved by rest (lying supine or side lying) or by de-loading such as by the patient supporting themselves to 'offload' their back. Pain relief by offloading is also one of the principles underlying such treatments as traction where some patients report significant pain relief at least while the traction/offloading therapy is underway.[15] Other aspects of disc-related pain include contributions of neoinnervation and neovascularization that can occur presumably secondary to pro-inflammatory changes within the disc.[8,16-18] It is important to recognize that a herniated disc (unless through overt trauma) is almost always downstream of internally dysregulated cellular/extracellular matrix integrity, a series of processes that can present through recurrent episodes of spinal and/or radicular pain or from an acute episode without a history of past events.

## Pain of disc origin

It has been extensively demonstrated that under a variety of circumstances, which predominantly include degeneration and damage, the IVD can be a cause of pain.[19-22] However, determining that the disc is the source of pain has been a clinical and experimental challenge for many years. Surgical removal of herniated disc tissue that compresses a spinal nerve can provide significant pain relief of up to 90% of patients in the immediate post-op period or within four weeks, however the pain reduction seems to lose significance at approximately one year post surgery.[23] With respect to the herniated disc, various non-operative treatments such as rest, extension-based exercise, epidural steroid injections, NSAIDS/analgesics also show good results with up to 90% experiencing relief within four to six weeks.[23] Non-operative treatments may result in resolution in most patients suggesting that the presence of the herniated fragment(s) alone may not account for the genesis of the patient's pain. Nonetheless, pain and disability do not resolve in a smaller number of patients for reasons that remain to be determined. In what may come as a surprise to many clinicians, imaging studies of patients suffering from disc herniation have shown that the size of the herniated disc material does not correlate with symptoms, suggesting that other causes of the patient's pain are at play, including macrophage mediated tissue digestion and immune modulatory mechanisms.[24]

Disc degeneration is common in persons over 30 years of age and in many cases is largely asymptomatic (aside from possible contribution to self-limiting back pain afforded perhaps by muscular adaptation to some degree of loadbearing anomalies).[25] In the event of a symptomatic herniated disc, there are myriad causes of pain both local and radicular that are more closely associated with the pathology affecting the disc. For example, distortion of and/or pressure/contact with the annulus fibrosus by herniated fragments may activate mechanoreceptors and nociceptors within the annulus, posterior longitudinal ligament and activate reflexive muscular activity leading to muscle spasm and the generation of pain.[22,26,27] Pressure placed upon spinal nerve roots plus inflammation associated with such contact often results in the advent of radicular pain within the dermatome of the specific nerve root(s) that may develop within hours, days, weeks, or months. A recent report by Gupta e*t al* examined the size of lumbar disc herniation and predictive value for the success of non-operative therapy.[24] This was a retrospective study of 368 patients who had a diagnosis of primary lumbar radicular pain with MRI documentation of a lumbar disc herniation and who also had completed at least a six-month course of non-operative, conservative management. The conservative management inclusion criteria included nonsteroidal anti-inflammatory medication, gabapentin or pregabalin, or pain medication, steroid injection, or physical therapy (not defined) in patients followed for a minimum of two-years. Interestingly the authors report no association between the size of the disc herniation and non-operative recovery. The odds ratio between herniation size and the likelihood of surgical treatment in this study was 1.003 indicating no statistical association between disc herniation size and failure (or success) of conservative treatment.[24] A similar report by

Benson *et al*.[28] found that large disc herniations could be managed conservatively, including massive disc herniations with up to 85% dural sac stenosis. In addition, a prospective cohort study by Gugliotta *et al*.[29] showed that surgical treatment had better pain relief in the short term (three months post op) but such benefits were no longer seen at one year without regard to the size of the herniated disc. It is noteworthy that in none of the above conservative vs surgical care published papers was spinal manipulation included within the conservative care treatment groups. Taken together these studies indicate that an optimal treatment to address disc herniation continues to remain elusive and that the resolution of a herniated disc follows a largely favorable natural history (of course associated with appropriate symptom management).

With respect to the genesis of pain from the disc, several mechanisms have been proposed and some have been validated using in vivo animal experiments, but much remains to be determined. However, pain emanating from the IVD must be facilitated via nociceptive capable neurons primarily within the annulus fibrosus but also the vertebral endplates and in some cases, from the nucleus pulposus. With respect to nociception, a class of proteins known as neurotrophins, and neuropeptides have been implicated in the development/modulation of pain including pain of IVD origin.[30-32] It has been shown that almost all painful human degenerative discs increase their expression of various neurotrophins such as Nerve Growth Factor (NGF), the Nerve Growth Factor Receptor (TrkA), Brain Derived Factor (BDNF), the BDNF receptor (TrkB), and the neuropeptides Substance P and Calcitonin Gene Related Peptide (CGRP) and its receptor, Calcitonin Receptor Like receptor (CALCRL).[30,32,33] Neurotrophins are factors important in the regulation of neuronal survival, development and nociception and are central to cellular responses to inflammation and pain.[21,30,34,35] Importantly, neurotrophin expression is also associated with neovascularization and neoinnervation that occurs with the degenerative disc that is a central aspect to the activity of IVD nociceptors and discogenic pain.[36] Low back pain of IVD origin has been associated with neural ingrowth and the expression of neurotrophic factors including NGF, BDNF, TrkA, and TrkB that are thought to contribute to primary disc pain.[36] Freemont *et al*.[16] were the first to report that nonmyelinated nerve fibres grew into intervertebral discs thought to be painful and that these fibres expressed Substance P. Freemont *et al*.[37] subsequently determined that these IVD-penetrating unmyelinated nerve fibres expressed TrkA as well as NGF. In another report Yamauchi *et al*.[38] showed that conditioned media developed by culturing human IVD tissues obtained from spinal surgery for painful DDD when cultured with neonatal rat dorsal root ganglia (DRG) cells led to axonal growth in the cultured DRG cells. In contrast to untreated media, the authors showed that neuropeptides such as substance P were induced within cultured DRGs only in the presence of media conditoned by degenerative human IVD cells.[38] It has been widely reported that inflammation associated with DDD such as increased expression of Il-1β and TNF-α are also associated with increases in pro-inflammatory cytokines within the IVD such as IL-6 and IL-8. These pro-inflammatory events together, potentiate the pro-catabolic, degenerative cascade that summate in a positive feedback cycle of inflammation, cellular/extracellular matrix degradation and elevated levels of neurotrophins/neuropeptides within the IVD, DRG and spinal cord and association with the development of a painful IVD.[9,30-32,38,39] Figure 1 depicts a pictorial representation of neurotrophin/neuropeptide expression and putative roles in nociception.

In a needle puncture-induced rat model of DDD, Sugiura *et al*.[40], reported that post IVD puncture and saline injection, there was a significant upregulation of the neuropeptide CGRP in the respective DRGs subserving the affected discs. This study provided support for the hypothesis that disc damage/inflammation may potentiate the expression of pain-related neurotrophins/neuropeptides and provide a basis for disc-mediated pain[40]. Further, Yamauichi *et al*.[41], reported that proliferation of sensory nerves that innervate the degenerative disc is induced by NGF, itself expressed within the NP[38]. Additionally, in a study examining healthy and degenerative human IVDs, Purmessur *et al*.[32], reported that the expression of TrkA and TrkB within the IVD are increased in cases of more severe disease. The author's group has recently published a manuscript in which, amongst other experiments, we assessed the expression of NGFr, BDNF, TrkB, and CALCRL (Calcitonin Receptor Like receptor) in human IVD tissue obtained in cases of discogenic pain and found that virtually all samples strongly expressed these neurotrophins/neuropeptides (Figure 2).[33] Tissues used in Figure 2 kindly provided by Dr. Ivan Cheng, Stanford University, and prepared as described in Matta *et a*l 2022.[33]

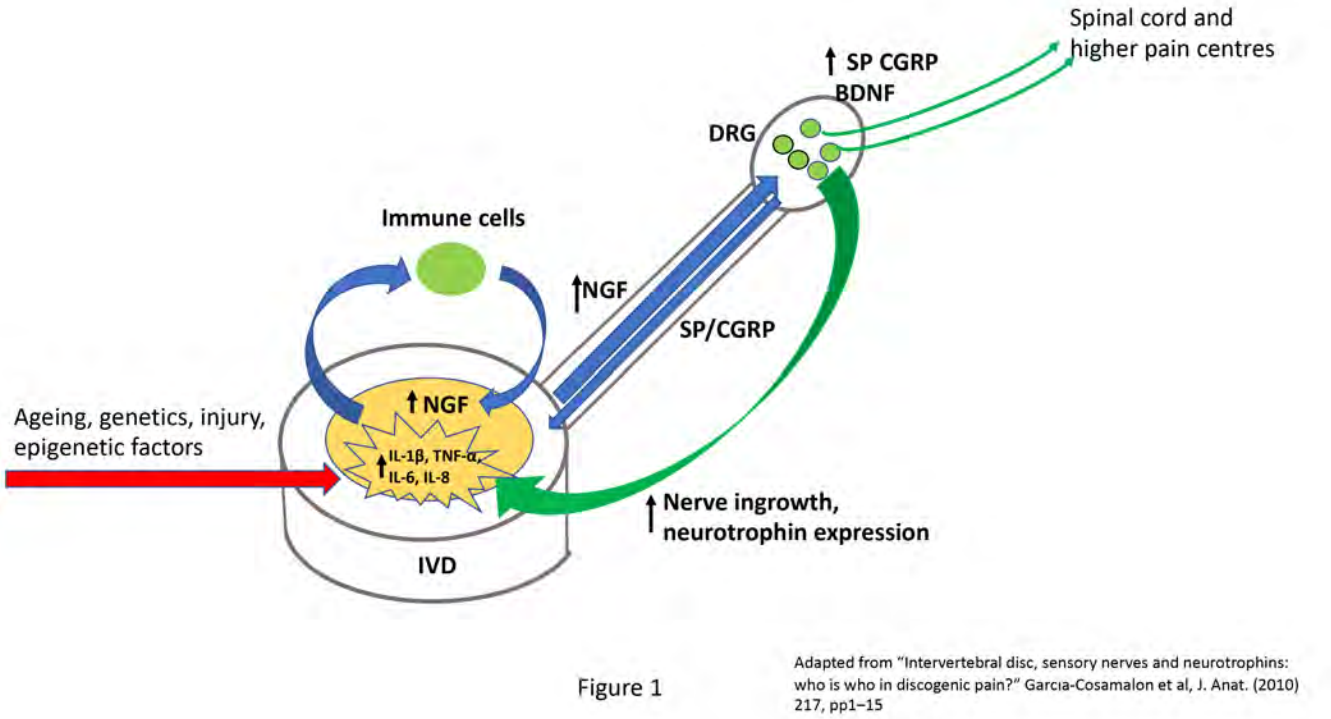


Figure 1.
*Pictorial representation of the interplay between pro-inflammatory cytokine expression within the degenerative disc, interaction within the peripheral nerovous system (DRG innervation and retrograde neurotrophin expression), neoinnervation and pain in a theorized mechanism of neurotrophin/neuropeptide/inflammatory cytokine induced IVD pain.*

In an in vivo study involving rodents subjected to painful whole body vibration, Kartha *et al*.[42] showed that cervical spine IVDs significantly increased their expression of pain-related neurotrophins as compared to controls. In the Kartha *et al*.[42] study, it was shown that after painful, whole body vibration, BDNF levels within the IVD were increased that also significantly correlated with increased levels of pain, thus supporting the hypothesis that BDNF may play a central role in the generation of discogenic pain.[42] BDNF is thought to play a central role in the modulation of nociception via anterograde transport from the DRG that in turn increases neuronal hyperexcitability in the spinal dorsal horn.[43] With respect to the important role played by BDNF in disc pain, the expression of BDNF in the disc increases with degenerative grade.[31,32,44]

Most recently in a paper by the author's group using a large animal study of needle puncture induced DDD, in injured IVDs that subsequently received a single intradiscal injection of saline, the annulus fibrosus showed significantly increased expression of neurotrophins/neuropeptides associated with pain.[33] However, a single injection of a molecular therapy that has been shown to inhibit DDD, significantly suppressed the expression of neurotrophins/neuropeptides at levels indistinguishable from untreated control discs.[33,45] Taken together, the preceding cited papers strongly support the hypothesis that disc injury is associated with inflammation and increased neurotrophin/neuropeptide levels that increase nociception and disc-related pain. Therefore, if pain arises as a consequence of cellular/molecular events unique to the damaged disc, how can an externally applied physical load (such as SMT) positively influence the expression

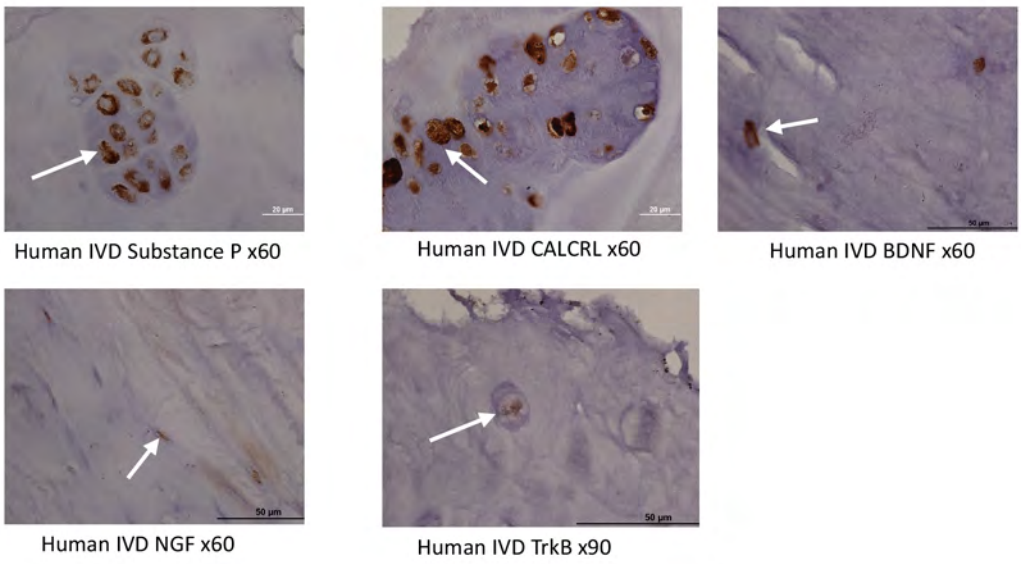


Figure 2. *Immunohistochemical staining (DAB chromogen) of human IVD tissues obtained at the time of spinal surgery. (a) Substance P, (b) CALCRL, (c) BDNF, (d) NGF, (e) TrkB. Immunohistochemical staining utilized the DAB chromogen with positive staining depicted by brown deposits (white arrows).*

of pain by these tissues? Furthermore, a seminal paper by Burke *et al*.[46] showed that the discs obtained from patients who had surgical treatment for disc disease (herniated/degenerative disc) and back/leg pain expressed significantly increased levels of interleukin-6 and -8 (IL-6 and IL-8) as compared to normals or persons experiencing only radiculopathy. The author's group published a large animal trial of needle puncture-induced DDD and showed that in animals that received needle puncture followed one month later by saline injection the treated discs also expressed significantly increased IL-6 and IL-8 as compared to no treatment control discs.[33]

Furthermore, recent work has determined that changes within the IVD NP milieu including the percentages of lactic acid, alanine, and propionic acid as well as alterations in the proteoglycan/collagen ratio may account for primary disc pain.[47] The determination of these changes uses a new (and investigative) technology termed 'MRI spectroscopy' (MRS). MRS is a non-invasive method of determining molecular alterations with the NP that has a high correlation with provocative discography without the downside of inducing disc damage.[48] In the future, it may be that such imaging will greatly assist the diagnosis of disc-centric pain. For the present however, in addition to the use of provocative discography (although due to significant inter-examiner reliability and possibility of downstream procedurally induced DDD), a combination of imaging such as MRI, physical examination and patient history remain the only methods available to determine the specific role played by the IVD in the generation of pain.

## Vertebral endplate-mediated pain

In addition to MR spectroscopy that can identify IVD NP biochemical sources of pain, recent research has focused upon the vertebral endplates as possible sources of pain, over and above pain of annulus/nucleus origin. Using modified MRI analytics, it has been shown in investigative reports, that Modic changes can be a source of pain and that Modic type 1 changes (inflammation related as compared to fatty infiltration such as is the case with Modic type 2) are more associated with LBP.[49,50] It has also been reported that Modic type 1 changes are more amenable to conservative management whereas Modic type 2 (fatty bone marrow infiltration) are refractory to therapy.[51] More emerging imaging platforms are currently under development that utilize short-echo time (TE) or ultrashort TE(UTE) MRI sequences that can detect pathological changes in vertebral endplate morphology.[52] The possible utility of these imaging platforms may be to replace the semi-quantitative Pfirrmann grading system with (in addition to MRI spectroscopy) and quantitate changes within the vertebral endplates that may significantly contribute to spinal pain associated with DDD. The

report by Berg-Johansen[52] suggests that vertebral endplate thickness is correlated with Pfirrmann grade, and that new MRI imaging technology may provide objective assessment of tissue sources of back pain.

## Clinical decision making

Clinical decisions with respect to the best treatment for a patient suffering from presumptive disc-related pain (a herniated disc in particular) will depend upon patient-specific conditions including age, overall health, neurological status, pain, function, and orthopedic testing plus relevant imaging. Once a presumptive diagnosis of disc-related pain has been made (axial and/or radicular), a treatment plan would be devised based upon available evidence, where the benefit of a given treatment should outweigh its risk These decisions are particularly important when contemplating spinal manipulation (SMT) since these types of treatments involve external loads applied to the involved spinal segment(s) plus areas remote to the injured/degenerative segment. The contribution of a degenerative disc to mechanical spinal pain is difficult to assess in that impaired loadbearing could certainly result in forces acting upon local and more remote spinal joints/tissues that result in adaptive muscular reflex action and presumably associated mechanical pain. Furthermore, it has been reported that the application of spinal manipulation to a given segment also loads segments remote from the 'targeted' vertebral segment.[53] It is likely that these conditions are a consequence of muscle spindle/golgi tendon organ mediated reflexive muscle splinting or 'spasm' when the patient's pain is of an axial character.[27] Such conditions have been reported to be amenable to physical therapeutic maneuvers including stretching, mobilization, manipulation, modified rest, and exercise.[54]

## Resolution of the herniated disc

As cited earlier, numerous published manuscripts detail that approximately 90% of herniated discs recover with 'conservative therapy' and have a favorable natural history. Various mechanisms have been proposed to explain the ability of herniated disc to resolve that include pressure upon the herniated mass from the posterior longitudinal ligament, macrophage invasion and resorption, resorption associated with inflammation and even dehydration.[55,56] There have also been hypotheses that the herniated material may retract back inside the IVD because of dehydration, although this has yet to be conclusively demonstrated.[24,28,56] The herniated disc can be considered to be a downstream effect of degeneration of the IVD (apart from overt trauma) that leads to loss of water binding within the IVD extracellular matrix, impaired loading tolerance, the development of fissures and tears within the annulus fibrosus that may extend into the nucleus pulposus.[2,12,57] It is therefore difficult to understand how a herniated disc could retract into the IVD NP and if so, how the material would remain in place given the degradation of the cellular/extracellular matrix, impaired water binding, fragmented proteoglycan core proteins and increased degradative enzymatic activity.[12,58] Therefore, the herniated disc may resolve/resorb over time, or it may not appear to change in size at all. However, many patients (up to 90%) experience relief within three months or more without surgery; raising the question of the relevance of actual herniated material to the pain experienced by the patient and is there any utility in attempting to affect the herniated material? Alternatively, if the herniated material persists, what might be the risk of dislodging such material through externally applied loads? At the present the precise mechanisms involved with resolution of the herniated disc remain to be clarified.

## Spinal manipulation and the intervertebral disc

In a case whereby the patient's pain is thought to be associated with an 'active' disc disorder, clinicians may consider the use of spinal manipulation as a treatment option. In the case of spinal manipulation, contemporary theories with respect to its mechanism of action include a gate-controlled theory involving stretch receptors and spinal/supraspinal pain regulation that may be associated with gapping of synovial joints and rapid pressure reduction within the joint and gaseous events associated with this maneuver.[27,59] However, the disc is not a synovial joint therefore the gapping of joints theory would not apply. Despite many years of use and several prospective studies (lacking controls), a cogent theory that may seek to explain a reason to contemplate the use of spinal manipulation with respect to the herniated disc remains elusive.[27,59] This form of treatment has in some publications, reported to be safe with a very low risk of adverse events.[60] With respect to the treatment of disc herniations by spinal manipulation Leeman *et al*.[61] published a manuscript that detailed the treatment of patients with MRI confirmed lum-

bar disc herniation and low back and/or leg pain associated with the disc herniation. In this manuscript, the authors presented data showing that patients treated with one of two different forms of manipulation yielded a favorable result with no patients experiencing untoward outcomes.[61] This study contains several limitations, chief among them is a lack of control group, therefore it is not possible to quantify any reported improvements that may be a product of natural history. This aspect is an important one in that the natural history of lumbar disc herniation is quite favorable. Numerous studies have reported a very favorable natural history with over 90% recovery between four to six weeks.[23] The Leeman *et al*.[61] study involving spinal manipulation, reported a very good recovery within 12 weeks, arguably well within the period where natural history may account for symptom resolution. Also, there were no post-treatment/symptom resolution MRI scans making it difficult to discern whether the manipulations performed had any discernible effect upon the herniated disc. A randomized, controlled study by Brontfort *et al*.[62] involving leg pain of 'back origin' reported that using spinal manipulative therapy (SMT) and home exercise/advice, and reported that there was an advantage of SMT plus home exercise and advice over home exercise and advice only after 12 weeks. In this study the authors reported that at 12 weeks, 37% of patients receiving SMT plus home exercise and advice had a minimum of 75% reduction in leg pain, as compared to a 19% reduction in the home exercise and advice group. There were no adverse events reported in this study. However, there was no discussion of any imaging results and there was not mention of diagnosis (Spinal stenosis? Herniated disc? Disc protrusion? Other?) thus creating difficulties with data interpretation.[62] Another report involving a series of patients with cervical spine disc herniations that were treated with spinal manipulation claimed to have offered relief with no instances of adverse events.[63] On the other hand, spinal manipulation has been found to be linked to worsening of the condition including cauda equina or spinal cord compression.[53,64,65]

It has been reported that various physical maneuvers such as lumbar joint mobilizations, prone press ups as well as spinal manipulation has an effect upon water movement within the disc (assessed by pre and post MRI) that has an association with changes in back pain.[66,67] These evaluations use a form of MRI assessment and a determination of "associated diffusion coefficient' (ADC) that ostensibly determines the migration of water within the disc. As much as there is an association with changes in water movement within the disc, currently there is no hypothesis concerning whether such changes in fluid flow within the disc affects pain or how this change in water content might have any effect(s) upon pain.

From the perspective of clinical decision making, due to a series of litigation cases, recent publications within the jurisprudence area has recommended that spinal manipulation treatments not be performed in acute cases of disc injury and that such treatment ought to be reserved for after a period of 'watchful waiting'/conservative care.[53] In particular, the courts found that lumbar disc herniation may be aggravated/caused by spinal manipulation even upon vertebral segments remote from the involved area and this was cited to be particularly the case when a disc herniation was already present.[53] A prior manuscript published by the author presented a review of the cellular/molecular biology of the intervertebral disc and included a clinical vignette of a patient who presented with spontaneous neck and arm pain some 15 years following a motor vehicle accident.[2] In this manuscript the patient in question was found to have a large disc herniation compressing the cervical spinal cord and associated nerve root that upon clinical examination showed elements of cervical spondylotic myelopathy. The patient was treated initially with a neck brace but was then referred for an anterior cervical discectomy and fusion following which she made a full recovery with complete resolution of the symptoms of myelopathy (abnormal gait, Hoffman sign).[2] The salient question in this case was what might have occurred should the patient's cervical spine been manipulated. In this case of course the pathology was spinal cord compression that is clearly more of a risk than dural sac compression that may occur in the lumbar spine. Of course, this publication is only a single case observational one and global conclusions would be inappropriate, nonetheless, the risk/reward ratio ought to be considered when the clinical encounters a symptomatic disc herniation-particularly in the cervical spine.

Taken together, there is a robust body of published data showing that with damage/degeneration, IVDs develop changes in their morphology and cellularity that increase the expression of pain-related neurotrophins/neuropeptides that are associated with IVD pain.[30-32]

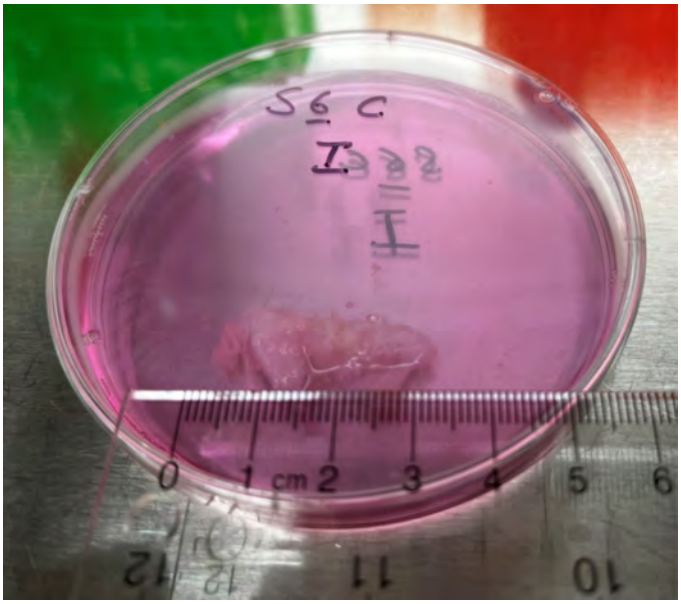


Figure 3.
*Gross operative specimen from a human herniated lumbar (L4/5) IVD. The specimen is approximately 3 x 1 cm in size, contained within a 70mm Petri dish in Dulbecco's Modified Eagle Medium.*

Further, disc damage and degeneration increase IVD NP expression of pro-inflammatory and catabolic molecules (IL-6, IL-8, lactic acid, alanine, and propionic acid that are associated with IVD pain) and develop pathological changes within the IVD endplates.[9,45-51,68,69] These and associated biomechanical abnormalities likely account for a large amount of the pain and disability associated with IVD pathologies and are clearly tissue level pathological changes that would not be amenable to spinal manipulative techniques. The cases of IVD pain that are refractory to conservative care account for most of the expense and disability associated with disc pathology that urgently require novel, effective therapies that can address the pro-catabolic, pro-inflammatory and anti-anabolic effects that occur in the presence of disc disease. However, the salient question remains, what is the most effective treatment method to use in the case of the herniated disc? Ought spinal manipulation be considered and if so, why? A 'chunk' of herniated nucleus pulposus tissue may be precariously attached to the disc itself, therefore the question of what externally applied loads may do to such tissue is an important consideration (Figure 3) (material graciously provided by Drs Paul Salo and Ganesh Swamy, University of Calgary). The tissue in Figure 3 is gross surgical material within tissue culture media (Dulbeccos' Modified Eagle Medium containing 10% fetal bovine serum, penicillin/streptomycin).

## Conclusions

The herniated disc with or without radiculopathy, presents a clinical challenge to the treating practitioner and the patient alike as the pain can be excruciating and debilitating. Fortunately, natural history is favorable with a large percentage of patients reporting recovery within three months largely regardless of the applied therapy. It remains to be seen whether non-surgical treatment hastens recovery although in some cases interventional care such as selective nerve root block injections can help to suppress pain until the disc injury heals on its own.[70] The same can be said about oral steroid medications that are used acutely with a steep decline in dose over a short period of time. The goal with these treatments is to suppress inflammation either directly by injection in the case of an epidural or transforaminal nerve root block or via systemic delivery. The commonality of these treatments is an attempt to modulate the inflammatory pathway(s) thought to be responsible for a good deal of the pain/disability in the patient suffering from disc herniation. Tissue level changes of the herniated disc downstream of the acute phase, whether it be resorption, dehydration, or macrophage-mediated digestion is likely variable and certainly incompletely understood. It may be that a combination of inflammation and increased nociception of the damaged disc (inflammation/neurotrophin expression?) are key players in the acute phase, with inflammation thought to

contribute to IVD endplate changes in the case of Modic type 1 changes.

As discussed within the body of this paper, there is a paucity of evidence to support the use of spinal manipulation to treat disc degeneration/herniation AND a relative lack of convincing supportive data for its use. Within the context of the pathologies known to affect the degenerative/herniated disc as presented herein, the clinician is therefore, left to ponder why the use of SMT would be contemplated at all? Published cases whereby SMT was used to treat the patient suffering from spinal pain and/or radicular pain in the presence of disc herniation for example, often lack suitable controls providing objective evidence that the herniated disc in question was causative of the patient's pain/disability (no provocative discography, MRI spectroscopy, electrodiagnostic evidence). Further, to the author's knowledge, there are no published studies that examine the appearance of the herniated disc (such as MRI) post treatment, leading unresolved the question of what SMT may accomplish and how. These continue to be unresolved and important questions; however, the clinician would be well advised to consider the risk/reward ratio when considering manipulating a patient's spine in the presence of a herniated disc and justifying such an approach in an absence of any proven mechanism of action.

From the author's perspective, when deciding upon a treatment for a patient suffering from a suspected herniated disc, particularly if there is a radiculopathy, it is wise to remember the salient 'first do no harm' principal contained within the Hippocratic Oath. There is no harm in watchful waiting when the patient can be provided with measures that they can follow (exercise, positional relief) to help manage their pain coupled, when necessary, with a multi-disciplinary plan of action such as medication and/or interventional measures. The use of spinal manipulation may have a role to play, however at present, there is insufficient data available to know when and how to apply such therapy and what to expect.

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# A narrative review of social determinants of health education in health professional programs and potential pathways for integration into Doctor of Chiropractic programs

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Objectives: *To conduct a narrative review of the literature pertaining to strategies employed by health professional programs to teach social determinants of health (SDOH) and use the results to describe pathways for integrating SDOH education into Doctor of Chiropractic programs (DCPs).*

Methods: *A narrative review of peer-reviewed literature describing SDOH education in health professional programs within the United States was performed. The results were used to inform potential pathways of integrating SDOH education into all aspects of DCPs.*

Results: *Twenty-eight papers demonstrated health professional programs' incorporation of SDOH*

Un examen narratif des déterminants sociaux de la santé dans les programmes de formation des professionnels de la santé et des possibilités d'intégration dans les programmes de doctorat en chiropratique

Objectifs : *Réaliser une analyse narrative de la littérature relative aux stratégies employées par les programmes de professionnels de la santé pour enseigner les déterminants sociaux de la santé (DSS) et utiliser les résultats pour décrire les voies d'intégration de l'enseignement des DSS dans les programmes de doctorat en chiropratique (PDC).*

Méthodes : *Une analyse narrative de la documentation évaluée par les pairs décrivant l'enseignement des déterminants sociaux de la santé dans les programmes de formation des professionnels de la santé aux États-Unis a été réalisée. Les résultats ont été utilisés pour éclairer les voies potentielles d'intégration de l'enseignement des DSS dans tous les aspects des PDC.*

Résultats : *Vingt-huit articles ont fait état de l'intégration, par les programmes de professionnels*

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*education and assessment into didactic and experiential learning opportunities. Educational interventions resulted in positive changes in knowledge and attitudes toward SDOH.*

Conclusion: *This review demonstrates existing methods for integrating SDOH in health professional programs. Methods may be adopted and assimilated into an existing DCP. Further research is needed to understand barriers and facilitators to the implementation of SDOH education into DCPs.*

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KEY WORDS: chiropractic, curriculum, education, health professional education, social determinants of health

*de la santé, de l'enseignement et de l'évaluation des DSS dans les possibilités d'apprentissage didactique et expérientiel. Les interventions éducatives ont entraîné des changements positifs dans les connaissances et les attitudes à l'égard des DSS.*

Conclusion : *Cette étude présente les méthodes existantes d'intégration des DSS dans les programmes de formation des professionnels de la santé. Ces méthodes peuvent être adoptées et assimilées dans un PDC existant. D'autres recherches sont nécessaires pour comprendre les obstacles et les facilitateurs de la mise en œuvre de l'enseignement des DSS dans les PDC.*

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MOTS CLÉS : chiropratique, curriculum, éducation, éducation des professionnels de la santé, déterminants sociaux de la santé

## Introduction

Social determinants of health (SDOH) are "the conditions in which individuals are born, live, learn, work, and age, and the wider set of forces and systems shaping the conditions of daily life."[1] SDOH include factors such as employment status, level of income, level of education, food and housing security, and access to health care throughout the lifespan.[1] SDOH account for between 30-55% of health outcomes[1], therefore it is critical for health professionals to identify and address these factors in patient encounters. As such, there have been calls to action for health professionals, including a recent educational framework proposed for health professionals to address SDOH that was developed by the National Academy of Sciences, Engineering, and Medicine (NASEM), and other collaborating organizations.[2]

The call to elicit changes within health professional education to recognize and address SDOH is relevant across all health professions, including chiropractic. A 2020 study of United States Doctor of Chiropractic degree program (DCP) curricula revealed that language inclusive of psychosocial factors related to health and health care were inadequately represented.[3] Thus, consistent with the Committee on Educating Health Professionals to Address the Social Determinants of Health,[2] to best prepare future chiropractors, expansion of SDOH training into didactic and experiential learning within DCPs is needed.

To better expose this idea, we conducted a narrative review of the literature pertaining to current strategies employed by health professional programs to integrate SDOH into their programs. We then used the results from this narrative review to describe potential pathways for integrating SDOH education into existing DCPs.

## Methods

A narrative review of peer-reviewed literature describing SDOH education in health professional programs was conducted. We selected a narrative review methodology because it is the most inclusive review format and thus would permit the most latitude in studying this topic. The literature search was modeled after "A Framework for Educating Health Professionals to Address the Social Determinants of Health",[2] which identified current trends, gaps, and recommendations for exposing students to SDOH in health professional programs.

PubMed and MedEd PORTAL databases were used in the literature search (Table 1). Articles returned in the search were reviewed by one author (JK). Articles

were included if they (1) described SDOH educational interventions (pedagogies, curricular design, assessment methods) in health professional programs, with no limits on date of publication; (2) were based on programs in the United States; (3) were written in English; and (4) were original work. Narrative reviews, scoping reviews, and systematic reviews were excluded. Returned articles were also reviewed for additional relevant referenced articles that met the inclusion criteria and were not returned in the initial literature search.

Table 1.
*Search terms used in the narrative review.*

| |
|---|
| ("Health Occupations/education"[Mesh]) AND "Social Determinants of Health"[Mesh]; Undergraduate"[Mesh] OR "Education, Medical, Graduate"[Mesh] OR "Education, Medical, Continuing"[Mesh]) AND "Social Determinants of Health"[Mesh]; (("Chiropractic"[Mesh]) AND "Public Health"[Mesh]); (("Health Occupations/ education"[Mesh]) OR "Education, Medical"[Mesh]) AND "Cultural Competency/education"[Mesh]; ("education" [Subheading] AND "Teaching"[Mesh]) AND "Social Determinants of Health"[Mesh]; "Social determinants of health"[All Fields] AND "Experiential learning"; "Medical Education" AND "Trauma-informed Care" OR "Adverse Childhood Experiences"; "Service Learning" AND "Social Determinants of Health" |

Data extracted from the articles were chosen by consensus among the three authors (JG, JK, PB). Specific data extracted from the articles included institution name, health professional program discipline (i.e., medicine, chiropractic, etc.), educational methods employed, educational level, educational themes, assessment methods, learner outcomes, and reported institutional facilitators and barriers for SDOH integration. One reviewer (JK) manually performed the data extraction. Articles were reviewed, and data obtained were recorded (Table 2).

We used the information learned in our narrative review, along with the recommended framework put forth by the Committee on Educating Health Professionals to Address the Social Determinants of Health,[2] to inform potential SDOH infusion into all aspects of the student experience. The following elements of the DCP were chosen by consensus amongst the authors to represent the total educational experience and provide maximum SDOH exposure throughout the chiropractic student journey: admissions, financial aid, student orientation, curriculum, clinical opportunities, scholarly activities, extracurricular activities, postgraduation education, student assessments, student affairs, and leadership. These elements were chosen based on the authors' knowledge of the DCP and broadly reflect recommendations highlighted in the document "A Framework for Educating Health Professionals to Address the Social Determinants of Health".[2]

## Results

A total of 28 papers were included in this narrative review. Some articles described SDOH curricular interventions, whereas others only described assessment of various SDOH elements in health professional programs. Healthcare disciplines included chiropractic, medicine, nursing, osteopathy, pharmacy, and pre-med/pre-health.

Programs demonstrated incorporation of SDOH education into lectures, clinical training, and experiential learning opportunities in undergraduate[4,5], graduate[6-20], and residency programs (Table 2)[21-25]. Educational methodologies employed included interprofessional education[9,15] and service learning[6,10,19]. Educational topics included SDOH[7,22,26], cultural competency[4,15], public health8, community health18, and health disparities[6,7,21].

Assessment methods were used to evaluate students' attitudes, knowledge gained, skills, and recognition of SDOH (Table 3). They varied to include pre-existing assessment instruments, and novel quantitative and qualitative assessments. Qualitative methods included reflection exercises[5-7,9,10,12,17-19,22,24,26], group discussions[5,16,27], open-ended questionnaires[8,16], and electronic health record (EHR) documentation of ICD codes representing SDOH[16]. Quantitative assessment methods included multiple-choice questions[8,18], clinical vignettes[18], and surveys[7,12,13,20,21,24-26]. Pre-existing assessment instruments included Attitude Toward Poverty Short Form Scale[11], Medical Students' Attitude Toward the Underserved[14], Implicit Bias Assessment Tool[28], Clinical Cultural Competency Questionnaire[29], the Caring with Compassion Domain I and II assessments[30], Structural Foundations of Health Survey[4], Caffrey Cultural Competence in Healthcare Scale (CCCHS)[15], and Global Worldview Cultural Competence Survey (GWCCS)[31].

Learner outcomes for SDOH education within health professional programs were positive overall. George Washington University required incoming medical stu-

Table 3.
*Summary of methods used to assess students' knowledge, skills, attitudes, and clinical integration of social determinants of health training.*

| Qualitative Assessment Methods | Quantitative Assessment Methods |
|---|---|
| Reflection exercises | Written Examinations<br>—Multiple-choice questions<br>—Clinical Vignettes |
| EHR documentation of ICD codes reflecting SDH | Assessment Instruments<br>—Attitude Toward Poverty Short form scale 46<br>—Medical Students Attitude Toward the Underserved 47<br>—Implicit Bias Assessment Tool 28<br>—Clinical Cultural Competency Questionnaire 29<br>—Caring with Compassion: Domain I & II 30<br>—Structural Foundations of Health Survey 4<br>—Caffrey Cultural Competence in Healthcare Scale (CCCHS) 48<br>—Global (Worldview) Cultural Competence Survey (GWCCS) 49 |
| Case presentations | Surveys |
| Focus groups | |
| Open ended questionnaires | |

dents to participate in a bus field trip of Washington, DC, guided by community partners.[7] This intervention aimed to expose students to the challenges faced by low-income minority neighborhoods.[7] Students demonstrated an increase in knowledge of local health disparities and comfort in addressing SDOH.[7] Another study described a service learning program at the Herbert Wertheim College of Medicine where medical students were assigned to a household in a medically underserved community.[9] Medical students provided clinical services, alongside learners from other professional schools for three years.[9] Participation in the program resulted in these graduates having the highest ratings in communication skills, cultural sensitivity and teamwork when surveyed by their residency directors.[9]

At Life Chiropractic College West, one study investigated chiropractic students' knowledge and confidence in serving diverse populations after completion of a public health course within the curriculum.[19] Qualitative analysis demonstrated competency in public health concepts such as organizational systems, levels of prevention, and the social-ecological model.[19] Another study assessed chiropractic students' pre- and post-training knowledge and confidence to serve diverse populations following six hours of cultural competency training. The results demonstrated an increased knowledge but no change in confidence.[20]

Cambridge Health Alliance internal medicine residency at Harvard Medical School implemented a year-long social medicine and research-based health advocacy curriculum.[25] Residents were required to participate in patient care within community health centers.[25] They attended curricular instruction focused on health equity, SDOH, health policy, and health services research methods.[25] They were also required to partake in a research-based health advocacy project centered on social systemic barriers to health equity.[25] Between 2012 and 2015, 32 residents participated in the course. The most

notable outcomes of the course were the scholarly projects.[25] Over the four years, all scholarly projects were accepted for presentation at regional and national internal medicine conferences.[25]

Morehouse School of Medicine implemented a two-semester community health course (CHC) into the first-year curriculum.[18] In addition to didactic instruction on community health topics, students were required to participate in a service learning program. Students along with faculty facilitators were assigned to community sites serving low-income and underserved populations.[18] There they performed health needs assessments and interventions in collaboration with community liaisons.[18] Over the course of the first 11 years (1999-2010) of the CHC, 500 students conducted 56 community interventions within the metropolitan Atlanta, Georgia area.[18] The two leading health problems students identified were violence and substance abuse.[18] Examples of interventions implemented included dental, physical fitness, parent education workshops, tutoring sessions, and sexual health education.[18]

At Columbia Vagelos College of Physicians and Surgeons, a novel online media-based public health curriculum was developed for students rotating through community hospitals.[8] The 5-week course included topics such as health systems, SDOH, race and health, injury and violence, and substance misuse and harm reduction.[8] Of the 59 students that completed the course between April and December 2017, thirty-two (54%) significantly improved their scores on a knowledge-based assessment.[8] Students were then asked which public health topic should be taught in medical school. The most frequently suggested topics post-course completion included SDOH, health systems, race, and substance misuse.[8] When asked how public health will impact their medical career post-course completion, students acknowledged a greater impact on clinical practice, clinical outcomes, and choice of residency program or employment site.[8]

Penn State College of Medicine implemented a health systems navigation curriculum to facilitate the alignment of medical education with health systems needs.[17] The course included didactic instruction on insurance, cost, care coordination, population and public health, SDOH, high-value care, and teamwork.[17] Additionally, the course required students to participate as learners in a patient navigator role.[17] Learner outcomes were based on a thematic analysis of students' written experience. The health systems course provided students with an enhanced understanding and appreciation for barriers to health and SDOH, patients' perception of health care, health care systems and delivery, patient communication, interprofessional collaboration, and clinical medicine.[17]

A.T. Still University School of Osteopathic Medicine implemented a novel approach to demonstrate the value of SDOH to medical students.[16] They assessed students' voluntary documentation of proprietary and ICD-10 codes reflecting SDOH during clinical encounters.[16] Students were also surveyed on their familiarity with concepts of SDOH twice throughout the study.[16] At the end of a two-year period, students showed a modest increase in positive perceptions about the role of SDOH in patient health.[16]

The University of Arkansas for Medical Sciences Northwest developed an interprofessional education program consisting of teams of medical, nursing, and pharmacy students participating in clinical care at a student-led clinic.[15] Outcomes demonstrated improved scores on two of the three subscales of the Caffrey Cultural Competence in Healthcare Scale.[15] Qualitative assessments demonstrated positive changes in students' knowledge, attitudes, and behavior toward interprofessional collaboration and working with underserved populations.[15]

Fourth-year students from Rutgers New Jersey Medical School/University Hospital participating in an emergency medicine clerkship underwent a SDOH curriculum.[26] Students were required to interview patients and discuss social influences affecting their health.[26] They were then required to complete written reflections, discuss individual cases in small groups, and select one patient case to review the literature pertaining to strategies to fit the patient's needs.[26] Students reported being able to recognize barriers to health faced by patients from diverse socio-economic backgrounds and recognize the importance of addressing SDOH as part of patient care.[26]

At the University of Alabama at Birmingham, educators developed a health disparities curriculum to prepare medical residents to care for vulnerable patients.[21] Preliminary data showed that students reported increased preparedness and skill in caring for vulnerable patients.[21]

First-year medical students at Tulane University School of Medicine participated in a patient-centered curriculum, where they were required to attend seminar series on SDOH and later matched with a patient to complete home

visits.[14] Outcomes demonstrated these students developed more positive attitudes toward the underserved compared to peers completing traditional clinic-based preceptorships.[14]

At the Perelman School of Medicine, fourth-year medical students participated in an elective rotation where they served as apprentices to community health workers.[10] This educational intervention enhanced students' cultural humility and confidence in addressing social determinants of health.[10]

Second-year internal medicine residents at Emory University School of Medicine completed a month-long experiential learning module focused on SDOH.[22] Residents' reflections suggested they gained an enhanced appreciation for SDOH and patent advocacy.[22]

Baylor College of Medicine required first-year medical students to participate in the Social Determinants of Health Orientation Program during their first week of school orientation.[13] The program served as an introductory course on the SDOH. Students demonstrated an increase in knowledge and confidence in discussing SDOH terms and discussing SDOH topics with patients.[13]

Second-year medical students at the George Washington University School of Medicine participated in a four-hour trauma-informed care (TIC) symposium.[12] Students reported an increase in their knowledge between adverse childhood experiences and health outcomes, an increased understanding of TIC, and a better understanding of how to incorporate TIC practices during patient encounters.[12]

Nursing students at the University of Arkansas for Medical Sciences participated in a service learning project to expose them to SDOH and health disparities.[6] Students were required to participate in long bus rides similar to those taken by children in communities affected by school consolidation.[6] Informal evaluation of post-project reflections demonstrated that the service learning project broadened the nursing students' perspectives on SDOH.[6]

Drake University College of Pharmacy investigated the impact of the Missouri Association for Community Action Poverty Simulation on second-year pharmacy students' attitudes toward poverty.[11] Upon completion of the simulation, students demonstrated a significant improvement in the stigma and structural domains on the Attitude toward Poverty (ATP) Short Form scale.[11]

Vanderbilt University offers a pre-health major titled Medicine, Health, and Society (MHS).[4] The major introduces topics such as health disparities and politics of health to undergraduate students. MHS students demonstrated a higher understanding of structural and cultural competency in health disparities and more frequently identified relationships between structural factors and health outcomes, when compared to those graduating from traditional pre-health or pre-med majors.[4]

Programs documenting SDOH education did not specifically detail broader institutional measures supporting implementation and sustainability. Institutions describing their SDOH educational intervention and assessment also did not discuss barriers encountered in the development and implementation of their programs.

## Discussion

This narrative review describes implementing SDOH education in a variety of health professional programs, including methods of assessment and learner outcomes. Programs that implemented SDOH education did not describe mechanisms for sustainability or barriers encountered, but other literature does provide recommendations for these issues (Table 4).[2,32] Consistent with prior literature,[3] findings from this review suggest a lack of published peer-reviewed literature describing integration of SDOH education in DCP curricula, particularly as it compares to medical curricula. For discussion, we organized the findings of this review into the various domains that were established *a priori* (admissions, financial aid, student orientation, curriculum, clinical opportunities, scholarly activities, extracurricular activities, postgraduation education, student assessments, student affairs, and leadership), and present them as a roadmap to SDOH integration throughout the chiropractic student's journey at DCPs (Figure 1). Our discussion expands on the concept of integrating SDOH into a DCP that follows this roadmap. Table 5 and Table 6 expand on the examples described in our discussion, that are broadly based on strategies used in studies included in this review.

Table 4.
*Recommendations for sustainability and potential barriers to teaching social determinants of health.*

| **Sustainability recommendations** | **Potential barriers** |
|---|---|
| Faculty development[2] | Resistance to curricular change[32] |
| Increase workforce diversity[2] | Low prioritization of SDOH[32] |
| Expand community partnerships[2] | Lack of resources[32] |
| Provide interprofessional workplace training[2] | Lack of clinical opportunities for experiential learning[32] |
| | Lack of expertise in SDOH among faculty[32] |

Figure 1.
*Conceptual roadmap depicting areas for social determinants of health integration and the underlying foundations of assessment and institutional support.*

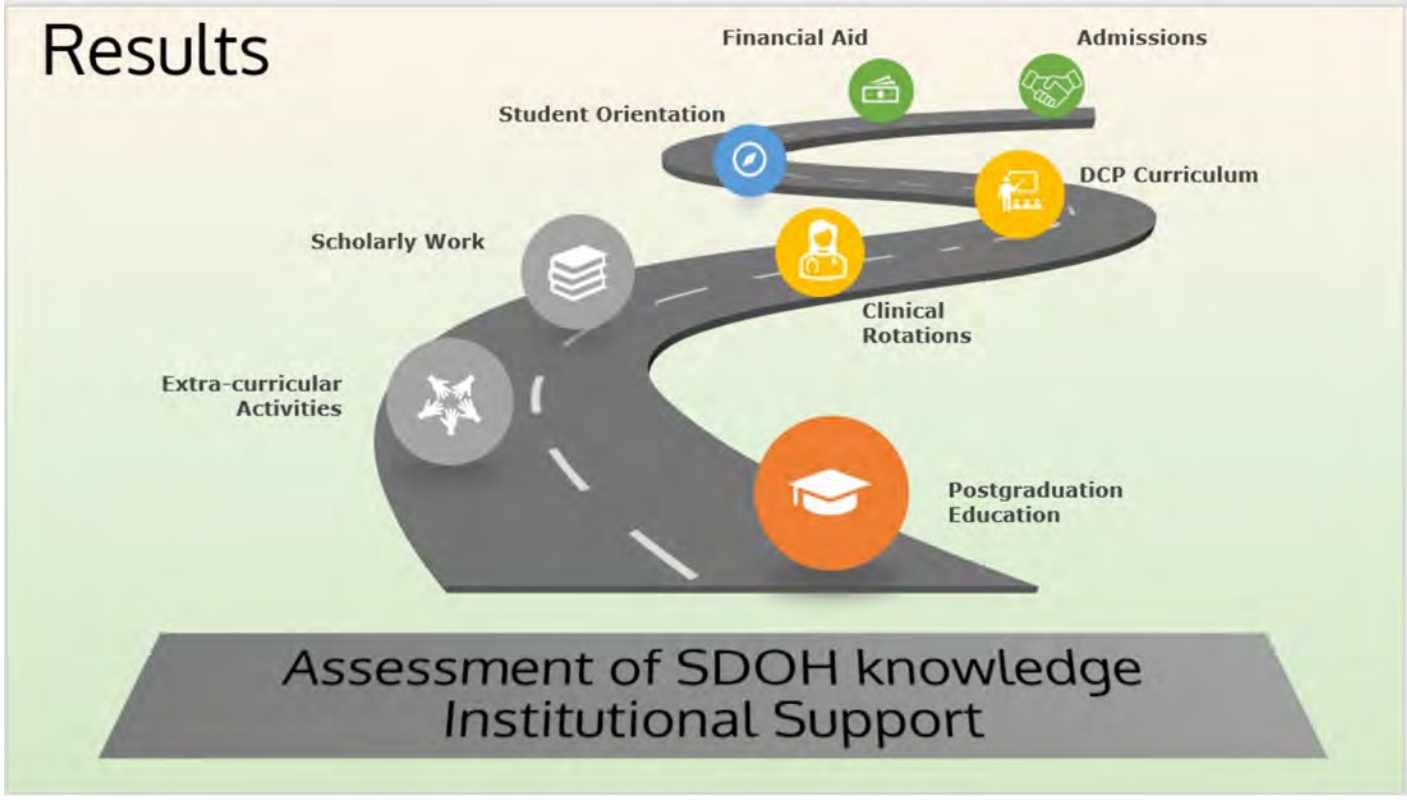

Table 5.
*Methods to integrate social determinants of health training into didactic coursework.*

| **Basic science** |
|---|
| Explain the role of social determinants in altering physiological processes<br>• Embed discussions of chronic environmental stress exposure (low-income level, low education attainment, perceived discrimination) and its effects on neuroendocrine processes that may predispose individuals to health conditions.[50]<br>• Explicitly demonstrate how constructs of allostatic load[40] and epigenetic inheritance may mediate the association between unfavorable social circumstances and poor health outcomes.[51]<br>• Include online course modules that provide relevant literature on the influence of social structures in normal biological processes along with mandatory discussion and reflection posts in courses such as biochemistry, neurology, pathology, and physiology. |
| **Clinical science** |
| Cognitive biases and implicit biases<br>• Incorporate questions that allow for the identification of cognitive biases and diagnostic errors within clinical case assignments given in clinical reasoning and clinical methods courses.[52]<br>• Introduce and discuss implicit bias, the role it plays in clinical decision making, and how it may negatively impact various demographic groups.[53,54]<br>• Administer the implicit association test (IAT) as an exercise to facilitate implicit bias awareness, discussion, and reflection through the lens of a healthcare provider.[28] |
| Race-based medicine and race correction in health care statistics<br>• Avoid defining race as a biological or genetic risk factor for health conditions in lectures and exam questions.[55-57]<br>• When discussing healthcare statistics among demographic groups, contextualize race as a social construct that has no biological or genetic basis.[57,58]<br>• Avoid teaching race correction in clinical algorithms without context, e.g., different eGFR for Black patients versus white patients or the ineffectiveness of ACE inhibitors in black patients.[58] |
| **Social science** |
| Trauma-informed care and adverse childhood experiences<br>• Develop and include modules that effectively teach students to identify common ACEs, describe the lasting impact ACEs have on the physical and mental health of individuals throughout their lifespan, and identify risk and protective factors for abuse and neglect in children.[59] Modules may include:<br>o Lectures<br>o mall group discussions<br>o Cases-based learning<br>o Assessments in the form of MCQ and written refection<br>• Training in TIC can coincide with ACEs training.<br>• Training can focus on the definition of trauma and its connection with adversity and health, the components of TIC, how to recognize and address trauma through the lens of a healthcare provider, and strategies to practice TIC within clinical encounters.[12]<br>• Student training may be in the form of didactic lectures, reiterated in other courses with simulated clinical encounters, and implemented as a stand-alone training seminar.<br>• Offer Mental Health First Aid training to students entering student clinic during their clinical training. |
| Mental health and substance abuse<br>• Training can focus on exposing the bi-directional relationship between mental health and substance abuse with health conditions such as chronic pain while highlighting the role of SDOH.<br>• Include didactic lectures and case-based exercises to train students to identify and address mental health disorders and substance abuse disorders.[60]<br>• Training may emphasize tools such as motivational interviewing and SBIRT[61] to facilitate evidence-informed practices in clinical care. |

| **Technique lectures** |
|---|
| Biopsychosocial framework and patient-centered care<br>• Contextualize how the role of social and cultural norms, social support, financial resources, and mental health play in patients' perception of treatment therapies.<br>• Provide training on practicing patient-centered TIC in a clinical setting when administering various manual therapies. |

Note: eGFR= estimated glomerular filtration rate; ACE= angiotensin-converting enzyme; ACEs= adverse childhood experiences; TIC= trauma-informed care; SBIRT= Screening, Brief Intervention and Referral to Treatment; WIC= Women, Infants and Children

Table 6.
*Integrating social determinants of health into experiential learning*

| **Service-learning** |
|---|
| Integrate required service-learning modules into existing courses<br>• Neurology courses can include service-learning opportunities at neuro rehabilitation facilities.<br>• Physical Rehab courses can partner with local community health centers to host exercise classes for their patients under chiropractic care with chronic back pain.<br>• Clinical methods courses can require rotations through organizations that provide services for the unhoused and shadow community health workers.<br>• Clinical Nutrition courses can offer rotations with nutritionists at community health centers.<br>• OBGYN courses can offer service-learning opportunities with women's health services at various community health centers.<br>• Pediatrics and pregnancy elective courses can offer rotations through community health centers that provide WIC services and child development services.<br>• Community health courses can require shadowing of community health workers and social workers and rotations through community outreach programs. |
| **Simulated clinical labs** |
| Social determinants of health themes in clinical encounters<br>• Patient histories can include dynamic psychosocial factors such as being unhoused, ACEs, suicide attempts, affective disorders, alcohol abuse, opioid misuse.<br>• Challenge students to identify and triage diagnoses e.g., a chronic low back pain case coupled with malignant hypertension, suicidal ideation, or intimate partner violence to integrate the knowledge of SDOH as well as simulate identifying and managing complex cases.<br>• Post-encounter discussions can focus on how students elicit information and its relevance to the case.<br>• Ensure faculty designing cases and those leading post encounters are knowledgeable and competent in teaching these concepts. |
| **Student health-center** |
| Apply SDOH knowledge into clinical care<br>• Bedside learning may be used to teach clinical examinations through a trauma-informed lens.[62]<br>• Encourage students to adopt a biopsychosocial approach to manual therapies and therapeutic exercises.[63,64]<br>• Require weekly clinical debriefing sessions with students and their supervising clinician.[65]<br>• Sessions can center on select patient cases and include a focus on social determinants of health elements that have been introduced in previous courses.<br>• Debriefing should require students to actively engage in discussions and meaningful reflection. |
| Expert guest lecturers<br>• Expert guests can be invited to lecture on relevant clinical topics such as:<br>o Information literacy/navigating and interpreting healthcare literature<br>o Evidence-informed practices for chronic pain management in multimorbid patients<br>o Healthcare systems including Medicare and Medicaid<br>o Public health<br>o Behavioral health and social work |

| External clinical rotations |
|---|
| Interdisciplinary care<br>• Require rotations in interdisciplinary care at local Community Health Centers, Veterans Affairs (VA) Hospitals, and other diverse institutional affiliated sites.<br>• Rotations can involve other disciplines such as primary care, behavioral health, MAT clinics, physical therapy, and occupational therapy. |

Note: ACEs= adverse childhood experiences

### 1. Admissions

Addressing SDOH often entails caring for a diverse patient population and therefore necessitates a diverse health professional workforce.[33,34] This need can potentially be addressed through the admissions department as they are often the first interface between prospective students and the DCP. The admissions department can play an important role in strengthening recruitment efforts among diverse individuals.[35-37]

For example, the institutions with DCPs can establish partnerships with local organizations and institutions such as Historically Black Colleges and Universities[35] and community colleges[36]. The DCPs could facilitate workshops and conferences to promote the chiropractic profession and create opportunities for College of Chiropractic faculty liaisons to provide mentorship to prospective DCP students at these external institutions. In addition, summer enrichment programs could be created to enhance healthcare-related undergraduates' understanding of the preparation needed for application and admission into the DCP.

Other undertakings could include expanding on the DCPs commitment to diversity and inclusion. For example, an enhanced focus on LGBTQ+ communities through the integration of gender-inclusive language on application forms and information packets could be established. In addition, highlighting resources and safe spaces available could be prioritized and highlighted.

Lastly, to support these recruitment efforts, it is important to consider further developing admissions coordinators in the areas of diversity and inclusion by providing implicit bias training, and training on barriers to graduate education attainment in minority groups.[38]

### 2. Financial Aid

The office of financial aid can support recruitment and retainment efforts by implementing programs to assist in removing financial barriers encountered by qualifying prospective students of low socioeconomic status (SES).[35] This consideration could be valuable as financial assistance is one of many barriers to attaining higher education among socially disenfranchised groups.[35] Efforts to achieve this include offering scholarships and other financial assistance programs for eligible prospective students and seeking donations and grants to fund and sustain financial assistance measures.[35]

### 3. Student orientation

Orientation is the bridge from admissions to the DCP. Orientation can calibrate incoming students to the health professions while emphasizing the social importance and obligations of a Doctor of Chiropractic. It also can demonstrate the DCPs commitment to providing care in underserved communities and addressing musculoskeletal pain through public health avenues. Lastly, opportunities for students to engage in rotations in multidisciplinary settings, volunteer in underserved communities, and work with vulnerable populations may be highlighted as well.

### 4. Doctor of Chiropractic basic, clinical, and social sciences curriculum

Basic, clinical, and social science courses are amenable to laying the foundational concepts of SDOH early on in students' training. Basic and clinical sciences (e.g., physiology, neurology, pathology, and physical diagnoses) could be modified to provide the appropriate social and historical contexts mediating health outcomes.[39] Course content can demonstrate how social and structural determinants of health can disproportionately affect various demographic groups and become embodied as physiological and behavioral traits.[40] Information disseminated in these courses may aid in deconstructing the misrepresentation of race and ethnicity as genetic constructs responsible for ill health.[41] Lectures can instead serve to articulate

debiased health-related statistics that avoid pathologizing race and gender in addition to highlighting the shared social circumstances and experiences that may shape a population's wellbeing.

Social science courses (e.g., clinical psychology and community health) can include topics such as trauma-informed care, adverse childhood experiences (ACEs), mental health illness, and substance abuse disorders. These topics could aim to demonstrate how psychosocial factors may contribute to poor health outcomes. Social science courses can also highlight the social drivers that mediate substance use and affective disorders while underscoring their ability to transcend SES, race, ethnicity, and gender orientation. These courses can potentially assist students to shift away from the paradigm of health being the sole result of personal lifestyle choices, to one that encompasses the influence of the greater social and structural forces. These concepts can be taught didactically and could potentially be reinforced throughout the DCP via transformative learning.

Integrating topics such as mood disorders, ACEs, TIC, maladaptive beliefs, fear-avoidance, pain related self-efficacy, pain catastrophizing, health literacy, educational attainment, community and financial resources, and social support into manual therapy courses (e.g., diversified technique, physical rehabilitation, advanced biomechanics) can demonstrate how SDOH has the potential to influence clinical decision-making and treatment outcomes. While these topics may not be the primary learning aim of these courses, it is important they be contextualized as integral to the implementation of manual, rehabilitative, mind-body therapies, and external referrals.

Simulated clinical encounters are also possible targets to include SDOH themes. These themes could include substance use, intimate partner violence, mental health challenges, suicidal ideation, and suicide attempts. Post-encounter discussions could be led by course faculty or guest lecturers proficient in addressing these topics. Discussions may be used to facilitate building communication and interpersonal skills needed to identify and address sensitive topics in a clinical encounter.

### *5. Clinical rotations and experiential learning*

Service-learning modules could be implemented into the syllabus of various didactic- and clinical-based courses in DCP curricula. These modules can include mandatory reflection exercises to understand one's positionality, solidify learning objectives, assess knowledge gained, and prepare students for more rigorous clinical training.

Many DCPs provide student health centers in which students gain introductory clinical training and application of previously acquired didactic knowledge. Students' initial clinical experience within the student health center could serve to provide a structured curriculum that reiterates previously taught SDOH concepts through a clinical lens. These topics can include information literacy, TIC, public health, insurance coverage, and healthcare system navigation. Student health center clinicians need not only be knowledgeable about such topics but also embrace and integrate them into patient care and clinical teaching. Expert guest lecturers could be invited, when appropriate, to supplement this learning.

External clinical rotation sites could be expanded to increase a DCPs capacity for student rotations in community health centers, Veteran's Affairs medical centers, and other teaching hospital systems. These site rotations could potentially include clinic rounds with other health professions. Further, alumni trained in integrated health care, and those practicing in integrative and hospital settings could be recruited to serve as clinical instructors for students.

### *6. Assessment of social determinants of health training*

Approaches to assess students' understanding of SDOH concepts can include integration into pre-existing course examinations, clinical assessments, and meta-competencies. Validated instruments and ordinal questionnaires can be adapted and utilized throughout the student journey to assess knowledge and awareness of SDOH-related concepts. These assessments could include both pre- and post-SDOH training interventions. Other questionnaires can be developed to assess knowledge and attitudes on topics such as health literacy, TIC, and ACEs.

Qualitative assessment tools can be used to gauge students' experiences and assess their ability to implement SDOH awareness into clinical practice. These may include reflection exercises and focus groups. Clinical simulations such as Objective Structured Clinical Examinations (OSCEs) and standardized patient exercises, can be used as performance-based assessments in evaluating students' ability to identify, document, and address specif-

ic domains of SDOH within a clinical encounter. Assessments would need to align with program and course learning outcomes, therefore necessitating their revision to include SDOH elements.

### 7. Scholarly work

Research involving chiropractic, public health, and SDOH is currently limited. Faculty and students can be encouraged to contribute to the literature by expanding on clinical research on SDOH and include diversity and social justice concepts into research strategies and agendas.[37] Including research participation as a graduation pre-requisite could be used as an incentive to increase DCP scholarship. In addition, offering research-based scholarships for students could be used as an incentive for increased DCP scholarship.

Faculty may also be incentivized by DCPs offering opportunities for internal research grants or funding for continuing professional education seminars, courses, etc. To facilitate this goal, information literacy classes could provide cross-curriculum training in research methods and scientific writing. Support from the department of research would likely be essential. Given that most United States DCPs are housed within small, private institutions without an established research infrastructure, dedicating resources for collaboration with external research-intensive universities could be advantageous.

### 8. Extracurricular activities

Extracurricular campus activities such as student chapter organizations, sororities, fraternities, and special interest clubs serve as opportunities for students to engage in peer interaction and mentorship. They may play a significant role in developing a student's mindset, interests, and trajectory for clinical practice. Student mentors and faculty advisors could be required to meet competencies in SDOH training or related concepts (TIC, ACES, Race/ethnicity bias, LGBTQ+-related bias, and public health) prior to engaging in leadership in these extracurricular activities.

Health care mission trips sponsored by DCPs could also serve as elective experiential learning opportunities. Prospective attendees could obtain prerequisite training in cultural awareness, public health, and the socioeconomic factors unique to the region they are visiting. Specific learning objectives would need to be established before the trip, and outcomes in the form of questionnaires and reflections should be obtained. These trips ultimately function as opportunities for students to engage with medically underserved populations while they provide beneficial care. If implemented, mission trips could be developed in a manner to actively negate any contribution to the exploitation of visited communities,[42] and avoid further reinforcement of negative stereotypes of impoverished individuals. These proposed methods of embedding SDOH education into extracurricular activities could also be implemented in peer tutoring, student ambassador organizations, and class representative boards.

### 9. Postgraduation education

Postgraduation education plays a key role in a clinician's professional development. Postgraduation education may be in the form of clinical residencies, certificate courses, seminars, or modules. Offerings in SDOH education can provide training for practitioners that have not been previously exposed to these concepts to better address SDOH encountered in practice. Continuing education can also promote lifelong learning for those formally trained in SDOH and allow for greater consolidation of concepts learned.[2] In addition to practicing clinicians, continuing education can greatly benefit faculty and those involved in curriculum development at DCPs. SDOH related continuing education efforts can act to further reinforce the need to well-integrate SDOH education into DCP curricula.

### 10. Student affairs

Student affairs interfaces with a student throughout their journey. To align with the SDOH theme, student affairs could prioritize initiatives such as policies ensuring TIC[43] and LQBTQ+ affirmative practices on campus. Members of student affairs can be trained in implicit bias and cultural awareness, and the department can implement mandatory training in pre-existing programs/resources to ensure a welcoming and safe environment for students of underrepresented backgrounds. Hosting events that bring awareness of diverse cultures and sensitive topics to the forefront of the entire campus community can be helpful. These efforts could be done in collaboration with the diversity and compliance officer, faculty, and staff to align themes with preclinical and clinical SDOH education and improve their impact on the campus community.

### 11. Leadership support

Support for the integration of SDOH requires support at all administrative levels.[44] Cultural practices must be observed throughout the institution to reflect diversity and inclusion, cultural competence and tolerance, and commitment to evidence-informed practices. Institutional collaboration, interprofessional collaboration, institutional partnerships, and research would need to be an ongoing priority to further support SDOH education within the DCP, and in the process, practice addressing SDOH at an institutional level.

Senior administration can leverage initiatives such as required cultural competence and TIC training at the faculty, administration, and student levels to ensure necessary practices and an optimal institutional culture. This is important to provide a culturally sensitive environment for a diverse student body to thrive in areas of academics, clinical skills, and leadership roles. Implicit bias training should not only be taught in the context of patient care but also can be included for all members of the campus community.

While discriminatory practices would likely not be tolerated by any institution, implicit biases could influence communication, students' grades, and opportunities. Results of these implicit biases could leave individuals or groups feeling alienated or marginalized. Teaching in an evidence-informed manner has the potential to reduce bias and anecdotes taught in the classroom and clinical settings. This provides room for teaching concepts of SDOH as it is increasingly commonplace in evidence-based care.

For Human Recourses, recruitment and retention of faculty and staff that represent racial and ethnic minorities,[2,45] LGBTQ+, and bi/multi-lingual individuals can be instrumental in this cause. If DCPs are to recruit a more diverse student population to care for a diverse patient population,[37] it is important that DCPs reflect those demographics.

Lastly, leadership can facilitate collaborations that serve this agenda. In addition to DCPs, collaboration with other local health professional programs can facilitate curricular design and increase research opportunities. Furthermore, these partnerships could expand educational resources and usher in an era of a well-integrated DCP. Partnerships can also emphasize contributing to the local community and gaining a comprehensive understanding of the community's health care needs. These partnerships could include community-based health centers and public health agencies.

### Future research

Given the paucity of literature on SDOH in chiropractic education, future research is needed to identify educational gaps within the curriculum. Knowledge gaps on SDOH concepts among students and faculty members is needed. Lastly, understanding of barriers and facilitators to the implementation of SDOH education in DCPs is needed.

### Limitations

Limitations of this review reflect those inherent to narrative reviews. The methods for article selection may be biased towards those supporting the inclusion of SDOH in health professions' education. Our search criteria did not include articles describing long-term outcomes of SDOH training in health professions beyond graduation and in clinical practice. Our search strategy could have been expanded to include specific professions in the search criteria (e.g., dentistry, nursing, osteopathy, acupuncture, pharmacy, physical therapy, and occupational therapy). This may have allowed us to better observe the breadth of SDOH educational interventions among a diverse group of health professional programs. Lastly, although our narrative review returned only two articles describing integration of SDOH training into a chiropractic program, this may not truly reflect the number of programs that have implemented SDOH into their DCP, as other efforts may not have been published.

### Conclusions

SDOH training is becoming more common place in health professional education. Literature suggests it is possible to implement SDOH training into didactic and experiential learning within health professional education. Integration of SDOH into chiropractic education is of critical importance. This study demonstrates existing methods for integrating SDOH in health professional programs. Methods may be adopted and assimilated into an existing DCP's admissions practices, financial aid practices, student orientation, curriculum, clinical training, research initiatives, extracurricular activities, student affairs, and institutional policies and practices. Further research is needed to understand barriers and facilitators to the implementation of SDOH training into United States DCPs.

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Table 2.

*List of Institutions and their associated disciplines, educational interventions, social determinants of health topics, assessment methods, and learner outcomes.*

| Institution | Discipline | Educational methods | Educational level | Educational theme | Assessment methods | Learner outcomes |
|---|---|---|---|---|---|---|
| Life Chiropractic College West[20] | Chiropractic | didactic learning | graduate | cultural competency | survey | Students demonstrated competency in public health concepts such as organizational systems, levels of prevention, and the social-ecological model. |
| Life Chiropractic College West[19] | Chiropractic | service learning | graduate | public health | reflections | Students demonstrated increased knowledge but no change in confidence in serving diverse populations. |
| Cambridge Health Alliance, Harvard Medical School[25] | Medicine | didactic lectures, research projects | residency | health equity, social determinants of health, and health policy | survey, scholarly papers | All participants' scholarly projects were accepted to internal medicine conferences. |
| Morehouse School of Medicine, Atlanta, Georgia[18] | Medicine | service learning | graduate | community health | multiple choice exams, class presentations, reflections | Students successfully implemented community interventions to promote and improve health outcomes. |
| The George Washington University School of Medicine and Health Sciences[7] | Medicine | interprofessional learning | graduate | health equity, social determinants of health | surveys, reflections | Students gained increased knowledge of local health disparities and increased comfort in addressing SDOH. |
| Columbia Vagelos College of Physicians and Surgeons[8] | Medicine | didactic learning | graduate | health systems, social determinants of health, race and health, substance abuse and harm reduction, injury and violence | multiple-choice questions, open-ended questions | Students identified SDOH, health systems, race, and substance abuse as important topics that should be taught in medical school. |

| Institution | Discipline | Educational methods | Educational level | Educational theme | Assessment methods | Learner outcomes |
|---|---|---|---|---|---|---|
| Penn State College of Medicine[17] | Medicine | experiential learning | graduate | health systems science | reflections, semi-structured interviews | Students gained an enhanced understanding and appreciation for SDOH, patients' perception of health care, health care systems and delivery, patient communication, interprofessional collaboration, and clinical medicine. |
| Florida International University Herbert Wertheim College of Medicine[9] | Medicine | service-learning, interprofessional learning, didactic learning, | graduate | social determinants of health | surveys | Graduates had the highest ratings in communication skills, cultural sensitivity and teamwork when surveyed by their residency directors. |
| Oregon Health and Science University[24] | Medicine | didactic learning, experiential learning | residency | health policy and health care safety net, addiction medicine | reflections, surveys | Not reported. |
| A.T. Still University School of Osteopathic Medicine[16] | Osteopathic medicine | EHR documentation | graduate | social determinants of health | Use of SDOH diagnostic codes, surveys | Students showed a modest increase in positive perceptions about the role of SDOH in patient health. |
| University of New Mexico[23] | Medicine | interprofessional learning | residency | social determinants of health | N/A | N/A |
| University of Arkansas for Medical Sciences Northwest[15] | Medicine | seminars, experiential learning, service learning, interprofessional learning | graduate | cultural competency | Cultural Competence in Healthcare Scale (CCCHS), focus groups | Students demonstrated positive changes in attitudes toward interprofessional collaboration and working with underserved populations. |
| Rutgers New Jersey Medical School/University Hospital[26] | Medicine | experiential learning | graduate | social determinants of health | surveys, reflections, presentations | Students increased their ability to recognize health barriers and the importance of addressing SDOH. |

| Institution | Discipline | Educational methods | Educational level | Educational theme | Assessment methods | Learner outcomes |
|---|---|---|---|---|---|---|
| University of Alabama at Birmingham[21] | Medicine | didactic learning, experiential learning | residency | health disparities | surveys | Students reported increased preparedness and skill in caring for vulnerable patients. |
| Tulane University School of Medicine[14] | Medicine | didactic learning, experiential learning | graduate | social determinants of health, implicit bias, cultural competence | Medical students' attitudes towards the underserved (MSATU), standardized patient encounters | Students developed more positive attitudes toward the underserved compared to peers completing traditional clinic-based preceptorships. |
| Perelman School of Medicine[10] | Medicine | didactic learning, group discussions, service learning, interprofessional learning | graduate | social determinants of health | interviews, discussions, reflections, skills assessments | Students demonstrated enhanced cultural humility and increased confidence in addressing SDOH. |
| Emory University School of Medicine[22] | Medicine | didactic learning, experiential learning | residency | social determinants of health | reflections | Students gained an enhanced appreciation for SDOH and patient advocacy. |
| Baylor College of Medicine[13] | Medicine | case based learning, group discussions | graduate | social determinants of health | surveys | Students demonstrated an increase in knowledge and confidence in discussing SDOH terms and discussing SDOH topics with patients. |
| George Washington University School of Medicine and Health Sciences[12] | Medicine | didactic learning, small group discussions | graduate | trauma informed care, adverse childhood experiences | surveys | Students reported an increase in knowledge and understanding of trauma-informed care. |
| University of Arkansas for Medical Sciences[6] | Nursing | service learning | graduate | social determinants of health | reflections | Students gained broadened perspectives on SDOH. |
| Drake University College of Pharmacy[11] | Pharmacy | simulation | graduate | poverty | Attitude toward Poverty (ATP) Short Form scale | Students demonstrated improved attitudes toward poverty. |
| Vanderbilt University[4] | Pre-med, Pre-health | didactic learning | undergraduate | health disparities | Structural Foundations of Health Survey | Students who received training in health disparities demonstrated better understanding of structural and cultural competency in health disparities. |

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# Impact of hype on clinicians' evaluation of trials – a pilot study

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Objective: *The purpose of this study was to determine the practicality of using a teleconferencing platform to assess the effect of hype on clinicians' evaluations of reports of clinical trials in spinal care.*

Methods: *Twelve chiropractic clinicians were interviewed via a videoconferencing application. Interviews were recorded and timed. Participant behaviour was monitored for compliance with the protocol. Differences between participants numerical ratings of hyped and non-hyped abstracts based on four measures of quality were analysed using pairwise comparisons (Wilcoxon signed rank test for independent samples). In addition, a linear mixed effects model was fitted with condition (i.e. hype vs. no hype) as a fixed effect and participant and abstract as random effects.*

Impact du battage médiatique sur l'évaluation des essais par les cliniciens - une étude pilote

Objectif : *L'objectif de cette étude était de déterminer s'il était possible d'utiliser une plateforme de téléconférence pour mesurer l'effet du battage médiatique sur les évaluations par les cliniciens des rapports d'essais cliniques dans le domaine des soins de la colonne vertébrale.*

Méthodes : *Douze chiropracticiens ont été interrogés par le biais d'une application de vidéoconférence. Les entretiens ont été enregistrés et chronométrés. Le comportement des participants a été contrôlé pour s'assurer qu'ils respectaient le protocole. Les différences entre les évaluations numériques des participants pour les résumés avec et sans publicité, basées sur quatre mesures de qualité, ont été analysées en utilisant des comparaisons par paire (test de rang signé de Wilcoxon pour les échantillons indépendants). En outre, un modèle linéaire à effets mixtes a été ajusté avec la condition (c'est-à-dire avec ou sans battage publicitaire) comme effet fixe et le participant et le résumé comme effets aléatoires.*

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Results: *The interviews and data analysis were conducted without significant technical difficulty. Participant compliance was high, and no harms were reported. There were no statistically significant differences in the quality rankings of hyped versus non-hyped abstracts.*

Conclusion: *The use of a videoconferencing platform to measure the effects of hype on clinicians' evaluations of abstracts of clinical trials is practical and an adequately powered study is justified. Lack of statistically significant results may well be due to low participant numbers.*

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KEY WORDS: pilot study, videoconferencing, hype, medical writing, spinal care, chiropractic

Résultats : *Les entretiens et l'analyse des données se sont déroulés sans difficulté technique majeure. Les participants se sont montrés très coopératifs et aucun problème n'a été signalé. Il n'y a pas eu de différences statistiquement significatives dans le classement de la qualité des résumés avec ou sans battage médiatique.*

Conclusion : *L'utilisation d'une plate-forme de vidéoconférence pour mesurer les effets du battage médiatique sur les évaluations des résumés d'essais cliniques par les cliniciens est pratique et une étude suffisamment puissante est justifiée. L'absence de résultats statistiquement significatifs pourrait bien être due au faible nombre de participants.*

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MOTS CLÉS : étude pilote, vidéoconférence, battage médiatique, rédaction médicale, soins de la colonne vertébrale, chiropratique

## Introduction

Abstracts of reports of randomised controlled trials (RCTs) provide primary care physicians with quick and easy access to information regarding the efficacy or effectiveness of treatment. The abstract may be the only source of information on which some readers base their assessment of a trial.[1] Therefore, to allow readers to make a critical and accurate appraisal, information in abstracts should be transparent, objective and sufficiently detailed.

However, there is a growing tendency for researchers to use subjective language to make the research field, methods or results seem more appealing to the target readers – a phenomenon referred to as 'hype'. This is evidenced by an 880% increase in the use of selected hype words (e.g. *crucial, novel, innovative, unprecedented*) in PubMed abstracts from 1974 to 2014[2], with similar trends in fundamental and clinical research journals[3], and in other disciplines[4].

A previous study of hype in a sample of 24 RCTs in orthopaedic medicine and spine care identified a total of 161 instances of hype occurring in all but two reports, with most hype targeted at methods (e.g. *robust, exhaustive, expert*), the outcome of the research (e.g. *vital importance*), and the novelty (e.g. *novel, innovative*).[5] In a follow-up interview study[6], authors identified their motivation for using hype as mainly promotional, but also related it to external editorial intervention, linguistic ability, and replication of conventionalised discourse, underlined by pressure to publish.

Of concern is that hype may undermine objective and disinterested interpretation, and so bias readers' evaluation of new knowledge. There is some evidence clinicians who read abstracts containing *spin*, a phenomenon akin to hype, may be biased towards a positive appraisal of treatment.[7,8] Spin is a related but broader concept involving distortion or misrepresentation of the findings so as to portray the study in a more favourable light[9] – for example, by presenting *post hoc* hypotheses as *a priori*, selectively reporting positive results or recommending a treatment without a clinically important effect.

However, notwithstanding the concerns cited above, there is currently no convincing evidence that hyping actually does bias readers' evaluation. In this pilot study, we explore the feasibility of using a videoconferencing platform to assess whether hype in reports of RCTs influences clinicians' appraisal of research.

## Methods

This study was approved by the institutional research ethics board of the Canadian Memorial Chiropractic College (REB approval #2006X01)

*Trial design*

We conducted a double blind randomised controlled pilot trial to compare how clinicians evaluated a trial when the abstract did or did not contain hype. We randomly assigned clinicians to read and evaluate sets of four abstracts in which two abstracts were in the original form (no hype) and two were manipulated versions (hype). The clinicians were asked to rank the abstracts according to the scale shown below under *outcome measures* and to recall information from each abstract.

*Materials*

From recent reports of RCTs published in the two leading journals in spinal care (*Spine, European Spine Journal*), we selected four structured abstracts that reported clinical research with human subjects, did not contain hype, and were of comparable length (mean word count 265, s.d. 44). We then added six hyping items (single words and short phrases) to each abstract, resulting in an original and a hyped version of each abstract – example shown in Table 1; all abstracts included as supplemental material in Appendix 1. Based on previous research[5], the additions were typical of hype in RCTs and targeted four aspects of the research: (1) how well the study was implemented (e.g. *carefully designed*); (2) the novelty (*this is the first study to …*); (3) the outcome (*convincing evidence*); and (4) the competence of the researchers (*an experienced radiologist*).

Twelve packages of four abstracts each were assembled by a research assistant not involved in the interviews or data analysis. While each package contained two original and two hyped abstracts, no one package contained the original and hyped version of the same abstract. This allowed for six permutations of each combination of abstracts, so that each permutation was tested on two participants. Assignment of the participants to abstracts was conducted by a researcher not involved in interviewing the participants and was conducted using a random number generator to create the sequence of presentation of packages to participants.

*Participants and procedure*

Participants were recruited by circulating an email to all clinical faculty at the chiropractic institution of one of the researchers. Inclusion criteria were that the participants were currently clinical instructors in the chiropractic institution of the corresponding author. Thirteen participants volunteered and completed the informed consent document after which an interview time was scheduled on Zoom (https://zoom.us). One participant's data were excluded as detailed below, resulting in analysis of 12 complete sets of data. Participants were not informed that the study was investigating hype in abstracts of RCTs. Rather, they only knew that they were being asked to read and evaluate abstracts. The actual interviews took between 20 and 25 minutes to execute, although no time limits were imposed on the participants. Each interview involved the single participant, the interviewer, who was blinded to the abstracts that the participant was viewing, and a research assistant on a separate computer who displayed abstracts only to the participant after the interviewer had explained the procedure of the interview. When the participant indicated that they had finished reading the abstract, the interviewer posed the four questions listed below under '*Outcome measures*.' Thereafter, the interviewer posed three open-ended questions regarding each abstract. Interviews were recorded to permit off-line transcription of participant comments.

*Outcome measures*

The primary outcome measures were numerical ratings on a scale of 0 to 10 given in response to the following questions:

1. Based on your reading of this abstract, rate how likely it is that you would implement the findings of this study in the same sorts of patients. (0 = I **certainly would not** implement this treatment; 10 = I **certainly would** implement this treatment)
2. Based on your reading of this abstract, rate how rigorous the study was. (0 = not at all rigorous; 10 = very rigorous)
3. Based on your reading of this abstract, rate how novel the study was. (0 = not at all novel; 10 = very novel)
4. Based on your reading of this abstract, how competent were the researchers to conduct a study of this sort? (0 = incompetent; 10 = extremely competent)

Table 1.
*Example abstract without and with hype (in bold font, underlined).*
From: Eur Spine J. 2014 Jun;23(6):1204-14 (reprinted with permission).

| Original version | Hyped version |
|---|---|
| **PURPOSE:**<br>To evaluate the effect of a programme of active self-correction and task-oriented exercises on spinal deformities and health-related quality of life (HRQL) in patients with mild adolescent idiopathic scoliosis (AIS) (Cobb angle <25°). | **PURPOSE:**<br>**<u>This is the first study</u>** to evaluate the effect of a programme of active self-correction and task-oriented exercises on spinal deformities and health-related quality of life (HRQL) in patients with mild adolescent idiopathic scoliosis (AIS) (Cobb angle <25°). |
| **METHODS:**<br>This was a parallel-group, randomised, superiority-controlled study in which 110 patients were randomly assigned to a rehabilitation programme consisting of active self-correction, task-oriented spinal exercises and education (experimental group, 55 subjects) or traditional spinal exercises (control group, 55 subjects). Before treatment, at the end of treatment (analysis at skeletal maturity), and 12 months later (follow-up), all of the patients underwent radiological deformity (Cobb angle), surface deformity (angle of trunk rotation) and HRQL evaluations (SRS-22 questionnaire). A linear mixed model for repeated measures was used for each outcome measure. | **METHODS:**<br>This was a parallel-group, randomised, superiority-controlled study in which 110 patients were randomly assigned to a **<u>carefully designed</u>** rehabilitation programme consisting of active self-correction, task-oriented spinal exercises and education (experimental group, 55 subjects) or traditional spinal exercises (control group, 55 subjects). Before treatment, at the end of treatment (analysis at skeletal maturity), and 12 months later (follow-up), for all patients, **<u>an experienced radiologist</u>** undertook **<u>detailed</u>** evaluations of spinal deformity (Cobb angle), surface deformity (angle of trunk rotation) and HRQL evaluations (SRS-22 questionnaire). A linear mixed model for repeated measures was used for each outcome measure. |
| **RESULTS:**<br>There were main effects of time ($p < 0.001$), group ($p < 0.001$) and time by group interaction ($p < 0.001$) on radiological deformity: training in the experimental group led to a significant improvement (decrease in Cobb angle of >5°), whereas the control group remained stable. Analysis of all of the secondary outcome measures revealed significant effects of time, group and time by group interaction in favour of the experimental group. | **RESULTS:**<br>There were main effects of time ($p < 0.001$), group ($p < 0.001$) and time by group interaction ($p < 0.001$) on radiological deformity: training in the experimental group led to a significant improvement (decrease in Cobb angle of >5°), whereas the control group remained stable. Analysis of all of the secondary outcome measures revealed significant effects of time, group and time by group interaction in favour of the experimental group. |
| **CONCLUSIONS:**<br>The programme of active self-correction and task-oriented exercises was superior to traditional exercises in reducing spinal deformities and enhancing the HRQL in patients with mild AIS. The effects lasted for at least 1 year after the intervention ended. | **CONCLUSIONS:**<br>**<u>The findings provide convincing evidence that</u>** a programme of active self-correction and task-oriented exercises is superior to traditional exercises in reducing spinal deformities and enhancing the HRQL in patients with mild AIS. **<u>It is noteworthy that</u>** the effects lasted for at least 1 year after the intervention ended. |

Secondary outcome measures were open-ended verbal responses to the following questions:

1. What 4 or 5 words or phrases do you recall from the abstract?
2. In just a few words, what would you describe as the strengths, if any, of the study?
3. In just a few words, what would you describe as the weaknesses, if any, of the study?

*Analytical methods*

The researcher performing data analysis was blinded as to which abstracts were original and which were hyped until

all data analysis had been completed. Differences between the numerical ratings for hyped and non-hyped abstracts were analysed using pairwise comparisons (Wilcoxon signed rank test for independent samples). In addition, a linear mixed effects model was fitted with *condition* (i.e. *hype* vs. *no hype*) as a fixed effect and *participant* and *abstract* as random effects. Quantitative analyses were carried out in R.[10]

Verbal responses were transcribed and analysed independently by two researchers for reference to the hyping items. Adjectives and adjectival phrases used in the open-ended responses were coded according to whether or not they could be classified by hype, based on previously published identification of the lexicon of hype.[2-4] Thus, each adjective and adjectival phrase was assigned to a semantic category corresponding to: (1) implementation (the clinical implications of the findings), (2) rigour of design and execution, (3) novelty of the study, (4) the competence of the researchers. Differences were resolved through discussion.

In an analysis conceived *post hoc*, the researchers also coded the open-ended responses according to which CONSORT item(s) for abstracts the response corresponded to.[11] Again, differences were resolved through discussion.

## Results

The final sample comprised data from twelve participants: eight males; mean age 42.5 years (±11.8), minimum = 27, maximum = 64; mean years since licensure 14.8 years (±11.4), minimum = 0, maximum= 38; five with post-graduate qualifications. Although data from a thirteenth participant were collected, the data set was discarded as they did not remain on topic during the experiment. The participants read each abstract in an average time of 94 seconds (s.d.= 26s) and reading times did not differ significantly abstract by abstract (p=0.174) nor by the order of presentation (p=0.899).

All interviews were conducted without significant technical issues, but that in one instance there was a transient loss of connection traced to a faulty modem, not to the application used for the interviews. There were no adverse events related to the interview process.

*Numerical ratings*

Table 2 compares the mean ratings given to original and hyped abstracts. The spread of the ratings is shown in the boxplots in Figure 1. All differences were statistically insignificant, although abstracts containing hype were rated somewhat more favourably in terms of novelty (mean difference = 1.14). Across the other criteria, the mean ratings were slightly lower when the abstracts contained hype.

The results of the Wilcoxon signed rank test for independent samples (effect size, as measured by *r*, and p-value) are given in the final two columns of Table 1. All comparisons were non-significant at $p<0.05$. Post hoc power analyses based on the effect observed on ratings for *novelty* showed that with an alpha = 0.05 and power = 0.80, the projected sample size needed is approximately 90 items, which is equivalent to N = 45 participants. In addition,

Table 2.
*Mean ratings by criterion and condition*

| Rating criteria | Condition | Mean rating | (sd) | Mean difference | r | p |
|---|---|---|---|---|---|---|
| **(1) implementation** | *original* | 6.67 | (2.18) | -0.38 | 0.086 | 0.560 |
| | *hyped* | 6.29 | (2.26) | | | |
| **(2) rigour** | *original* | 6.12 | (1.85) | -0.04 | 0.035 | 0.818 |
| | *hyped* | 6.08 | (2.26) | | | |
| **(3) novelty** | *original* | 5.50 | (2.15) | 1.14 | 0.215 | 0.139 |
| | *hyped* | 6.46 | (2.36) | | | |
| **(4) competence** | *original* | 6.46 | (1.47) | -0.52 | 0.088 | 0.548 |
| | *hyped* | 6.12 | (1.92) | | | |

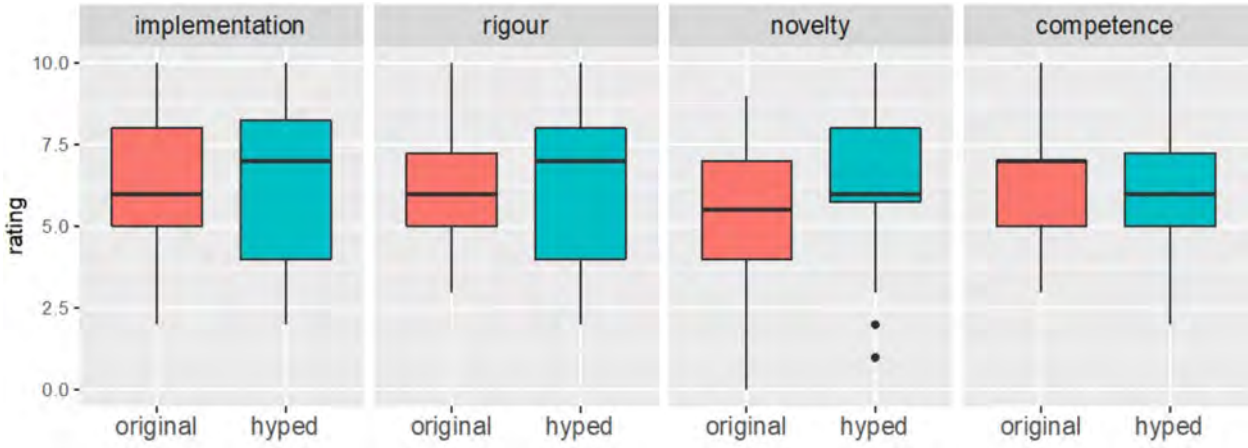


Figure 1.
*Comparison of participant ratings of original and hyped abstracts*

for each of the outcome measures, a linear mixed effects model was fitted with *condition* as a fixed effect and *participant* and *abstract* as random effects. In all four models, condition (i.e. the presence or absence of hype) had no statistically significant effect on the ratings.

*Verbal responses*

The design of the trial created 144 exposures to hype: 12 participants x two hyped abstracts x six hype items per abstract. In open-ended responses to hyped abstracts, five participants mentioned a total of seven hyping items either as 'phrases recalled' (*experienced, first study, unique*) or as strengths (*experienced* x2, *novel, qualified*). One of these participants also described the methodology of a hyped abstract as 'rigorous'.

Table 3 shows the classification of participants comments according to their reference to hype and items in the CONSORT 2010 checklist of information to include when reporting a pilot or feasibility randomized trial in a journal or conference abstract.[11]

## Discussion

While unstructured conversations via Zoom may be challenged to a degree by small delays in transmission, this did not present a problem for the structured interviews conducted in this study.[12] Furthermore, and perhaps because of the convenience with regard to timing and place for participation, all participants attended their scheduled appointments and all interviews were conducted within the scheduled time. Data collection proceeded as planned, and others have demonstrated that data collection in structured interviews is as effective via Zoom as it is in person.[13] This study was conducted in the midst of the COVID pandemic, and so the use of remote interviews mitigated any risk of disease transmission between participant and researcher. Further, there were no dropouts and no adverse responses to the interview process.

With regard to the experimental results, in this small study there were no statistically significant impacts of hype on clinicians' evaluations of abstracts of randomized clinical trials in spinal care. A post hoc power analysis suggested that in order to demonstrate with confidence the effect of one use of hype (novelty*)* on clinicians' evaluations of abstracts would require a cohort of 45 participants, not an impractical number. In response to open-ended questions, there were relatively few references to hype items and references to CONSORT items in discussions of study designs and weaknesses were sparse and unevenly distributed across items.

*Limitations*

This was a pilot study with a small cohort, and so the experimental results should not be interpreted as having any implications for the results of an adequately powered

Table 3.
*Open-ended responses referring to strengths and weaknesses of studies.*

| | Strengths (hyped) | Strengths (original) | Weaknesses (hyped) | Weaknesses (original) |
|---|---|---|---|---|
| Title | 4 | - | - | - |
| Trial design | 16 | 15 | 2 | 2 |
| **Methods per CONSORT** | | | | |
| Participants | 4 | 2 | 5 | 1 |
| Interventions | 13 | 10 | 10 | 15 |
| Objective | 0 | 0 | 0 | 1 |
| Outcome | 10 | 10 | 6 | 2 |
| Randomization | 10 | 8 | 1 | 1 |
| Blinding (masking) | 4 | 4 | 3 | 0 |
| **Sum** | **57** | **49** | **27** | **22** |
| **Results/Conclusions per CONSORT** | | | | |
| Numbers randomized | 7 | 6 | 4 | 3 |
| Recruitment | 0 | 0 | 0 | 0 |
| Numbers analysed | 1 | 4 | 6 | 5 |
| Outcome | 1 | 2 | 2 | 0 |
| Harms | 1 | 0 | 0 | 0 |
| Conclusions | 0 | 1 | 2 | 2 |
| **Sum** | **10** | **13** | **14** | **10** |

study. Similarly, the facility of conducting interviews in this study should not imply facility with other videoconferencing platforms in other locations where internet connectivity may differ. Additionally, as the study participants were all teaching faculty, the results should not be extrapolated to other populations, for example non-teaching community-based practitioners.

## Conclusion

The use of a videoconferencing platform, Zoom, to measure the effects of hype on clinicians' evaluations of abstracts of clinical trials was practical and essentially problem-free in this exercise. Hype in abstracts did not appear to affect clinicians' evaluations of articles in this small pilot study, and so a larger, adequately powered study is justified.

*Acknowledgements*

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Appendix 1.
*Abstracts*

**Eur Spine J. 2014 Jun;23(6):1204-14** (reprinted with permission).

| Original version | Hyped version |
|---|---|
| **PURPOSE:**<br>To evaluate the effect of a programme of active self-correction and task-oriented exercises on spinal deformities and health-related quality of life (HRQL) in patients with mild adolescent idiopathic scoliosis (AIS) (Cobb angle <25°). | **PURPOSE:**<br>**This is the first study** to evaluate the effect of a programme of active self-correction and task-oriented exercises on spinal deformities and health-related quality of life (HRQL) in patients with mild adolescent idiopathic scoliosis (AIS) (Cobb angle <25°). |
| **METHODS:**<br>This was a parallel-group, randomised, superiority-controlled study in which 110 patients were randomly assigned to a rehabilitation programme consisting of active self-correction, task-oriented spinal exercises and education (experimental group, 55 subjects) or traditional spinal exercises (control group, 55 subjects). Before treatment, at the end of treatment (analysis at skeletal maturity), and 12 months later (follow-up), all of the patients underwent radiological deformity (Cobb angle), surface deformity (angle of trunk rotation) and HRQL evaluations (SRS-22 questionnaire). A linear mixed model for repeated measures was used for each outcome measure. | **METHODS:**<br>This was a parallel-group, randomised, superiority-controlled study in which 110 patients were randomly assigned to a **carefully designed** rehabilitation programme consisting of active self-correction, task-oriented spinal exercises and education (experimental group, 55 subjects) or traditional spinal exercises (control group, 55 subjects). Before treatment, at the end of treatment (analysis at skeletal maturity), and 12 months later (follow-up), for all patients, **an experienced radiologist** undertook **detailed** evaluations of spinal deformity (Cobb angle), surface deformity (angle of trunk rotation) and HRQL evaluations (SRS-22 questionnaire). A linear mixed model for repeated measures was used for each outcome measure. |
| **RESULTS:**<br>There were main effects of time ($p < 0.001$), group ($p < 0.001$) and time by group interaction ($p < 0.001$) on radiological deformity: training in the experimental group led to a significant improvement (decrease in Cobb angle of >5°), whereas the control group remained stable. Analysis of all of the secondary outcome measures revealed significant effects of time, group and time by group interaction in favour of the experimental group. | **RESULTS:**<br>There were main effects of time ($p < 0.001$), group ($p < 0.001$) and time by group interaction ($p < 0.001$) on radiological deformity: training in the experimental group led to a significant improvement (decrease in Cobb angle of >5°), whereas the control group remained stable. Analysis of all of the secondary outcome measures revealed significant effects of time, group and time by group interaction in favour of the experimental group. |
| **CONCLUSIONS:**<br>The programme of active self-correction and task-oriented exercises was superior to traditional exercises in reducing spinal deformities and enhancing the HRQL in patients with mild AIS. The effects lasted for at least 1 year after the intervention ended. | **CONCLUSIONS:**<br>**The findings provide convincing evidence that** a programme of active self-correction and task-oriented exercises is superior to traditional exercises in reducing spinal deformities and enhancing the HRQL in patients with mild AIS. **It is noteworthy that** the effects lasted for at least 1 year after the intervention ended. |

**Spine (Phila Pa 1976). 2000 Jun 15;25(12):1523-32** (reprinted with permission).

| Original version | Hyped version |
|---|---|
| **STUDY DESIGN**: A prospective randomized controlled trial of exercise therapy in patients who underwent microdiscectomy for prolapsed lumbar intervertebral disc. Results of a pilot study are presented. | **STUDY DESIGN**: A prospective randomized controlled trial of exercise therapy in patients who underwent microdiscectomy for prolapsed lumbar intervertebral disc. Results of a pilot study are presented. |
| **OBJECTIVE**: To determine the effects of a postoperative exercise program on pain, disability, psychological status, and spinal function. | **OBJECTIVE**: To determine the effects of a postoperative exercise program on pain, disability, psychological status, and spinal function. |
| **SUMMARY OF BACKGROUND DATA:** Microdiscectomy is often used successfully to treat prolapsed lumbar intervertebral disc. However, some patients do not have a good outcome and many continue to have low back pain. The reasons for this are unclear but impairment of back muscle function due to months of inactivity before surgery may be a contributing factor. A postoperative exercise program may improve outcome in such patients. | **SUMMARY OF BACKGROUND DATA:** Microdiscectomy is often used successfully to treat prolapsed lumbar intervertebral disc. However, some patients do not have a good outcome and many continue to have low back pain. The reasons for this are unclear but impairment of back muscle function due to months of inactivity before surgery may be a contributing factor. A postoperative exercise program may improve outcome in such patients. |
| **METHODS:** Twenty patients who underwent lumbar microdiscectomy were randomized into EXERCISE and CONTROL groups. After surgery, all patients received normal postoperative care that included advice from a physiotherapist about exercise and a return to normal activities. Six weeks after surgery, patients in the EXERCISE group undertook a 4-week exercise program that concentrated on improving strength and endurance of the back and abdominal muscles and mobility of the spine and hips. Assessments of spinal function were performed in all patients during the week before surgery and at 6, 10, 26, and 52 weeks after. The assessment included measures of posture, hip and lumbar mobility, back muscle endurance capacity and electromyographic measures of back muscle fatigue. On each occasion, patients completed questionnaires inquiring about pain, disability and psychological status. | **METHODS:** Twenty patients who underwent lumbar microdiscectomy were randomized into EXERCISE and CONTROL groups. After surgery, all patients received normal postoperative care that included **detailed advice** from an **experienced physiotherapist** about exercise and a return to normal activities. Six weeks after surgery, patients in the EXERCISE group undertook an **innovative** 4-week exercise program that concentrated on improving strength and endurance of the back and abdominal muscles and mobility of the spine and hips. **Comprehensive** assessments of spinal function were performed in all patients during the week before surgery and at 6, 10, 26, and 52 weeks after. The assessment included measures of posture, hip and lumbar mobility, back muscle endurance capacity and electromyographic measures of back muscle fatigue. On each occasion, patients completed questionnaires inquiring about pain, disability and psychological status. |
| **RESULTS:** Surgery improved pain, disability, back muscle endurance capacity and hip and lumbar mobility in both groups of patients. After the exercise program, the EXERCISE group showed further improvements in these measures and also in electromyographic measures of back muscle fatigability. All these improvements were maintained 12 months after surgery. The only further improvement showed by the CONTROL group between 6 and 52 weeks was an increase in back muscle endurance capacity. | **RESULTS:** Surgery improved pain, disability, back muscle endurance capacity and hip and lumbar mobility in both groups of patients. After the exercise program, the EXERCISE group showed further improvements in these measures and also in electromyographic measures of back muscle fatigability. **Notably**, all these improvements were maintained 12 months after surgery. The only further improvement showed by the CONTROL group between 6 and 52 weeks was an increase in back muscle endurance capacity. |
| **CONCLUSION**: A 4-week postoperative exercise program can improve pain, disability, and spinal function in patients who undergo microdiscectomy. | **CONCLUSION**: **This is the first randomized controlled trial to demonstrate that** a 4-week postoperative exercise program can improve pain, disability, and spinal function in patients who undergo microdiscectomy. |

**Spine (Phila Pa 1976). 2005 Apr 1;30(7):711-21** (reprinted with permission).

| Original version | Hyped version |
|---|---|
| **STUDY DESIGN:** A randomized clinical trial with blinded assessment. | **STUDY DESIGN:** A randomized clinical trial with blinded assessment. |
| **OBJECTIVES:** To investigate the clinical efficacy of 2 active interventions for patients with chronic low back pain. | **OBJECTIVES:** To investigate the clinical efficacy of 2 active interventions for patients with chronic low back pain. |
| **SUMMARY OF BACKGROUND DATA:** Manual therapy and exercise prescription are treatments frequently prescribed for patients with chronic low back pain. The evidence for the relative benefit of these treatments is limited, and questions concerning the most appropriate type of intervention remain unanswered. | **SUMMARY OF BACKGROUND DATA:** Manual therapy and exercise prescription are treatments frequently prescribed for patients with chronic low back pain. The evidence for the relative benefit of these treatments is limited, and questions concerning the most appropriate type of intervention remain unanswered. |
| **METHODS:** Eighty patients with chronic low back pain (>3 months) were randomized to one of the following treatments, involving 8 treatments over 8 weeks; 1) one-to-one treatment involving 30 minutes of manual therapy (mobilizations to the spine) and spinal stabilization exercises, and 2) a 10 station exercise class involving aerobic exercises, spinal stabilization exercises, and manual therapy. Three physiotherapists led the hour long group with a maximum of 10 patients. Questionnaires were completed, and physical measurements were taken by a blinded observer before randomization, at the completion of treatment, and at 6 months and 12 months after the completion of treatment. The intention-to-treat principle was used in data analysis. | **METHODS:** Eighty patients with chronic low back pain (>3 months) were randomized to one of the following treatments, involving 8 treatments over 8 weeks; 1) one-to-one treatment involving 30 minutes of manual therapy (mobilizations to the spine) and spinal stabilization exercises, and 2) a 10 station exercise class involving aerobic exercises, spinal stabilization exercises, and manual therapy. Three **experienced, qualified physiotherapists** led the hour long group with a maximum of 10 patients. **Carefully designed** questionnaires were completed, and **detailed** physical measurements were taken by a **trained** blinded observer before randomization, at the completion of treatment, and at 6 months and 12 months after the completion of treatment. The intention-to-treat principle was used in data analysis. |
| **RESULTS:** Eleven patients dropped out of the individual treatment sessions and 7 dropped out of the exercise group. There was a significant reduction (reduced disability) in the questionnaire score in both groups, and there were significant increases in range for all the physical movements tested in both groups. The exercise group was 40% more cost effective than the individual treatments. | **RESULTS:** Eleven patients dropped out of the individual treatment sessions and 7 dropped out of the exercise group. There was a significant reduction (reduced disability) in the questionnaire score in both groups, and there were significant increases in range for all the physical movements tested in both groups. **A novel finding was that** the exercise group was 40% more cost effective than the individual treatments. |
| **CONCLUSION**: Both forms of intervention were associated with significant improvement. On-going clinical research is necessary to provide guidance as to the clinical efficacy of various forms of intervention. | **CONCLUSION**: **The findings provide convincing evidence that** both forms of intervention are associated with significant improvement. On-going clinical research is necessary to provide guidance as to the clinical efficacy of various forms of intervention. |

**Spine (Phila Pa 1976). 2009 Jun 15;34(14):1436-40** (reprinted with permission).

| Original version | Hyped version |
|---|---|
| **STUDY DESIGN:** This study was a prospective, randomized, controlled study. | **STUDY DESIGN:** This study was a prospective, randomized, controlled study. |
| **OBJECTIVE:** To compare the effectiveness of aquatic exercise interventions with land-based exercises in the treatment of chronic low back pain (CLBP). | **OBJECTIVE:** To compare the effectiveness of aquatic exercise interventions with land-based exercises in the treatment of chronic low back pain (CLBP). |
| **SUMMARY OF BACKGROUND DATA:** Land-based exercise and physiotherapy are the main treatment tools used for CLBP. Clinical experience indicates that aquatic exercise may have advantages for patients with musculoskeletal disorders. | **SUMMARY OF BACKGROUND DATA:** Land-based exercise and physiotherapy are the main treatment tools used for CLBP. Clinical experience indicates that aquatic exercise may have advantages for patients with musculoskeletal disorders. |
| **METHODS:** A total of 65 patients with CLBP were included in this study. Patients were randomly assigned to receive aquatic exercise or land-based exercise treatment protocol. Aquatic exercise program consisted of 20 sessions, 5 x per week for 4 weeks in a swimming pool at 33 degrees C. Land-based exercise (home-based exercise) program were demonstrated by a physiotherapist on one occasion and then they were given written advice. The patients were assessed for spinal mobility, pain, disability, and quality of life. Evaluations were performed before treatment (week 0) and after treatment (week 4 and week 12). | **METHODS:** A total of 65 patients with CLBP were included in this study. Patients were **carefully** randomized to receive aquatic exercise or land-based exercise treatment protocol. **The innovative** aquatic exercise program consisted of 20 **specially designed** sessions, 5 x per week for 4 weeks in a swimming pool at 33 degrees C. Land-based exercise (home-based exercise) program were demonstrated by a **qualified, experienced physiotherapist** on one occasion and then they were given written advice. The patients **underwent detailed assessment of** spinal mobility, pain, disability, and quality of life. Evaluations were performed before treatment (week 0) and after treatment (week 4 and week 12). |
| **RESULTS:** In both groups, statistically significant improvements were detected in all outcome measures (except modified Schober test) compared with baseline. However, improvement in modified Oswestry Low Back Pain Disability questionnaire and physical function and role limitations due to physical functioning subpart of Short-Form 36 Health Survey were better in aquatic exercise group ($P < 0.05$). | **RESULTS:** In both groups, statistically significant improvements were detected in all outcome measures (except modified Schober test) compared with baseline. However, improvement in modified Oswestry Low Back Pain Disability questionnaire and physical function and role limitations due to physical functioning subpart of Short-Form 36 Health Survey were better in aquatic exercise group ($P < 0.05$). |
| **CONCLUSION:** It is concluded that water-based exercises produced better improvement in disability and quality of life of the patients with CLBP than land-based exercise. | **CONCLUSION: This is the first randomized controlled trial to demonstrate** that water-based exercises produce better improvement in disability and quality of life of the patients with CLBP than land-based exercise. |

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# Spinal gout diagnosis in chiropractic practice: narrative review

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Objective: *To review and summarize the recent literature, increase awareness and provide guidance for chiropractic physicians regarding the diagnosis of spinal gout.*

Methods: *A search of PubMed was undertaken for recent case reports, reviews and trials relating to spinal gout.*

Results: *Our analysis of 38 cases of spinal gout revealed that 94% of spinal gout patients presented with back or neck pain, 86% displayed neurological symptoms, 72% had a history of gout, and 80% had raised serum uric acid levels. Seventy-six percent of cases proceeded to surgery. A combination of clinical findings, laboratory tests and appropriate utilization of Dual Energy Computed Tomography (DECT) has the potential to improve early diagnosis.*

Diagnostic de la goutte spinale dans la pratique chiropratique : analyse narrative

Objectif : *Examiner et résumer la littérature récente, sensibiliser les médecins chiropraticiens et les guider dans le diagnostic de la goutte spinale.*

Méthodes : *Une recherche a été entreprise dans PubMed pour trouver des rapports de cas, des études et des essais récents concernant la goutte spinale.*

Résultats : *Notre analyse de 38 cas de goutte spinale a révélé que 94 % des patients souffrant de goutte spinale présentaient des douleurs dorsales ou cervicales, 86 % des symptômes neurologiques, 72 % des antécédents de goutte et 80 % une élévation du taux d'acide urique sérique. Soixante-seize pour cent des cas ont donné lieu à une intervention chirurgicale. La combinaison des résultats cliniques, des tests de laboratoire et de l'utilisation appropriée de la tomographie informatisée à double énergie (DECT) peut améliorer les chances d'un diagnostic précoce.*

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Conclusion: *Gout is an uncommon cause of spine pain; however, it must be considered in the differential diagnosis as outlined in this paper. Increased awareness of the signs of spinal gout and earlier detection and treatment has the potential to improve the quality of life of patients and reduce the need for surgery.*

(JCCA. 2023;67(1):50-66)

KEY WORDS: chiropractic, gout, spine

Conclusion: *La goutte est une cause peu fréquente de douleur vertébrale, mais elle doit être prise en compte dans le diagnostic différentiel, comme indiqué dans le présent document. Une meilleure connaissance des signes de la goutte spinale et une détection et un traitement plus précoces pourraient améliorer la qualité de vie des patients et réduire la nécessité d'une intervention chirurgicale.*

(JCCA. 2023;67(1):50-66)

MOTS CLÉS : chiropratique, goutte, colonne vertébrale

## Introduction

Gout is an inflammatory arthritis caused by the deposition of monosodium urate crystals (MSU) in the synovial fluid and other tissues. Hyperuricaemia is correlated with gout incidence and recurrence.[1] Gout usually presents as monoarticular and is more likely to affect the distal joints, most frequently the first metatarsophalangeal joint, ankle, and mid-foot, however it may also affect the hands, wrists, elbows, knees, hips and spine. Polyarticular gout is typically associated with chronic gout symptoms.[2]

The prevalence of gout worldwide is estimated to be 1-4%. It is more common in men (3:1 to 10:1) and older age groups, and is increasing in many developed countries (New Zealand, Canada, United Kingdom, Korea).[3–5] In 2017, the greatest point prevalence estimates for gout were in New Zealand, Australia and the United States of America (US).[5]

In the US, general gout prevalence is 5.2% in males and 2.7% in females.[6] With age greater than 80 years the prevalence increases to 9% in men and 6% in women. Prevalence of hyperuricaemia remained stable in the US from 2007-2016. However, Chen-Xu *et al*.[7] propose that a new wave of rising obesity in younger age groups may lag a future increase in gout prevalence. It is suspected that Western diets, sedentary lifestyle, an increased frequency of obesity and hypertension are contributing factors to raised uric acid levels.

Spinal gout, once thought to be a rare condition, may be more common than previously appreciated. Spinal gout has been identified in 14 to 29% of patients with a confirmed diagnosis of extremity gout.[8–10] Prevalence may be significantly underestimated as only patients with severe symptoms, such as neurological deficit and fever, or those failing to respond to other therapies are investigated further.[11]

Advancements in imaging technologies such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Dual Energy Computed Tomography (DECT) have significantly improved the detection of spinal gout. DECT is an emerging technology designed to detect the presence of MSU crystalline deposits. The technology is well established for assisting with the diagnosis of extremity gout but is yet to be commonly utilized for detecting spinal gout. Several case reports summarized in our paper mention DECT as an important diagnostic tool for confirming spinal gout.[12–14]

In this paper we analyse 38 case reports of spinal gout from between 2017 and 2022. Consistent with previous reviews, a high proportion (76%) of cases of spinal gout proceed to surgery with diagnosis only confirmed after excision and lab analysis.[15–17] This highlights the need for earlier and less invasive detection methods for spinal gout, with particular application in primary care settings. In this paper we review advances in clinical diagnosis and imaging and recommend tools to improve recognition and earlier diagnosis of spinal gout.

## Methods

A search of PubMed was undertaken for case reports, systematic reviews, literature reviews, observational studies,

clinical trials and radiological investigations relating to spinal gout. Keywords searched were "gout", "spinal", "axial", "vertebral", "tophaceous", "prevalence", "imaging", "case reports", and "case review". Reference lists of included and key articles were searched to identify other potentially suitable articles. Data from included studies were extracted by one review author including data such as participant characteristics (age/sex, history of back and neck pain, neurological signs and symptoms), location, history of gout, imaging and treatment (Table 1). As this is a narrative review, no critical appraisal of the included articles or confirmation of data extraction was undertaken. Cases containing incomplete data were not excluded from analysis, however when specific data was missing (e.g. laboratory findings) the case was excluded from analysis for that item only. For example, Serum Uric acid (sUA) above 6.0 mg/dL = 28 cases. Three of our 38 cases did not report sUA and were therefore excluded from our calculations resulting in the formula 28/35 (80% of cases)

There have been several comprehensive spinal gout reviews covering case reports between 1950-2017.[11,15–17] In order to avoid case report duplication with previous reviews we limited our search for case reports to the period between January 2017 and April 2022.

## Results

Forty-five case reports, four systematic reviews, fourteen literature reviews and nine observational studies were identified. The systematic reviews provided case series analysis of 454 cases of spinal gout (including duplicated cases) between 1950 and 2017. After removing duplicates, Zhang *et al*.[16] found 287 cases of spinal gout for this period, however only 142 cases met criteria for further analysis. To avoid duplication, we excluded seven case reports (which appeared in previous reviews[16,18]), leaving 38 cases for inclusion in our analysis. Our case study findings are summarized in Table 1.

Our case review analysis revealed that 85% of patients diagnosed with spinal gout were male. Ninety-four percent

Table 1.

*Summary of findings from case studies. From the following 38 case reports, specific facts and figures emerge on the diagnosis and treatment of spinal gout. These statistics are taken from and grouped into pertinent and clinically related data on the demographics, diagnostic imaging, anatomical location, diagnosis and the ultimate impression of gout.*

| Authors | Age/ Sex | Hx BP/NP | Neuro S/s | Hx Joint Pain | Location | Hx Gout | sUA >6.0 mg/dL | Imaging Findings | Tx |
|---|---|---|---|---|---|---|---|---|---|
| Wu Z *et al*. 19 | 48 M | 8/52 sharp LBP | Y | Y | L2-3 Epidural Space | 10yrs | Y | MRI - extradural mass/ lesion to the left | Surgery |
| Wu Z *et al*. 19 | 63 M | 2yrs LBP | Y | NR | L4-5 Epidural Space | 30yrs | Y | MRI and CT – nerve root compression, LCSS | Surgery |
| Sullivan *et al*.20 | 63 M | Weeks severe LBP | Y | Y | Lx, SIJ's | Y | Y | DECT - diffuse MSU deposition Lx Spine, sacrum and SIJ's | Medication |
| Wang *et al*. 21 | 48 M | 1/52 severe LBP | N | NR | Lx Erector Spinae | N | N | MRI - large mass (intermediate attenuation) | Medication |
| Sanchez *et al*. 22 | 41 M | 4/52 LBP | Y | Y | L5-S1 Facet Joints | 7yrs | Y | CT - erosive changes L5-S1 facet joint with hypertrophy | Medication |
| Park *et al*. 12 | 49 M | NR | Y | NR | C1-2 Epidural Space | NR | NR | CT - erosive appearance, lytic bone lesions, DECT - extradural tophus (central-posterior to C1 body) | Deceased (before Tx) |

| Authors | Age/ Sex | Hx BP/NP | Neuro S/s | Hx Joint Pain | Location | Hx Gout | sUA >6.0 mg/dL | Imaging Findings | Tx |
|---|---|---|---|---|---|---|---|---|---|
| Romero *et al*. 23 | 82 M | Neck Pain | Y | Y | C1-2 Vertebra, transverse ligament, Epidural Space | 40yrs | N | CT - rat-tooth erosions, retrodental mass arising from transverse ligament of atlas - 80% central CSS | Medication |
| Si *et al*. 24 | 49 F | 2yrs severe LBP | N | NR | L3 Intradural | NR | N | MRI and CT - calcified mass causing displacement of dural sac and nerve roots | Surgery |
| Yip *et al*. 25 | 43 M | 7/52 severe LBP | Y | Y | L4-5 Epidural Space | 20yrs | Y | MRI with gadolinium - epidural lobulated lesion | Surgery |
| Martins *et al*. 26 | 55 M | 1/52 LBP | Y | Y | L4-5 Epidural Space | 8yrs | N | CT and MRI - calcified mass causing central and foraminal stenosis and compressing/ displacing the dural sac | Surgery |
| Emsen *et al*. 27 | 63 F | NR | NR | NR | C3-T1 Facet Joints | NR | NR | FDG PET/CT - multiple osteolytic lesions C3-T1 with joint erosions | Surgery |
| Ayoub *et al*. 28 | 27 M | 4/52 LBP | NR | Y | L5-S1 Facet Joint Lamina, Epidural Space | 5yrs | Y | CT and MRI - impingement of S1 nerve root in lateral recess | Medication |
| Wang *et al*. 13 | 32 M | acute severe LBP | N | Y | L3-S1 Facet joints | Y | Y | MRI, DECT - focal erosions at right L3-4, L4-5 and L5-S1 facet joints | Medication |
| Wang *et al*. 13 | 74 M | 6/52 LBP | N | Y | L4/5 Facet Joints | N | Y | CT and MRI, DECT - erosion of L4-5 facet joint, calcified peri-articular mass, marked stenosis, compression of the L5 descending nerve root, | Medication |
| Matos *et al*. 29 | 50 F | Neck Pain | Y | N | C7 Lamina Facet Joints | N | Y | MRI - spinal canal stenosis, CT - lytic lesions of C6 spinous and posterior elements | Surgery |
| Mishra *et al*. 30 | 33 M | 9Mths BP | Y | N | T9-11 Intradural, Ligamentum Flavum | NR | Y | Thoracic plain film normal, MRI - posterolateral lesion at T10-11, focal hyperintense cord signal | Surgery |
| Thuraikumar *et al*. 31 | 68 M | 1yr LBP | Y | Y | L5-S1 Vertebra Anterior Longitudinal Ligament | Y | N | MRI - end-plate destruction of L5-S1, partial vertebral body destruction, cystic fluid collection, ALL spread and LCSS | Surgery |
| Kao *et al*. 18 | 38 M | 8/52 BP | Y | Y | T11-T12 Epidural Space | 10yrs | Y | CT - T11-12 epidural mass causing CCS and left foraminal stenosis | Surgery |

| Authors | Age/ Sex | Hx BP/NP | Neuro S/s | Hx Joint Pain | Location | Hx Gout | sUA >6.0 mg/dL | Imaging Findings | Tx |
|---|---|---|---|---|---|---|---|---|---|
| Chen *et al*. 32 | 64 M | 11Mths LBP | Y | N | L4-5 Epidural space | N | N | CT and MRI - consistent with a large disc protrusion causing canal stenosis and left lateral recess stenosis | Surgery |
| Salazar *et al*. 33 | 44 M | 1yr severe LBP | Y | Y | L4-5-S1 FJ Epidural space Interspinous space | NR | Y | X-Ray- lytic spondylolisthesis, MRI - facet joint and interspinous space lesion | Surgery |
| Zhou *et al*. 34 | 50 M | Neck Pain 5yrs | Y | Y | C5-6 IVD Vertebra | 20yrs | Y | CT and MRI - osteolytic destruction of vertebral endplates | Surgery |
| Akhter *et al*. 35 | 26 M | NR | Y | Y | T6-8 Facet Joints Epidural space | N | Y | MRI - epidural mass right posterolateral, severe central canal stenosis, lytic/erosive lesions facet joints | Surgery |
| Ma *et al*. 36 | 45 M | 2yrs LBP | Y | Y | C4-5 and L5-S1 Epidural space, Ligamentum Flavum | 14yrs | Y | CT and MRI - herniated lesion with cord compression C4-5, L5-S1 LDH | Surgery |
| Ma *et al*. 36 | 61 M | 2yrs LBP | Y | Y | L4-5 Facet Joints | Y | Y | CT and MRI - bony erosion | Surgery |
| Ma *et al*. 36 | 70 F | 8 yrs Neck Pain | Y | Y | C3-6 Ligamentum Flavum Epidural space | Y | Y | CT and MRI - high density mass extending into spinal canal | Surgery |
| Ma *et al*. 36 | 24 M | 1yr LBP | N | Y | L3-4 Facet Joint | Y | Y | CT - bony erosion, high density | Surgery |
| Ma *et al*. 36 | 78 M | N | Y | Y | C2-5 Posterior Longitudinal Ligament | Y | Y | CT and MRI – bony erosion, high density | Medication |
| Wan *et al*. 37 | 42 M | 2yrs LBP | Y | Y | L4-S1 Facet Joints, Lamina | 4yrs | N | MRI - end-plate erosions, Hyperintense disc signal L4-5 & L5-S1 | Surgery |
| Xie *et al*. 38 | 73 M | N | Y | N | C5-6 Ligamentum Flavum | N | Y | CT - spinal stenosis due to LF ossification - left side | Surgery |
| Liu *et al*. 14 | 35 M | LBP | Y | Y | L2-5 Facet Joints Lamina Spinous Process Epidural space | Y | Y | XR - facet joint erosions L2-5, MRI and DECT - LCSS due to tophi | Surgery |
| Al-Jebaje *et al*. 39 | 26 M | NR | Y | Y | C3-T1 and T7-11 Epidural space | Y | Y | MRI - severe LCSS at C6-7 and right C7 foraminal stenosis, multilevel degeneration, spinal stenosis T12-L1 | Surgery |

| Authors | Age/ Sex | Hx BP/NP | Neuro S/s | Hx Joint Pain | Location | Hx Gout | sUA >6.0 mg/dL | Imaging Findings | Tx |
|---|---|---|---|---|---|---|---|---|---|
| Gago *et al*. 40 | 55 M | 12/52 LBP | Y | Y | L3-5 Facet Joints | Y | Y | MRI - exophytic lesion extending posteriorly from L3-4 facet joint, L4-5 facet joint inflammation | Surgery |
| Ding *et al*. 41 | 36 M | 2/52 BP | Y | Y | T9-10 Intradural | 2 yrs. | Y | CT - spinal stenosis due to occupied lesions T9 and T10, MRI - cord ischemia | Surgery |
| Cheng *et al*. 42 | 23 M | LBP 6yrs | Y | Y | Thx and Lx Epidural space | Y | Y | MRI - epidural collection C4-T11 along anterior thecal sac, CT - bone erosions L2-3 facet | Surgery |
| Borges *et al*. 43 | 56 M | 2yrs LBP | Y | Y | T8-9 Epidural space | 15 yrs | Y | CT and MRI - space occupying lesion at T8-9 - indentation of dural sac, multi-level facet joint hypertrophy and erosion of articular surfaces | Medication |
| Ng *et al*. 44 | 66 M | 1/52 Neck Pain | Y | N | C4-5 Vertebra | N | Y | XR - C5-6 end-plate erosions, C5 vertebral body destruction, CT-prevertebral fluid C2-5, MRI - C5-6 CSS and myelomalacia | Surgery |
| Ng *et al*. 44 | 68 M | 8/52 LBP | Y | Y | L4-5 Epidural space Ligamentum Flavum, Interspinous, Supraspinous Ligament | N | Y | MRI - epidural soft tissue signals around bilateral L4-5 pars defects causing severe LCSS and bilateral foraminal stenosis, cauda equina compression | Surgery |
| Vergara *et al*. 45 | 60 F | 16/52 severe LBP | Y | NR | L3-4 Epidural space | NR | NR | CT Myelogram - severe LCSS L3-4, moderate LCSS L2-3 | Surgery |

Legend: *M=Male, F=Female, LBP= Low Back pain, BP=Back pain, Y= Yes, N= No, sUA = Serum Uric Acid, NR= Not reported, Mths= Months, /52 = weeks, Lx= Lumbar, Thx= Thoracic, Cx= Cervical, ALL= Anterior Longitudinal Ligament, LDH: Lumbar Disc Herniation XR= X-ray, CT= Computed Tomography, MRI= Magnetic Resonance Imaging, DECT= Dual Energy Computed Tomography, Yrs= Years, LCSS= Lumbar Central Spinal Stenosis, CSS= Cervical Spine Stenosis, Hx= History, Tx= Treatment*

presented with back or neck pain and 86% displayed radiating/neurological symptoms. Back pain varied from mild to severe with onset months to years prior to presentation. Only two patients did not report a history of axial pain[36,38] (four case studies did not report this clinical data[12,27,35,39]). Neurological symptoms and signs included upper and lower limb radiating pain, arm or leg paresthesias/numbness/weakness, claudication, muscle atrophy, bowel or bladder incontinence, clumsiness, and falls. Patients with spinal gout were more likely to have a history of extremity joint pain (84%) and peripheral gout (72%) with the feet, ankles, knees, wrists, and hands commonly affected. Subdermal gouty tophi were observed in 69% of cases.

The lumbar spine (61%) was the most affected spinal region, particularly the facet joints (37%) and epidural space (50%). Spinal gout was reported less commonly in the ligamentum flavum (13% of cases[30,36,38,44]), vertebrae (11% of cases[23,31,34,44]) and the lamina (11%[14,28,29,37]). There were isolated cases involving other spinal elements (intervertebral disc[34], spinous process[46], anterior longitudinal ligament[31], posterior longitudinal ligament[36], interspinous/supraspinous ligament[44], transverse ligament[23], erector spinae[21]). The cervical spine was involved in 29% of cases and the thoracic spine in 21% of cases. The most involved vertebral segments for each spinal region were L4-5 and L5-S1, T8-9 and T9-10, and C4-5 and C5-6. Spinal gout was also identified in the sacroiliac joints by a DECT scan in one of our cases.[20]

Laboratory findings demonstrated serum uric acid (sUA) levels above 6 mg/dL in 80% of patients, raised C-Reactive Protein (CRP) in 48%, and raised Erythrocyte Sedimentation Rate (ESR) in 48% of patients. Twenty-nine percent of patients had a sUA level over 10 mg/dL[13,29,30,33,36,39,40,42,43]. Twenty percent of patients were reported to have sUA levels in the normal range[21,23,24,26,31,32,37]. Three cases failed to report sUA levels[12,27,45], one case reported sUA as 'normal'[24], and one case reported sUA as 'elevated'[35]. In most cases X-ray, CT and MRI scans did not offer a definitive diagnosis. DECT scans assisted in the diagnosis of spinal gout in five of our cases[12,13,20,46]. Wang *et al*.[13] identified two cases of spinal gout utilizing DECT. Comorbid conditions were present in 75% of spinal gout patients. Obesity, type two diabetes, renal impairment, and hypertension were the most common comorbidities.

Twenty-eight cases (76%) in our review proceeded to surgery. One case was scheduled for surgery but passed before surgery was performed. Of our 38 cases, only eight cases were suspected as having spinal gout.[12,20,23,25,28,33,43,46] The most common presumptive diagnoses (79% of cases) were infection[21,22,31,34,37,40,42,44] (osteomyelitis, septic arthritis, spondylodiscitis, epidural abscess, tuberculosis), tumour[19,21,26,30,36,41] (meningioma) and disc herniation/degenerative stenosis[18,19,32,36,38,39,45]. Laminectomy/decompression was the most common surgical procedure. The majority of patients treated by surgery experienced an improvement in their symptoms. Seven of our nine cases treated conservatively with anti-inflammatories and uric acid lowering medication also experienced symptomatic improvement.[20–23,36,43] There were two cases treated with medication which did not report the outcome.[13,28] Our analysis is summarized in Table 2 below.

## Criteria for the clinical diagnosis of gout

Recognizing the importance for earlier detection of gout in primary practice, Janssens *et al*.[47] developed diagnostic criteria emphasizing the clinical features of gout in preference to diagnosis by joint aspiration. Various clinical features were studied and given a point rating according to their association with gout. In combination they found that male sex, involvement of the first metatarsophalangeal joint, and elevated serum uric acid (> 5.88 mg/DL, 0.35 mmol per L) were highly correlated with a diagnosis of gout. Low scores, <4.0 points were found to have 97% sensitivity for excluding gout whilst high scores, >8.0 points were found to have 80% sensitivity for diagnosing gout (confirmed by joint aspiration).[47] Kienhorst *et al*.[48] validated Janssens *et al*.'s diagnostic rule (Table 3). Joint aspiration and crystal analysis remains the gold standard for gout diagnosis, however the challenges posed by joint aspiration, particularly in the case of spinal gout, limits the viability of this diagnostic tool.

The American College of Rheumatology and the European League against Rheumatism (ACR/EULAR) include joint aspiration and crystal analysis in their diagnostic criteria[49], however as per Janssens *et al*., clinical features are also strongly represented. Importantly, a negative joint aspiration does not necessarily exclude a diagnosis of gout if other clinical features score highly.[49] In contrast to the Janssens *et al*. criteria, the ACR/EULAR criteria only apply if there is a history of at least one episode of 'swelling, pain or tenderness of a peripheral joint or bursa.'

Table 2.
*Summary of case report analysis*

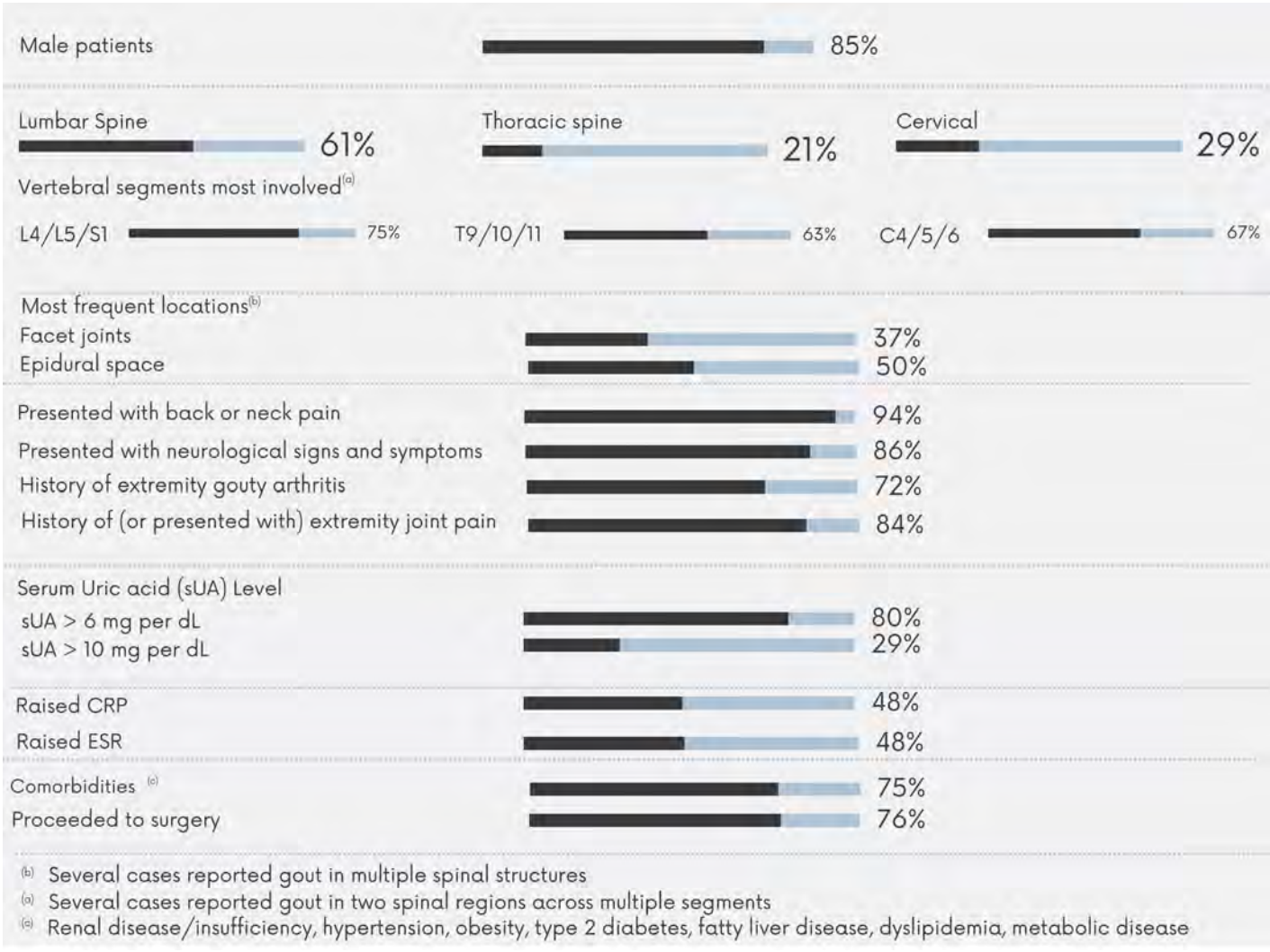

Table 3.
*Diagnostic rule for gout diagnosis in clinical practice*

| Patient With Monoarthritis | |
|---|---|
| Clinical variables | |
| Male Sex: | 2 points |
| Previous attack of patient reported arthritis attack | 2 points |
| Onset within 1 day: | 0.5 point |
| Joint redness | 1 point |
| Involvement of the first MTP joint: | 2.5 points |
| Hypertension or >1 cardiovascular diseases* | 1.5 points |
| Serum uric acid > 5.88 mg/dL (0.35 mmol per L) | 3.5 points |
| Total score: (maximum: 13 points) | |
| Interpretation: | |
| >8 Points | Gout in 87% |
| >4 and <8 Points | Uncertain diagnosis, Perform joint fluid analysis |
| <4 Points | Non-gout in 95% cases, consider non-gout diagnosis – CPPD, septic arthritis, reactive arthritis, rheumatoid arthritis, osteoarthritis, or psoriatic arthritis |

*—Cardiovascular diseases include angina pectoris, myocardial infarction, heart failure, stroke, transient ischemic attack, and peripheral vascular disease.
CPPD: calcium pyrophosphate dihydrate deposition disease

Reprinted with permission: Kienhorst et al. The validation of a diagnostic rule for gout without joint fluid analysis: a prospective study. Rheumatology. 2015;54(4):609-614.

### *Imaging of spinal gout*

Imaging modalities utilized for detecting spinal gout have been well researched. Patients presenting to primary practice for management of neck/arm pain or back/leg pain may typically undergo further assessment with x-ray, CT scan, MRI or DECT. Bony erosions and spinal tophi are well demonstrated by CT and MRI, however both technologies often lack the ability to differentiate spinal gout from other space occupying lesions such as abscess, tumour and disc extrusion.[50]

Based upon the imaging findings presented in Table 1, we provide the following summary of the radiological features suggestive of spinal gout, as observed using each of the most common imaging modalities:

### *X-ray*

- Signs may have a similar appearance and be difficult to distinguish from osteoarthritis (OA) and age related changes – subchondral bone cysts, facet joint erosions with sclerotic borders, odontoid process erosion, soft tissue oedema.[11]

### *Computed tomography (CT scan)*

- Bone or facet joint erosions with well-defined sclerotic margins.[11,15] Bone resorption occurs under the articular surface and may be accompanied by high-density tophi around the joint.[50]
- Facet or intervertebral bone neoformation, or juxta-articular or intra-articular masses that have increased density compared to surrounding muscle.[15]
- Tophi appear as a high-density mass and need to be distinguished from other space occupying lesions.[15,50]

Note: Patients presenting with an acute first episode of extremity gout are less likely to have evidence of joint erosions on imaging.[51]

### *Magnetic resonance imaging (MRI)*

Tophi appearance

- T1 – hypointense to isointense signal, homogenous mass.
- T2 – hypointense to hyperintense signal, homogenous mass (tophi). Peripheral heterogenous contrast enhancement patterns.[11,15,52]

Disc space appearance:

- T1 hypointense signal. T2 – variable hypointense to isointense signal, contrast enhancement of the disc which can mimic discitis, degenerative changes or CPPD.[11,15,52]

Vertebra:

- Normal bone marrow signal of adjacent vertebrae.[11]

### *Dual energy computed tomography (DECT):*

DECT scanning has been utilized for more than a decade for detecting and monitoring monosodium urate (MSU) deposits in gout patients. It has been found to have high sensitivity and specificity[53–55]. Dalbeth *et al*.[56] observed MSU deposits in 24% of individuals with asymptomatic hyperuricaemia, 79% with early gout (<3 years) and 84% with late gout. MSU deposits occurred in joints and tendons and were of a larger volume in the symptomatic patients.

False negatives on DECT scans are more commonly observed during a first flare of gout (< 6 weeks) or when MSU deposits are smaller in volume, such as those found in the facet joints. DECT is being utilized increasingly for detecting spinal gout, however there is ongoing research regarding the optimization of parameters/thresholds to minimize false positives and negatives.[51] Artefacts mimicking MSU deposits can be caused by beam hardening and image noise (patient movement). Beam hardening may occur due to the presence of metal implants, metal rings/piercings or dense cortical bone. Post-processing software may produce artefacts.[55] Toprover *et al*.[57] also propose that aged costochondral cartilage, which contains low concentration calcium deposits, may be mistaken for MSU deposits (due to having similar DECT attenuation properties).

Whilst further research is needed regarding the utility of DECT for diagnosing spinal gout, when combined with clinical findings, lab results and other imaging (CT and MRI)[52], DECT may prove to be a useful tool for improving diagnostic certainty in primary care settings. Figure 1 through 6 feature CT, MRI and DECT scans demonstrating spinal gout.

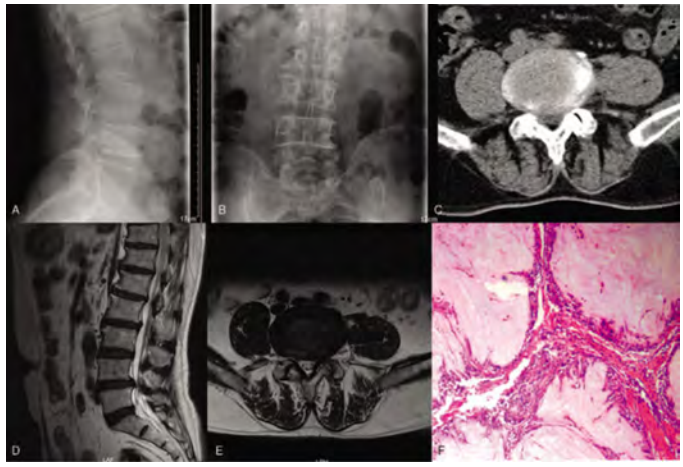

Figure 1.

*Spinal gout imaging: x-ray, CT, MRI and histology of a 64-year-old male with an 11-month history of lower back pain and worsening left sided sciatica/leg weakness. (A) Lateral x-ray & (B)A-P x-ray show mild degenerative changes. (C) Axial CT shows left sided lateral recess stenosis at L4/5. (D) Sagittal MRI and (E) Axial MRI showing L4/5 disc herniation and left lateral recess narrowing. (F) Pathology examination revealing abundant MSU crystals surrounded by a foreign body-type giant cell reaction.*

Reprinted with permission (CC-BY): Chen et al. Percutaneous transforaminal endoscopic decompression for the treatment of intraspinal tophaceous gout: a case report. Medicine. 2020;99(21)[32]

### *A proposed diagnostic algorithm for spinal gout in chiropractic practice*

As far as the authors are aware, with reference to primary care settings, a clinical criterion specific to spinal gout diagnosis is yet to be developed. We reference current gout classification criteria guidelines[47,49] and combine them with clinical and diagnostic data derived from this, and previous spinal gout reviews,[11,15,16] to develop a diagnostic algorithm for spinal gout (Figure 7). We recommend this algorithm be utilized as an adjunct to standard diagnostic procedures used by chiropractic physicians rather than

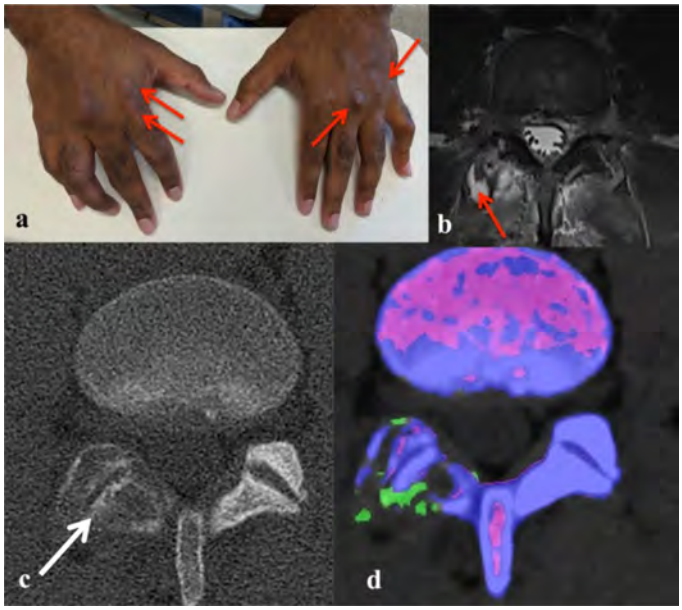


Figure 2.
*Spinal gout imaging: CT, MRI, DECT of a 32-year-old man with fever, acute severe lower back pain, history of left knee pain and gout.(a) A 32-yo man with probable gouty tophi affecting both hands (red arrows), (b) Axial MRI of his Lumbar spine (T2) reported as showing an abscess surrounding the right L4/5 facet joint (red arrow). (c) Axial CT of lumbar spine showing erosions (white arrow); and (d) corresponding DECT image (Siemens Somatom ForceTM) showing MSU crystal deposition (green).*

Reprinted with permission (CC-BY): Wang et al. The utility of dual energy computed tomography in the management of axial gout: case reports and literature review. BMC Rheumatol. 2020;4: 22.[13]

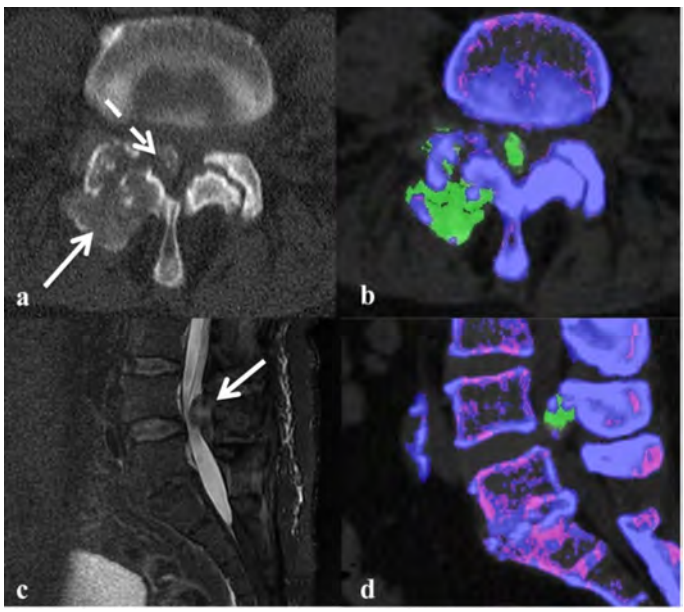


Figure 3.
*Spinal gout imaging: CT, MRI and DECT of a 74-year-old male, six-week history of lower back pain and longstanding bilateral knee pain.*

*(a) Axial CT showing right L4/5 facet joint erosion (white arrow) with calcified peri-articular mass encroaching on the lumbar canal (dashed white arrow) (b) Corresponding DECT image (Siemens Somatom ForceTM) showing MSU crystal deposition (green). (c) Sagittal T2-fat suppressed MRI image of the lumbar spine showing the soft tissue mass seen in (a) and (b) causing marked lumbar canal stenosis, and (d) corresponding DECT image showing attenuation consistent with MSU crystal deposition.*

Reprinted with permission (CC-BY): Wang et al. The utility of dual energy computed tomography in the management of axial gout: case reports and literature review. BMC Rheumatol. 2020;4:22.[13]

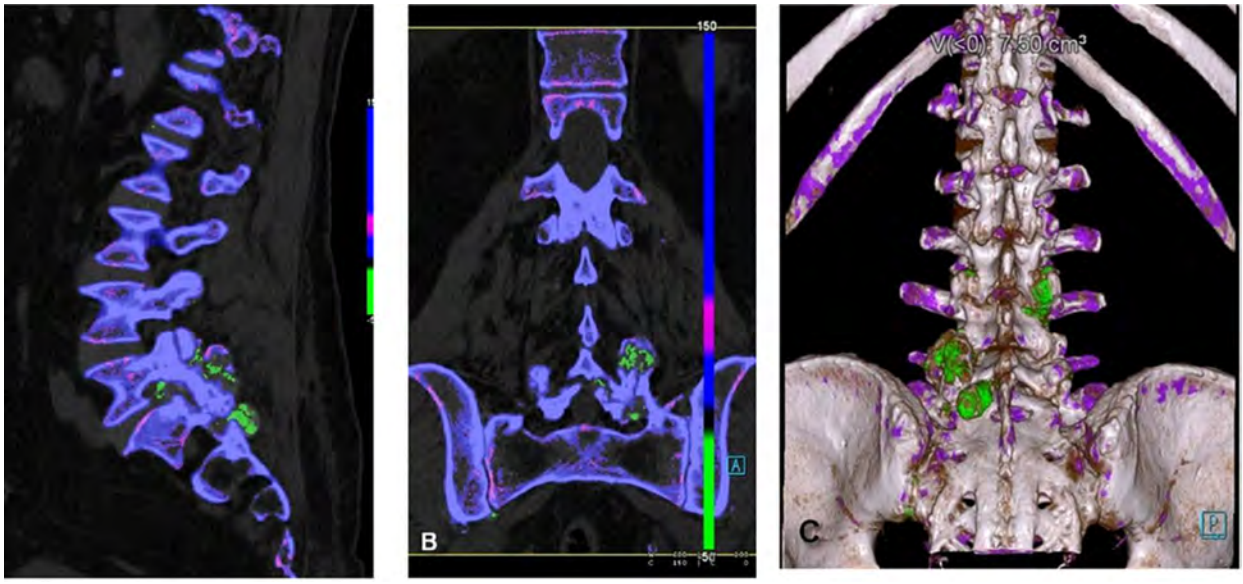


Figure 4.

*Spinal gout imaging: DECT of a 67-year-old male patient presented with an exacerbation of acute-on-chronic lower back pain.*

*Spinal urate deposits Lumbar spine DECT (A) Sagittal view (B) Coronary view (C) 3D rendered images showing urate deposits in facet joints (green).*

Reprinted with permission (CC-BY): Ahmad et al. Urate crystals; beyond joints. Front Med. 2021;8:649505.[58]


Figure 5.

*Spinal gout imaging: MRI, CT and DECT of a 54-year-old with chronic lower back pain and a five-year history of gout. Presented to emergency with severe lower back pain and right buttock pain.*

*Lumbar spine MRI and CT in axial gout. (A) Increased signal intensity on T2 weighted imaging of L4-5 and L5-S1. Intervertebral disc and erosive changes on the posterior cortices and endplates of L4-L5-S1 vertebra. (B) Enhancement of epidural space on T1WI. (C) Erosive changes in L4-5 and L5-S1 endplates on conventional CT. (D) MSU deposits (green) in the erosive foci of endplate on DECT.*

Reprinted with permission (CC BY): Jin et al. The frequency of axial deposition in Korean patients with gout at a tertiary spine center[8]

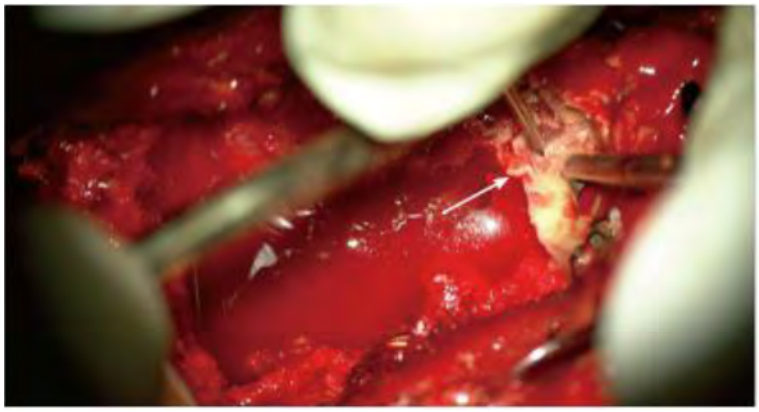

Figure 6.
*Spinal gout: tophus removal. Intraoperative photograph taken by the surgical microscope showed a well-marked chalky white tophus lesion (arrow).*



a replacement. When navigating the algorithm, the term 'usual spine care' indicates the usual process of diagnosis and management performed by chiropractors, including identifying other potential red flags.

## Discussion

Spinal gout may present in an acute, subacute or a chronic stage of disease.[15] Spine related symptoms have been reported as the 'first manifestation of gout' in up to 25% of cases.[11] In a review of 131 cases of spinal gout, Toprover *et al*.[15] reported that patients usually described pain in the general area of urate crystal deposition, although this was not consistent.

To the best of our knowledge, the current paper is the first to provide analysis of spinal gout case reports published since 2017. We found 94% of patients in our review presented with spinal pain, and 86% displayed neurological symptoms and/or signs. This is consistent with a review by Hasegawa *et al*.[11] in which spinal pain was present in 93% of cases and neurological signs in 77.9% of cases. However, in a large cases series involving 142 cases of spinal gout, Zhang *et al*.[16] found 79.6% of patients presented with pain and 45.8% with neurological symptoms.

Consistent with previous reviews we found the lumbar spine to be the most common region reported for urate crystal deposition (61%). The thoracic spine (21%) and cervical spine (29%) were also frequently affected, noting several of our cases reported simultaneous gout in more than one spinal region.[27,36,39,42]

MSU deposits and tophi were found most frequently to involve the facet joints (14 cases) and epidural space (19 cases). Although occurring less frequently, MSU deposits were also reported in the sacroiliac joints, vertebrae, lamina, intervertebral discs, spinous processes, spinal ligaments (ligamentum flavum, anterior and posterior longitudinal ligaments, interspinous ligament, transverse ligament, and supraspinous ligaments) and soft tissues (erector spinae). Toprover *et al*.'s analysis of 131 spinal gout cases found 18 of 131 cases (14%) reported gout in the sacroiliac joint.[15] One case in our series reported gout in the sacroiliac joint.[20]

In twenty-five of our cases (68%) urate crystal deposition was confirmed by surgical excision and lab analysis. In one case, a chalky white material resembling gouty tophi was observed during surgical excision, however confirmation by histological analysis was not reported.

MSU deposition in the facet joints (and other spinal structures) may be more frequent than currently appreciated. Jin *et al*.[8] reviewed the spinal CT imaging of 95 patients diagnosed with gout finding 15.8% of patients demonstrated CT evidence of spinal gout. Yang *et al*.[50] reviewed the spinal CT scans of 17 patients with a diagnosis of spinal gout finding 84% of patients had evidence of facet joint bone resorption and erosion (41% involving multiple facet joints) and all patients demonstrating high density spinal tophi. Tophi were observed anterior and/or posterior to the facet joints, with several cases showing intrusion into the epidural space. Sullivan *et al*.[20,57] compared the spinal DECT scans of 50 gout patients with non-gout controls finding 20 to 40% of gout patients had MSU-coded lumbosacral lesions.

In our case series, most patients presenting with spinal pain and/or neurological symptoms were confirmed as having spinal gout following surgery. Prior to surgery, the most common presumptive diagnosis was infection or malignancy/tumour. Seven cases were suspected of having disc herniation and/or degenerative spinal stenosis.

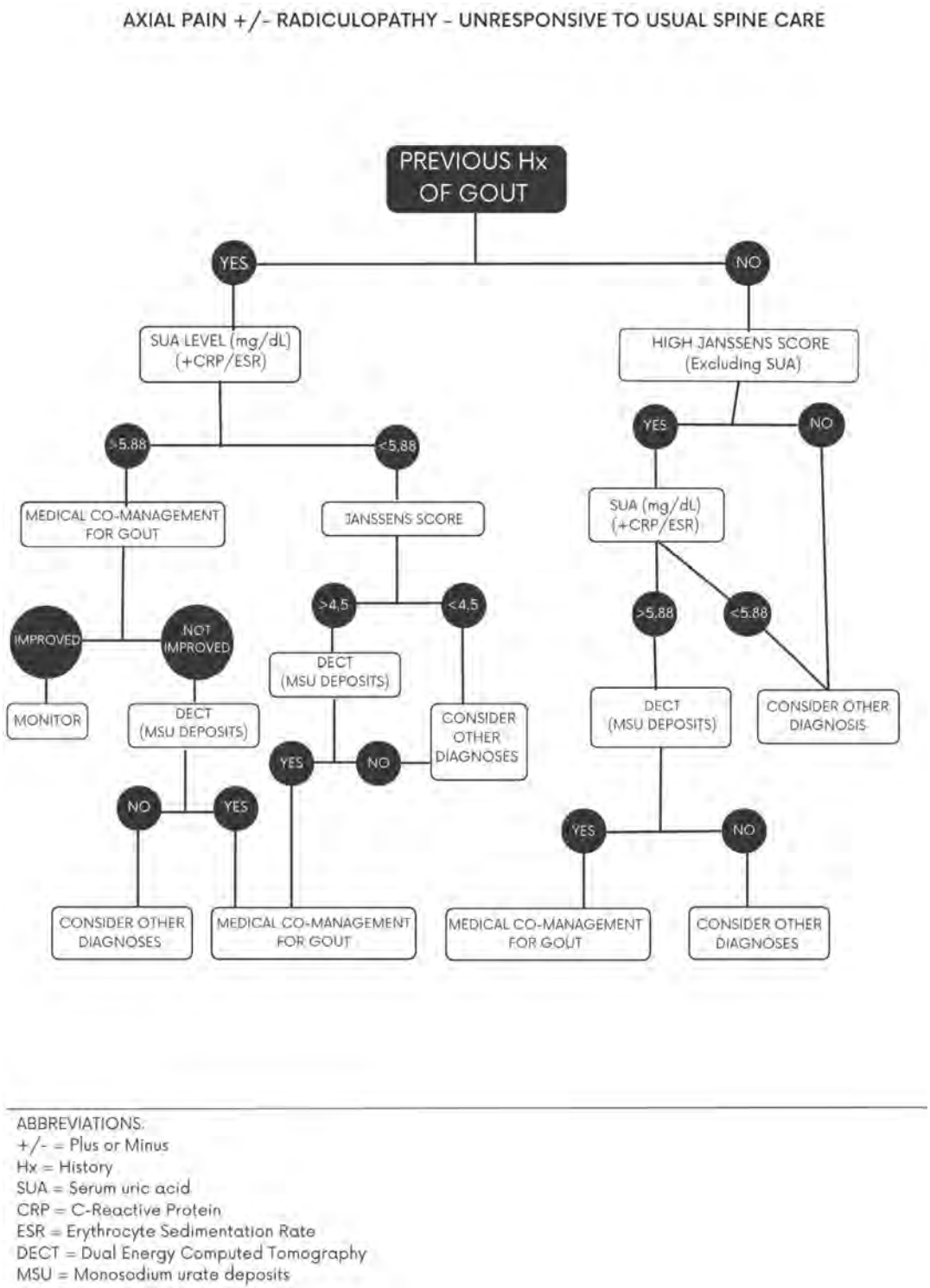


Figure 7.
*Spinal gout: proposed diagnostic / treatment algorithm*

Chen *et al*.[32] presented a case of a 64-year-old man with an 11 month history of lower back pain and worsening left sciatica. CT and MRI findings were consistent with a large L4/5 disc herniation causing neurological compromise, uric acid levels were normal, and there was no history of gout recalled. However, during surgery, gouty tophus was identified surrounding the disc extrusion (Figure 1). Consistent with previous literature reviews[16,17,59], our review found a continuing pattern of late diagnosis and surgical treatment of spinal gout. Seventy-six percent of the cases reviewed proceeded to surgery.

It has been proposed that spinal gout may develop asymptomatically, or with only mild symptoms, months or years prior to diagnosis.[60] We combined Zhang et al.'s review of 142 cases of spinal gout (1950-2017) with our review of 38 cases to calculate the percentage of patients presenting without a history of gouty arthropathy (a total of 34 cases were excluded due to incomplete data). We found 26% of the cases did not record a history of gout, although we note that by excluding some cases our figure may have overestimated this finding. Other literature reviews have reported similar percentages of patients presenting without a history of gout episodes (16.8-24.6%).[11,15]

Nine of our cases were managed conservatively with anti-inflammatories and uric acid lowering medications. Symptom duration in this small group was generally short: five patients presented within one to six weeks after the onset of symptoms. Three cases did not define symptom duration and one case described intermittent symptoms over a 2-year period. Larger prospective studies are required regarding early presentation and patient outcomes.

### *Limitations and future studies*

A proportion of the spinal gout case reports we reviewed contained incomplete data, therefore our calculations and consequent conclusions may be inaccurate, however, as detailed in this paper, our findings are consistent with similar spinal gout reviews. As this is a narrative review no confirmation of data extraction or critical appraisal of the included articles was undertaken.

Historically, a majority of case reports involving spinal gout have described patients in an advanced state of the disease. Most often patients presented to medical facilities for evaluation before proceeding to surgery. Patients falling into this demographic may be less likely to have primary contact with a chiropractic physician. The clinical presentation of spinal gout in the chiropractor's office may therefore differ substantially from the patients included in this paper. Further research is required to improve our clinical understanding of spinal gout in primary care settings.

Secondly, the frequency of spinal gout locating to the facet joints (and other spinal tissues) may be under-estimated in our study. MSU deposits in the facet joints are difficult to verify without joint aspiration or DECT scanning. In addition, whilst MSU deposits may be present, they may be too small in volume to be detected (especially earlier in the disease). As most of the cases we reviewed did not utilize DECT or facet joint aspiration, a greater prevalence of facet joint involvement cannot be excluded.

## Conclusion

Spinal gout, once considered a rare manifestation of peripheral gout, is being reported with increasing frequency and may be a more common source of spine related pain than previously appreciated. Chiropractic physicians are primary care providers for spine complaint patients and as such are responsible for the diagnosis and appropriate care of the patient. Chiropractors have an important role in the early detection of spinal gout potentially influencing the course of conservative management and reducing the burden of surgery to health care systems. Patients meeting clinical criteria may be referred for further screening and medical co-management.

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# Diagnosis and conservative management of sural neuropathy: a case report

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*Nerve entrapments in the lower extremity are rare and can be difficult to diagnose. Here we describe a Canadian Armed Forces veteran with left posterior-lateral calf pain. The patient's condition was previously misdiagnosed as a left-sided mid-substance Achilles tendinosis, which subsequently led to mismanagement, persistent pain and severe functional limitations. After performing a thorough evaluation, we diagnosed the patient with chronic left-sided sural neuropathy secondary to entrapment within the gastrocnemius fascia. The patient's physical symptoms abated completely with chiropractic care, while overall disability improved substantially after taking part in an interdisciplinary pain program. The objectives of this case report are to describe a challenging differential diagnosis of sural neuropathy, and present conservative*

Diagnostic et traitement conservateur de la neuropathie surale : un rapport de cas

*La compression des nerfs dans les membres inférieurs est rare et peut être difficile à diagnostiquer. Nous décrivons ici le cas d'un vétéran des Forces armées canadiennes souffrant d'une douleur postéro-latérale gauche au mollet. L'état du patient avait été diagnostiqué à tort comme une tendinite achilléenne moyenne du côté gauche, ce qui a entraîné une mauvaise prise en charge, une douleur persistante et de graves limitations fonctionnelles. Après une évaluation approfondie, nous avons diagnostiqué chez le patient une neuropathie surale chronique du côté gauche, secondaire à une compression du fascia gastrocnémien. Les symptômes physiques du patient ont complètement disparu grâce aux soins chiropratiques, tandis que l'incapacité globale s'est considérablement améliorée après avoir participé à un programme interdisciplinaire de lutte contre la douleur. Les objectifs de ce rapport de cas sont de décrire un diagnostic différentiel difficile de neuropathie surale et de présenter des options de gestion*

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The involved patient provided consent for case publication.

*whole-person management options according to the patient's needs and goals.*

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KEY WORDS: neuropathic pain, interdisciplinary, rehabilitation, differential diagnosis, sural nerve

*conservatrice de la personne entière en fonction des besoins et des objectifs du patient.*

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MOTS CLÉS : douleur neuropathique, interdisciplinaire, réhabilitation, diagnostic différentiel, nerf sural

## Introduction

The sural nerve originates in the popliteal fossa from branches of the tibial and fibular nerves, with constituent fibers derived primarily from the S1 nerve root level, and variable contribution from the L5 level.[1] The nerve travels between the two heads of the gastrocnemius muscle and becomes subcutaneous at the distal one-third of the lateral lower leg within the gastrocnemius fascia. The sural nerve travels inferiorly along the lateral aspect of the Achilles tendon, posterior to the lateral malleolus and along the lateral foot. The nerve provides cutaneous innervation to the lateral lower third of the leg and the dorsolateral aspect of the foot before terminating on the lateral aspect of the fifth toe. The lateral calcaneal branch of the sural nerve innervates the skin over the lateral one-fourth to one-third of the heel and the pre-Achilles fat pad.

Entrapment neuropathies are caused by compression or irritation of peripheral nerves in narrow anatomical spaces. The mechanistic etiology of nerve entrapment is multifactorial, with contributing factors including prolonged ischemia, neuroinflammation, axonal demyelination and fibrosis, and central sensitization.[2] For sural neuropathy specifically, nerve trauma from ankle fracture, repetitive or prolonged external ankle compression, or iatrogenic injury, have been most commonly reported in the literature.[3-6] Entrapment of the sural nerve due to thickening of the gastrocnemius fascia has been previously described in cadaveric studies.[7]

Patients with sural neuropathy often present with persistent pain, burning, aching, or numbness in the posterolateral leg, lateral ankle, or lateral foot, that has failed to respond to nonsurgical management.[3] Delayed diagnosis and/or management of persistent neuropathic pain can have a significant impact on individuals, contributing to anxiety, depression and sleep difficulties.[8] In military personnel and veterans, rates of persistent pain are two to three times higher than in the general population.[9] Here we describe a case of a 36-year-old male Canadian Armed Forces veteran with left-sided posterior-lateral calf pain secondary to sural neuropathy. The objectives of this case report are to describe the clinical process for the diagnosis of sural neuropathy, and describe the conservative whole-person management approach which resulted in complete recovery for this individual.

## Case presentation

A 36-year-old male Canadian Armed Forces veteran with chronic posterior-lateral calf pain was referred to The Pain and Wellness Centre (PWC) in Vaughan, Ontario for a pain medicine consultation in November 2020. The PWC is a community-based interdisciplinary pain clinic, offering pain medicine consultations, alongside a range of allied healthcare services, including chiropractic. Specifically, chiropractors at the PWC are responsible for obtaining a full history and performing a detailed neuromusculoskeletal evaluation alongside pain physicians. An interdisciplinary plan of management is subsequently proposed for a select number of patients who meet specific eligibility criteria.[10]

The patient's problem started with the gradual onset of episodic left lateral calf tightness in May 2010 while in active military service, which progressively resolved without intervention. However, the tightness gradually returned, typically presenting after performing activities such as jumping jacks, rucksack marching and running. The symptoms gradually resolved after physiotherapy, but returned after rucksack marching up a steep hill in January 2011. The patient continued to suffer frequent episodes of activity-related pain exacerbations, which impaired his ability to engage in normal duties. Diagnostic

imaging, including a right ankle MRI and an ankle/foot ultrasound performed in 2013, were unremarkable. He underwent orthopedic, sports medicine and interventional consultations, which concluded he suffered from left-sided mid-substance Achilles tendinosis. He subsequently underwent several interventional pain treatments including left-sided Achilles peri-tendinous corticosteroid injections, prolotherapy and tendon scraping, which failed to provide analgesic effect. Ultimately, the patient was voluntarily released from the Canadian Military in 2016.

On evaluation at the PWC, the patient described intermittent searing and burning left lateral calf pain. He marked his posterior-lateral lower leg on a pain diagram (Figure 1). The pain was rated as 0/10 on the Numeric Pain Rating Scale (NPRS) on the date of presentation, with 0/10 being his lowest pain rating, and 9/10 being his highest pain rating. His pain was aggravated by end-range ankle dorsiflexion, running and marching, and relieved by rest. He scored 54/70 on the Pain Interference Scale of the Brief Pain Inventory, indicating a high degree of pain-related functional interference.[11] He additionally scored 22/27 on the Patient Health Questionnaire-9 questionnaire (PHQ-9) indicating severe depression[12], and 18/21 on the Generalized Anxiety Disorder-7 questionnaire (GAD-7) indicating severe anxiety[13].

We observed mild bilateral standing calcaneal inversion. The left Achilles tendon appeared unremarkable to visual inspection. Repeated left-sided standing heel-raising aggravated the left lateral lower leg pain. Repeated standing lumbar flexion and extension significantly improved the calf pain with heel raising. Deep tendon reflexes were graded 2+ in the upper and lower extremities. Plantar responses were flexor bilaterally. We noted pin-prick hyperalgesia and dynamic mechanical brush allodynia in the left sural nerve distribution. Palpation of the left sural nerve lateral to the left Achilles tendon recreated his pain. Figure 2 outlines the area of sensory alteration (dotted line) and the point of palpation (arrow). Tinel's

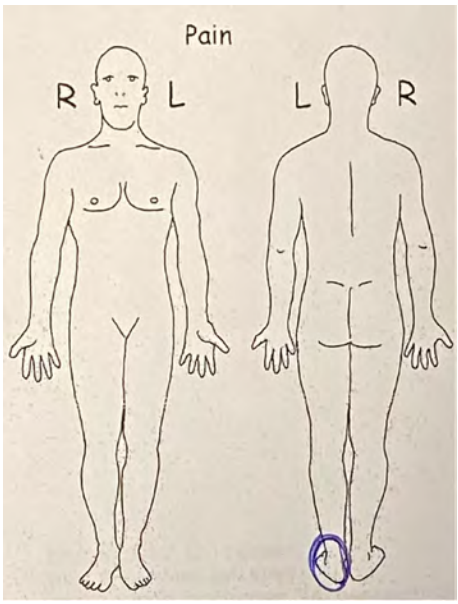


Figure 1
*Patient-marked pain diagram at presentation.*

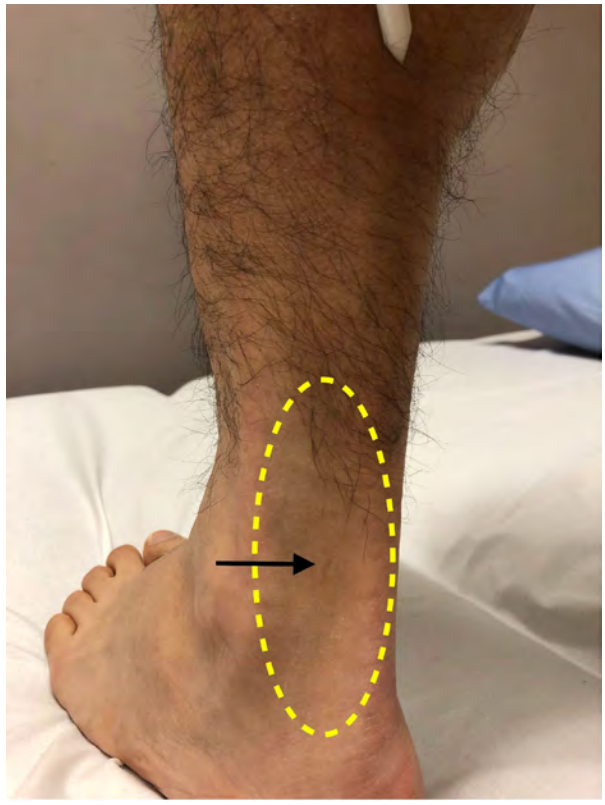

Figure 2.
*Area of hyperalgesia and allodynia is encircled in yellow. Point of palpation and Tinel's test reproducing the symptoms is marked by the black arrow.*


Figure 3.
*Sural nerve sliding mobilization. Patient lies supine and moves from a position of knee flexion, and ankle inversion/dorsiflexion (a) to a position of knee extension, and ankle eversion/plantarflexion (b).*

test[14] over the sural nerve, left sural nerve tension test[15] and Slump test[16] reproduced his symptoms.

From the biomedical point of view, the patient was diagnosed with chronic left-sided sural neuropathy secondary to entrapment within the gastrocnemius fascia, and from the psychological point of view with Major Depressive Disorder and Generalized Anxiety Disorder rendered by the pain physician, based on our evaluation and the patient's scores on baseline questionnaires. The patient was admitted to the PWC's government-funded Interdisciplinary Pain Program (IDP) that operates on a shared decision-making model and offers 80-90 hours of one-to-one treatment across multiple disciplines on the basis of "whole person approach", at no cost to the patient[10]. All patients complete baseline (pre-program) psychometric questionnaires, which were repeated at three months, six months and one year post-program.

Of note, our case report only discusses in detail the chiropractic portion of the patient's care. Additionally, the patient also received psychological treatment and mindfulness training aimed at managing depression, anxiety, and pain coping, naturopathy treatment to address digestive issues, and massage therapy.

In regard to chiropractic treatments, IDP patients attend a total of 24 chiropractic visits, each 60-minutes in duration, consisting of variable combinations of manual therapy, physical rehabilitation, strength and conditioning, and general counseling. The program was modified to accommodate the patient who was coming to PWC weekly from a distance greater than 100 km. Therefore, the chiropractic visits were divided into 11 in-person and 13 by phone. Our patient's long-term program goals were to reduce pain and to run three times weekly for 30 to 45 minutes at a 6/10 rating of perceived exertion (0 indicates complete rest, and 10 indicates maximal exertion).

Passive therapy, in the form of cupping over the suspected sural nerve entrapment site in the lateral gastrosoleus region, was utilized in five of the 11 in-person treatments as a form of pain modulation. In-person visits were otherwise focused on active care to improve running tolerance, and to gradually expose the patient to running. Phone visits were dedicated to goal setting for the week, education and problem solving.

Five minutes of cupping was performed during the first visit after assessment, diagnosis, and completion of informed consent. The rest of the session focused on performance of active treatments including repeated standing lumbar spine extension end-range loading (two sets of 10 repetitions), and dynamic left-sided sural nerve sliding mobilizations (two sets of 10 repetitions; see Figure 3). He was instructed to perform up to 10 repetitions of supine sural nerve sliders three times daily, and 10 repetitions of standing lumbar extensions every hour. The patient was additionally introduced to the *Activity Traffic Light* handout, which served as an education tool to differentiate hurt versus harm, and to provide personalized guidance on how to respond to increased pain as a result of exercise performance (Table 2).[17,18]

At the next visit (phone), reported pain levels during walking had decreased. A shared decision-making process

Table 2.
*Activity traffic light (adapted from O'Connor A, Lotus TJ. Chapter 12: Therapeutic Exercise. In: Truumees E & Prather A, editors. Orthopedic Knowledge Update Spine 6. American Academy of Orthopedic Surgeons; 2021 p. 155-171.)*

| *Harm Check: Walking his dogs for 20-minutes daily | | | |
|---|---|---|---|
| *A harm check is defined as a range of motion, strength, or functional activity that is consistently performed on a daily basis that the patient has confidence in performing. The patient is educated that a 50% reduction in their harm check alongside other indicators (below) is an indication that they may have suffered a new tissue injury, and a check-up from their therapy team is warranted. | | | |
| **Traffic Light Colour** | **During and Post-Activity Pain** | **Harm Check** | **Meaning/Action** |
| Red | Severe pain aggravation that does not allow continued activity that persists for > 4-days to several weeks | 50% reduction in harm check (eg. < 10-minutes dog walking duration after 4-days. | Potential new injury or aggravation of current injury. Contact therapy team. Stop prescribed activity. |
| Yellow | Moderate-to-severe pain during and after an activity, which returns to baseline pain intensity within 12-48-hours | No loss of ability to walk dog for 20-minutes the day following activity performance | Indication that no new injury has taken place (ie. Hurt does not equal harm). Advised to continue or mildly reduce activity, and to pace. |
| Green | Mild-to-moderate pain during activity that returns to baseline within a 30-minute to 24-hour period. | No loss of ability to walk dog for 20-minutes the following activity performance | Indication that no new injury has taken place (ie. Hurt does not equal harm). Advised to continue or increase activity. |

was employed to create a meaningful home exercise program, in keeping with the patient's stated long-term goal to improve running tolerance. The goal for that week was to run for five minutes on a treadmill at a self-perceived intensity of 30%. The running duration and intensity were gradually increased thereafter on a weekly basis, using a shared decision-making model. By visit eight (phone) the patient reported complete resolution of symptoms at rest and during activity.

On visit 15 (in-person), the patient reported an exacerbation of postero-lateral calf pain rated 5/10 after performing 30 minutes of treadmill running at five miles per hour. Modification of the sural neuromobilization to a "tensioning" exercise reduced this pain to 2.5/10, within the session. The patient was instructed to discontinue supine sural nerve sliding neuromobilizations, and transition to supine sural nerve tensioning exercises three times daily, with the intent of habituating the patient to simultaneous proximal and distal tensioning of the sural nerve while running. Figures 3 and 4 indicate the differences between sliding and tensioning maneuvers.

The patient was discharged from the PWC IDP on February 19, 2021. At this time, he reported complete resolution of left calf pain, and was able to run two to three times weekly for 20 minutes, including hill training. Re-examination demonstrated complete resolution of sensory alteration. Left-sided sural nerve tension and Slump testing produced a perception of tension in the left posterior thigh, but were otherwise negative. At six and 12-month follow-up, he reported continuation of pain-free running (Table 4). Additionally, there was substantial improvement across emotional and mental health domains, based on our model of care. Furthermore, he rated himself as "very much improved" on the Patient Global Impression of Change Scale. Table 1 presents baseline and follow-up psychometric questionnaire scores.


Figure 4.
*Sural nerve tensioning mobilization. Patient lies supine and moves from a position of knee flexion, ankle plantarflexion and foot eversion (a) to a position of knee extension, ankle dorsiflexion and ankle inversion (b).*

## Discussion

Neuropathic pain as a clinical descriptor is defined by the International Association for the Study of Pain (IASP) as "pain caused by a lesion or disease of the somatosensory nervous system".[19] The IASP Neuropathic Pain Grading Criteria[19] stipulates that a description of symptoms within a neuroanatomically plausible distribution alongside clinically demonstrable sensory signs is indicative of "probable neuropathic pain." A Delphi study by Smart *et al*.[18] identified that a cluster of symptoms and signs including "pain referred in a dermatomal or cutaneous distribution", "pain/symptom provocation with mechanical/movement tests that move/load/compress neural tissue", and "history of nerve injury, pathology or mechanical compromise" has high levels of classification accuracy. Our clinical evaluation satisfied all of the above-mentioned criteria.[19,20]

Our evaluation also found that leg symptoms were reduced after performance of repeated end-range lumbar flexion and extension. Performance of this procedure is rooted in principles from the Mechanical Diagnosis and Therapy (MDT) system for classification and rehabilitation of spinal and extremity pain, and aids in the identification of Extremity Pain of Spinal Source (EXPOSS).[21] The proportion of patients with ankle or foot symptoms suspected to have a spinal source is estimated to be as high as 29.2%.[21] A plausible mechanism for this phenomenon has not been elucidated, and requires further study. However, based on our physical examination findings, lumbar end-range extension was proposed as a 'directional preference' that the patient could repeatedly perform to provide self-generated symptomatic relief.

The suspicion of a peripheral neuropathic pain mechanism also guided the incorporation of neural mobilization as an intervention. Neural mobilization purports to restore nervous system homeostasis through movement of neural structures within their interface.[22] The effectiveness of neural mobilization for management of exercise-related lateral ankle and foot pain in an athletic population has been previously reported.[23] The improvement of pain and baseline symptoms within the first session supported the prescription of self-guided neural mobilization for continued self-treatment. Previous literature has suggested that within-session improvements in an episode of care can positively influence patient prognosis and the success of a program of care.[24-26]

To further provide early short-term symptom modulation, brief sessions of cupping were provided in the first few in-person visits. Cupping, as used in this plan of management, may beneficially modify perceptions of pain and increase pressure pain threshold for short periods of time.[27,28] It is proposed that cupping accomplishes this by modifying viscosity and flexibility of fascia.[29] However, evidence in this area is of low quality and further research may help elucidate the mechanisms by which cupping and other forms of manual therapy provide pain modulation in some patient populations. Regardless, the

Table 1.
*Outcome measures at baseline and follow-up*

| Outcome measure | Baseline | 3 months | 6 months | 12 months | Questionnaire description |
|---|---|---|---|---|---|
| Brief Pain Inventory (BPI): Pain interference score | 54/70 | 14/70 | 11/70 | 10/70 | A 70-point scale reflecting how much pain interferes with physical function, emotional function and sleep[11]. There is no minimal clinically important difference (MCID) for chronic non-cancer pain. |
| BPI: pain severity score | 20/40 | 3/40 | 9/40 | 10/40 | The sum of pain ratings between 0-10, for pains at the worst, least, average and current[11]. The MCID is 2.2, corresponding to 34.2% reduction in baseline score[33] |
| Center for Epidemiological Studies Depression (CES-D) | 46/60 | 38/60 | 22/60 | 23/60 | A 20-item measure that asks individuals to rate how often over the past week they experienced symptoms associated with depression, such as restless sleep, poor appetite, and feeling lonely. Scores ≥ 16 are indicative for a high risk of depression, with higher scores indicating greater depressive symptoms. |
| Generalized Anxiety Disorder-7 (GAD-7) | 18/21 | 15/21 | 11/21 | 13/21 | A seven-item instrument that is used to measure or assess the severity of generalized anxiety disorder. The MCID is four points. A score greater than 15 is indicative of severe anxiety, with 10-14 considered moderate anxiety. |
| Pain Self-Efficacy Questionnaire | 20/60 | 45/60 | 40/60 | 49/60 | A 10-item questionnaire developed to assess the confidence people with ongoing pain have in performing activities while in pain. Lower scores are indicative of lower perception of self-efficacy regarding a range of functions. A higher score indicates greater self-efficacy. The MCID is 9 points[34] |
| Patient Global Impression of Change (PGIC) Scale | N/A | N/A | N/A | Very much improved | A seven-point scale measuring a patient's beliefs about efficacy of treatment. Patients rate their change as "very much improved," "much improved," "minimally improved," "no change," "minimally worse," "much worse," or "very much worse." "Much improved" or "very much improved" are considered clinically important[35] |
| Self-reported running | No running | Daily running 20 minutes | Daily running 15-20 minutes | 3x weekly running 15-20 minutes | |

Table 3.
*Self-reported progression of running ability*

| Visit number | Date | Running progression |
|---|---|---|
| 3 | November 27, 2020 | 5 mins, 3.5 mph, grade 2 |
| 5 | December 4, 2020 | 7.5 mins, 3.5 mph, grade 2 |
| 7 | December 11, 2020 | 10 mins, 4 mph, grade 2 |
| 10 | January 6, 2021 | 6-7 minutes daily |
| 11 | January 8, 2021 | 10 mins daily<br>15 mins, 4 mph |
| 13 | January 15, 2021 | 20 mins, 4 mph, grade 2% |
| 15 | January 22, 2021 | 30 mins, 5 mph (resulted in pain occurrence) |
| 17 | January 29, 2021 | 30 mins, 5 mph, grade 1 |
| 19 | February 9, 2021 | 20 mins, 6 mph |
| 22 | March 12, 2021 | 30 mins 3xweekly |
| 24 | April 23, 2021 | 20 mins including hills |
| 6 months | | 15-20 mins daily |
| 12 months | | 15-20 mins every 2-3 days |

goal of using manual therapy in this case was to positively modulate pain, and to encourage within session performance of rehabilitation and exposure to running, and not as a mainstay of treatment.

The key element in the chiropractic management of this patient's pain was behavioural activation through goal-setting and progressive rehabilitation, rooted in motivational models of pain self-management.[30] Ongoing support, appraisal, and feedback in action planning and goal negotiation are important components of the rehabilitation process[31], and can be well-addressed as part of chiropractic care. The patient's pre-program questionnaires indicated high levels of depression, anxiety, and functional interference, and low pain self-efficacy. The exercise plan, alongside use of the *Activity Traffic Light*[15,16], and continued education provided the patient with tools to immediately reduce symptoms on his own, and thus allowed him to progressively reach his goals.

### *Strengths and limitations*

The strength of our case report relies on our ability to provide proper diagnosis and chiropractic care within the context of a "whole person" management, at no cost to the patient. Our model of care is unique and results in high levels of success and positive long-term outcomes.[10,32] A limitation of our case report, is the lack of generalizability to other settings and practices, exactly because of the uniqueness of our care model, including our Ontario Ministry of Health funding.

## Summary

A 36-year-old Canadian Armed Forces veteran presented with chronic left lateral calf pain, with significant pain-related disability and loss of quality of life. After appropriate assessment and diagnosis, chiropractic care within the context of an interdisciplinary pain management program resulted in significant improvements of pain and physical/ emotional disability, with complete resolution of physical symptoms. This case provides an example of an isolated lower limb neuropathy with a non-traumatic origin, and describes the use of rehabilitative symptom modulation and goal-based, holistic behavioral interventions by a chiropractor as part of an interdisciplinary team.

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# Chiropractic management of a U.S. Veteran with myofascial pain and concurrent distal bimelic amyotrophy (Hirayama disease): a case report

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Background: *Distal bimelic amyotrophy (DBMA) also known as Hirayama disease, is a rare, self-limiting motor neuron disease manifesting as atrophy of C7-T1 innervated muscles. We present a case report describing the chiropractic management of neck and thoracic pain in a patient with known DBMA.*

Case presentation: *A 30 year-old black male U.S. veteran with DBMA presented with myofascial pain of the neck, shoulder, and back. A trial of chiropractic care was undertaken involving spinal manipulation of the thoracic spine and cervicothoracic region, manual and instrument-assisted soft tissue mobilization, and*

Prise en charge chiropratique d'un vétéran américain souffrant de douleurs myofasciales et d'une myélopathie cervicale basse (maladie d'Hirayama): rapport de cas

Contexte : *La myélopathie cervicale basse, également connue sous le nom de maladie d'Hirayama, est une maladie rare et spontanément résolutive du motoneurone qui se manifeste par une atrophie des muscles innervés C7-T1. Nous présentons un rapport de cas décrivant la prise en charge chiropratique de douleurs cervicales et thoraciques chez un patient atteint d'une maladie d'Hirayama connue.*

Présentation du cas : *Un vétéran américain noir de 30 ans, atteint de myélopathie cervicale basse, s'est présenté avec des douleurs myofasciales au cou, aux épaules et au dos. Un essai de soins chiropratiques a été entrepris comprenant des manipulations vertébrales de la colonne thoracique et de la région cervicothoracique, des mobilisations manuelles et instrumentales des tissus mous, et la prescription d'exercices à domicile.*

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*home exercise prescription. The patient reported modest improvement in pain intensity and did not experience any adverse events.*

Summary: *This case presents the first documentation of chiropractic services in musculoskeletal pain management of a patient with concurrent DBMA. At this time there is no guidance in the existing body of literature for the safety and effectiveness of manual therapy in this population.*

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KEY WORDS: chiropractic; bimelic amyotrophy; hirayama disease; myelopathy; manual therapy

*Le patient a fait état d'une amélioration modeste de l'intensité de la douleur et n'a pas ressenti d'effets indésirables.*

Résumé : *Ce cas présente la première documentation des services chiropratiques dans la gestion de la douleur musculo-squelettique d'un patient souffrant d'une myélopathie cervicale basse. À l'heure actuelle, il n'existe pas d'orientation dans la littérature existante sur la sécurité et l'efficacité de la thérapie manuelle dans cette population.*

(JCCA. 2023;67(1):77-84)

MOTS CLÉS : chiropratique ; myélopathie cervicale basse ; maladie d'Hirayama ; thérapie manuelle

## Introduction

Distal bimelic amyotrophy (DBMA) is a phenotypic variant of monomelic amyotrophy, also known as Hirayama disease. It is a motor neuron disease first described by Hirayama *et al*.[1,2] in 1959. Other proposed terms for DBMA, depending on the location of extremity involvement, include brachial monomelic amyotrophy, crural monomelic amyotrophy, or proximal bimelic amyotrphy.[2,3] Early descriptions of DBMA only recognized upper extremity involvement, with the most identifiable characteristic being sensory-sparing, motor amyotrophy commonly limited to weakness in the C7 to T1 myotomes.[4] Clinically presenting as an insidious onset of weakness and atrophy in the unilateral or bilateral distal upper extremities, DBMA has been described in the literature as self-limiting, with muscle atrophy plateauing around five years after onset.[5] Although DBMA is considered self-limiting, the extent of atrophy acquired is permanent[6], and atrophy-related fatigue is the most common long-standing symptom[7].

Monomelic amyotrophy is reported to range from 8% to 29% of all motor neuron diseases (e.g. amyotrophic lateral sclerosis, Madras motor neuron disease).[8–10] The dominant limb is affected more commonly, as reflected in a 3:1 right-sided predominance.[11] It is seven times more prominent in males and more commonly reported in Asian countries.[6] The initial diagnosis classically occurs during the adolescent and young adult years.[6] DBMA is a rare condition and the prevalence is unknown.[12] The rarity of cases has limited investigation into familial, or other potentially causal, relationships which may predispose individuals to developing DBMA.[13] Although the exact etiology is unknown, it has been theorized that DBMA presentation is the result of growth discrepancies between the vertebral column and spinal canal contents.[7,14] Individuals with a long vertebral column and short thecal sac may be at higher risk of repetitive cord compression, or venous congestion[13], as a result of the anterior thecal sac being displaced into the posterior surfaces of the vertebral bodies during cervical flexion[14,15]. Table 1 presents common and less commonly observed features of distal bimelic amyotrophy.

Table 1.
*Distal bimelic amyotrophy characteristic features*.[8]

| Common | Less common |
|---|---|
| Young age of onset<br>Sporadic occurrence<br>Male preponderance<br>Weakness and atrophy affecting intrinsic muscles of hand and forearm<br>Commonly confined to single limb | Cold paresis<br>Hyperhydrosis with abnormal sympathetic skin response<br>Bilateral |

Unlike presentations of cervical myelopathy or amyotrophic lateral sclerosis (ALS), the lower extremity is typically spared in DBMA. The differential diagnosis for DBMA includes peripheral neuropathy (e.g. pronator

syndrome), spinal cord pathologies (e.g. syringomyelia), and multisystem genetic disorders (e.g. myotonic dystrophy).[16] Diagnosis of DBMA may be suspected through cervical MRI and is confirmed through repeat MRI with the patient positioned into cervical flexion.[14,15] The addition of a cervical flexion MRI demonstrates the anterior displacement of the thecal sac along with a high signal intensity crescent-shaped lesion in the posterior epidural space, most easily seen with T2 weighted sequences.[17] With this displacement, compression into the posterior element of the vertebral bodies occurs at the anterior horn of the spinal cord and ventral roots, resulting in the hallmark motor deficits with sensory sparing.[14,16]

Patients with DBMA are commonly advised to avoid cervical flexion due to the increased pressure placed on the anterior spinal cord, putting it at risk for further injury, and they often describe electric-like pain/sensations in the upper extremities when performing cervical flexion movement.[18,19] Surgical management may be considered to reduce the risk of continued cord compression.[13] Physical and occupational therapy is reported to improve and maintain adaptations to living with muscle atrophy.[18,20] To the authors' knowledge, there are no prior reports in the literature detailing the role of chiropractic care in the management of musculoskeletal complaints in patients with DBMA.

## Case presentation

This case report was approved by the VA Puget Sound Privacy Officer. The patient provided consent for publication, and we followed CARE guidelines of reporting for case reports.[21] A 30 year-old black, right-hand dominant male was referred by a Veterans Health Administration (VHA) physical medicine and rehabilitation physician to a VHA chiropractic clinic for neck pain and upper back tension. Ten years prior to his chiropractic presentation, he began experiencing neck pain and hand weakness that limited his ability to complete his service responsibilities in the U.S. Army. His symptoms progressed over two years and he was medically discharged from military service and initiated evaluation with VHA. Neurosurgery consulted and deemed him to not to be a suitable candidate for surgical intervention due to the stabilization of symptoms, and recommended conservative management. At the time of his presentation to the chiropractic clinic, 10 years after initial presentation, his treatment team consisted of a physical medicine & rehabilitation physician, psychologists, and occupational therapists.

On presentation, he described muscular neck and upper back pain. Pain intensity was rated four out of 10 on a numeric pain rating scale (NPRS). Function and disability were rated 14 out of 50 (28%) with the Neck Disability Index, correlating with a "mild disability" score.[22] He reported bilateral upper extremity weakness, atrophy, and muscle fatigue which worsened with aerobic activity and cold weather, with the left upper extremity weakness more prominent. This often resulted in clumsiness of his hands (dropping items, general difficulty with hand dexterity) throughout the day. He reported managing his symptoms with cool showers and self-massage of the neck and upper back musculature. Prior to the COVID-19 pandemic, the patient participated in long-boarding and exercising at a mix-martial arts gym. His review of systems was unremarkable. Upon review of the electronic health records, a cervical MRI from six years prior demonstrated mild atrophy of the anterior cord at levels C5 through C7 without abnormality of the cord signal, findings consistent with DBMA (Figures 1 and 2). A cervical MRI with flexion views was not available in the records. The patient's past medical history was not significant for any other relevant comorbidities. At the time of presentation to the VA chiropractic service the patient was not taking any prescription medications.

Diffuse atrophy of the upper extremities distal to the elbow was noted. Neurological examination revealed right arm pronator drift, a single beat of clonus in the left ankle, and bilateral strength deficits at the C8 and T1 myotomes. Romberg's test, heel and toe walk were performed without difficulty, Hoffman's reflex was absent bilaterally, cranial nerves were grossly intact, heel-to-shin test was unremarkable, muscle stretch reflexes of the upper and lower extremities were all 2+ bilaterally, and sensation to light touch was normal in all extremities. The patient had previously been instructed to avoid cervical flexion movements, but did so at the examination without being prompted and no range of motion deficits or pain of the cervical spine was observed. Axial compression, cervical distraction, shoulder depression, and upper limb tension tests were all unremarkable. Joint movement restrictions were noted in the thoracic spine with hypertonicity of the upper trapezius muscles. The patient was diagnosed with

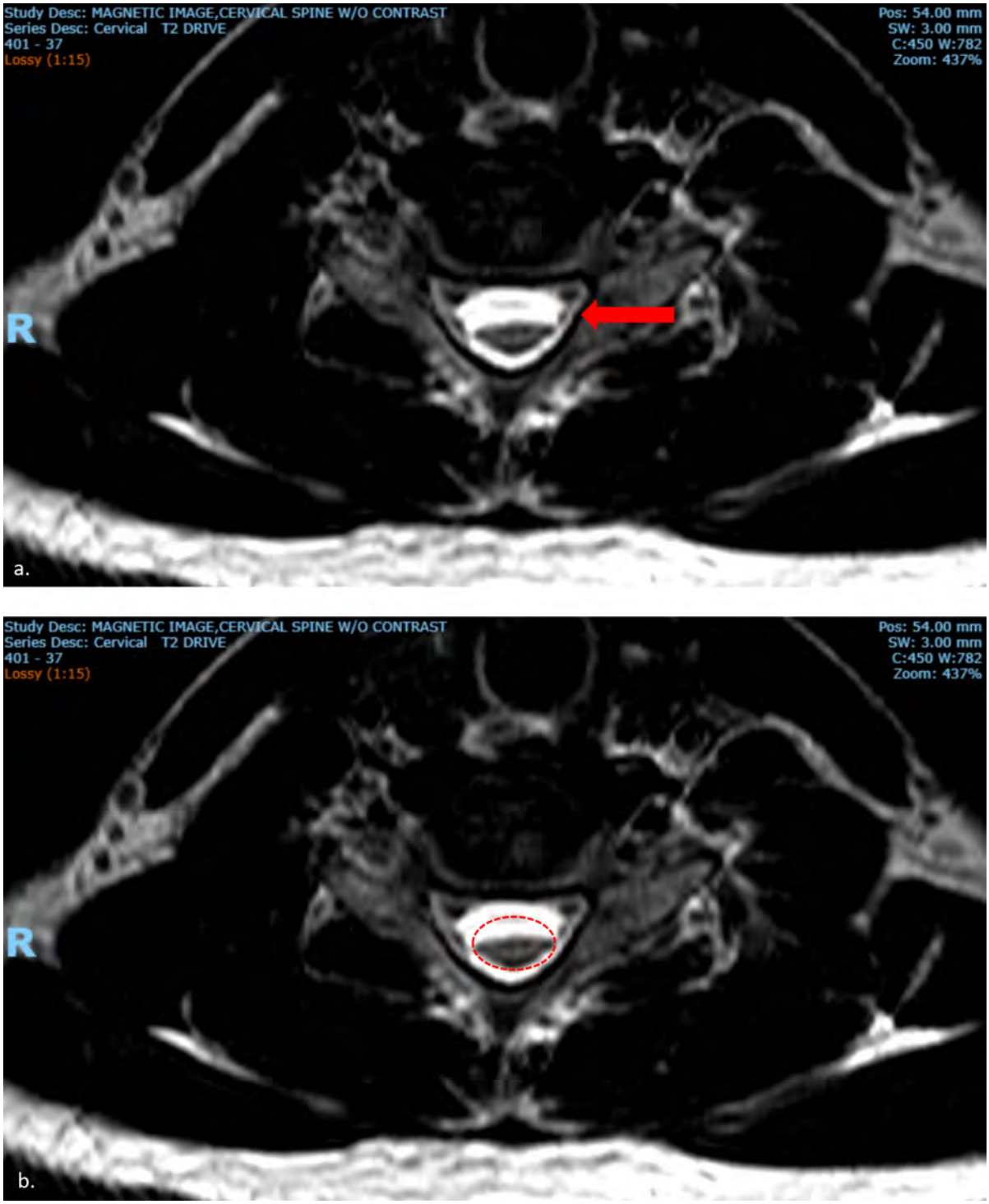


Figure 1.
*a.T2 weighted axial cervical MRI demonstrating mild anterior cord atrophy at C6-C7 (red arrow). b. Red dotted line approximates normal cord volume at this spinal level.*

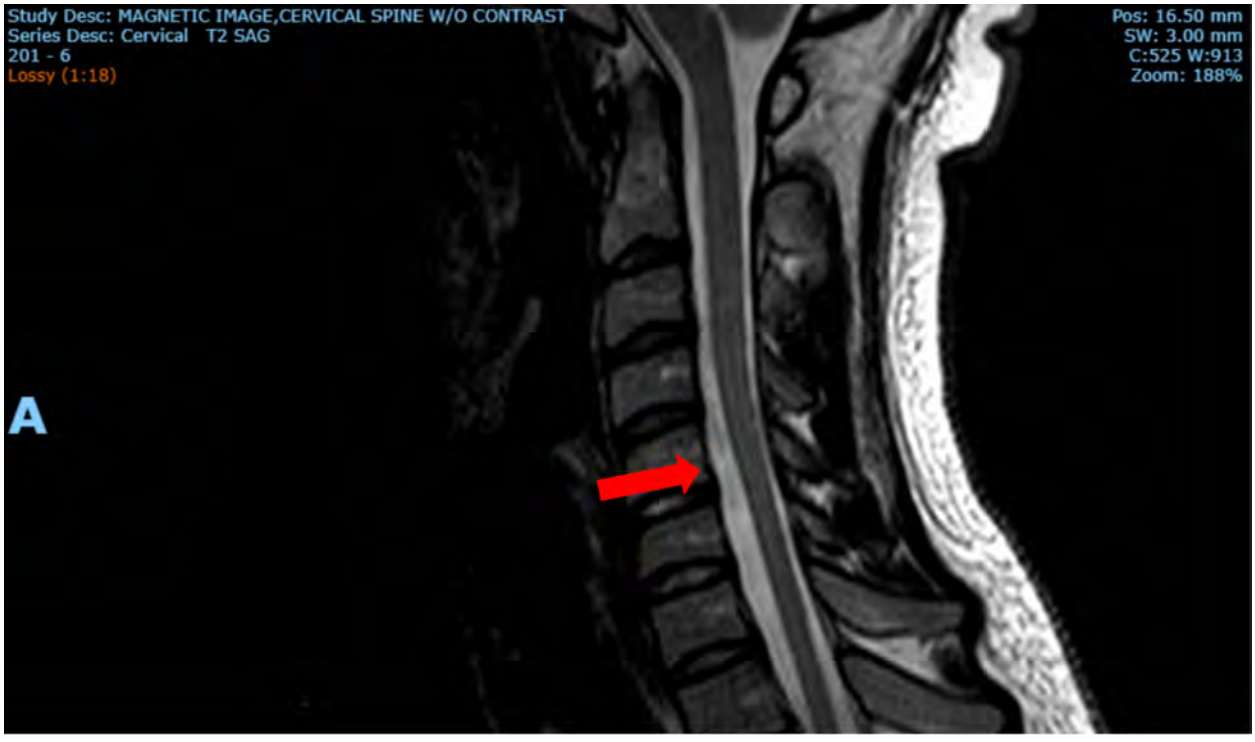


Figure 2.
*T2 weighted sagittal cervical MRI demonstrating mild atrophy of the anterior cord at the C5, C6, and C7 levels (red arrow). No abnormal cord signal noted. The remainder of the visualized spinal cord was normal in course, caliber, and signal.*

myofascial upper thoracic pain complicated by concurrent DBMA.

A trial of manual therapy was initiated with high-velocity, low-amplitude (thrust) supine thoracic spine manipulation, manual myofascial release, and post-isometric relaxation to the upper trapezius bilaterally. At each session, following manual therapy, the patient participated in supervised exercise and was provided home exercise instructions to perform four bodyweight rehabilitation exercises (Y, T, W, L) for five repetitions each[23] (Figure 3). Each movement was then repeated with elastic resistance bands (e.g., TheraBand) added.

At a follow-up session six weeks later, the NPRS was rated 0 out of 10, but he noted two out of 10 "tension" in the upper thoracic and cervicothoracic region. He described increased general activity and engagement in the home exercise program. Over a subsequent four visits in a three month period, seated cervicothoracic long axis manipulation (Figure 4) and instrument-assisted soft tissue mobilization were additionally incorporated into the treatment plan. Soft tissue techniques were applied to the suboccipital, cervical paraspinals, levator scapulae, rhomboids, and periscapular muscles as indicated. Care was taken to maintain neutral cervical positioning and no active or passive movements were attempted that involved cervical flexion.

At four months following the initial presentation an updated NDI was scored 11 out of 50 (22%), and he reported benefit in general mobility following manual therapies, and quality of life as a result of encouragement from the treatment team to remain active. He was seen for seven visits over five months. After his final visit he was referred to a Whole Health[24] introductory class intended to inform veterans about additional opportunities offered within the

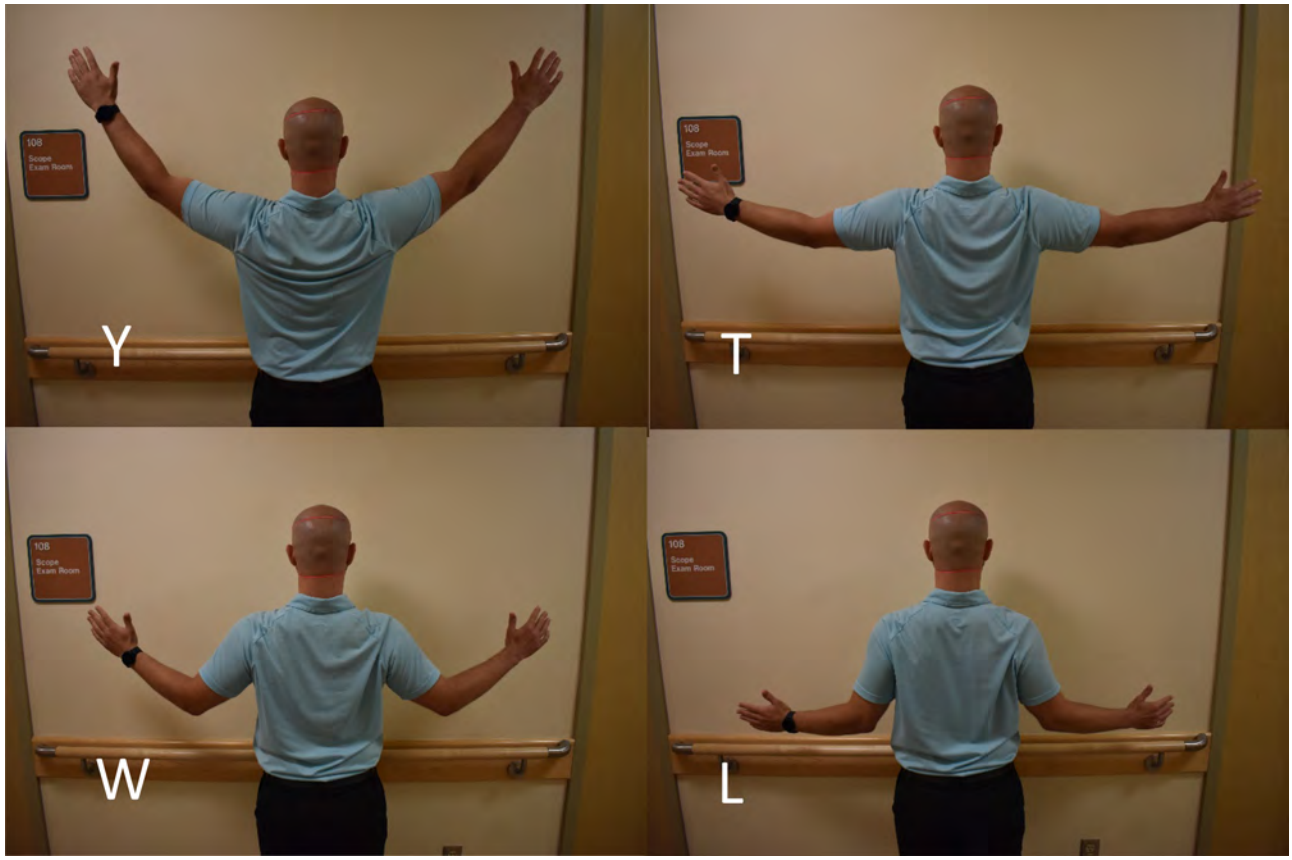


Figure 3.
*Depiction of Y,T,W,L movements. The patient is not pictured.*

VHA to engage in self-directed active care strategies (e.g. tai chi, yoga). Over the course of care, no adverse events occurred. The patient was lost to follow-up.

## Discussion

This case report is the first documented account of the chiropractic management of cervico-thoracic region myofascial pain in a patient with previously diagnosed distal bimelic amyotrophy. Due to the relatively low intensity of the patient's pain experience, it was difficult to determine the impact of chiropractic care on his complaints; however, there was no exacerbation or progression of DBMA and no adverse events were reported. Current literature has focused on the recognition and diagnosis of the DBMA disease entity and very little exists on the symptomatic management of this disorder.[25]

Surgical management options for DBMA diagnosis include posterior cervical duraplasty or anterior cervical fusion.[13] Cervical duraplasty is typically performed via a two-step surgical procedure: laminectomy followed by expansile duraplasty (an opening is created in the dural sac and covered using grafted fascia).[26] This procedure aims to create more space around the spinal cord during flexion-based movements. Anterior cervical fusion, with the aim of restricting cervical flexion, through the addition of instrumentation to immobilize segments of the spinal column is another option in patients with progressive symptoms. A recent study compared the outcomes of surgical (duraplasty) to conservative management (i.e. cervical collar) revealing better patient outcomes with surgery.[26] A clinical practice guideline on diagnosis and treatment of Hirayama disease recommended offering both options with the individual patient assessed for risk and benefit of each.[13] Our patient was referred for neuro-

Figure 4.
*Depiction of seated cervicothoracic spinal manipulation with the cervical spine maintained in a neutral position. An upward force is generated by the provider as part of this manipulation maneuver. The patient is not pictured.*

surgical evaluation to discuss surgical intervention which was deemed not to be appropriate. There is a paucity of literature to guide clinicians in the nonsurgical management of pain conditions in patients with DBMA.

As the patient presented 10 years after the initial disease presentation and without recent progression of signs or symptoms, we considered the patient to be neurologically stable and thus proceeded with a trial of care. At each session, we assessed for appropriateness of high velocity, low-amplitude thoracic manipulation by applying pre-loading positioning consistent with the given spinal manipulation technique and sought patient feedback on tolerance. With the potential risk of injury to the spinal cord from cervical range of motion in the presence of DBMA, cervical spine manipulation was considered to be contraindicated and was not performed. Spinal manipulation was initiated in only the thoracic spine, with addition of the cervicothoracic junction after established tolerance without adverse event. In accordance with guidelines[13] and prior patient education, cervical flexion was avoided during all manual treatment and rehabilitative exercise instruction. The patient was able to tolerate the exercise as well, although he struggled to sustain strength improvements due to fatigue of the upper extremities with repetitions. The Y, T, W, L exercises prescribed have been demonstrated to induce moderate to high activation of the periscapular and lower trapezius muscles.[23]

The score change of the NDI did not achieve the minimal clinically important difference (MCID) of a five-point (10%) decrease.[22] However, the NPRS score did decrease by four points (meeting MCID) and subjective improvements were noted by the patient. Treatment focused on providing pain relief and improving the mobility of the neck, shoulder, and back musculature. The authors hypothesize that atrophy of distal upper extremity muscles may have led to increased stress on the spinal and proximal muscle groups. Further research into this population may prove difficult given its rarity. The majority of current evidence exists from individual cases and expert consensus guidelines and provides no insight on manual therapy in the long-term management of this condition.[13] Future case reports and cohorts detailing conservative management by chiropractors, physical therapists, occupational therapists, and other manual therapy providers may help to guide nonpharmacologic management. The authors theorize that introducing manual therapy and other conservative interventions following the plateau of disease progression could positively impact patient symptom management and quality of life.

### *Limitations*

There is a paucity of evidence for conservative management in the setting of stable DBMA. Patient safety and provider confidence with treating rare disorders should be considered before beginning any trial of care. Bimelic amyotrophy is a rare condition and the findings of our report of a single case may not be generalizable. While our patient did not report any adverse events, this does not mean that adverse events are unlikely to occur with manual therapy approaches being utilized in patients with DBMA, and trials of care should be undertaken with caution.

## Summary

Bimelic amyotrophy is a rare and complicated condition with the potential for serious adverse events (e.g., spinal cord trauma). This case demonstrates conservative

management of concurrent myofascial pain in a patient with known DBMA without experiencing any reported adverse events. Co-management with physical medicine & rehabilitation, or other specialty physicians, is appropriate in the presence of stable bimelic amyotrophy.

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### *Authors contributions*

KM, MP, SP, and CD all cared for the patient. KM, MP, and CD drafted, and all authors critically revised and approved the final manuscript.

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# Differentially diagnosing chronic upper limb paresthesia in a 24-year-old patient: is thoracic outlet syndrome the culprit? A case report

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Objective: *To describe the differential diagnosis, diagnosis, and chiropractic management of a case of chronic upper extremity paresthesia.*

Clinical features: *A 24-year-old woman presented with recent neck stiffness, along with a primary complaint of chronic upper extremity paresthesia and hand weakness of insidious onset.*

Intervention and outcome: *Results of previous electro-diagnostic and advanced imaging studies were combined with clinical assessment to diagnose thoracic outlet syndrome (TOS). Discontinuing after five weeks of chiropractic management, the patient reported significant improvement of paresthesia but less improvement of her hand weakness.*

Diagnostic différentiel de la paresthésie chronique des membres supérieurs chez une patiente de 24 ans: le syndrome du défilé thoraco-brachial est-il en cause? Un rapport de cas.

Objectif : *Décrire le diagnostic différentiel, le diagnostic et la prise en charge chiropratique d'un cas de paresthésie chronique des membres supérieurs.*

Caractéristiques cliniques : *Une femme de 24 ans s'est présentée avec une raideur de la nuque récente, ainsi qu'avec une plainte primaire de paresthésie chronique des membres supérieurs et de faiblesse de la main d'apparition insidieuse.*

Intervention et résultats : *Les résultats d'un électrodiagnostic antérieur et d'examens d'imagerie avancée ont été combinés à une évaluation clinique pour diagnostiquer un syndrome du défilé thoraco-brachial. Après cinq semaines de traitement chiropratique, la patiente a signalé une amélioration significative de ses paresthésies, mais une amélioration moindre de la faiblesse de sa main.*

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Summary: *Several etiologies can give rise to symptoms in common with TOS. It is imperative to rule out mimicking conditions. A battery of clinical orthopedic tests has been proposed in the literature for the diagnosis of TOS but with reported questionable validity. As a result, TOS is mostly a diagnosis of exclusion. Chiropractic treatment shows potential for effective management of TOS, but research is required.*

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KEY WORDS: chiropractic, thoracic outlet syndrome

Résumé : *Plusieurs étiologies peuvent donner lieu à des symptômes communs avec le syndrome du défilé thoraco-brachial. Il est impératif d'exclure les affections mimétiques. Une batterie de tests orthopédiques cliniques a été proposée dans la littérature pour le diagnostic du syndrome du défilé thoraco-brachial, mais leur validité est discutable. Par conséquent, le syndrome du défilé thoraco-brachial est le plus souvent un diagnostic d'exclusion. La chiropratique est susceptible de permettre une prise en charge efficace du syndrome du défilé thoraco-brachial, mais des recherches s'imposent.*

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MOTS CLÉS : chiropratique, syndrome du défilé thoraco-brachial

## Introduction

Over 30 years ago, thoracic outlet syndrome (TOS) was a controversial medical diagnosis.[1] Today, it seems to be more understood and surprisingly more prevalent than once thought.[2] Over the years, it had been termed costoclavicular syndrome, cervical rib syndrome, scalenus anticus syndrome, subclavius tendon syndrome, or musculus pectoralis major syndrome by various authors.[3,4]

This previous controversy might be related to the complexity of TOS involving several different anatomical structures (brachial plexus, subclavian artery, and subclavian vein) that are compromised in different anatomical spaces (scalene triangle, pectoralis minor and costo-clavicular). Thus, the clinical picture of TOS remains challenging to diagnose because it has been reported to cause an array of signs and symptoms.[5] Perhaps it is also because of the lack of valid clinical tests[6], relegating it to a diagnosis of exclusion. Therefore, it is important to rule out several potentially serious conditions that can compromise the neurovascular bundle of the upper extremities.

The purpose of this case report is to review a clinical presentation of chronic neuropathic symptoms affecting the upper extremity of a 24-year-old woman. Electrodiagnostic investigation and advanced imaging suggested this case was compatible with the neurogenic type of TOS. Several differential diagnoses along with their clinical examination are presented to help the astute clinician rule out important conditions before making a clinical diagnosis of TOS.

## Case report

A 24-year-old female, right-handed building inspector presented with a main complaint of muscular atrophy in her right hand and chronic paresthesia of her right little finger. She also reported stiffness in the neck and right trapezial region. The paresthesia in her right little finger began insidiously over the past two years. She described her paresthesia as a constant tingling sensation affecting her entire fifth digit and more recently the medial aspect of her forearm to the elbow. Sleeping on her right side with her right arm under her pillow aggravated the tingling sensation in the fifth digit.

For the past two months, she noticed some muscular wasting involving the palmar aspect of her right thumb (Figure 1), as well as weakness with grip strength. As a result, she had difficulty grasping objects with her right hand, such as a glass of water. Also, for the past couple of months, she had noticed some neck stiffness, more so on the right than the left. She had no recent history of trauma to her neck or right upper extremity. However, she was involved in a highway rollover motor vehicle accident (MVA) three years prior without any apparent injur-

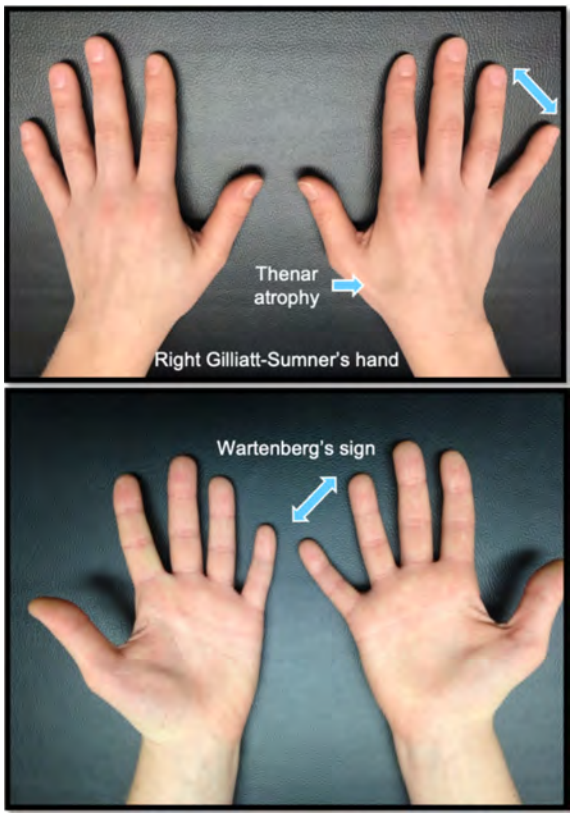


Figure 1.
*Gilliatt-Sumner's hand and Wartenberg's sign*

ies or hospitalization. She was in good general health, a non-smoker, and did not take any medication.

Two months prior to her presentation, she consulted with a neurologist regarding the tingling in her right little finger. The neurologist's report indicated significant muscular atrophy and weakness (3/5) of the right first interosseus muscle, abductor pollicis brevis and abductor digiti minimi. Deep tendon reflexes of the upper extremities were symmetrically 2+, except for a diminished right triceps reflex (1+). Hypoesthesia was noted in the right C8-T1 distribution, especially in the ulnar nerve territory. Tinel's sign was absent at the wrist (over the flexor retinaculum and Guyon's canal) and elbow (cubital canal). At that time, she underwent electromyography of the right upper extremity which revealed abnormal electrical activities of the median and ulnar nerves, with significant denervation of the abductor pollicis brevis and first interosseus muscle of the right hand.

To rule out a cervical radiculopathy, MRI of the cervical spine and brachial plexus without contrast was ordered by the neurologist. The MRI showed no cervical disc herniation, lateral/foraminal stenoses or cervical ribs. Though the diagnosis remained uncertain, no further investigations were planned. She decided to seek chiropractic care to alleviate her symptoms.

On presentation at the chiropractic clinic, the Neck Disability Index (NDI) was rated at 18%, indicating only a mild neck pain-related disability.[7] She reported the intensity of her tingling ranging from 6 to 8/10 on a visual analogue scale (VAS).[8] The Disabilities of the Arm, Shoulder, and Hand Score (QuickDASH) was 48%, suggesting a moderate amount of disability with using her right hand. The QuickDASH questionnaire measures an individual's ability to complete tasks and absorb forces, and the severity of symptoms for any patient with upper extremity musculoskeletal disorders.[9]

### *Physical examination*

Examination at the Outpatient Student Chiropractic Clinic revealed hollowing of the intermetacarpal spaces and the web space of the right hand giving the appearance of the Gilliatt-Sumner's hand (Figure 1). The muscular atrophy was especially noticeable at the thenar eminence and, to a lesser extent, the hypothenar eminence. Wartenberg's sign was present with the right fifth digit maintained in abduction position at rest suggesting weakness of the adducting palmar interosseous muscle innervated by the ulnar nerve (Figure 1).[10]

She was able to make a fist and there was no claw hand deformity at rest or Benediction hand with a fist. There were no colour or temperature changes in the right upper extremity. Allen's test to assess blood flow in the right upper extremity was normal.

Neurological examination revealed hypoesthesia of the right fifth finger with two-point discrimination at 10mm (normal = < 6 mm), as well as diminished light touch sensation along the medial border of the forearm to the elbow. Two-point discrimination has been shown to be a valid test in routine examination of suspected nerve injuries of the hands and fingers.[11] Strength testing revealed 4/5 strength of the flexor digiti minimi, abductor digiti minimi and abductor pollicis brevis. Froment's sign was positive for weakness of the adductor pollicis, innervated by the ulnar nerve.[10] Deep tendon reflexes of the upper ex-

tremities were symmetrically 2+. Plantar responses were down going and ankle clonus was absent.

Cervical spine active range of motion was full in all directions. Forward neck flexion revealed some discomfort at the back of the neck. Side neck flexion caused contralateral neck pain. Cervical extension was pain-free. Spurling's test was negative for reproducing or aggravating the right upper extremity symptoms. Sustained maximal elbow flexion (60 seconds) increased the tingling in the right fifth digit. However, tapping over the right Guyon's canal, cubital tunnel or supraclavicular fossa did not reproduce her tingling sensation along the medial forearm and fifth digit. Upper limb neurodynamic test (ULNT-Ulnar)[12], which is considered to stress the ulnar nerve, aggravated the tingling in the right little finger and caused a burning sensation in the right lower neck area. The EAST (Elevated Arm Stress Test or Roos test) provocation manoeuvre for TOS[13] was performed for three minutes without exacerbation of symptoms. Hyperabduction and Wright's tests, which are included in the Gillard's provocation tests for TOS[13], did not reveal any diminution of the right radial pulse or reproduction of tingling in the right fifth digit. Muscle tenderness and hypertonicity were noted at the right scalene and pectoralis minor muscles. Spinal joint palpation revealed restriction of C7 on left rotation and restricted movement of the first rib on the right side. Range of motion of the right shoulder was full and pain free in all planes.

### *Diagnosis*

In view of neurological signs and symptoms of the right hand on clinical examination, abnormal electrical activities of the median and ulnar nerves from a recent EMG study, and a negative cervical spine MRI, a diagnosis of chronic neurogenic TOS was given to her condition.

### *Intervention and outcome*

The persistent tingling over the right medial forearm nearly resolved during the course of five weeks of care (twice per week). She received a total of ten chiropractic treatments consisting of spinal manipulation therapy using diversified adjusting technique to C7 vertebra and first rib articulations to restore motion. Hypertonic scalene and pectoralis minor muscles were provided soft tissue therapy (trigger point therapy, hold-relax with antagonist contraction (PNF), and deep tissue massage), as well as a daily home program of stretching exercises. Also, she was given a home program of isometric exercises to strengthen the intrinsic muscles of her right hand. She reported an overall improvement of 50% for the significant improvement of her tingling sensation but none regarding the return of strength of her right hand. The tingling sensation of the right little finger had mostly dissipated, although some hypoesthesia at the tip of the fifth digit as well as the muscular atrophy of both the thenar and hypothenar eminences persisted. The complaints of neck stiffness and trapezial pain had resolved completely. Unfortunately, the NDI and QuickDASH questionnaires were not reassessed at self-discharge or upon the telephone interview at two years follow-up.

In the middle of winter, the patient had to travel 45 minutes each way to attend her chiropractic treatments and, with consideration of the cost of chiropractic treatments, eventually decided to discontinue her care. She was referred to her family physician for a referral for a physiotherapy and strengthening program, which would have no cost to the patient. At follow-up two years later, she reported no change in her condition. She did not go for physiotherapy after all and occasionally receives chiropractic treatments closer to her home. She has continued to work full-time as a building inspector.

## Discussion

Based on the clinical presentation alone, the diagnosis of neurogenic TOS is very challenging. A systematic review by Sanders *et al*.[5] revealed a wide diversity of symptoms in neurogenic TOS: upper extremity paresthesia (98%), neck pain (88%), trapezius pain (92%), shoulder and/or arm pain (88%), supraclavicular pain (76%), chest pain (72%), occipital headache (76%), and paresthesia in all five fingers (58%), the fourth and fifth fingers only (26%), or the first, second, and third fingers (14%). Any of these symptoms can be caused by various musculoskeletal dysfunctions of the cervicothoracic region and upper extremity, instead of or concurrently with TOS. Depending on the predominant structure and site of compression involved (Figure 2), TOS can be divided into three subtypes, namely neurogenic TOS (nTOS, compression of brachial plexus), arterial TOS (aTOS, compression of subclavian artery) and venous TOS (vTOS, compression of subclavian vein).[2] Mechanisms of compression have been reported to include fibrous muscular bands, cervical

ribs, and pressure in the inter-scalene triangle space, the pectoralis minor space and the costo-clavicular space.[14]

Arterial TOS is characterized with coolness and pallor in the hand (similar to Raynaud's phenomenon), upper limb ischemia and digital ulceration, while vTOS presents with upper limb swelling and cyanotic discoloration.[15] The venous and arterial subtypes of TOS affect only 3% and <1% of all TOS patients, respectively.[16] The diagnosis of arterial and venous TOS can be confirmed by angiography.[17]

The most common form by far is believed to be the neurogenic type (nTOS), which may account for >90% of all TOS cases.[2] The brachial plexus trunks or cords, originating from nerve roots C5 to T1, are affected in nTOS and can present variable patterns of upper limb weakness, numbness and paresthesia.[15] The paresthesia can involve all five fingers but commonly is worse in the ulnar nerve distribution involving the fourth and fifth fingers.[18]

Neurogenic TOS can be further divided into true or disputed nTOS, with the latter representing 95 to 99% of all neurogenic cases.[19] The symptoms of true and disputed nTOS are largely the same, though objective findings from motor nerve conduction studies and needle electromyography are notably negative in disputed nTOS.[20] Kim *et al*.[21] recently confirmed that true nTOS is predominantly a lower roots/trunk brachial plexopathy involving T1 with clinical and electrodiagnostic features that are largely the same.

### *Clinical features of the reported case*

The case presentation has many characteristics of a true nTOS involving the medial cord of the brachial plexus derived from nerve roots C8 and T1:

1) She is a 24-year-old female with unilateral chronic paresthesia of her right fifth digit. This seems to fit the targeted population for nTOS because teenaged to 60-year-old females are most often affected by true nTOS.[2]
2) The presence of the Wartenberg's sign of the right fifth digit, which is an involuntary abduction of the fifth finger due to a lack of opposition action from the extensor digiti minimi, suggests chronic ulnar nerve palsy. A positive Froment's sign and a positive maximal elbow flexion test further warranted the likelihood of an ulnar nerve lesion at the level of the elbow. However, adding to the complexity of the clinical examination findings, other tests like Tinel's sign at the cubital canal or even at the wrist was absent. Also, there was no acquired claw hand deformity to suggest a simple ulnar nerve palsy. Consequently, the wide range of neurological deficit had to involve different motor fibres, at the level of the brachial plexus.
3) Involvement of the medial cord (C8-T1) was demonstrated from the electromyography study which revealed objective findings of abnormal electrical activities of the median and ulnar nerves, with significant denervation of the abductor pollicis brevis and first interosseus muscle of the right hand that could not be explained by MRI of the cervical spine and brachial plexus.
4) The EMG findings were in keeping with the diffuse muscular atrophy of the right hand giving the appearance of the Gilliatt-Sumner's hand. The Gilliatt-Sumner's hand is a clinical presentation that includes atrophy of the abductor pollicis brevis (median nerve), interosseous (ulnar nerve) and abductor digiti minimi (ulnar nerve) muscles, making it a strong diagnostic indicator of nTOS.[22]
5) Three different types of scale ratings were used.
   a. She scored 18% on the NDI, suggesting only a mild neck pain-related disability. Therefore, it was less likely that her symptoms were directly from a specific neck condition. She had a rollover motor vehicle accident three years prior to the onset of her arm symptoms, but she denied having any sequelae from the MVA.
   b. A visual analogue scale was used to rate the intensity of the paresthesia affecting her entire right fifth digit and the medial aspect of her forearm, which was rated as relatively high at 6 to 8 out of 10. This confirmed the presence of her paresthesia in a distribution consistent with the C8 dermatome, a characteristic of nTOS.
   c. Her ability to use her right hand was 48% on the QuickDASH, suggesting a moderate amount of disability. This could be attributed to the diffuse muscular atrophy of the right hand (Gilliatt-Sumner's hand). The literature indicates that the Quick DASH can be used to measure disability/symptom severity in a variety of upper extremity disorders.[9]

As shown in this case report, several conditions must be excluded prior to establishing a diagnosis of nTOS. The

clinical findings that can mimic nTOS are also consistent with conditions such as cervical radiculopathy, Pancoast tumor, cubital canal syndrome, arcade of Struthers syndrome and Guyon canal syndrome. Consequently, a thorough history, clinical examination, and investigation to exclude similar presenting conditions can increase the accuracy in making the diagnosis of nTOS.[20] These conditions are summarized below with their respective clinical examination findings (Table 1).

Table 1.
*Conditions that can mimic neurogenic Thoracic Outlet Syndrome*

| Condition | Signs and symptoms | Clinical examination | Ruled out in this case report |
|---|---|---|---|
| Cervical spine radiculopathy involving C8 and T1 nerve roots | Neck pain, scapular/periscapular pain and diminished cervical ranges of motion (ROM) are common clinical findings.[38]<br>Loss of dermatomal sensation to the medial aspect of the forearm (C8) or arm (T1), sometimes with diminished deep tendon reflexes and unilateral hand muscle weakness, atrophy or fasciculation in a myotomal distribution.[39] | Combination of Spurling's cervical compression, axial cervical traction, and an Arm Squeeze Test[40] to increase the likelihood of a clinical diagnosis of cervical radiculopathy.<br>Combined results of four negative upper limb neurodynamic tests (ULNT-1-2-3-4) and Arm Squeeze Test could rule out cervical radiculopathy.[12] | Cervical ROM unaffected. Loss of dermatomal sensation to the 5th digit and medial aspect of the forearm (C8) but not the arm (T1).[41, 42]<br>Negative Spurling's test.<br>Reflexes of the upper extremities were symmetrical at 2+. MRI of the cervical spine was unremarkable. |
| Pancoast tumour<br>Tumour growth and local invasion may lead to a combination of signs and symptoms (Pancoast-Tobias syndrome), the latter presenting several similarities with the clinical presentation of nTOS or C8-T1 radiculopathy (e.g., radiating pain to the neck, the medial aspect of the arm and forearm as far as the wrist).[43] | Middle-aged patient presenting with radicular-like symptoms should be examined neurologically for Horner's syndrome; miosis, partial ptosis and hemifacial anhidrosis.[44] Red flag signs and symptoms of lung malignancy (e.g., cough, hemoptysis, dyspnea, fever, weight loss) may also be seen in the later stages of the disease.[41, 45] | The presence of one or more signs characterizing Pancoast-Tobias syndrome (i.e., Horner syndrome, upper arm edema, paresthesia, weakness in the intrinsic hand musculature), combined with tumour localization through imaging, enable this condition to be distinguished from nTOS or degenerative cervical spine disorders.[43] | Patient is young and did not present with Horner's syndrome. There were no constitutional signs and symptoms. |
| Ulnar neuropathy<br>The ulnar nerve provides sensory innervation to both the palmar and dorsal aspect of the medial half of the fourth finger, the entire fifth finger and to the ulnar border of the hand.[42] | The typical patient presentation for cubital tunnel syndrome in the early phase involves numbness/paresthesia of the 4th and 5th digits[10] with weakness or atrophy of the intrinsic muscles of the hand in more chronic cases[46]. Occasionally, pain is experienced along the course of the ulnar nerve from the posteromedial elbow into the ulnar forearm or hand.[47]<br>At the level of the wrist an ulnar nerve compression in the ulnar tunnel (Guyon's canal) is characterized by loss of sensation with or without motor dysfunctions, affecting the hypothenar region and the ventral aspect of the fourth and fifth digits.[42, 48]<br>In chronic cases, ulnar nerve compression in the cubital tunnel may lead to paralysis of lumbricales and interossei resulting in acquired claw hand deformity (i.e., hyperextension at the metacarpophalangeal joints and flexion at the proximal and distal interphalangeal joints of the fourth and fifth fingers).[49] | Impaired sensation can be quantified with two-point discrimination examination.[11] Tinel's percussion test can be done over Guyon's canal (ulnar tunnel) and over the cubital tunnel. The latter may be positive for creating a radiating sensation along the ulnar border of the forearm into the hand.[10]<br>The sustained elbow flexion test with the elbow held in full flexion with the wrist in extension may also be positive (reproducing paresthesia and pain). [50] In chronic cases with the acquired claw hand deformity, the patient will still be able to make a fist.<br>In cases of severe and chronic compressive neuropathy of the ulnar nerve, hypothenar atrophy may be present, in addition to positive Froment's and Wartenberg's signs.[10] | Patient's presentation and clinical findings were indicative of mixed neuropathies: Electromyography confirmed abnormal electrical activities of the ulnar and median nerves. Distribution of the paresthesia (fifth digit), muscular atrophy of both the thenar and hypothenar eminences (Gilliatt-Sumner's hand), hand weakness, Wartenberg's and Froment's signs were positive for ulnar neuropathy. However, Tinel's tests were negative along the trajectory of the ulnar nerve (cubital tunnel and Guyon's canal). Although sustained maximal elbow flexion test and neurodynamic tests were positive, there was no claw hand deformity. Unfortunately, the scratch collapse test, which has been described as a useful examination manoeuvre for the evaluation of median and ulnar neuropathy (carpal and cubital tunnel syndromes), was not performed. According to Cheng *et al*.[51] the scratch collapse test is more sensitive than the Tinel's sign. As such, it is possible that our case had a mix of ulnar neuropathy and nTOS. |

| Condition | Signs and symptoms | Clinical examination | Ruled out in this case report |
|---|---|---|---|
| Brachial plexopathy injuries (BPI) Neuropraxia, axonotmesis, and neurotmesis are the three main classifications of nerve injuries, with neurotmesis being the most severe form of nerve injury.[52] The neuropraxia form of nerve injury is most seen in entrapment neuropathies or pressure palsies, usually with complete recovery within days to weeks.[53] | The signs and symptoms of a BPI depend on the injury's location and extent. In American football, traumatic upper trunk brachial plexopathy injuries, also known as a cervical stinger or burner, is the most common upper extremity neurologic injury, most commonly involving the upper trunk.[54] | Lower brachial plexus lesions, affecting the C8-T1 nerve roots, can mimic the clinical presentation of nTOS, resulting in sensory (i.e., pain, numbness or tingling) and motor (i.e., weakness or paralysis) deficits of the forearm flexors and the intrinsic muscles of the hand, without corresponding to a peripheral nerve distribution.[55, 56] As the sympathetic chain arises from the C8 and T1 nerve roots, damage at this point may also result in Horner's syndrome[55, 56], making it important to assess for P.A.M. (Ptosis, Anhidrosis and Miosis). | Contrary to BPI, the patient's symptoms were not related to a history of traumatic onset. |
| Neuropathic pain "Pain caused by a lesion or disease of the somatosensory nervous system"[57]. | Chronic neuropathic pain is more frequently observed in women above 60 years old[58, 59], and is characterized by spontaneous pain and increased pain sensitivity to painful (hyperalgesia) and nonpainful (allodynia) stimuli, often causing major suffering and disability.[57, 58, 60, 61] | Screening tools have been developed and validated to help identify it in clinical practice.[58] Pain medications might be reported by the patient; recent medical practice guidelines for chronic neuropathic pain recommend Duloxetine, Venlafaxine and Gabapentine as first-line treatments.[62, 63] | The patient did not report any pain, allodynia or hyperalgesia in her upper extremity, only paresthesia mainly of her little finger. She did not receive anti-neuropathic medication. Based on the QuickDASH she was not in the category of high disability. |
| Progressive neurological disorder such as: Amyotrophic Lateral Sclerosis | Clinically Definite ALS is defined on clinical evidence alone by the presence of UMN (pathologic spread of reflexes), as well as LMN signs (weakness, atrophy and fasciculations), in the bulbar region and at least two spinal regions or the presence of UMN and LMN signs in three spinal regions.[64] | ALS starts with limb weakness in about 2/3 of patients, while the remaining 1/3 have bulbar weakness causing dysarthria and dysphagia.[65] Neurological examination reveals weakness, atrophy and fasciculations, as well as hyperreflexia and increased tone in the same motor segment often combined with an extensor response to plantar stimulation.[65] | Muscular atrophy was noticeable in the thenar and hypothenar eminences of the right hand without apparent fasciculations. Hypoesthesia was limited to the 5th digit. Strength testing showed weaknesses (4/5) of the abductors of the thumb and 5th digit. Deep tendon reflexes of the upper extremities did not show any hyperreflexia and were symmetrical at 2+. Furthermore, there were no UMN signs and no dysarthria or dysphagia. |

Legend: *ROM - Ranges of motion (ROM), ULNT – Upper Limb Neurodynamic Test, MRI – Magnetic Resonance Imaging, BPI - Brachial plexopathy injuries, ALS – Amyotrophic Lateral Sclerosis, UMN – Upper Motor Neuron, LMN – Lower Motor Neuron*

## Diagnosis of Thoracic Outlet syndrome

### *Orthopedic examination for Thoracic Outlet Syndrome*

Depending on the type of TOS suspected, diagnostic investigations can vary, necessitating a good history taking and clinical examination.[15] Thus far, the scientific literature does not offer any valid orthopedic test to clinically confirm the diagnosis of the different types of TOS.[6] Moreover, it is important to rule out a cervical brachial pain syndrome, such as a cervical radiculopathy, cubital tunnel syndrome, carpal tunnel syndrome, and Guyon's canal syndrome with a neurological examination.

On examination, signs of swelling and cyanotic discoloration may be in keeping with Paget-Schroetter syndrome, also called "effort thrombosis," seen in vTOS (Figure 2). In other instances, Raynaud's phenomenon, upper limb ischemia, and digital ulceration may be more in keeping with compression of the subclavian artery (aTOS).[23] However, any swelling of the upper extremities or changes in skin colour, texture and temperature can also suggest complex regional pain syndrome, but

typically the differentiating hallmark of this condition is excruciating pain, even to light touch.[24] Chronic nTOS might show muscular atrophy of the thenar eminence, hypothenar eminence, and the interossei suggestive of the Gilliatt-Sumner's hand.[25]

It has been suggested that provocative manoeuvres can add weight to a suspected diagnosis of TOS, but alone their utility is questionable.[15] Commonly used provocative manoeuvres have been incorporated into the Gillard's clinical prediction rule, which includes a cluster of five provocative manoeuvres (Adson's, Hyperabduction or Eden's, Wright's, EAST, and Tinel's sign over the supraclavicular fossa). To increase the specificity to 84% all five tests must be positive.[13]

The structures which can cause TOS (hypertonic scalene or pectoralis minor muscles, cervical ribs) can be detected by palpation. Joint movement restrictions can be significant in the cervico-thoracic region, as well as the costovertebral joint of the first rib. Thus, the experienced clinician should be able to diagnose TOS by excluding mimicking conditions through the history (including mechanism of onset of the condition, type of symptom and its localization) as well as the observation of subtle clinical signs.

### *Imaging*

Clinicians must often rely on imaging modalities in combination with provocative tests since little evidence supports the validity of a single orthopedic test for the diagnosis of TOS.[6] Since electromyography results are commonly normal in patients with nTOS (i.e., ''disputed nTOS'')[26], imaging is used to rule out other neurologic conditions (e.g., ulnar or median neuropathies, cervical radiculopathy)[27].

The American College of Radiology (ACR) criteria for imaging in the diagnosis of TOS suggest that chest radiography should be considered as a primary imaging modality, given its low cost, ease of access and safety profile.[28] This type of imaging enables the identification of osseous abnormalities such as cervical ribs, first rib defects, other congenital malformations or soft tissue lesions[29], as well as pathologies such as lung tumors, which can trigger symptoms of nTOS. MRI without contrast is also recommended for the diagnosis of nTOS, typically performed during provocative positioning (e.g., patient's arm in abduction). Ultrasonography (US) can be useful

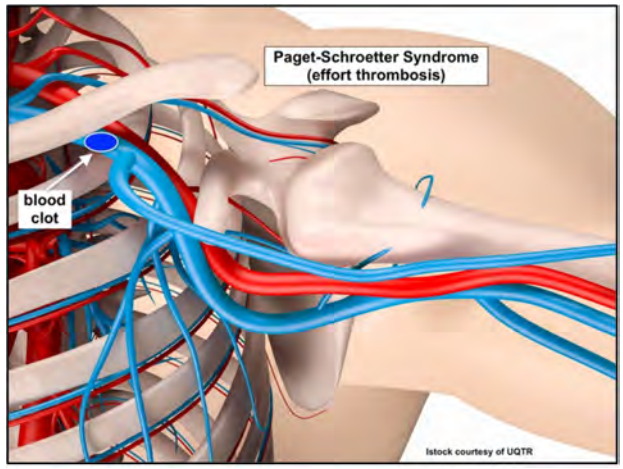


Figure 2.
*Paget-Schroetter syndrome*

in the identification of fibromuscular bands that may cause compression of the lower brachial plexus[30] or can be used to rule out more distal compression of peripheral nerves by similar anatomical structures (e.g., Arcade of Struthers)[31, 32].

### *Outcome measures*

To date, there are no validated scales or questionnaires that have been developed specifically to measure functioning or quality of life in patients diagnosed with TOS. Recent studies assessing the impact of conservative approaches to treat TOS[33, 34] have used the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire or its shortened version (QuickDASH), both validated and designed to monitor upper extremity function over time[9]. A patient with no disability will score 0; one who has maximal disability will score 100. Also, the validated Cervical Brachial Symptom Questionnaire (CBSQ) can be used for widespread sensory and motor findings that would indicate a condition such as cervical radiculopathy, carpal tunnel syndrome or ulnar neuropathy. It is used by adding together the sum of all 12 numerical questions. A patient with no disability will score 0; one with maximal disability will score 120.[35] Lately, a group of experts has worked on the development of a thoracic outlet syndrome index (TOSI), combining several items from validated questionnaires.[36] Although preliminary results of this study are promising, further research is warranted to support its validity and promote its use.

### *Chiropractic management*

A recent published scoping review on exercise rehabilitation for neurogenic TOS did not find any randomized controlled trials.[37] They found several treatment options such as analgesic and anti-inflammatory medication, botox injections, hot/cold therapy, electrophysical modalities (TENS, US), manual therapy, orthoses, night splinting, and patient education regarding ergonomics and postural awareness. They concluded that the clinical rationale proposed by most authors involved postural correction and decompression of the thoracic outlet via restoring proper muscular balance. Rehabilitative exercises for strained musculature would commonly be prescribed. Luu *et al*.[37] reported inconsistency across studies regarding exercise dosage.

Since these treatment approaches target dysfunctional muscles and articulations, and not directly nerves or blood vessels, the question arises: Does differentiation of TOS into neurological or arterial subtypes serve a purpose in the conservative management of TOS? The nerves and blood vessels travel through the thoracic outlet in close proximity (Figure 3). It is unlikely that different degrees of muscle tension would selectively compress, for example, arterial rather than nervous structures. Furthermore, if aTOS compromises the arterial blood flow through the vasa nervorum of the nerves coursing through the thoracic outlet, should the resultant symptomatology be diagnosed as nTOS or aTOS? If a manoeuvre compromising the thoracic outlet and eliciting or exacerbating upper extremity symptoms, whether with or without attenuation of the radial pulse, were considered positive, it could make the clinical assessment and diagnosis of TOS simpler, more valid, and possibly more reliable.

In the case presented, the diagnosis of chronic neurogenic thoracic outlet syndrome (nTOS) was based on the normal MRI that excluded the presence of a cervical disc herniation, Pancoast tumor, fibrous band, cervical rib or other space occupying lesions. While the EMG study indicating abnormal electrical activities in both the median and ulnar nerves was consistent with disturbance at the lower trunk of the brachial plexus, the appearance of a Gilliatt-Sumner's hand suggested C8 and T1 nerve root involvement. Though the natural history of TOS is not well defined, the chronicity of the symptoms, abnormal electromyography, and muscular wasting of the hand

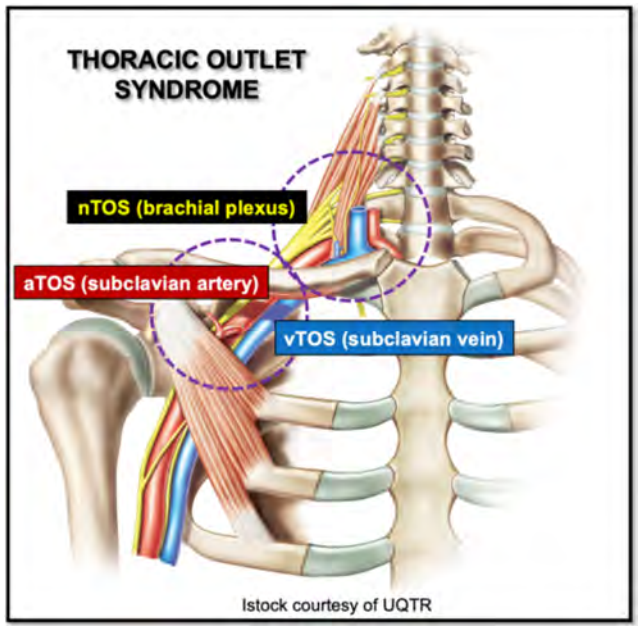


Figure 3.
*Relevant anatomy of three types of thoracic outlet syndrome*

strongly suggested that the patient was not likely to recover on her own.

Numerous mechanisms associated with TOS have been reported, including motor vehicle accident, repetitive motions and anatomic variations.[20] Our patient was involved in a roll-over motor vehicle accident three years prior to receiving chiropractic treatments. Although she denied any sequelae post-MVA, the role of this trauma in initiating musculoskeletal dysfunctions which caused her subsequent nTOS symptoms cannot be ruled out.

Following a trial of ten sessions of manual therapy (joint mobilization, manipulation, and soft tissue massage) for a diagnosis of neurogenic TOS, the patient reported a 50% improvement, with no tingling along the medial border of the forearm and resolved neck stiffness. Manual therapy seems to have had an effect by relaxing the scalene and pectoralis minor muscles, which could have resulted in lesser compression of the lower cord of the brachial plexus, thus improving her paresthesia. However, over the relatively short period of treatment, the hand muscular atrophy and hypoesthesia at the tip of the fifth digit persisted. Two years later, she reported no further improvement in her condition. For comparison, in a

case series of nine TOS patients surgical decompression of a fibrous cervical band was beneficial for the relief of hand pain and paresthesia and slight recovery of power on the affected hand, but muscle wasting in the hand appeared to be unchanged up to eight years later.[25] Given the opportunity to provide more chiropractic treatments to our patient, it is possible that more improvement could have been obtained with regards to the paresthesia in the fifth digit, but improvement of the muscular atrophy would be unlikely.

### *Surgical management*

The patients who are likely to benefit from a surgical intervention are those with troublesome pain and paresthesia, and those with a progressive history of weakness and muscle wasting.[25] Upon the telephone interview two years post-treatment, our patient indicated that a surgical intervention was not being considered at the present time. Typically, surgical interventions involve the division of a fibromuscular band that may cause compression of the lower brachial plexus or a resection of a rudimentary cervical rib.

## Summary

Due to the three subtypes of TOS (aTOS, vTOS and nTOS) as well as true versus disputed TOS, its diagnosis remains a challenge. The difficulty arises not only from the plethora of clinical presentations but also from the poor reliability of most orthopedic provocative manoeuvres. Consequently, the diagnosis of TOS is mostly done by exclusion. In challenging chronic cases of TOS, investigations should include electrodiagnostic, imaging and laboratory studies to rule out other potentially serious diagnoses, such as Paget-Schroetter syndrome, brachial plexopathy, and Pancoast tumour.

This case report describes the promising management of chronic neuropathy of the upper extremity, diagnosed as nTOS, with chiropractic treatment. Research into the diagnosis and conservative versus surgical management of TOS is warranted.

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# Splenic calcifications in a patient with Systemic Lupus Erythematosus: an imaging case review

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*A 47-year-old female presented to a chiropractic clinic with known diagnosis of systemic lupus erythematosus. Radiographic examination demonstrated multiple splenic calcifications, an uncommon, yet important finding. The patient was subsequently referred to her primary care physician for co-management and further evaluation.*

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KEY WORDS: spleen, calcifications, systemic lupus erythematosus

Une femme de 47 ans s'est présentée dans une clinique chiropratique avec un diagnostic connu de lupus érythémateux disséminé. L'examen radiographique a mis en évidence de multiples calcifications spléniques, une découverte peu commune mais significative. La patiente a ensuite été adressée à son médecin traitant pour une prise en charge conjointe et une évaluation plus poussée.

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MOTS CLÉS : rate, calcifications, lupus érythémateux disséminé

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## Case presentation

A 47-year-old female with known history of systemic lupus erythematosus (SLE) and fibromyalgia diagnoses presented to a chiropractic clinic with right-sided lower back and right hip pain. The patient described the pain as sharp and constant and rated its severity as a 5 out of 10. She noted intermittent facial paralysis and numbness in her hands and feet. No facial rash or other clinical manifestations were present. The patient also had occasional joint pain and stiffness when she experienced flare-ups. Due to the history of lupus with prolonged corticosteroid use, a standard lumbar radiographic series was performed at the chiropractic clinic. Prolonged steroid use can result in many complications such as osteopenia and avascular necrosis.[1]

A lumbar spine series was taken at the clinic (Figure 1) which demonstrated loss of bone density, mild degeneration, and calcification in the left upper quadrant. Figure 2, a magnified image of the left upper quadrant on the AP lumbopelvic projection, confirmed innumerable calcifications within the spleen. The calcifications appeared as distinct, round nodules measuring 2-3mm in diameter.

## Discussion

Etiology of left upper abdominal quadrant calcification can include *Mycobacterium tuberculosis* infection, *Histoplasma capsulatum* infection, pleomorphic sarcoma, hemangioma, angiosarcoma[2], along with SLE. In SLE, the pattern of calcification is typically widely distributed, small, round, calcified nodules in a random and scattered pattern in the spleen.[3] Due to the distinct calcification pattern and patient history, the radiologist confirmed the calcifications in this case were due to SLE. The key imaging features and differential diagnoses for diffuse, punctate splenic calcifications are listed in Table 1.

### *Intervention and outcome*

The patient was referred to her primary care physician for management of the splenic findings and evaluation for pneumococcal vaccination. Splenic calcification may foreshadow autosplenectomy and hyposplenism.[3] Hyposplenic individuals are particularly vulnerable to encapsulated bacterial infections such as those caused by pneumococcal bacteria; this emphasizes the need for pneumococcal vaccination.[4] The patient continues to be treated by a chiropractor for her musculoskeletal complaints.

This patient had no evident cause for the splenic calcifications except for her known SLE. Splenic calcifications are a rare finding, but the distinct pattern can be a key aid in diagnosis.[5] Although this finding is rare, patients should be co-managed with the primary care provider for pneumococcal vaccination and to manage any concurrent systemic manifestations. It is important for chiropractors to properly investigate new and rare symptoms, especially in clinical situations where there are pre-existing conditions, and to know the proper medical professional to refer to in such cases.

SLE is a chronic, complex autoimmune inflammatory disease that can affect any part of the body and have various manifestations. Musculoskeletal complaints are extremely common in patients with SLE, most patients seek medical attention for joint pain.[6] Chiropractors must be aware of the potential manifestations that can arise due to SLE and subsequent corticosteroid treatment such as loss of bone density[7], potential for avascular necrosis[7], and various vascular deficiencies[6] that may arise as a result of SLE. Any contraindications to care such as vertebral-basilar insufficiency, osteoporosis, or ostemyelitis[8] must be ruled out before proceeding with treatment.

Key messages

- Splenic calcifications are a rare, yet important finding in patients with SLE
- The etiology of splenic calcifications can usually be determined by patient history along with the pattern of the calcifications
- Patients with this finding should be co-managed with their PCP for pneumococcal vaccination


Figure 1.
*AP lumbopelvic and lateral lumbar spine radiographs demonstrating osteopenia, mild degenerative changes, and left upper quadrant calcifications.*


Figure 2.
*Magnified image of the left upper quadrant demonstrating innumerable 2-3 mm calcifications within the spleen.*

Table 1.
*Differential diagnoses for diffuse, punctate splenic calcifications and key imaging features*

| **Differential Diagnoses** | **Key imaging features** |
|---|---|
| *Mycobacterium tuberculosis* or *Histoplasma capsulatum* | Diffuse calcifications without associated mass; scattered punctate calcifications[2] |
| Pleomorphic sarcoma; hemangioma; angiosarcoma | Mass with internal calcifications; punctate calcifications[2] |
| Systemic Lupus Erythematosus | Widely distributed, small, round, calcified nodules in a random and scattered pattern[3] |

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