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Editorial Board

Contemporary biopsychosocial exercise prescription for chronic low back pain: questioning core stability programs and considering context

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This commentary explores the importance of considering the biopsychosocial model and contextual factors when prescribing exercise. Diverse exercise programs for patients with chronic low back pain (CLBP) produce similar outcomes, without one specific exercise protocol demonstrating clear superiority. One clear barrier to positive outcomes is poor exercise adherence. We suggest that there are certain common contextual factors present in all exercise prescription scenarios that may impact adherence and health-related outcomes. While challenging common core stability exercise prescription, we present an argument for enhancing and intentionally shaping the following contextual factors: the therapeutic alliance, patient education, expectations and attributions

Cet article explore l'importance de considérer le modèle biopsychosocial et les facteurs contextuels avant de prescrire des exercices. Divers programmes d'exercices pour les patients qui souffrent de lombalgie chronique produisent des résultats semblables, sans qu'un protocole d'exercices particulier démontre une supériorité claire. Un obstacle évident à l'atteinte de résultats positifs est le fait de ne pas persister à faire les exercices. Nous laissons entendre qu'il existe certains facteurs contextuels communs dans tous les scénarios de prescription d'exercices pouvant avoir des répercussions sur la persistance et les résultats axés sur la santé. Tout en contestant la prescription d'exercices communs de stabilisation du tronc, nous présentons un argument en faveur de l'accroissement et l'élaboration intentionnelle des facteurs contextuels suivants : l'alliance thérapeutique, la sensibilisation du patient, les attentes et les attributions du succès ou de l'échec thérapeutique, ainsi que la maîtrise ou le contrôle cognitif d'un

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of therapeutic success or failure, and mastery or cognitive control over a problem. Overall, this commentary argues that to improve exercise adherence and outcomes in the CLBP population, the context in which exercise is delivered and the meaning patients embody need to be considered and shaped by clinicians.

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KEY WORDS: chiropractic, low back pain, chronic, exercise, prescription

problème. Dans l'ensemble, cet article soutient qu'afin d'améliorer la persistance à effectuer les exercices et les résultats au sein de la population atteinte de lombalgie chronique, le contexte dans lequel l'exercice est fourni et la signification exprimée par le patient doivent être pris en considération par les cliniciens.

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MOTS CLÉS : chiropratique, lombalgie, chronique, exercice, prescription

Burden of low back pain

Low back pain (LBP) is the leading cause of disability worldwide.[1] Many individuals with a LBP episode will not be pain-free within a year, despite seeking care from a general practitioner or chiropractor.[2] Although many individuals with acute LBP (pain for less than three weeks) see improvements over time; up to 73% will have a recurrence within 12 months.[3] Individuals with chronic low back pain (CLBP; pain for greater than three months) also have poor outcomes; 60-80% of those seeking help will continue to have LBP after one year.[4] Data shows that disability from back pain has increased since the late 1990's, despite advances in technology, improved imaging techniques, and a plethora of available passive interventions.[5] In light of this high burden, it is worthwhile to examine the effectiveness of CLBP treatments; including frequently prescribed exercise programs.

Prescribing exercise for CLBP

Exercise is one of the few interventions for CLBP that has consistently been demonstrated to reduce pain and improve function.[6] Exercise alone or in combination with education is also an effective LBP prevention strategy.[7] Although effect sizes for exercise are modest in reducing pain and improving function[8,9], it is a desirable part of a treatment program because it is a safe self-management technique that can be performed outside of the clinical environment. As a result, it is possibly the most cost-effective and evidence-informed intervention currently available for CLBP. Unfortunately, while exercise can be effective, only a small percentage of patients with CLBP adhere to a prescribed exercise program, and poor adherence is associated with poor outcomes.[10,11] In other words, patients have to do the exercise to reap the benefit. While there are many potential barriers to exercise adherence in patients with CLBP, diagnostic uncertainty and fear of pain or harm are among the most commonly cited.[12]

Clinicians often prescribe exercise for CLBP with a focus on biomechanics and the musculoskeletal system. This includes a focus on muscle strength, endurance, timing, or mobility. Although targeting the musculoskeletal system can lead to physical changes, current evidence suggests that these changes do not correlate well with meaningful clinical outcomes[13,14] and these structured impairment-based programs may not facilitate long-term adherence[12]. As outlined in the next sections, a contemporary biopsychosocial approach to exercise prescription with an increased focus on clinician-patient communication and contextual factors surrounding exercise prescription may improve adherence and patient outcomes.

What type of exercise to prescribe?

Despite years of research, the active agent in therapeutic exercise for CLBP is elusive and we also lack high quality evidence to support the long-term effectiveness of one form of exercise over another for non-specific CLBP.[8,15-25] This includes a comparison of programs focused on: general exercise, low back strengthening, increasing flexibility, improving motor control, Pilates, Yoga, and various forms of aerobic exercise.[8,15-25] To further complicate things, many clinicians, researchers, and patients may be looking in the wrong place for the beneficial effect (i.e., the musculoskeletal system). In a systematic review of exercise therapy for non-specific CLBP, Steiger

and colleagues concluded that the treatment effects are not directly attributable to changes in the musculoskeletal system (e.g., muscle strength, mobility, or muscular endurance).[13] Their findings challenge long-held beliefs that exercise programs specifically targeting core stability/neuromuscular control have a regional structural or biomechanical impact and are key to successful CLBP rehabilitation. Furthermore, a systematic review of studies of transversus abdominis training for LBP patients reported that changes in muscle morphometry or activation were not associated with clinical outcomes.[14] They also found that the relationship between clinical improvements and changes in lumbar multifidus characteristics were unclear.[14] Another study found that even when individuals with LBP were subgrouped and those with motor control impairments were identified, there was no additional benefit to prescribing 'corrective' motor control impairment exercises compared to a general exercise program.[19] This finding is consistent with a recent Cochrane systematic review of studies of motor control exercises for non-specific CLBP which reported that no form of exercise is superior to another.[21]

Rather than only focusing on clinician-identified musculoskeletal impairments that have questionable relevance, we hypothesize that exercises for CLBP may be better selected and taught using a biopsychosocial approach[26]; considering patients' cognitions and self-identified functional goals or meaningful movements that have been avoided due to provoked pain or the expectation of pain. This could be combined with encouraging patients to engage in regular exercise that they expect will help and that they personally enjoy (e.g., walking in nature or yoga with meditation etc.). This is consistent with the World Health Organization (WHO) approach to disability, where a biopsychosocial approach is recommended, without making the mistake of "...reducing the whole, complex notion of disability to one of its aspects".[27 p.9] Unfortunately, many exercise programs used in clinical practice have deep-rooted patho-anatomic underpinnings that may be hard for clinicians to change from. The concern is that outdated or unfounded unidimensional tissue-based approaches that appear ubiquitous, ignore the current biopsychosocial understanding of pain.[28] Using the example of core stability exercises for CLBP that are popular with chiropractors and other clinicians, the next section describes how there may be drawbacks to the way they are widely explained and prescribed. In turn, the benefits of viewing exercise prescription through a contemporary biopsychosocial lens and harnessing the therapeutic context may be better appreciated.

Questioning core stability exercise prescription

Popular core stability exercise programs commonly focus on bracing or activating the trunk muscles that are believed to support the spine. This includes exercises such as: crunches, planks, bird-dogs, or those aimed at specifically targeting the transversus abdominis. While it is agreed that core stability/neuromuscular control are needed to perform activities of daily living, only low levels of muscle contraction that occur beyond conscious control are needed to stabilize the spine.[29,30] Meanwhile, current biomechanics literature demonstrates that individuals with LBP already have increased levels of abdominal and lumbar muscle activity[31], which persist despite symptom improvement[32]. With this increased muscle activity, it is of little surprise that patients with LBP have increased trunk stiffness[33], which is even higher in patients with kinesiophobia[34,35] and catastrophizing[36]. Although this increased muscle co-contraction and trunk stiffness may provide short-term protection, in the long-term it appears to be maladaptive as it can increase lumbar spine compression and limit movement.[33,37-39] Considering this evidence, we must question the value of core stability exercise programs that promote bracing or excessively increasing trunk muscle activation, especially for CLBP patients that are exhibiting fear and guarding to avoid lumbar spine movement. Alternatively, many CLBP patients may be better instructed to perform trunk muscle relaxation techniques with movement, rather than trunk muscle activation.[40] Indeed, many contemporary approaches to core stability focus on neuromuscular control, where patients are instructed to find a balance between movement and spinal stiffness to optimally perform a task. While this is a positive step away from programs promoting excessive bracing and stiffness; still, the relationships among pain, movement, and injury remain unclear[41] and the theories of dysfunctional neuromuscular control in patients with LBP continue to be challenged[19,42-45].

Furthermore, the way core stability exercises are prescribed may be problematic, as it may create rather than reduce negative cognitions about the patient's back. A systematic review with meta-analysis of stabilization exer-

cises for LBP by Smith and colleagues found that there is strong evidence that core stability exercises are not more effective than any other form of exercise in the long-term (pain or disability) and that the rationale provided for the need of core stability could increase fear-avoidance as compared to other exercises.[22] In addition, the Military (POLM) cluster randomized trial (n = 4,147) by George *et al*.[46] found, as compared to traditional lumbar exercises, there was no benefit of core stability exercises for preventing the onset of LBP that resulted in healthcare seeking. Instead, a brief psychosocial education program aimed at reducing fear and threat of LBP in combination with either exercise program resulted in lower two-year incidence of healthcare seeking for LBP. These studies suggest that the context of exercise prescription is important. When anatomical explanations or words like spinal 'weakness' or 'instability' are used to explain why patients get pain or continue to have pain, the meaning patients embody may create and reinforce hyper-vigilance and enduring beliefs that the spine is vulnerable and in need of protection.[47-50] As clinicians focus on structural explanations for persistent pain, this presents a dilemma which is nicely summarized by Moseley (2003): "However, there is a vast body of evidence to the contrary; nociception is neither sufficient nor necessary to evoke pain and psychosocial factors are more important than physical factors in the development of chronic nonspecific pain. The latter finding is reflected in management guidelines for spinal pain throughout the world."[51 p.184] Furthermore, there is research suggesting that patients are actually quite unfamiliar with words such as 'instability' and 'muscle weakness', leading to misunderstanding.[52] This includes believing that their problem is permanent, it will progress, and that their spine can 'go' at any time – so they must remain on edge, expecting the worst and unable to relax.[52] As highlighted above, these beliefs may unconsciously produce more lumbar spine compression, fear-avoidance, and reduced range of motion. Once again, this demonstrates the importance of exploring the context of exercise prescription and considering the complex interplay between biological, psychological, and social factors.

Common contextual factors

If there are similar effect sizes and long-term outcomes for a large variety of exercise programs, this leads us to consider the context of exercise prescription. The context of exercise prescription may produce positive or negative effects, in addition to any specific exercise-derived musculoskeletal effects. A similar inquiry applied to psychotherapy interventions led to what is now understood as common contextual factors that are therapeutically valuable, possibly producing even more potent effects than those derived from specific intended interventions.[53,54] Common contextual factors are clearly not limited to just psychotherapy; they are also present in the clinical encounters that chiropractors[55] and physiotherapists[56] create with their patients – they are just not commonly appreciated or discussed.

Placebo and nocebo effects

While exercise behavior change is ultimately the responsibility of the patient, clinicians can have a significant impact because "...with every utterance, the practitioner has the power to make things better or worse, and influence the outcome." [57 p.3] The concept of common contextual factors overlap with placebo and nocebo effects. As clinicians work with patients, the context that is created can have a positive impact beyond the specific efficacy of the treatment intervention or natural fluctuations in pain and function.[58] This is commonly known also as the placebo effect. In contrast, clinicians can also promote a negative context and poor outcomes; the lesser-discussed nocebo effect.[59,60]

Historically, the term placebo has carried negative connotations, viewed as something inert, non-specific, or fake.[58] More recently, placebo is not being viewed just as a sugar pill or an inactive 'sham' treatment, instead clinicians are being encouraged to embrace the contextual elements of treatment that can produce positive effects.[54,58,61] Indeed, Miller and Kaptchuck have suggested that the term placebo effect should be abandoned, promoting a non-stigmatized term such as 'contextual healing'.[58] Häuser and colleagues recently published a concise and all-encompassing description of placebo and nocebo effects, stating that they can be viewed as: "...psychobiological phenomena that arise from the therapeutic context in its entirety (sham treatments, the patients' treatment expectations and previous experience, verbal and non-verbal communications by the person administering the treatment, and the interaction between that person and the patient)." [62 p.465]

While harnessing placebo effects or 'contextual heal-

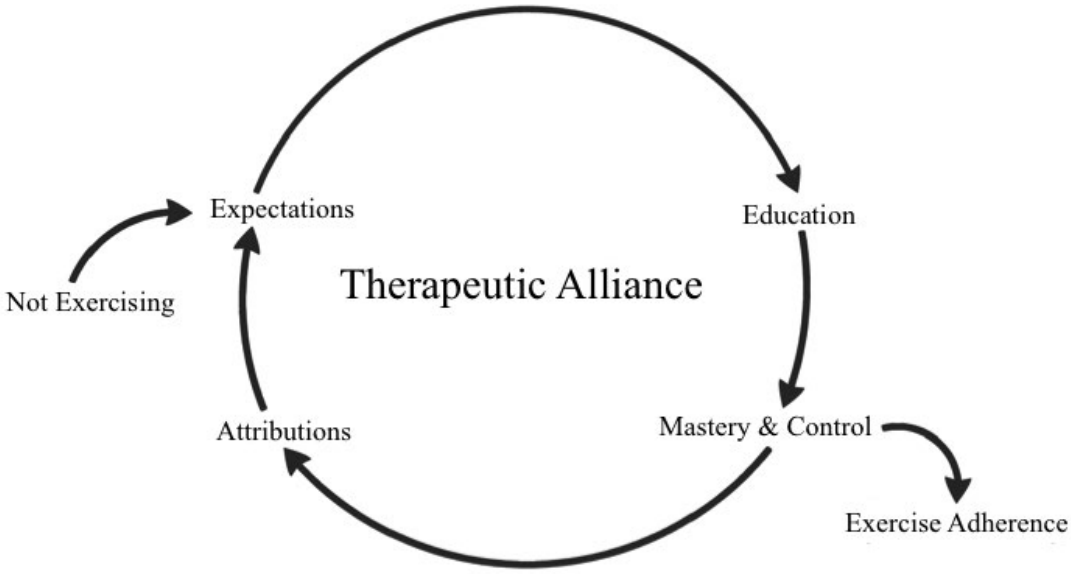

Figure 1.
Common contextual factor interplay. The Therapeutic Alliance is presented as a key contextual factor, providing the foundation for the others. Each of the five contextual factors presented (1. Therapeutic Alliance. 2. Education. 3. Expectations. 4. Attributions. 5. Mastery & Control) overlap and influence the others, potentially producing positive (placebo) or negative (nocebo) effects. Embedded within each contextual factor is the opportunity to facilitate positive beliefs and behavior change - working towards improved exercise adherence and patient outcomes.

ing' is a worthy endeavor, avoiding nocebo effects may be just as, or even more important, because the magnitude of nocebo effects in pain can be large.[63] Furthermore, the power of negative communication and nocebo in health care consultations has been suggested to be stronger than positive communication and placebo.[64] Studying placebo and nocebo effects in health care is complex, as there are many contextual factors linked to these effects. Furthermore, some patients and conditions may be more susceptible to placebo and nocebo than others.[60, 65, 66] By exploring common exercise prescription contextual factors and their possible effects, a clinician can see beyond the spine for the positive or negative impacts of their interactions and interventions.

Exploring common contextual factors

We argue that the following contextual factors can significantly impact prescribed exercise adherence and outcomes: 1. The therapeutic alliance (relationship between the clinician and the patient), 2. Patient education, 3. Expectations (of therapeutic success or failure), 4. Attributions (of therapeutic success or failure), and 5. Providing an experience of mastery or cognitive control over a problem.[54]

1. The therapeutic alliance

The therapeutic alliance has been defined as "a trusting connection and rapport established between therapist and client through collaboration, communication, therapist empathy and mutual understanding and respect".[67 p.44] Furthermore, the therapeutic alliance is based on: collaborative goal setting, agreeing upon interventions, assigning tasks linked to goals, and bonding as rapport and trust are established.[68] Specific to chiropractic, the therapeutic alliance is known to be forged in an environment of emotional support, which fosters the growth of the belief that the problem (i.e., CLBP) is manageable[69] promoting the placebo effect[55]. As noted in Figure 1, we

are suggesting that the therapeutic alliance provides the central foundation for patients to receive the benefits from other contextual factors and their placebo effects, further improving health-related outcomes and exercise adherence. Research is starting to support this as positive effects on pain and disability have been found when the therapeutic alliance is enhanced during the delivery of LBP interventions.[70-73] In contrast, the therapeutic alliance can be weakened by clinician behaviors such as discrediting and blaming a patient, or being non-supportive.[64] We hypothesize that this may stimulate potent nocebo effects, and have a negative impact on self-efficacy, exercise adherence, and patient outcomes.

2. Education

Not all education and exercise prescription are equal, as during their delivery there is potential for both placebo and nocebo effects. The following quotations from a qualitative study by Slade and colleagues[74 p.563] highlight how, in the absence of an easy explanation for CLBP, clinicians may resort to blaming past practitioners and the patient:

> "*You've got to sell it, show them what they do wrong, and that's the hardest thing*" and "*It's because you're doing everything wrong, you'll continue to get your back pain*".[74 p.563]

Yet, they deliver their own questionable and potentially fear-inducing persistent LBP explanations and exercise advice:

> "*I generally talk about instability... you've got instability at this level and your movement pattern aggravates and it's because you're moving through one area too much*" and "*We see bad movement patterns... it's all about correcting movement patterns*".[74 p.563]

This type of blaming may not only cause patient confusion, the language delivered to certain patients may elicit nocebo effects and reinforce the fear that they are failing to get better because they are incompetent and that they have something seriously wrong with their back. Instead, explaining persistent pain using modern neuroscience approaches may not only open the door to exercise prescription, it may also improve exercise adherence and patient outcomes.[75] Pain neuroscience education resources such as Explain Pain[76] or Therapeutic Neuroscience Education[77] are becoming popular as they can help demystify and unravel the complex and sometimes unpredictable nature of CLBP. These resources provide illustrations and explanations about the neurophysiology of pain and can be used to help patients change their understanding and beliefs about the pain that they are experiencing.[78] In essence, education and learning about pain can reduce uncertainty and perceived threat, which can reduce pain.[76] We believe that patients with CLBP can then begin to view their backs as sensitized rather than fragile and prone to injury or damage. While research examining pain science education is relatively new, evidence is rapidly building that supports its use with patients experiencing CLBP.[79-84]

3. Expectations of therapeutic success or failure

There is a large body of literature that demonstrates the strong positive relationship between beliefs and outcomes [for review see Maddux][85] – that is, if a patient expects they will have a positive result from a treatment, there is a strong likelihood that they will experience a positive result from that treatment[86-89]. There is also evidence that expectations can be modified to produce better intervention outcomes through placebo effects.[71,90,91] But we must also consider potential nocebo effects on patients. Individuals in stressful positions are vulnerable to nocebo effects[60] and living with CLBP is distressing, accompanied by a sense of loss, lowered self-worth, and fear of the future[92]. Unfortunately, as previously discussed, clinicians may create or facilitate negative expectations through poor communication or inappropriate language, which can then lead to poorer patient outcomes.[59] It is also possible that messages from the media, family, and friends could facilitate negative expectations about the back and exercise, impacting exercise adherence and health-related outcomes. When clinicians explain pain and the purpose of an exercise, "... it may be healthier to err on the side of optimism...".[60 p.610] This is especially true with the non-specific LBP population where there is no significant underlying pathology, yet patient fear-avoidance beliefs can be high – already negatively affecting outcomes.[93] Once again, we argue that evidence-based pain neuroscience education should be used to promote positive expectations while avoiding nocebo effects (e.g., pain does not equal damage, the back is inherently strong, and the spine/nervous system is adaptable).

4. Attributions of therapeutic success or failure

Attributions are an individual's explanation or understanding of why things have occurred the way they did – it is a way of making sense of past experiences.[54] Attributions help us to create a useful understanding of the world, as far as we can predict or control events.[94] When an intervention is judged as a success or failure in the past, it shapes expectations of success/failure for similar interventions in the future.[85] Another important impact of attribution is on the strength or stability of treatment outcomes. If a patient believes that their improvement was due to what a clinician did, then any beneficial effect is significantly shorter than if a patient believes that they improved because of their own actions.[54] Furthermore, people act on their beliefs,[95] if a patient attributes their back pain to the fact that their spine is unstable or weak, and they are educated on how they are failing to do an exercise properly, it should not be a surprise that they would expect to get worse if they engaged in exercise or load their spine. This type of unintended nocebo effect created by clinicians is clearly demonstrated in the following quote from a study by Darlow and colleagues:[47 p.532]

> "*Basically all I've kind of been told to do by physios is to work on my core...I've been tested by various different physios, and Pilates, and* ***I'm apparently ridiculously weak*** *.... I had an abortion because I didn't think I could have a baby. I didn't think I could handle it...carrying it, and having extra weight on my stomach*."[47 p.532] (**Bolding** added for emphasis).

This last quote may be an extreme example of how education can shape attributions and expectations, and how these beliefs can shape behaviors. Still, as highlighted above, the increased use of individualized approaches that facilitate positive beliefs about the back and empower patients with CLBP is clearly needed.

5. Mastery or cognitive control over a problem

Mastery is defined as "control over those circumstances that importantly bear on the life of the individual".[96 p.164] In the context of musculoskeletal rehabilitation, both cognitive and physical control is needed to achieve mastery - which often requires deliberate practice with performance feedback.[97-100] Emerging neuroscience research suggests that positive neuroplastic changes appear to be enhanced by slowly increasing the complexity of motor skill tasks, promoting cognitive effort and learning.[101] This process is thought of as 'working through' the new behavior while paying attention to thoughts and responses to the movement.[54] With practice, patients can learn and believe that they are capable of consistently overcoming their challenging movement tasks, which can increase their self-efficacy and result in mastery.[95] These ideas are supported by findings in a recent synthesis of systematic reviews that identified self-efficacy as one of the most consistent predictors of exercise participation.[102] Furthermore, a reciprocal relationship between improved exercise adherence and self-efficacy has been demonstrated. Simply put: participation in exercise tends to increase exercise self-efficacy, which in turn reinforces exercise behavior and continued exercise participation.[103] Positive beliefs are a key feature in self-efficacy and mastery, but they can also modulate the placebo effect.[104] This suggests that if an exercise is expected by a patient to reduce pain and improve function, the patient is not only more likely to do it, they are also more likely to derive benefit from it. In contrast, the potential for nocebo effects through conditioning and expectation should also be considered. If a patient repeatedly fails when attempting their meaningful movement task(s) and the clinician provides poor education and negative comments, such as telling them how they move wrong, their spine is unstable, or how a passive 'fix' is the key to success – the end result can be something like learned helplessness.[105] This occurs when a patient feels that they do not have control over their situation and their pain, and that they only make things worse when they try to help themselves, so they give up.

We believe that once the patients' self-identified movement goals are achieved, they should be encouraged to engage in regular exercise that they expect will help and that they personally enjoy. Here, patient preferences should be key considerations when prescribing exercise. When a patient can select the exercise they enjoy and/or expect will help, the beneficial effects of the exercise may not only be potentiated through expectations/placebo effects[104], but also through improved practice/adherence, leading to improved self-efficacy and mastery[106]. Research supports this idea, as it has been found that incorporating patient preference and tailoring treatment programs to patients

is associated with improved self-management adherence and health-related outcomes.[107,108]

The complex positive feedback loop in Figure 1 can now be better appreciated; a strong therapeutic alliance with effective education can promote placebo effects, while avoiding nocebo effects. We argue that positive changes in attribution and expectations can then result in exercise engagement, which can feed forward into increased exercise self-efficacy and mastery.

Conclusion

Evidence keeps building about the multi-system benefits of exercise[109]; this includes therapeutic exercise for CLBP. As suggested throughout this commentary, a focus on gross biological changes alone (muscle strength, endurance etc.) has limited value. Instead, more research is needed to examine the interplay between biological, psychological, and social factors - as this may have novel exercise prescription implications for patients with CLBP. This commentary provided an overview of some of the contextual factors that have biopsychosocial implications. It was described how these contextual factors can facilitate placebo or nocebo effects, impacting patients' behaviors and outcomes. The therapeutic alliance was presented as an important foundation, impacting patient education, expectations and attributions of therapeutic success or failure, and the patient's sense of mastery or control. Current evidence suggests that a strong therapeutic alliance, pain neuroscience education, and incorporating the functional needs and preferences of the patient can positively impact patients' beliefs and behaviors. Overall, this commentary suggests that to improve exercise adherence and health-related outcomes in the CLBP population, the context in which exercise is delivered and the meaning patients embody need to be carefully considered and shaped by clinicians. More research is needed to further define and measure the active components within the common contextual factors presented in this commentary, as well as others factors shaping patients' exercise beliefs and behaviors.

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The physical and psychological impact of neurogenic claudication: the patients' perspectives

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Background: *The patient perspective regarding the impact of neurogenic claudication (NC) has not been well studied. The objectives of this study were to determine what is most bothersome among patients with NC and how it impacts their lives and expectations with surgical and non-surgical treatment.*

Methods: *Semi-structured telephone interviews were*

Contexte : *Le point de vue du patient concernant l'effet de la claudication neurogène (CN) n'a pas fait l'objet d'études poussées. Les objectifs de cette étude étaient de déterminer ce qui gêne le plus les patients atteints de CN, ainsi que les répercussions sur leur vie et leurs attentes vis-à-vis des traitements chirurgicaux et non chirurgicaux.*

Méthodologie : *Entrevues téléphoniques semi-*

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conducted, audio recorded and transcribed verbatim. A thematic analysis categorized key findings based on relative importance and impact on participants.

Results: *Twenty-eight individuals participated in this study. Participants were most bothered by the pain of NC, which dramatically impacted their lives. Inability to walk was the dominant functional limitation and this impacted the ability to engage in recreational and social activities. The most surprising finding was how frequently participants reported significant emotional effects of NC.*

Conclusions: *From a patients' perspective NC has a significant multidimensional effects with pain, limited walking ability and emotional effects being most impactful to their lives.*

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KEY WORDS: chiropractic, spinal stenosis, neurogenic claudication, outcome measurement, qualitative research

structurées avec enregistrement audio et transcription textuelle. Une analyse thématique a permis de catégoriser les principales conclusions selon l'importance relative et les répercussions sur les participants.

Résultats : *Vingt-huit personnes ont participé à l'étude. Les participants étaient surtout gênés par la douleur de la CN, qui a d'énormes répercussions sur leur vie. L'incapacité à marcher constituait la limitation fonctionnelle dominante qui avait des conséquences sur la capacité à réaliser des activités récréatives et sociales. La conclusion la plus surprenante était la fréquence à laquelle les participants ont déclaré d'importantes séquelles émotionnelles associées à la CN.*

Conclusions : *Du point de vue des patients, la CN présente d'importants effets multidimensionnels avec la douleur, la capacité de locomotion limitée et les séquelles émotionnelles comme répercussions les plus considérables sur la vie des patients.*

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MOTS CLÉS : chiropratique, sténose rachidienne, claudication neurogène, mesure des résultats, recherche qualitative

Introduction

Neurogenic claudication (NC) is the clinical syndrome associated with symptomatic lumbar spinal stenosis (LSS). It is characterized by bilateral or unilateral buttock, thigh or calf discomfort, pain, numbness or weakness precipitated by walking or prolonged standing and relieved by sitting and lumbar flexion.[1,2] Low back pain may or may not be present in individuals with NC. The pathophysiology is thought to be compression and/or ischemia of the lumbosacral nerve roots due to narrowing of the lateral and central vertebral canals, usually as a consequence of degenerative osteoarthritic changes in the lumbar spine.[1,3] Neurogenic claudication due to LSS is one of the most common causes of disability and loss of independence in older adults[4] and the most common reason for spine surgery in this population[5].

New cases of NC due to LSS are expected to rise dramatically over the next 20 years when an estimated 25% of the population in both the U.S. and Canada will be over the age of 65.[6] Studies evaluating the effectiveness of both operative and non-operative treatments for NC have used a wide variety of primary and secondary outcome measures.[7-10] These outcome measures assess various constructs including bodily pain, bodily function, low back pain disability, back and leg pain, other leg symptoms, walking capacity (distance and time), walking performance, global improvement, quality of life, ranges of motion, treatment satisfaction and medication use.

In most studies the outcome measures used are reflective of the bias of the investigator(s) and is often inferred as the desired outcome of the patient. However, rarely has the perspective of the patient regarding the most important outcome been considered. For example, limitation in walking is felt to be the hallmark of NC and is used as a

primary outcome measure in clinical trials.[7,11,12,28] However, previous systematic reviews by this group[7,11,12] have demonstrated that many interventions for NC did not significantly improve walking performance or capacity. Despite this, several interventions were still associated with good patient satisfaction and/or pain relief.

Given the burden of NC, a lack of understanding of what outcomes are most important to those afflicted with NC represents a significant gap in both clinical and academic knowledge. Clinicians need to know what is most important to a patient in order to recommend effective intervention(s) that address the patient's concerns. Researchers need to know what to measure in order to assess the most relevant patient outcome for a given intervention. Moreover, to make valid comparisons across studies and enable the pooling of data, a standardized set of outcome measures unique to this population and most relevant to patients is essential. In addition, there may be other constructs beyond those currently measured that may help to explain how this condition impacts people in different ways, and how these other factors can affect the patients experience and outcomes of NC.

The objectives of this study were to determine what outcomes matter most among individuals with NC due to LSS and to assess patients' expectations and their experiences with surgical and non-surgical treatment.

Methods

Participant population and setting

We recruited a purposeful sample[13] of participants from two university-affiliated hospital surgical and non-surgical spine clinics both located in Toronto, Canada. To be eligible to participate, patients had to experience NC with axial imaging-confirmed LSS, and be able to communicate in English. To gain maximum variation of patient perspectives regarding their condition and success with treatment an attempt was made to select participants along the continuum of care. Specifically, we recruited participants scheduled for non-surgical (early, less severe symptoms) or surgical care (late, more severe symptoms), as well as those who had received surgical and non-surgical treatment. We included individuals of varying ages (50-90 years), gender, intensity and type of symptoms, as well as duration of symptoms (months to years).

All participants provided written informed consent. Research Ethics Board (REB) approval was received from the Mount Sinai Hospital REB Registration Number 13-0184-E and University Health Network REB Registration Number 13-6914-BE, as well as the Institutional Review Board (IRB) at the University of Pittsburgh (PRO13090531).

Semi-structured interviews

Research assistants, trained by a qualitative research expert (SZ), conducted semi-structured telephone interviews lasting between 40 and 60 minutes. Interviews were audio recorded, and transcribed verbatim. Interviewers followed a standardized set of open-ended questions asking participants about their condition, focusing on what bothered them most and expectations regarding treatment. Figure 1 outlines a sample list of open-ended questions that were used.

Quantitative measures questionnaire

A questionnaire was administered by telephone directly following the completion of the semi-structured inter-

1. What things bother you most about your lumbar stenosis (condition)? Degree of pain in your back or legs? Functional ability? Walking ability (distance), independence? Getting up from chair? Posture? Balance? Falls? Medication used? Overall health?
2. If you had to pick one important thing that bothers you most what would that be? How has your condition changed over time? What would be the least thing that bothers you about your lumbar stenosis?
3. What aspects of your condition would you like your treatment to address?
4. What type of treatment did your specialist recommend? What treatments have you received? How effective have the treatments been?
5. How would you measure the success of your treatment?
6. What would you consider the smallest improvement that would be worthwhile following your treatment... for each of the important outcomes you mentioned?
7. How much do you expect that things that bother you the most will change with your treatment?

Figure 1.
Sample questions for the semi-structured interviews.

view. The aim of the questionnaire was to characterize the participant sample with respect to demographics, duration of symptoms, pain intensity and functional status and to compare surgical and non-surgical participants. Box 1 below lists the measures included in the questionnaire.

Analysis

Descriptive statistics were used to analyze the questionnaires. We compared pain, function and symptom outcomes among and between participants recruited from surgical and non-surgical clinics.

For the semi-structured interviews the frequency and types of responses were determined using the Crabtree and Miller "editing" approach to qualitative data.[18] Coding categories were developed through an open, iterative process that involved reading the interviews with a focus that included physical and emotional effects of NC. From this process, a master code list of categories was developed. These codes were refined with inclusion and exclusion criteria, and then applied to the transcribed interviews. Two analysts [KW and MH], the qualitative expert [SZ], and the study team discussed the coding categories (e.g. coping) and worked to integrate the codes into the larger analysis.

Primary coding was completed on all transcripts, and secondary coding was completed on 25% of the transcripts. Cohen's Kappa statistics[19] were then calculated

Box 1.
Quantitative questionnaire measures

Socio-demographic characteristics
Dominant pain location (back or leg)
Duration of symptoms
Numerical rating scale for back pain with and without activity[14]
Numerical rating scale for leg pain with and without activity[14]
Zurich Claudication Questionnaire[15]
Oswestry Disability index[16]
Modified Patient Centered Outcome Questionnaire[17]

Table 1.
Characteristics of study participants

Characteristics	Summary (N= 28) n= count (%) unless otherwise specified
Age Range (y)	
50-59	1 (3.6)
60-69	13 (46.4)
70-79	10 (35.7)
80-89	3 (10.7)
90-99	1 (3.6)
Female	15 (53.6)
Married or living with other	16 (67.9)
**Education (N=27)*	
≤ Grade 8	1 (3.7)
> Grade 8 but did not graduate from high school	1 (3.7)
High school graduate	3 (11.1)
Post-Secondary school	10 (37.0)
Technical graduate	1 (3.7)
University graduate	11 (40.7)
**Employment*	
Full Time	4 (14.3)
Part-time	2 (7.1)
Retired	20 (67.9)
Disability Leave	2 (7.1)
Other	1 (3.6)
Dominant Pain	
Legs	16 (57.1)
Back,	3 (10.7)
Back & Legs	9 (32.1)
Duration of symptoms impacting standing/walking (years)	
0-1	4 (14.3)
1-	11 (39.3)
5+	13 (46.4)
Usual Mean Numeric Pain Score (SD) (N=26)	5.1 (2. 9)
Walking duration before symptoms (minutes)	
0-5	6 (22.2)
5-10	6 (22.2)
10-30	9 (33.4)
30-60	4 (14.8)
60+	2 (7.4)
Spinal Stenosis Score (symptoms) (sd)	2.8 (0.7)
Spinal Stenosis Score (function) (sd)	2.1 (0.7)
Oswestry Disability Index (sd)	40.2 (16.8)
Oswestry Disability Index Walk Score (range 0-5) (sd)	2.9 (1.8)
Source of Participants (N=27)	
Non-surgical clinic: receiving treatment	5 (18.5)
Non-surgical clinic: completed treatment	10 (37.0)
Surgical clinic – had surgery	7 (25.9)
Surgical clinic – scheduled for surgery	2 (7.4)
Surgical clinic – not scheduled for surgery	3 (11)

Legend:
SD= standard deviation. Variable number of responses due to missing data
*characteristics with categories that are not mutually exclusive

Table 2.
Comparison of non-surgical and surgical clinic participants

Mean (SD)	Mean Usual overall NPS (0-10)	Mean SSS Symptoms (1-5)	Mean SSS Function (1-4)	Mean ODI (0-100)	Mean ODI Walk (1-5)	Mean Usual Interference with activity (0-10)	Duration of symptoms impacting walk/stand Years n, %
Non-surgical clinic n=16	5.2 (2.8)	2.9 (0.6)	2.0 (0.7)	37.6 (14.8)	2.8 (1.8)	4.6 (4.1)	0-1 2, 12.5% 1-5 8, 50.0% 5+ 6, 37.5%
Surgical clinic n=12	4.9 (3.1)	2.7 (0.8)	2.3 (0.8)	43.7 (19.3)	3.0 (2.0)	5.1 (3.9)	0-1 2, 16.7% 1-5 3, 25.0% 5+ 7, 58.3%
All participants n= 28	26	28	28	28	28	26	28
p-value (from T-test or Chi-square)	0.82	0.33	0.25	0.36	0.79	0.78	0.40

Legend:
NPS= numeric pain scale (higher score worse pain), SSS= Spinal Stenosis Score (higher score worst symptoms/function), ODI– Oswestry Disability Index (higher score worst disability/walk ability), SD= Standard Deviation

on each code to determine inter-coder reliability. A mean Kappa score of 0.71 was obtained, indicating substantial agreement.[19] Discrepancies in coding between the analysts were resolved via discussion and then recorded in a final dataset for use in the analysis. Coded passages were then examined to better understand patients' views and perspectives. The software program *Atlas.ti* (Scientific Software, Berlin, Germany) was used to assist in data organization and management. Quotations were chosen based on representativeness and their capacity to convey common participant views and themes.

Results

Participant characteristics

A total of 28 participants agreed to participate in a phone interview and complete a questionnaire. Table 1 describes the characteristics of the participants. Sixteen were recruited from a non-surgical clinic and 12 from a surgical clinic. The majority of participants (82%) were between 60 and 79 years of age, 54% were female, 68% were retired and over 80% received post-secondary education. Most participants reported that their dominant symptoms involved chiefly the leg(s) (57%) or their back and leg(s) equally (32%). Almost half of the participants had symptoms for more than five years and over 75% experienced symptoms within 30 minutes of commencing walking. Participants from the surgical clinic appeared to have greater functional limitations and longer duration of symptoms compared to participants from the non-surgical clinic (see Table 2).

Major themes from interviews: Participants' experiences with LSS (see Quotes Table 3)

1. Physical effects:

The most commonly reported symptoms were pain and discomfort; mentioned by each of the 28 participants. The location of the pain varied but included lower back pain and leg pain. Other reported discomforts included: tingling, leg and knee failure (i.e. sudden inability to stand, sit or walk, including falling), burning, a sensation of something crawling just under the skin (i.e. paresthesia), and a sensation of fullness or heaviness in the legs (Table 3: Theme 1 Quotes A.1-3). Problems with fatigue centred on the legs or other body parts tiring quickly such that walking for long distances or, in the case of a school teacher, standing at work all day became impossible (Table 3: 1 A.4-5).

While a few participants did not describe their pain from stenosis as particularly intense, most regarded their pain as debilitating. One described it as "pure hell." For some participants the pain had always been intense, whereas for

Table 3.
Example quotes from participant interviews

Theme	Example Quotes from Participant Interviews
1. Physical Effects	A. Symptoms of Pain, Discomfort: 1. "It's the pain in my leg and also there is times that when I have to go to the washroom; excuse me; that I have to sit. It's my knees; like sometimes I can hardly sit down on the toilet and sometimes it's hard for me to get up. Let's say, if I sit down on the chair, I'm fine, but then when I have to stand up, I cannot stand up or when I start walking, it's hard to walk. When I feel better it's when I'm lying down or sitting down, but then when I'm sitting down and then stand up and starting walking that's the worse part." 2. "A burning feeling say from the top of the leg to the knee. A feeling that there was something crawling, as if they were bugs just underneath the surface of the skin crawling up and down and you know, it was pretty disconcerting." 3. "Like I said it started in 2010 and I had often a lot of back pain, lower back pain. It went down into my left leg, but it was also accompanied by numbness in both legs, so severe at times that I would lose the feeling in both my legs and I would fall and go down." 4. "Not being able to walk as far as I would like to without having to stop and experience the tingling in the front of my leg and the numbness in my foot and the pain associated with it." 5. "When I first started the clinic here, I could not walk for than a minute and a half and I had to stop. My legs would swell. My feet would hurt that the sciatic nerve in my back would almost pull me down that it would cripple me. Even to walk, I work at [Name of Location] and to walk here I got to stop 6 or 7 times and this is me, I'm use... to running that distance." 6. "It started I suspect 5 years ago, as a minor back pain. One usually would think it is just a strain, but over the years it has gradually progressed to the point where now it is very debilitating." 7. "Now I've had that for very many years, but it's always been bearable. The stenosis has really affected my daily life and it makes me sad at times, such I have to contend with it. At the same time, I must honestly admit that I am grateful for the health I've had. I realized that I have been very lucky. So, I can't have it always, but at the same time its human nature to resent it that I get such pain all the time."
2. Activity Effects	A. Limitations on Walking/Standing/Sitting: 1. So I really, I can walk may be 4 or 5 minutes. It's really tough on my lifestyle. I used to love to walk. Me and my wife used to walk for miles... and now I cannot walk a block." 2. "Like I say everything depends on my legs because I walk and I'm one of them simple people; I don't do anything. I don't travel. I have no interest in that." 3. "Well it affected my ability to get around and walk... It affected my exercising, which is walking. I do quite a bit of walking for exercising and I just love to walk. I get out and I walk all over the place... Now, I go around in the car... I take the dog. Instead of walking about three blocks to take my dog out to run, I take the car there to let her run." B. Limitations on Recreational Activities: 1. "Usually each weekend in the summer I'm outside... in the canoe or with backpack you know, but now I am sitting at home." 2. "When it first started what it did curve is my physical activities such as curling and walking long distances and so on, and eventually it curved all activities that even stairs were very difficult to manage." 3. "...we were in a wedding and I was dancing. It was a slow dance and it seemed that my legs were giving up on me. I was shocked and I didn't know what was happening. I had to go and sit down." 4. "Because I wasn't able to, say, walk any distance, so that pretty well inhibited, so you were sort of left with sedentary hobbies like reading and crocheting that sort of thing because you've found that you've gravitated towards that than avoiding the physical."

Theme	Example Quotes from Participant Interviews
2. Activity Effects (continued)	C. Limitations on Social and Household/Daily Activities: 1. "It changed my lifestyle because you know, as I said before I was very cheerful. I like friends. I like being among people. I am [a] social person. I'm a socializing person and all this pain and weakness, like, it stopped me from being among people." 2. "One of the major and also major things that really bothered me a lot; my granddaughter had a child, two and half years ago and also I'm crazy about babies. I found that profoundly sad that I couldn't hold the baby. I cannot even lift him of course...I cannot lift him." 3. "Well, it affected me to the point where I couldn't go walking with my wife for more than a block and a half and standing around talking or when we go to parties, I would stand talking then I would have to sit down because I just couldn't stand up anymore after a while. " 4. "Well, I love to garden. I kind of filled in my flower beds with rocks because that's just another thing I can't do." 5. "I couldn't do my usual home activities like cooking. I depended on my husband to assist me with the cooking and housework and things like that." 6. "Eventually it got to the point where I couldn't even rinse off three cups, three bowls, and put them into the dishwasher. I couldn't stand up long enough with that pain." 7. "Or go shopping, I used to go by myself for the shopping and now I got to go with my husband or my son because I realized that I cannot take shopping bags or heavy things. I used to do my grocery shopping and now I got to go with my husband. Why? Because I cannot lift anything." 8. "I think on a daily basis is that I cannot shower, dry my hair, and put on my makeup without sitting down and that kind of happened in the last few months. I have to take a break, you know sit down for 5 or 10 minutes. We put a stool in the bathroom, so that I can sit and do my makeup and stuff like that."
3. Emotional Effects	A. Depression/Social Isolation: 1. "Really, it's a miserable life, miserable. I don't wish this to no one... The worst thing is... how people see you in the outside; your face, they think you're not sick; you're not suffering, but inside you are suffering. I have a life, but it's not life because you cannot do what you want to do... I was a very active woman and which right now I feel inside of me, I feel 90 years old. I feel terrible, like inside because I want to do things with eyes and with my mind, but then when I start doing things it stops me from doing them." 2. "My life is not the best, you know. Sometimes if I want to go out or let's say go to parties or if I am invited to parties, sometimes I avoid it. I don't feel like do nothing. I rather stay home and do whatever I can." 3. "I can't take part in my church activities in the same way that I did. I tend to give money instead of labour and I know you have to give what you can, but that's all I can give, but it grieves me. I rather be in there with all the other women doing things. It upsets me very much." 4. "Well, I have hard times walking and I feel a little out of place when I can't go that fast anymore. I have to stop or I have to sit down or I have to do something like that. It sort of puts me in a different area than the friends that I'm with who can do all this stuff." B. Anxiety: 1. "Well, I guess there is an underlying stress all the time that you know, I'm waiting for an operation and it may not be and it's probably not going to be 100% successful, so it is a gradual accommodation to the fact that this is who I am now." 2. "Well, it's yes, but not that fine. Before it was the walking, I felt like I was going to be kind of paraplegic that I wouldn't be able to do things myself and I would have to sit in one of those electronic chair things." C. Frustration: 1. "The first time I had it I thought it was a condition that I was fighting that I would get rid of it, which I did and it would go away, but it has been there all the time. The lack of information I had at that time was, I would get free of this, but eventually I knew that I got this for life. This is something you inherit for life. It is threatening and it is very debilitating." 2. "You had to this, this and this and I thought quite naively that if I did the regimen while I was taking physiotherapy then when we were finish we were finish and that was good... I would be cured. I <u>did not realize</u> that this was an ongoing thing that just got worse when I stopped doing it."

Theme	Example Quotes from Participant Interviews
3. Emotional Effects (continued)	D. Hurt Pride 1. "It affects in so many ways, it's the whole quality of life, the whole thing. Your wife is dependent on you, your kids and grandkids are dependent on you for doing these things. Now all of a sudden this person who used to run with me and play with me and can't even walk down the end of the street with me and it takes a lot of your pride, well at least me it takes a lot of my pride. Even to think of someone having to take care of me, to me it's just unacceptable." 2. "I walk kind of awkwardly. I cannot wear heel shoes either, but that really does not bother me that much. All my days of heel shoes are really behind me, so that would be in anyway an older woman wouldn't be wearing fancy shoe anymore. I am the same as the other old ladies. You know it is awful giving up your autonomy and moving into a different phase. This is one of the reasons why I lie about my age all the time. People tend to put you in category of nature. If you are a certain age, you are just kind of put aside."
4. Coping Strategies	A. Coping Mechanisms for Physical Effects: 1. "I have to... generally stand a few seconds or so before my husband is ready, maybe while he is doing the cheque... I stand right there waiting for him because if I get up there is no way I can start walking again because of the pain in my thighs. The front of my thighs is screamingly painful. I just stand for a minute or two and get my act together... I do walk strangely to begin with when I've been sitting down." 2. "My condition, you know the pain in my legs increased. I get tingling in my legs, sometimes pain, but I learned not to take painkillers. I don't take nothing. When I get like this, I just lay down, I rest for a bit and after rest I feel a little bit better."
5. Treatment Effects	A. Partial Relief from treatments: 1. "It just involves may be 2 hours a day of specific exercise and walking and if you don't do it, you know you can't miss 2 days in a row because your symptoms all come back." 2. "...now having done the physiotherapy it's been a miracle. It is just wonderful. It's so much better. It will never go away, but at least I can do things that can help the pain and you know alleviate the different symptoms that occur." 3. "They helped, but it's not like they changed my life, either." B. Complete Relief from Treatments: 1. "I don't have this excruciating pain. I can walk up the stairs. I can run up the stairs. I can run down the stairs... since I had the surgery, this surgery, I have improved considerably and I am almost back to normal like a normal person."
6. Expectations from Treatment	A. Pain Relief/Decreased Pain 1. "I try to keep an open mind that the treatment will alleviate the pain. If that happens, so much the better, but I am not counting on it to eliminate the pain. I will continue with the process and do the exercises and just hope for the best, but I haven't set a high level of expectations that this is going to cure me." 2. "I would like to think in doing the treatment that the pain level will be not necessarily gone, but certainly tolerable and not be something that I thought would stop me from doing what I wanted to do." B. Pain Elimination 1. "Based on my own experience, I would expect it to eliminate the problem. It did the first time and I would assume that it would the second time." 2. "Well, I would say significantly. It wouldn't make much sense to have an operation if it was not going to have much effect on the pain [in reference to surgery]." C. Increased Physical Activity 1. "That I can walk better. Walk with more distance and that I can stand on my own feet and do at least my housework. Taking care of my family properly. Instead of being in pain, when I'm standing or walking I'm in pain, but pain goes away. To relieve me from pain and suffering." 2. "Run around with the grandkids a little bit maybe, you know, maybe be able to do some things and not feel like I have to stop because of the pain in my leg" 3. "...consciously plan my route when I wanted to do an activity that I wouldn't have to very, very specifically, what is it that I need to do to accomplish today and how am I going to do it and not have my back stop me from doing it" 4. "Just to be able to stand around more without the pain and be able to walk farther without stopping because of the pain in my leg."

others it had gradually increased to the point of causing debilitation (Table 3: 1 A.6). In addition to concerns about the severity of their pain, participants described the emotional impact of the wearing, grinding nature of having to endure ongoing pain, including feelings of resentment (Table 3: 1 A.7).

2. *Activity effects:*

Participants mentioned a wide range of activities that their NC interfered with including: walking, recreational activities (such as sports and exercise), standing, social activities, household activities, controlling comorbid health conditions, working, sleeping and lifting.

Each participant mentioned that their NC interfered with their ability to walk. Interference with walking was most frequently mentioned as the "most bothersome" aspect of the condition, identified as such by 17 of the 28 participants. For some participants this was a minor concern or one that had affected them profoundly in the past but with successful treatment was no longer an issue. For many however, the walking limitations caused major disruptions in their lives, from being unable to walk or run for exercise, to being unable to do basic social and daily activities such as grocery shopping, holiday shopping, going to the mall with family and friends, or even visiting neighbors (Table 3: 2 A.1-3). Related to walking, many participants described being unable to participate in recreational activities. Recreational activities mentioned included walking itself or hiking, various sports (football, cricket, soccer, golf, badminton, curling, snowshoeing, cross-country skiing, squash), travel (due to the walking that travel entails), dancing, bicycling, and aerobics (Table 3: 2 B. 1-3). Many participants described themselves as active, outdoorsy people who, as a result of their NC, had become sedentary and were unable to participate in what had been previously seasonal outdoor activities (Table 3: 2 B.4). Inability to participate in recreational activities was mentioned as the "most bothersome" aspect of having LSS by 11 of the 28 participants.

Interference with social activities was mentioned fairly often, and was linked to participants' difficulties with walking, standing, or doing recreational activities. Many described limiting time with family and friends, difficulties standing while socializing or being unable to play with grandchildren in the way that they wanted (Table 3: 2 C.1-3). Often the inability to stand or pain upon standing was linked with an inability to do household/daily activities, such as cleaning or other chores, in the way that the participants were used to doing. For many there was difficulty with transitioning between positions or activities, describing not being able to walk immediately after standing for example, or having extreme difficulty sitting and standing back up. This difficulty in transitioning made a wide range of activities difficult or impossible, from social events to using the toilet.

For some participants, the amount of pain experienced while standing meant that they could not wait in lines, go shopping without physical support such as a shopping cart or another person, clean their households, cook, or even stand in the bathroom to do their hair or makeup in the morning (Table 3: 2 C.4-8). This directly impacted individuals' sense of independence, and for some, eliminated activities that they had previously found enjoyable, such as cooking or gardening (Table 3: 2 C.4).

3. *Emotional effects:*

In addition to their physical symptoms, participants reported an array of emotional responses to their condition. Twenty-two of the 28 participants reported emotional impacts that were associated with their NC. The most frequent of these was depressed mood, although not always specified by name. Instead they described their feelings as sadness, loss of interest in activities, or hopelessness (Table 3: 3 A.1). These participants were likely to mention deep feelings of sadness, discouragement, social isolation or loss, as their NC prevented them from doing activities that they enjoyed (i.e., walking or other outdoor activities) or from which they derived meaning (i.e., work, volunteer work, being independent, socializing, lifting and holding grandchildren) (Table 3: 3 A.2-4). Additionally, for some of these participants, the perceived incurable/untreatable nature of NC was described as "depressing" in and of itself.

Eight of the participants mentioned anxiety, expressing deep worries that family members would have to take care of them, or that their condition would worsen significantly (Table 3: 3 B.1-2). Seven participants expressed feelings of frustration with their NC (Table 3: 3 C.1-2). For some, this was focused on the physical limitations imposed on them by NC, such as only being able to walk for short distances or the ongoing relationship between exercise and pain relief.

Lastly, six of the participants described NC as having hurt their pride. Most of these participants mentioned in

passing feeling embarrassed at having to rest frequently, or lamented the loss of complete independence (Table 3: 3 D.1). One participant had concerns about loss of independence that were so severe that he spoke favourably of assisted suicide. Similarly, another participant spoke of the embarrassment of dealing with NC in social situations, describing the limitations that always having to sit at parties imposed on her, and describing NC as having pushed her into an older, different phase of life (Table 3: 3 D.2).

4. Treatment effects, non-surgical:

Participants had experienced a wide array of treatments for their NC. The most common treatments were manual therapy and supervised exercise (rehab therapy), and pain medication (see Table 2). Of the two, rehab therapy was spoken of more favourably. Rehab therapy was described as significantly to relieving pain and increasing mobility. For some participants, it provided complete relief, although that relief was contingent upon continuing the therapy. Some participants noted that the frequency with which one had to do the therapeutic exercises was sometimes frustrating (Table 3: 5 A.1). For others, however, while rehab therapy did not provide complete relief, it reduced pain or discomfort in ways that were meaningful, such as allowing them to sleep at night, or increasing the distance they could walk at one time from under 100 metres to one kilometre. Others mentioned that rehab therapy could provide temporary relief, interspersed with some relapses (Table 3: 5 A.2). More participants found it efficacious than those who did not, and some found that it completely relieved their symptoms.

5. Treatment effects, surgical:

Seven participants had undergone surgery for their NC, four of whom directly praised the surgery as effective (Table 3: 5 B.1). Two participants found that their surgeries were initially successful but that over time, their symptoms were beginning to return. Another two participants found their surgeries to be helpful, but had them so recently that they weren't sure what level of function they would ultimately achieve in the longer term.

6. Expectations from treatments

When it came to the relief that participants expected from their treatment, the most frequently mentioned expectations were decreased/eliminated pain and increased physical abilities. Overall, the majority of participants (n=20/28) felt that treatment would have to improve (rather than simply maintain) their condition in order to be worthwhile.

(i) Pain relief.

Many participants expected and accepted that they would live with some level of chronic pain. Those who expected to live in pain frequently indicated that simply being in less pain would be adequate for them, and that any amount by which it could be lessened would be beneficial. They described themselves as going through life by just dealing with it (Table 3: 6 A.1). For example, one participant called her desire to be without pain "greedy," and described pain as her "partner in life." Two others indicated that if 10 were the worst pain possible, they would be willing to live at a constant two. Another participant indicated that a five out of 10 would be acceptable. These participants seemed aware and accepting of the fact that they would never be completely pain free (Table 3: 6 A.2)

Rarely, participants expected complete and total relief of their symptoms, and expressed a desire to have no pain whatsoever (Table 3: 6 B.1). It seemed that participants expected more in terms of absolute pain relief from surgery than they did from other interventions, such as rehab therapy, although relatively few participants spoke about this issue (Table 3: 6 B.2).

(ii) Physical abilities.

Relief from pain overwhelmingly appeared to be the single most important thing that could be done for these NC sufferers. However given that decreased pain should lead to increased physical ability, these two outcomes generally go hand-in-hand.

When participants spoke about increased mobility, they generally did not expect 100% recovery but rather would set an individual benchmark, which generally meant being able to do "more" than they currently could do. Benchmarks included: being able to walk a greater distance, being able to handle household chores alone, being able to transition from sitting to standing without pain, being able to perform activities like playing with grandchildren, or being able to "get out of vehicles" (Table 3: 6 C.1-3). Echoing the data discussed earlier about activities impacted by LSS, the most commonly mentioned activity in this area was walking: participants strongly want to be able to walk without pain (Table 3: 6 C.4).

Discussion

In this study we interviewed 28 individuals with NC due

to LSS with the goals of better understanding how this condition impacts their lives and what they expected from non-surgical and surgical treatments. This study uniquely confirms that from the perspectives of patients, NC has a multidimensional impact on individuals with pain, limited walking ability, and depressed mood arising as the most common and significant symptoms. Most participants had undergone multiple treatments for their NC, many of which they found to be ineffective. The most effective treatments were rehab therapy/exercise and surgery. Pain medication was also frequently used but participants generally indicated that they wanted to reduce or eliminate use of medications. Patients felt that treatment would have to improve (rather than simply maintain) their condition in order to be worthwhile. Finally, a consistent theme arose amongst participants suggesting that pain, physical abilities, emotional state, and their expectations of treatment are strongly inter-related and at times inseparable.

By far our participants were most bothered by the pain associated with NC. Described pain ranged from somewhat mild and well controlled to absolutely crippling and debilitating. For most participants, the pain from their NC had dramatically impacted their lives; the impact of which cannot be overstated. Beyond the experience of pain itself, participants regularly expressed the desire to re-engage in their regular day-to-day, recreational and social activities. The activity most frequently mentioned, and the source of the most frustration, was the inability to walk and/or stand. In a study using focus groups to assess important outcomes among 33 older patients receiving epidural injections for NC, Edward *et al*.[20] had similar findings. In their study the highest rated problem areas were "experiencing pain/discomfort" (88% of participants), "problems with physical function" (85%), "difficulty exercising" (73%), "difficulty participating in hobbies and leisure activities" (55%), and "problems with weakness" (52%)[20].

In a recent qualitative study by Lyle *et al*.[21] assessing 15 patients undergoing physiotherapy for NC, pain and the threat of pain was the most prominent feature leading to a loss of engagement in meaningful activities and sense of self. Similarly in our study the majority of patients perceived pain as the central cause of their other symptoms, with relief from pain overwhelmingly being the single most important thing that could be done for them. This finding was also prominent in the study by Lyle *et al*.[21], where most participants wished to get rid of the pain completely as they felt that was key to getting back to their normal activities. While others implied complete relief was unlikely and they would be happy if they could get relief of some of the pain. In our study participants hoped for their pain levels to decrease and walking to return to the levels that they were capable of prior to their symptoms arising. However, the majority of participants were willing to accept any achievable improvement over their current symptoms.

Perhaps the most surprising finding was how frequently participants reported various emotional effects that resulted from living with NC. The most common was an expression of depressed mood. In addition to depressed mood, participants mentioned experiencing anxiety (i.e., fear that it would become worse or that they would be debilitated), frustration and hurt pride (i.e., hurt pride at having to be taken care of or being viewed as disabled or unattractive) as a result of their NC. In the study by Lyle *et al*.[21], the authors noted fluctuating and unpredictable symptoms resulted in anxiety and uncertainty, however, they did not report depressed mood as a prevalent theme. Although we did not specifically ask about treatment for psychological illness in our interviews, it is worth noting that patients did not report receiving treatment for their mood alteration. The apparent emotional (psychosocial) impact of NC on patients suggests that these factors should be considered during assessment and management not unlike patients who suffer from chronic pain. Current diagnostic criteria for neurogenic claudication due to degenerative lumbar spinal stenosis do not include psychosocial factors[2,29].

Our findings strongly suggest that the emotional aspects of NC, particularly given the high prevalence of depressed mood, need to be considered and that treatment for depression and/or anxiety is possibly an unmet need in this population. Specifically, the emotional effects of NC may be important mediators of pain intensity, and/or related to limitations in walking and standing ability, and recreational activity. Emotional effects may also explain why there is a lack of correlation between decreased pain or disability scores and improved walking ability.[12] It is also possible that the emotional effects may explain why patients' symptoms and functional status are variable, as noted in the Lyle *et al*.[21] study and concurs with recent clinical trial data (Ammendolia *et al*. and Schneider *et al*.,

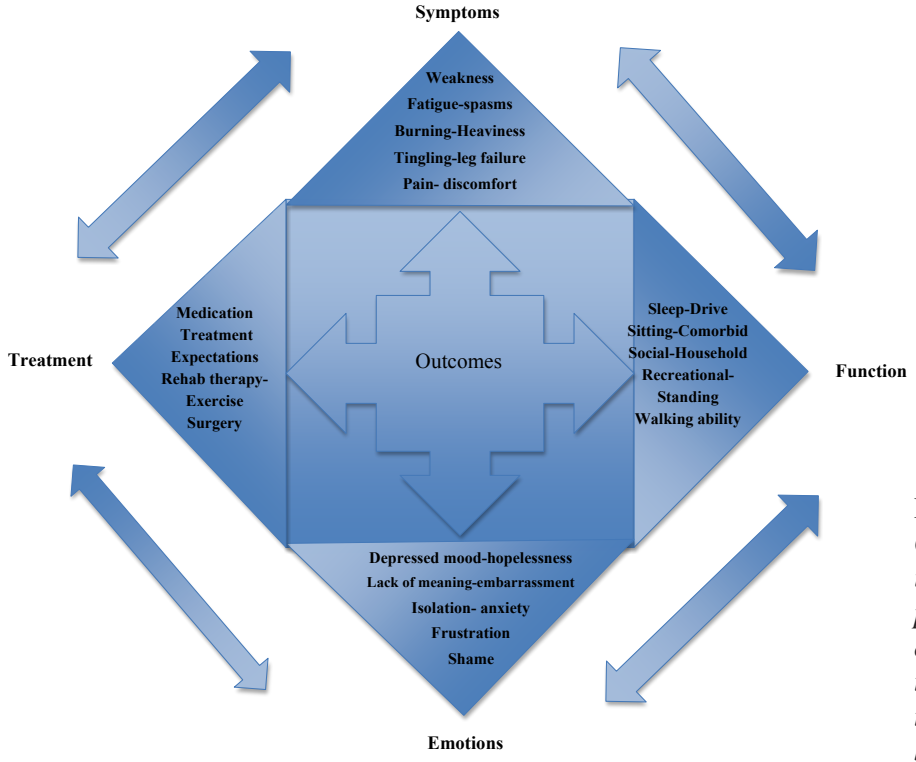

Figure 2.
Conceptual Model of potential interrelationships of factors impacting patient outcomes in neurogenic claudication. Items are ranked with the most important items being in the centre, and least important items being at the periphery.

unpublished data). These results are consistent with the literature on psychosocial impacts of NC. Studies have shown that high levels of depression and hopelessness may have a compounding effect on walking ability and recreational activity in individuals with NC, as well as surgical outcomes.[22] A systematic review of prognostic factors in NC showed that pre-operative depression is likely a prognostic factor for post-operative NC related symptom severity and disability. However, the prognostic value of depression on the outcome of pain and walking capacity was less clear.[22] Therefore, interventions directed at addressing psychosocial issues associated with NC might improve pain levels and functional activity through better coping mechanisms .[22,23]

For the most part participants' expectations for treatment seemed realistic, likely in part because most received education on what they could expect from treatment by their practitioners (CA, RR). Patient expectations are known to impact outcomes[24,25] and the ability to mitigate unrealistic expectations prior to treatment would likely reduce the risk of disappointment and despair, as well as facilitate the acceptance of some degree of pain and physical limitation. In this study, patient expectations for improvement appeared higher for surgery than non-surgical treatment. This suggests that the minimally clinically important difference (MCID) may be different between patients in these two groups. This has been demonstrated in quantitative studies evaluating the MCID for the Spinal Stenosis Survey and Oswestry Disability Index.[26,27] This may have implications in clinical trials when comparing the proportion of participants achieving MCID among subjects receiving surgery and those receiving non-surgical treatment for NC.

Based on our patient-centred findings, we propose that both clinicians and researchers need to address NC as a multidimensional entity when considering management options and designing or evaluating specific intervention(s). We have proposed a theoretical framework to illustrate the potential inter-relationships of factors that impacts patient outcomes in NC (Figure 2). In this framework we ranked, based on our participants' experiences, the most bothersome symptoms, functional limitations, emotional aspects and treatment successes and hypothesized how these factors potentially interact. Patients who

are depressed are not likely good surgical candidates, and this is an example of how psychosocial factors can impact treatment decisions. Treatment outcomes can change the direction of future treatment is another potential interaction. This framework can provide a guide to clinicians to establish how NC individually affects their patients and to inquire about their treatment expectations. This can allow for a more stratified approach to management ranging from rehabilitation therapy, psychosocial support and /or surgery that may lead to better individual patient outcomes. Future research is needed to validate and quantify these proposed interactions between pain, physical ability, emotional state and treatment expectations in NC.

Future studies should address and measure priority areas including pain, walking and standing ability, recreational and social activity and emotional well being. In a Cochrane review examining non-operative interventions to improve outcomes in symptomatic LSS, none of the 21 studies reviewed directly assessed recreational activity, while only seven of 21 studies assessed psychosocial status, and 12 of 21 studies used an objective walking measure.[12] This paper provides valuable insight from a patient's perspective and this information can influence how we treat LSS patients in future and how we select outcomes for research.

Study limitations

Our study is not without limitations. Our qualitative approach is not designed to be generalizable, but instead to provide depth and insight into patients' lived experience. For that reason we sought to achieve thematic saturation per group, which can be achieved with 10-12 interviews per group. We were able to recruit additional subjects per group and in our thematic coding we noted saturation, which occurs when key themes such as physical limitations are present for all participants. However, it is still possible that if more patients were interviewed different themes may have emerged.

Another potential limitation is that our purposeful sample focused on a Canadian sample in a hospital setting. Variations in health care system characteristics and related factors such as access to treatment may impact patients' outcomes and expectations. Recruiting from a hospital setting may result in participants with more severe symptoms and physical limitations. Although an attempt was made to recruit a representative sample of patients with NC due to LSS, it may be that the participating sample was not a true general reflection of this population. This selection bias may also be reflected in our conceptual model of factors that impact patient outcomes and their potential interactions. These hypothesized interactions should be determined quantitatively using a random representative sample.

Conclusions

The results of this qualitative study show that NC should be considered as multidimensional in its impact on patients. We found that pain, and limited walking and standing ability were the most bothersome aspects of NC that significantly impacted important activities of daily living, as well as meaningful recreational and social activities. Additionally, this study is the first to qualitatively identify the significant emotional impact of NC. This is a finding that should not be overlooked in clinical practice and future research. A holistic understanding of how psychosocial and other factors impact outcomes in this population is needed. We present a conceptual model of potential interactions between important outcomes in LSS as a framework for future study.

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A proposed in vitro model for investigating the mechanisms of 'joint cracking': a short report of preliminary techniques and observations

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Joint "cracking" is common but not a clearly understood audible phenomenon. In this brief report we propose an in-vitro model to potentially assist in revealing a mechanism for, and therefore source of, this phenomenon. Using a suction cup under tension and de-nucleated fluid to simulate synovial fluid, an audible release with intra-articular cavity formation was elicited. This was followed by a refractory period during which no audible crack could be elicited until the observed cavity had slowly reabsorbed back into the joint fluid. Conversely, if regular fluid containing pre-existing nuclei was used, a cavity formation occurred but with neither an audible release nor subsequent refractory period. With this simple in-vitro model, we were able to reproduce the characteristic audible release, cavity formation and related refractory period typically observed in related

Le « craquement » des articulations est un phénomène sonore commun, mais mal compris. Dans ce court rapport, nous proposons un modèle in vitro *pouvant aider à révéler un mécanisme, et par conséquent une source, pour ce phénomène. À l'aide d'une ventouse sous tension et d'un fluide énucléé ayant pour but de simuler la synovie, on a entendu un son provenant de la cavité intraarticulaire, suivi d'une période réfractaire au cours de laquelle on n'a pas obtenu de craquement sonore jusqu'à ce que la cavité observée se soit réabsorbée lentement dans le liquide articulaire. À l'inverse, lorsqu'on utilisait le liquide régulier contenant les noyaux préexistants, il se produisait une perforation de la cavité, mais sans son ni période réfractaire. Ce modèle* in vitro *simple a permis de reproduire le son, la cavité et la période réfractaire connexe caractéristiques qu'on observe en général lors d'expériences connexes sur des*

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experiments in human joints. This simple in-vitro model may be of use in helping to discern both the timing and precise nature of other yet to be discerned mechanisms related to joint cracking.

(JCCA. 2017;61(1):32-39)

KEY WORDS: chiropractic, joint, cavitation, mechanism

articulations humaines. Ce modèle in vitro *simple peut aussi servir à discerner à la fois le moment et la nature précise d'autres mécanismes qu'on n'a pas encore perçus concernant le craquement des articulations.*

(JCCA. 2017;61(1):32-39)

MOTS CLÉS : chiropratique, articulation, cavitation, mécanisme

Introduction

"Cracking" or "popping" is common in many joints, particularly the knuckles, however the mechanisms responsible for the sound remains unclear. In 1938, Nordheim *et al*. used x-rays to investigate joint cracking and observed the presence of intra-articular radiolucencies after joints were moved beyond their normal range of active motion.[1] These lucencies were believed to be due to gas formation, however, no elaborate in vitro model was offered at the time to help explain this phenomenon. Instead, a simple analogy based on a water-filled syringe was proposed. (see Figure 1) In that most basic model, gas formation is reproduced within the syringe by simply pulling on the plunger while the needle end remains sealed. This action generates a bubble that expands in proportion to the increase in volume and corresponding negative pressure created as more tension is applied to the syringe. In accordance with Henry's law of solubility, dissolved gas comes out of solution as greater tension on the syringe reduces its partial pressure. Additionally, in accordance with Boyle's law, the volume of an otherwise fixed amount of undissolved gas increases, again, as its absolute pressure is reduced. Yet gas formation with the syringe model does not generate a cracking sound, and therefore it does not fully explain the events associated with gas formation within joints.

In 1947, Roston *et al*. also detected radiolucencies on x-ray images of cracking joints and hypothesized that they represented bubble formation in the midst of a vacuum created by joint tension or distraction.[2] Roston *et al*. theorized that the bubbles originated from smaller pre-existing gas nuclei (i.e., small spherical bubbles or gas cavities trapped in crevices on hydrophobic surfaces that are ubiquitous in polar fluids such as water), which transitioned to larger visible bubbles at lower vacuum thresholds.[3] These gas nuclei can be dissolved and elim-

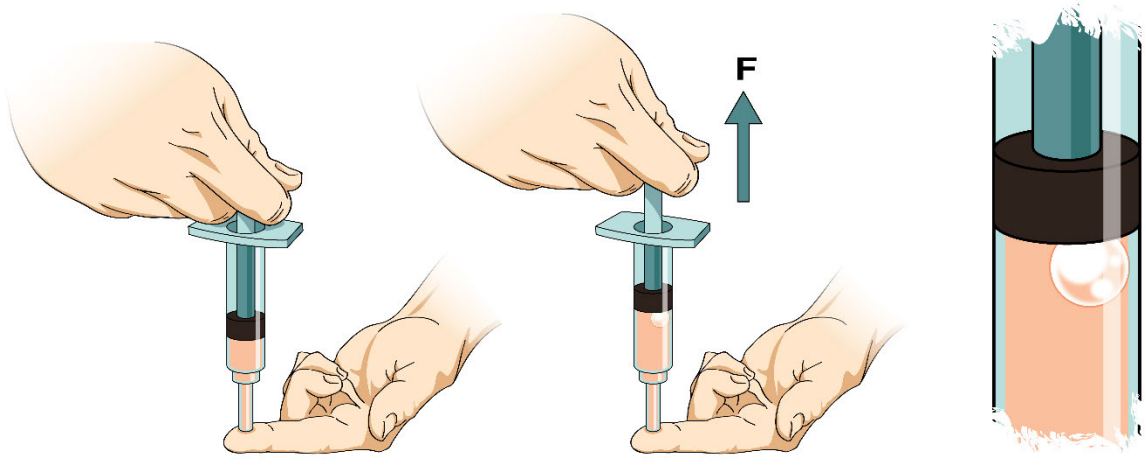

Figure 1.
Water filled syringe under tension.

inated by either hydrostatic compression, boiling at sea level pressure at 100°C, or boiling under high vacuum at room temperature. Although this theoretical framework of denucleation was introduced, no subsequent physical in vitro model evolved from that study.

By 1971 Unsworth *et al*. introduced the 'cavitometre', which was the first in vitro synovial joint model that was developed specifically to study joint cracking.[4] This model was constructed out of nylon and plexiglass with surfaces similar in contour to a metacarpophalangeal joint, only at double the normal size, and separated by synovial fluid. When tension across the system was applied quickly to simulate a joint crack, a cavity appeared and then disappeared. Furthermore, a sound was generated, which the authors concluded was due to bubble collapse rather than bubble formation (the latter of which Roston *et al*. had hypothesized in an earlier study). However, unlike a real synovial joint, the model was open to ambient air, from which gas nuclei could be introduced. Furthermore, the model could be cracked repeatedly without hindrance by any refractory period between sequential iterations.

Irrespective of the model's limitations, the collapsing bubble hypothesis of Unsworth *et al*. remained the most popular explanation for joint cracking sounds for over four decades. However in 2015, Kawchuck *et al*. used magnetic resonance imaging (MRI) to reveal the occurrence of a hypointense area coincidental to the time of a metacarpophalangeal crack.[5] This led to renewed interest in Roston's original theory of bubble formation as a viable alternative to Unsworth's theory of bubble collapse. In further support of Roston *et al.'s* work, Kawchuk *et al*. showed that traction of the finger caused the hypointense area to remain present in the field of view, similar to what is observed in the basic syringe model. But controversy would still exist between the two competing hypotheses as the time window between MRI frames in the study by Kawchuk *et al*. was 0.3 sec, whereas that of the video imaging in the cavitometre study by Unsworth *et al*. was within 0.01 sec.

Kawchuk *et al*. further concluded that the process of cavity formation was likely due to tribonucleation, which by definition is a process of bubble formation from the relative motion of two solid structures under liquid tension.[6,7] However, other studies on tribonucleation do not indicate that this phenomenon is associated with the generation of any notable cracking sounds.[7,8]

To assist in resolving this ambiguity, we describe an in vitro model that possesses three important properties: 1) It is a closed system that mimics the sealed environment of the synovial joint in vivo; 2) It contains de-nucleated fluid and 3) It reproduces both a cracking phenomenon and subsequent refractory period identical to that which is seen in real synovial joints. We believe that this new in vitro model could be a basis for further advancement of previous research on the mechanisms of joint cracking. This improved model simulates much of the natural anatomy and geometry of a real metacarpophalangeal joint. The objective of the current paper is to describe this new-and-improved joint cracking model and to also present some qualitative observations from preliminary tests involving this model.

Materials and Methods

The development of our latest model began with construction of a very basic dry joint model initially (Model A), followed by the sequential construction of 5 additional models (Models B to final Model F). Each model represented a minor modification of the one temporally preceding it.

Model A: Basic dry joint

This model consisted of an elastic suction cup (diameter 10mm) adhered to a polished flat glass plate with an air-filled space simulating a joint cavity. In this model, the suction cup was pressed up against the glass plate, and subsequent traction was applied in two different ways: 1) with just enough tension force to cause partial detachment of the cup (i.e., the centre of the cup) without breaking the seal around its perimeter; and subsequently 2) with greater and sufficient tension to cause the cup to detach fully (i.e., both centre and peripheral margin of the cup) from the glass surface.

Model B: A wet joint

This model was identical to Model A, except that the suction cup was immersed in a beaker of distilled water so that the simulated joint space was filled with fluid. In this model, the suction cup was pressed up against the beaker wall to create a suction adherence, but this time, traction was applied with just enough tension force to cause partial detachment of the cup (i.e. the centre of the cup) without breaking the seal around its perimeter, similar to the first way in Model A.

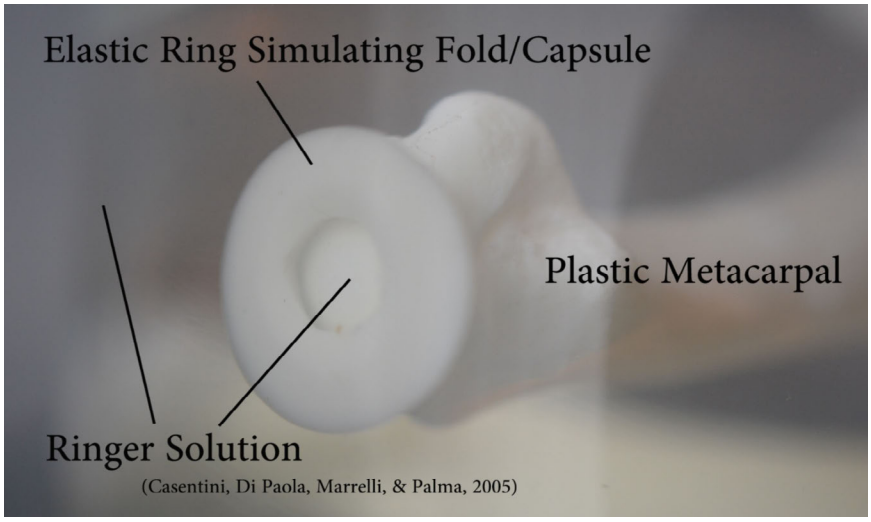

Figure 2.
Model E

Model C: A "de-nucleated" wet joint

This model was identical to Model B, except that the suction cup was immersed in "de-nucleated" distilled water. As mentioned previously, nucleated water refers to normal distilled water, which contains visible bubbles that form through the coalescence of pre-existing gas cavities (i.e., gas "nuclei") within the fluid.[4] These pre-existing nuclei are either smaller unattached spherical bubbles or larger gas volumes that are attached to hydrophobic crevices on solid particles.[9] Both types of nuclei can be partially removed by boiling the fluid for 30 minutes with the suction cup immersed in the fluid and letting cool. Another approach to de-nucleate is by over pressurization[6] and a third approach is by vacuum, which we performed by using -110 kPa for 20 minutes while the suction cup was fully immersed in the fluid. After denucleating the fluid, the suction cup was pressed up against the glass beaker wall to generate a suction adherence. We then pulled on the suction cup with just enough manual force to cause only the centre of the cup to detach from the wall, without compromising the seal around the perimeter of the suction cup.

Model D: A Ringer's solution-filled wet joint

This model was identical to model C, but to more closely simulate the actual fluid in a synovial joint, a Ringer's solution, manufactured as per Casentini *et al*.[10,] was used and de-nucleated as we did with distilled water for model C. Again, after pressing the suction cup to the beaker wall to create a suction adherence, we pulled on the suction cup with just enough manual force to cause only the centre of the cup to detach from the glass beaker wall without compromising the seal around the perimeter of the suction cup.

Model E: Wet joint model with realistic surface geometry

To determine if the cracking event was influenced by the geometry of the suction cup surfaces employed for models A through D, the suction cup was replaced by a polyurethane metacarpal bone. This was achieved by creating a mold of a cadaveric metacarpal bone and pouring an identically shaped polyurethane copy. To roughly simulate the presence of a synovial fold and capsule, an elastic ring was attached to the polyurethane metacarpal head with an adhesive, exposing the central surface of the metacarpal head. This structure was then immersed in a glass beaker with Ringer's solution and de-nucleated under vacuum conditions. After 30 minutes of -110 Kpa the polyurethane metacarpal head was pressed up against the inside of a glass beaker wall while completely immersed in denucleated fluid. (see Figure 2) During testing of this model, we pulled on the polyurethane metacarpal base with just enough manual force to cause only the centre aspect of the metacarpal head to release from the beaker wall, but again without breaking the seal around the perimeter being maintained by the elastic ring.

Model F (Final Model): Compressible wet joint with realistic surface geometry

To test whether changes in joint tension affected the duration required for the model to return to its baseline state (of cavity dissolution) after simulated cracking, a plexiglass apparatus with a fulcrum mechanism was used to apply slight compression to the joint represented by the previous model (Model E). Again, de-nucleated Ringer's solution was used to simulate the presence of synovial fluid. During our tests, we first pulled on the polyurethane metacarpal base with just enough manual force to cause the centre aspect of the metacarpal head to detach from the beaker inside wall below the fluid line, again without compromising the seal around the perimeter of the elastic ring. Following detachment of the metacarpal head and corresponding cavity formation within the simulated joint, we applied compression to the joint model with a clamp (i.e. a fulcrum mechanism), which is depicted in Figure 3. The amount of compression force was not measured at the time, but was subsequently estimated to be between 15 and 30 N.

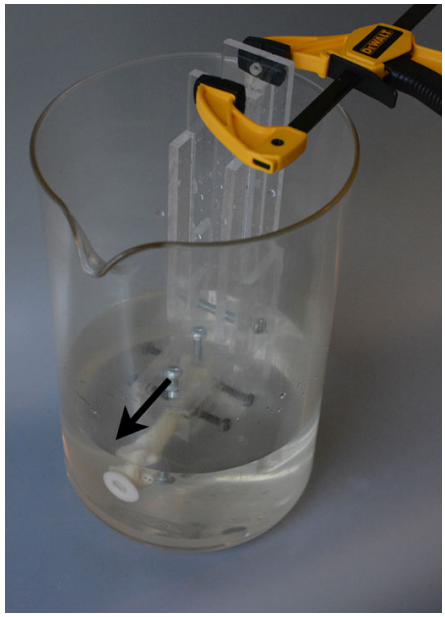

Figure 3.
Compression tension apparatus

Results of preliminary testing

With the Model A dry joint, pulling of the suction cup to detach only the centre aspect of the suction cup was not associated with an audible event. Only with further traction and detachment of the cup perimeter did a cracking sound occur.

With the Model B wet joint, as the suction cup was slowly pulled from the inside of the beaker wall in its closed state, a gas cavity formed silently as the centre of the suction cup detached without breaking the seal around its perimeter. Furthermore, when tension was subsequently reduced in order to allow the suction cup to return to its previous neutral position, the cavity disappeared (as

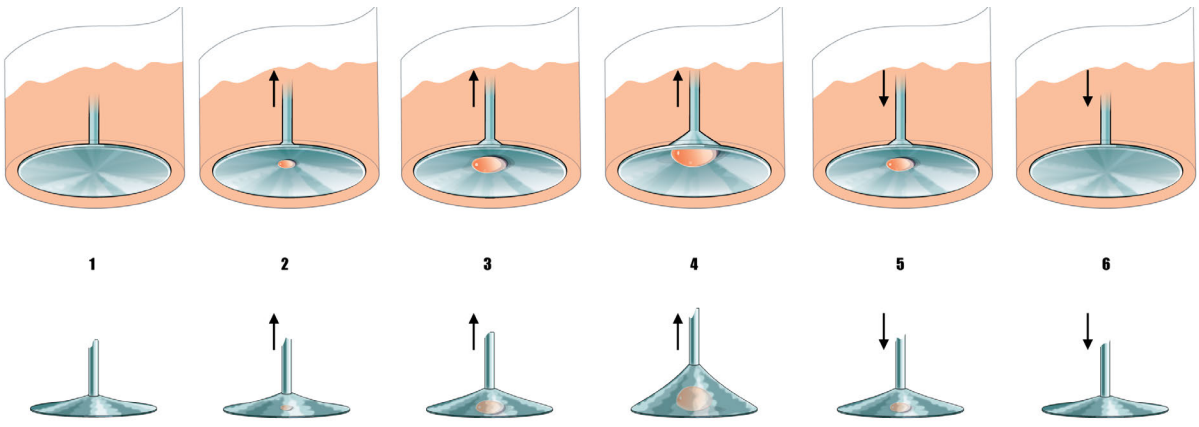

Figure 4.
Model B. Within a simulated wet joint space (without de-nucleated fluid) in a sealed condition (1), decompression and volume expansion results in expanding bubble formation (2-4) while return to initial tension and volume normalization results in bubble disappearance (5-6).

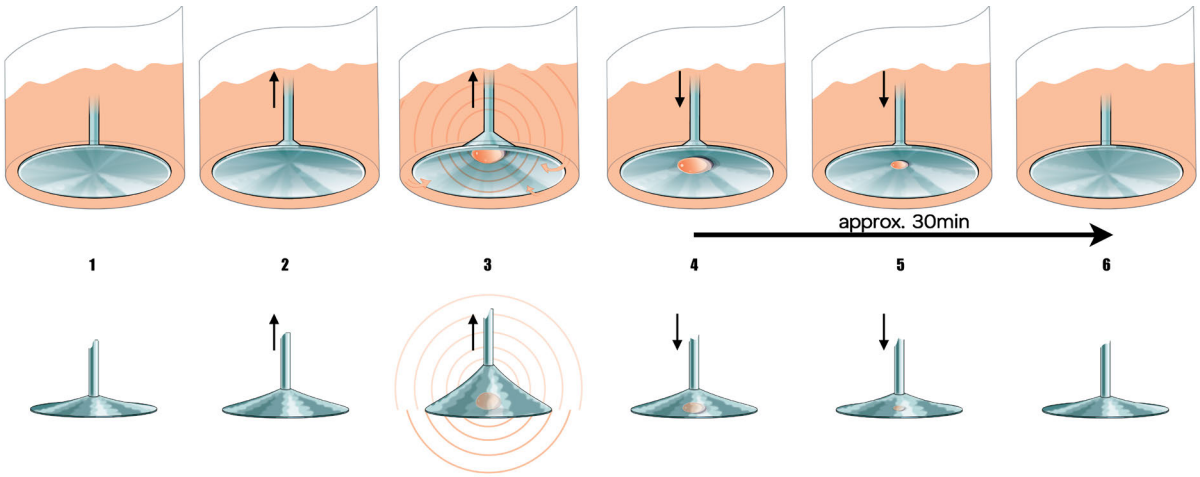

Figure 5.
Model C Within a simulated wet joint space (with de-nucleated fluid) in a sealed condition (1), decompression results in suction cup stretch without lift and without cavity (2). Suddenly, when sufficient tension is applied a cavity and sound spontaneously forms (3) and further decompression leads to increasing cavity volume formation. Relaxation of tension leads to enduring cavity (4) and over time, cavity size shrinks (5-6). The sequence 1-6 can then be repeated.

was expected under Boyle's Law, which describes the inverse relationship between pressure on the one hand and volume of an otherwise fixed amount of undissolved gas on the other hand). This sequence of events is depicted in Figure 4.

With Model C in which distilled water within the simulated joint space was replaced by de-nucleated water, neither central cup detachment nor gas cavity formation was observed when the suction cup was pulled with the same initial force as was used in Model B. In other words, with initial tension the centre of the suction cup did not release from the beaker wall but instead remained completely adherent to it. It is noteworthy that in the previous model employing nucleated fluid (Model B), bubble formation was observed immediately during traction, whereas in Model C employing denucleated fluid, gas bubble formation was no longer evident early on. Only later with Model C, when the suction cup was pulled with greater force did its centre detach from the surface. Moreover, upon detachment, a stable gas cavity formed in association with an audible crack. Also with Model C, when the suction cup was released and allowed to return to its baseline position, a visible cavity remained, and then disappeared only gradually over approximately 30 minutes. Finally, so long as a bubble or cavity remained visible to the naked eye, no further cracking sound could be elicited during re-pulling of the suction cup. On the other hand, once the bubble was no longer visible to the naked eye, an audible crack could again be elicited from the model (Figure 5).

With Model D, we observed the same findings that we observed during experiments with Model C. More specifically, the experiment with de-nucleated Ringer's solution resulted in joint cracking and a corresponding refractory period that was identical to that of a model employing de-nucleated distilled water.

With Model E, regardless of whether the joint was immersed in nucleated distilled water or nucleated Ringer's solution, the observed events were identical to those that were observed in Model B. In contrast, when either the distilled water or Ringer's solution was de-nucleated, our observations were identical to those obtained with Model C.

Under Model E, we also were able to generate the cracking sound when the model was pulled off-axis, which we did in order to simulate cracking of a real knuckle joint in a partially flexed or non-neutral position (https://youtu.be/TzC7PkgbHGA).

With our final model, Model F, the application of com-

pression through the joint (subsequent to cavity formation and an audible release) resulted in a reduction in the time required before cavity formation and joint cracking could be repeated. In this regard, the so-called refractory period without compression was previously 30 minutes, whereas the refractory period with joint compression was only 12 minutes. Qualitatively, we observed that the greater the amount of compression that was applied to the model, the shorter was the refractory time.

Discussion

We have introduced a series of in vitro models and a final model that will serve as a basis for our future investigations into the mechanisms of synovial joint cracking. Our observations at this time are too anecdotal to warrant a full report, however they are presented here for the purpose of soliciting immediate comments and criticisms from the broader research community. In the meantime, a key preliminary finding is that the events we observed after replacing regular fluid with denucleated fluid (in Models C, D and E) are completely consistent with the same cavity formation and refractory period phenomena that is associated with the cracking of real synovial joints. Specifically, within a closed system employing denucleated fluid, as long as a bubble or cavity formation is visible within the simulated joint space, a crack can not be repeated. In contrast, once the cavity disappears, a crack can again be elicited from the model.

This behaviour of gas within liquid is typically interpreted to reflect the dissolution of a spherical bubble by the forces of surface tension. Until its dissolution, a bubble acts as a gas nucleus (as observed in Model B) which permits formation of a larger visible gas cavity during decompression of liquid within a closed system, but in the absence of generating an audible crack. Epstein and Plesset derived equations that describe the time to dissolution of a bubble in relation to absolute pressure, dissolved gas tension, and surface tension.[11] Accordingly, in Model F, a reduced refractory period was both expected and observed, and ultimately reflected faster re-solution time in response to increased local absolute pressure.

Admittedly, the precise timing of the crack in relation to the timing of bubble formation was not discernible from these preliminary experiments. At this time, it remains a mystery whether sound generation occurs before, after, or simultaneously to the time of cavity formation. The timing of the crack in relation to bubble formation will be the focus of our future work. Additionally, we plan to quantify corresponding forces, tensions, bubble sizes, and dissolution times through the use of multiple imaging methods (i.e., cinematography, ultrasound, and MRI).

Conclusion

In this brief report, an in-vitro model has been developed and proposed to investigate the origins of the cracking sound within synovial joints. So far, we have observed that when a de-nucleated fluid is introduced, decompression of a sealed joint elicits both cavity formation and an audible event, similar to what occurs in human synovial joints. Immediately afterward, a refractory period occurs during which an additional audible event cannot be elicited regardless of how much joint decompression or tension is applied. In contrast, if the fluid used in the model is nucleated, decompression of the simulated joint elicits cavity formation in the absence of an audible event. Additional measurement techniques will be developed and applied to this new model with the intent of better clarifying the mechanisms of in vivo joint cracking.

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Calcium pyrophosphate deposition disease in the ankle joint: a case report

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Objective: *To detail the presentation of calcium pyrophosphate deposition disease (CPPD) in the ankle joint. The aim of this case report is to inform health-care practitioners about the presentation of this condition in an uncommon location and discuss the diagnosis, potential treatment, and management strategies for a patient with CPPD.*

Clinical Features: *A 36-year-old male patient presented to a chiropractic clinic with an acute, painful, and swollen ankle, which was later diagnosed by plain film radiograph as CPPD. A rheumatology follow-up was recommended and at-home treatment was prescribed to treat acute symptoms and monitor progress.*

Outcome: *No chiropractic treatment was provided and the patient has been referred to a rheumatologist*

Objectif : *Expliquer en détail la présentation de la chondrocalcinose articulaire (CCA) dans l'articulation de cheville. Cet exposé de cas a pour but d'informer les professionnels de la santé à propos de la présentation de ce trouble dans un endroit inhabituel et de discuter du diagnostic, du traitement potentiel et des stratégies de prise en charge pour un patient atteint de CCA.*

Caractéristiques cliniques : *Un patient de 36 ans se présente à une clinique de chiropratique avec une cheville enflée avec douleur aiguë, trouble qu'on a plus tard diagnostiqué au moyen d'un cliché sans préparation comme* étant *une CCA. On a recommandé un suivi en rhumatologie et prescrit un traitement à domicile pour traiter les symptômes aigus et surveiller la progression.*

Résultat : *On n'a pas fourni de traitement chiropratique et le patient a été envoyé à un rhumatologue pour une évaluation plus poussée. Le*

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The patient has provided written consent to have this case report published.
The authors have no competing interests or conflicts of interest to declare. There was no financial support received in preparation of this manuscript.

for further assessment. The diagnosis of CPPD was confirmed and he was advised to take an anti-inflammatory if symptoms recurred and booked for further follow-up in six months.

Summary: *Although the presentation is less common, CPPD can present in the ankle joint and mimic other inflammatory disorders. Conservative treatment can be applied to treat acute symptoms and referral to a rheumatologist is suggested to monitor progress of this condition.*

(JCCA. 2017;61(1):40-44)

KEY WORDS: chiropractic, ankle, calcium pyrophosphate deposition disease

diagnostic de CCA a été confirmé; on lui a conseillé de prendre un anti-inflammatoire si les symptômes réapparaissaient et on a planifié un suivi six mois plus tard.

Résumé : *Bien que la présentation soit moins commune, la CCA peut se présenter dans l'articulation de cheville et imiter d'autres affections inflammatoires. Un traitement conservateur peut permettre de soigner les symptômes aigus et on recommande d'envoyer le patient voir un rhumatologue pour surveiller la progression du trouble.*

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MOTS CLÉS : chiropratique, cheville, chondrocalcinose articulaire

Introduction

Calcium pyrophosphate deposition disease (CPPD) is a condition that is characterized by the deposit of pyrophosphate crystals into tendons, ligaments, cartilage and synovium.[1,2] CPPD may be associated with elevated levels of calcium, pyrophosphate or local cartilage matrix changes.[3] Typically, CPPD is found in older aged individuals, with an onset of 30 years of age and a peak at 60 years[2], CPPD is often associated with primary and secondary osteoarthritis, which results in decreased joint congruency and degeneration due to the aging process[1].

Both the cause of CPPD and the mechanism of onset of crystal deposition remain largely unknown and vastly debated throughout literature.[1,2] The formation of calcium pyrophosphate crystals is extracellular, however, pyrophosphate is a by-product of several intracellular reactions thus unable to diffuse passively across the cell membrane.[1] It is unclear whether crystal deposition occurs as a result of extracellular pyrophosphate synthesis by plasma membrane-bound plasma cell glycoprotein 1 or whether pyrophosphate is transported across cell membranes by ankylosis human protein.[1] Causes of CPPD can be classified into the following categories: idiopathic, metabolic, hereditary and post-traumatic.[1] CPPD can be linked to underlying metabolic disorders such as hemochromatosis, hyperparathyroidism, hypophosphataemia, hypomagnesaemia and hypothyroidism, all of which increase the risk for calcium pyrophosphate deposition.[3] Numerous cases of CPPD have shown familial links in the ANKH gene, which functions to upregulate protein.[4] When the ANKH gene becomes mutated, protein activity is enhanced and thus extracellular pyrophosphate levels increase and promote the formation of pyrophosphate crystals leading to CPPD.[1,3,4] Despite attempts to determine etiology, the majority of CPPD cases remain idiopathic.[3,4]

This condition has not yet shown an association with gender, obesity, or lifestyle characteristics, although it is slightly more common in Caucasian individuals.[1,2] CPPD has been documented most commonly in the knees, wrists, symphysis pubis and hips.[1] This condition is a common rheumatologic disease in elderly individuals, and is noted most often in knees and pelvis.[1] CPPD has been found to appear in one of three forms: asymptomatic, acute or chronic.[1] Asymptomatic patients most often discover the deposit of pyrophosphate crystals through plain film radiographs for an alternative reason.[1] Acute CPPD, a presentation that is highly suggestive of acute crystal inflammation, is associated with the rapid development of joint pain, swelling, tenderness, warmth and restricted movement, often reaching its maximum within 6-24 hours of symptom onset.[1] Chronic CPPD presents simi-

larly to osteoarthritis with progressive joint pain, chronic synovitis, crepitus and warmth at the joint line.[2]

Traditionally, patients presenting with suspected CPPD can be screened for chondrocalcinosis using plain-film radiographs, however, microscopic analysis of synovial fluid provides a more definitive and accurate diagnosis due to the ability to detect calcium pyrophosphate crystals.[5] Chondrocalcinosis, calcification in hyaline or fibrocartilage, is considered the key identifying feature of CPPD on radiographs, however this diagnostic method is neither highly sensitive nor specific.[5] Synovial fluid analysis can be used to identify weakly positively birefringent crystals using polarized light microscopy.[5] More recently, ultrasonography of articular and fibrocartilage has been used to indicate the presence of CPPD crystals.[6] Ultrasound is used to detect hyperechoic bands in hyaline cartilage and hyperechoic spots in fibrous cartilage.[6] Further studies are required to compare the diagnostic value of ultrasound with existing diagnostic methods, however ultrasound remains a promising tool for diagnosis of CPPD.[6]

Strategies for treatment and management of CPPD vary depending on the symptom severity, stage and clinical manifestation of CPPD. Staging for CPPD presentation includes the following categories: asymptomatic, acute, chronic, presenting with OA or as a pseudo-arthritide.[1,5] Common treatments that provide symptomatic relief include conventional anti-inflammatory medications, such as non-steroidal anti-inflammatories (NSAIDs) and corticosteroids.[5] Although the progression of this condition may vary between individuals, most will experience recurrent symptomatic episodes.[7] During acute attacks, patients often experience severe pain.[7] Optimal and safe treatment for acute pain includes ice, temporary rest, intra-articular injections and joint aspiration.[7] Despite the incurable nature of this condition, the prognosis is good, as long as symptoms are controlled and patients are monitored for pre-disposing conditions that may be treatable and preventable.[8]

The objective of this case report is to highlight a unique incidence of CPPD in the ankle, a less common location for this condition with minimal documentation in current literature. Additionally, this case report aims to provide health-care practitioners with a detailed case presentation, radiographic findings, and potential treatment and management options for future patients with this case presentation.

Case Presentation

History and Physical Examination Findings

A 36-year-old male initially presented to the Canadian Memorial Chiropractic College (CMCC) campus clinic with a primary complaint of acute mechanical low back pain. He reported no comorbidities, medical history or medication use. At a subsequent visit, the patient reported a new complaint of an acutely swollen left ankle, with an onset of pain six days prior to his appointment. At this time, his back pain was resolved. There was no history of trauma to the ankle. Twenty-four hours after the onset of his ankle symptoms, he was woken up in the middle of the night by severe pain that resulted in the inability to fall back asleep. Over the course of the weekend, prior to his appointment, the ankle became swollen. The patient was self-medicating with ibuprofen, which helped to relieve but did not eliminate the pain. Following observation of the joint and orthopaedic testing of the ankle, all tests created pain due to palpation of the joint but no tests were positive for ligament injury or trauma. The patient was sent for diagnostic imaging in consideration of differential diagnoses of gout, pseudogout, osteoarthritis, rheumatoid arthritis and septic arthritis.

Imaging

A plain-film radiographic series for the left ankle (Figures 1 and 2) was taken in addition to a bilateral AP knee radiograph (Figure 3). There was adequate bone density with no osteochondral defects detected at the tibial plafond and talar dome. All bony joints appeared unremarkable, however blurring of Kager's fat pad was visualized. Radiographic findings included apparent chondrocalcinosis with joint effusion in the talotibial joint, which is highly suggestive of pseudogout associated with CPPD. As well, there was subtle chondrocalcinosis of the menisci bilaterally visualized on the bilateral AP knee radiographs (Figure 3).

Diagnosis, Treatment and Referral

The patient was diagnosed, by plain-film radiography, with CPPD in the left ankle. At the time of writing, the patient did not receive any chiropractic treatment and was referred to a rheumatologist for further assessment. The patient declined conservative care, and was advised to

Figure 1.
Left medial oblique ankle (left) and left AP ankle (right).

Figure 2.
Left lateral ankle.

Figure 3.
Bilateral AP knee – subtle chondrocalcinosis is visualized in the menisci bilaterally.

treat the acute symptoms of CPPD at home and monitor his progress.

Discussion

Direct research evidence to support treatment recommendations are lacking therefore management strategies will vary according to the clinical presentation. Conservative treatment of CPPD is mainly symptomatic and often limited due to the etiology of the disease.[1] Currently, there are no treatments that modify calcium pyrophosphate crystal formation or dissolution.[1] High-quality evidence is limited for non-pharmacological treatment interventions for managing CPPD, however, expert opinion recommends the use of cryotherapy and temporary rest during acute attacks.[7] Education is also an essential part of conservative care as it allows for patient involvement in the decision making process of their clinical management.[7] Patient-centered care is optimized when the patient understands the characteristics of their diagnosis, available treatment options and associated benefits and risks.[7]

The medical management of CPPD is challenging due to the fact that the condition is often associated with other disorders. The course of treatment often varies widely across patients depending on their specific health conditions and their unique case of CPPD.[5] Research shows the most common medications prescribed for CPPD are for symptomatic relief within the joint including conventional anti-inflammatory medications, such as NSAIDs.[5] However it is important to note since CPPD prevails in older patients, additional caution and careful considerations should be taken when recommending NSAIDS due to drug interactions and harmful side effects. A safer alternative is joint aspiration or intra-articular injection of glucocoricosteroids.[7] Glucocorticosteroids and joint aspiration have been shown to be a viable and effective option in the treatment of acute and painful CPPD attacks in addition to ice and rest.[7] Dosage recommendations, however, are vague and often based on clinical expertise and research related to the management of gout.[7]

In addition to NSAID use, the management and treatment strategies should involve correcting the underlying metabolic abnormalities and treating the conditions.[5] Newer therapies that require more evidence include substances targeting anti-crystal formation (such as probenecid) as well as anti-inflammatory medications (such as methotrexate) that target interleukin pathways to prevent recurrent attacks.[5] At this time however, there is no definitive treatment available to dissolve the crystal deposits or prevent future crystal deposition.[5] Due to the incurable nature of this condition, CPPD is classified as a chronic disorder with recurrent episodes. The prognosis is good, as long as symptoms are controlled and patients are monitored.[8]

Numerous clinical presentations of CPPD make diag-

nosing and treating this condition challenging. In this case specifically, CPPD targeted the menisci of the knees and the talotibial joint. A common location for CPPD includes, but is not limited to, the menisci of the knee and the patellofemoral joint, only one of which was seen in this case. It is apparent that there is irregular joint involvement, seeing that CPPD was also present in the ankle, which is a less common location for this condition. Although CPPD is often associated with osteoarthritis, it is important to understand the difference in clinical presentation between the two conditions. A large proportion of patients with CPPD follow a progressive course of articular degeneration in an irregular distribution pattern.[5] Typically, around 50% of these individuals will experience acute attacks of pseudogout superimposed on their underlying osteoarthritis, whereas the remaining present with classical osteoarthritis.[5] Features that distinguish CPPD from osteoarthritis include atypical joint distribution, presence of contractures and valgus knee deformities.[5] Clinically, CPPD has the potential to mimic several forms of inflammatory arthritic conditions resulting in a wide array of clinical manifestations.[5] These presentations include asymptomatic or lanthanic chondrocalcinosis, acute pseudogout, pseudo osteoarthritis (with or without acute attacks), pseudo rheumatoid arthritis, pseudo-polymyalgia rheumatica and pseudo-neuropathic arthropathy.[5] It is possible for CPPD to co-exist with other arthritic conditions, further complicating diagnosis and management strategies. Further research on diagnosing, managing and reducing calcium pyrophosphate crystal deposition is essential seeing that CPPD and the associated CPPD-related arthropathies are likely to increase in prevalence due to the current aging population.[5]

Summary

This case report highlights a 36-year-old male patient who presented to a chiropractic clinic with an uncommon presentation of a common arthritic condition. Clinicians should take note of this unique presentation, as CPPD is prevalent in older, Caucasian populations and can often present concurrently with osteoarthritis.[1,7] It is imperative to understand which joints can be targeted by CPPD and what treatment options are available. As well, it is clinically important to note the patient in this case report also had subtle findings of chondrocalcinosis in the menisci of the knees. Thus, inferring that if chondrocalcinosis is found in one joint in the body, there may be other joints in the body targeted as well. Further research is necessary to investigate the benefits of chiropractic care for the treatment and management of patients presenting with acute and chronic forms of CPPD, specifically with respect to providing pain relief and improving joint mobility.

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Chiropractic management of a geriatric patient with idiopathic neuralgic amyotrophy: a case report

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Objective: *The purpose of this paper is to describe chiropractic management of a patient with neuralgic amyotrophy (NA) and to provide discussion regarding presentation, differential diagnosis, management and prognosis of idiopathic NA.*

Case presentation: *An 85 year old Caucasian male presented to a chiropractic clinic with right periscapular and lateral rib cage pain. The patient had previously sought evaluation and treatment from multiple health care providers and underwent multiple interventions without relief.*

Intervention and outcome: *The patient was managed with a course of chiropractic care and an ongoing home exercise program was carried out. The patient reported*

Objectif : *Ce document a pour objectif de décrire la prise en charge chiropratique d'un patient atteint d'amyotrophie névralgique (AN), ainsi que de discuter de la présentation, du diagnostic différentiel, de la prise en charge et du pronostic d'AN idiopathique.*

Exposé de cas : *Un homme blanc de 85 ans se présente à une clinique de chiropratique en se plaignant de douleur périscapulaire droite et latérale à la cage thoracique. Le patient s'était* déjà fait évalué *et traité par nombre de fournisseurs de soins de santé et avait subi de nombreuses interventions, sans soulagement.*

Intervention et résultat : *Le patient a reçu des soins chiropratiques et on lui a créé un programme d'exercices à domicile. Le patient a déclaré une*

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spontaneous resolution of pain approximately 14 months post onset.

Summary: *NA is a poorly known clinical entity amongst health care providers and poses challenges in timely and proper diagnosis. Recognition of NA is important for patients to be best managed and for more optimal patient outcomes to be achieved.*

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KEY WORDS: chiropractic, neuralgic amoytraophy, Parsonage-Turner syndrome, brachial neuritis

disparition spontanée de la douleur environ quatorze mois après l'apparition des symptômes.

Résumé : *L'AN est une entité clinique mal connue des fournisseurs de soins de santé, ce qui complique le fait de parvenir à un diagnostic exact avec rapidité. Il est important de reconnaître l'AN pour assurer une prise en charge optimale des patients et obtenir des résultats optimaux.*

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MOTS CLÉS : chiropratique, amyotrophie névralgique, syndrome de Parsonage-Turner, névrite brachiale

Introduction

Neuralgic amyotrophy (NA) is a marked sudden onset disorder which may present in otherwise healthy individuals characterized by abrupt symptoms of severe neuropathic pain of the upper extremity and subsequent neuromusculoskeletal dysfunction of the shoulder girdle.[1,2] Though NA is also known as Parsonage-Turner syndrome, it may additionally be referred to as acute brachial neuritis, acute brachial plexitis, acute brachial neuropathy, Kiloh-Nevin syndrome, brachial plexus neuropathy, idiopathic brachial plexopathy, idiopathic brachial neuritis, localized neuritis of the shoulder girdle, multiple neuritis of the shoulder girdle, paralytic brachial neuritis, serum neuritis, shoulder girdle neuritis, or shoulder girdle syndrome.[3] The hallmark symptom of NA is sudden onset of intense shoulder girdle pain with no precipitating traumatic event. The initial onset of pain may last up to several weeks[3] and subsequently transition to varying presentations of local paresis, sensory deficit, progressive weakness, or atrophy of the shoulder girdle and upper extremity musculature.[2] The variety of interchangeable symptoms reported with NA which may overlap with more commonly known disorders, multiple specialists often consulted by patients suffering from NA, and the lack of recognition of NA amongst health care providers can lead to lengthy differential diagnosis, delayed diagnosis, misdiagnosis and mismanagement.[3]

This syndrome was first reported in the 1880s by Dreschfeld with many subsequent cases described over the next half century.[4] Parsonage and Turner introduced a description of clinical characteristics associated with neuralgic amyotrophy in a series of 136 cases in 1948.[4,5] Though Parsonage and Turner referred to this disorder as neuralgic amyotrophy, it has become commonly referred to as Parsonage-Turner syndrome as well. The exact etiology of NA is unknown and may occur as a sporadic condition, though it has also been shown to present as an autosomal dominant hereditary trait known as hereditary neuralgic amyotrophy (HNA).[6] Though infectious and malignant causes have been recently discredited, there is some discussion of possible autoimmune origin.[7] It is possible that NA may be a clinical entity which manifests itself as a collection of multiple underlying mechanisms, phenotypes, and prognoses, and not as a single disorder.[6] A lumbosacral variant of NA exists and is known as lumbosacral radiculoplexus neuropathy which is more commonly known to occur in patients with mild type 2 diabetes.[7] Traditionally the prevalence of NA has been thought to be 2-4 cases per 100,000; though recent reports suggest an incidence rate of 1 per 1,000 per year.[7] NA is found to be more common in males than females, and most often presents in the second, third, and seventh decade of life.[8,9] While it seems NA is mostly known in the adult population, incidence of NA presenting in children and infants have been reported.[7] Recurrences are not uncommon and may appear in either the same extremity or an entirely new region. Manifestation of symptoms and symptom patterns may even emerge differently in reoccurrences as well.[7] Diagnosis of NA can be difficult due to the varying degree of patient presentation including severity and lo-

cation of pain, paresis, and atrophy. The differential diagnosis requires clinicians to distinguish NA from peripheral neuritis, radiculopathy, shoulder pathology, complex regional pain syndrome, rotator cuff injury, acute calcific tendonitis, adhesive capsulitis, cervical spine disorders, peripheral nerve compression, tumor, acute poliomyelitis, amyotrophic lateral sclerosis, posterior interosseous nerve palsy[10,11] and costovertebral/costotransverse joint irritation. The goal of treatment largely focuses on pain management with additional attention paid to maintaining functionality of the affected limb, most commonly the shoulder and arm.

As reported above, the prevalence of NA is quite low; furthermore the number of documented cases presenting to the chiropractic clinician is even smaller. To our knowledge, there are only two preceding reports of NA published in the chiropractic literature.[9,12] Both cases involved male patients in their thirties with an idiopathic acute onset of symptoms and electrodiagnostic evidence of neurologic involvement. Rix and colleagues described a patient that was improving with a combination of reassurance, range of motion and strength exercises, though this patient was lost to follow-up.[12] Charles described a patient that had failed surgical pronator teres release and was subsequently treated with cervical manipulation, deep tissue therapy, and hand/finger exercise.[9] This latter case resulted in full functional and pain recovery after 12 treatment sessions. An improved ability for health care providers to recognize the distinct clinical manifestations of NA, formulate differential diagnosis, appreciate best management strategies, and understand prognoses associated with NA is needed. The objective of this article is to describe a patient with NA presenting to a private chiropractic practice and further discuss clinical presentation, differential diagnosis, management, and prognosis of idiopathic NA.

Case presentation

An 85-year-old Caucasian male presented to a private chiropractic clinic with a chief complaint of right periscapular and lateral rib cage pain. The area of greatest pain was localized about the right inferolateral scapular border. Excluding this condition, he appeared to be in good health, ambulatory, and maintained an active lifestyle. The patient denied family history of related musculoskeletal disease or symptoms. The patient reported an unremarkable health history including no history of smoking, cardiovascular disease and a healthy weight throughout life. Past medical history was unremarkable.

The patient's pain began with sudden onset of severe pain while lying in bed prior to waking in the early morning period. His pain gradually decreased over the next few hours to a tolerable level. The following night the pain returned to a severe level and persisted for approximately 2 days. The patient presented to the local Emergency Department and was evaluated by electrocardiogram (EKG) which was unable to establish a cardiovascular causation. The patient was discharged with instructions to follow up with his primary care provider. Upon primary care evaluation, further diagnostic studies were performed, including a second EKG and computed tomography (CT) of the chest which the patient reported revealed no abnormal findings. Subsequent referral to a cardiologist was given. Upon cardiology evaluation, the patient was determined to have vascular blockage, despite having no typical associated symptomatology, and a coronary artery bypass graft (CABG) surgery was recommended. CABG surgery was completed 4 months after initial complaint. The patient began cardiac rehabilitation with a local physical therapist following surgery. At this time the patient reported that his chief complaint of right periscapular and lateral rib cage pain remained the same. The patient was referred to interventional pain medicine and spinal magnetic resonance imaging (MRI) of unknown regions was performed. These investigations revealed findings consistent with the patient's age and no definitive causation of pain was determined. The patient underwent two thoracic nerve block procedures which yielded no substantial benefit with relief lasting only a few days. The patient was prescribed opioid medication which provided appreciable relief; however, the patient did not like taking this medication and wished to avoid taking them long term. The patient was subsequently referred for chiropractic care following a cardiac rehabilitation session in which the physical therapist noticed prominent right scapular winging.

The patient presented for initial chiropractic evaluation 8 months following initial onset. Pain was reported to fluctuate between 5-8/10 on a numerical pain rating scale. The patient reported pain constant in nature which intensified in the evening. Provocative activities included raising the right arm and applying direct pressure to the

shoulder blade region, such as sitting against the back of a chair. The patient reported noticing discomfort while seated against the back of a chair soon after initial onset of pain, and described that prominent right scapular winging was noticed by a family member as well at this time.

Physical examination revealed thoracic spine ranges of motion grossly within normal limits with pain noted at right rotational end range. Cervical ranges of motion were reduced in bilateral lateral flexion, extension, flexion, and bilateral rotation. Shoulder ranges of motion were grossly within normal limits bilaterally. Palpation revealed tension and tenderness in the cervical and thoracic paraspinal musculature, greatest at the right levator scapula and right serratus anterior regions. Passive joint motion palpation revealed restricted mobility in the lower cervical and upper thoracic spine regions. Sensory examination of the upper extremity was grossly intact to light touch. Gross motor strength testing of the upper extremity was within normal limits. Scapular movements were determined to be reduced and more difficult to achieve on the right compared to left. Visual inspection revealed winging of the right scapula measured at 2 inches on the right compared to ½ inch on the left. (Figure 1) Attempts to obtain past medical records and diagnostic studies were unsuccessful.

Figure 1.
Appearance of marked winging right scapula observed upon initial chiropractic examination. The patient presented for chiropractic evaluation approximately 8 months post onset of symptoms.

Clinical diagnosis

A working diagnosis was established with multifactorial consideration, including history and physical examination findings. The patient was determined to be in the chronic musculoskleletal and paretic phase of neuralgic amyotrophy[1]with residual biomechanical pain contributed via paresis of the right serratus anterior. A thorough history and physical examination provided classic criteria indicating the diagnosis of NA, such as sudden onset of severe cervicothoracic/scapular pain initiating at night[1], lack of benefit with various musculoskeletal related interventions[1], presence of winging scapula[1], lack of benefit with cardiac intervention, lack of appreciable sustained benefit from pain management interventions and a reported lack of abnormal findings of visceral origin upon diagnostic studies (in this instance, MRI, CT, and EKG).

Chiropractic management and outcome

The patient was placed on a treatment plan of 3 visits per week for duration of 4 weeks with treatment consisting of spinal manipulation administered to the thoracic spine, myofascial release therapy, and medium frequency electrical stimulation of the serratus anterior with an aim to reduce subjective pain levels. Additionally, scapular function rehabilitation exercise therapy was included in the treatment plan with an objective to reduce functional limitations. A home exercise program (HEP) was established. A lumbar chair support was dispensed and prescribed to be used to encourage proper spinal posture and reduce discomfort associated with sitting in a chair. TENS device was also dispensed to the patient for consideration as a self-care palliative relief strategy. The patient was provided with educational materials regarding the benign nature and treatment options for the management of neuralgic amyotrophy. The patient was referred to his primary care physician for co-management of the patient, particularly in relation to the patient's desire to discontinue his prescribed pain medication. The aforementioned trial of chiropractic care was carried out with which the patient

Table 1.
Comparison of hallmark features and case specific features of neuralgic amyotrophy

Hallmark features of neuralgic amyotrophy	**Case Descriptors**
Males more common than females[8]	Male
Most often presents in 2nd, 3rd, 7th decades of life[8,9]	85 years of age
Initial onset characterized by abrupt severe pain often at night[1,2]	Initial onset of severe pain in early morning hours while in bed
May present in otherwise healthy individuals[2]	Past medical history unremarkable; patient reported healthy lifestyle
Patchy paresis often in serratus anterior and/or trapezius with secondary musculoskeletal asymmetries and faulty movement patterns[1]	Prominent winging scapula and scapular dyskinesia
Sensory deficits presenting in non-dermatomal pattern atypical in location in relation to nerve distribution associated with involved muscle paresis which may last for weeks to months.[1,7]	No sensory deficits appreciated at time of chiropractic evaluation at 8 months post-onset
No gold standard laboratory, diagnostic, or specific imaging test to give a definitive diagnosis[7]	EKG, CT, MRI revealing no causation
Best treatments focus on manual and rehabilitation therapy, NSAIDs, opioids[7]	Patient failed to show appreciable relief of chief complaint with CABG surgery and two thoracic spine nerve block procedures; Patient obtained reduction in pain complaints with pain medication and manual/rehabilitation treatments

was willing and compliant. Upon completion of the initial treatment plan, a re-evaluation was performed revealing no appreciable change in objective clinical findings. Numerical pain rating scale revealed improvement in pain levels, recorded at 0-1/10 at time of re-evaluation; though the patient reported daily fluctuation of pain, which some days reached a 7/10 rating. The patient expressed subjective value in pain relief and functional ability at this time, reporting ongoing treatment and HEP compliance provided adequate pain relief comparable to relief obtained from previous opioid medication usage. The patient was recommended continued care for palliative relief aligning with the patient's values of maintaining non-prescriptive pain relief interventions. The patient elected to continue chiropractic care on an as needed basis with continuation of a daily HEP. The patient adhered to this treatment plan, presenting for an additional 18 chiropractic visits, and reported abrupt spontaneous resolution of symptoms six months after beginning chiropractic care.

Discussion

Presentation

This case supplements two other known cases reported in the literature of chiropractic management of NA. Our case is unique in that it exemplifies the elusiveness of proper and timely diagnosis of NA and illustrates the potential of multiple and possibly unnecessary interventions for this particular syndrome. The patient in this case presented with symptoms often typical to initial onset of NA such as severe acute onset of pain located in the shoulder girdle and thorax/rib area which began in the early morning hours while in bed. Patients presenting with NA report cervical, shoulder, and/or arm pain in 96% of all cases. Pain levels are high and 90% of patients grade their initial onset of pain at 7 or greater on a Numerical Rating Scale.[1] Pain most commonly is reported at night and often there is no means of palliative relief at this time, with their pain spontaneously lessening. The pain can also present

with an intermittent onset and can take up to 3 weeks to transition out of the acute onset phase.[1,7] During the acute phase, pain fails to respond well to traditional palliative treatments.[7]

Once the acute onset stage is over, paresis and subsequent local musculoskeletal dysfunction and possible atrophy most often will occur.[1] While NA patients often have several symptoms including pain, paresis, shoulder dysfunction, and atrophy, they are not all necessarily consistently present at the same juncture[1] or periods of time in any given presentation. When present, shoulder girdle dysfunction results from scapular instability due to the functional loss of the serratus anterior, rhomboid, or the trapezius muscles.[1] The majority of patients will experience additional periods of pain once the initial onset is over.[1] These subsequent pain experiences are thought to be the result of two consequences of the NA syndrome process. First, the irritated or injured nerves in the plexus can result in amplified mechanical sensitivity, producing neuropathic pain in the affected nerves' regions from increased strain on them with extension, abduction or elevation of the arm. This may last from a few weeks up to months in any given case.[1] Secondly, due to the dysfunction associated with local neuromsuculoskeletal tissue such as local shoulder girdle muscular paresis, proper biomechanics may be strained and place excessive stress on compensating musculature resulting in ongoing pain throughout the progression of NA.[1]

Differential diagnosis

A thorough physical exam should be specific and complete to help distinguish between the multiple conditions which may present with similar features as NA. One of the hallmark signs of NA presenting in the upper extremity is substantial scapular winging and scapular dyskinesia. Though serratus anterior paresis is commonly thought to be the main offended musculature resulting in musculoskeletal asymmetry/abnormalities, other muscles of the shoulder girdle may be affected resulting in presentations. For example, trapezius paresis may cause an appearance of a depressed shoulder and scapular sagging.[1] Many patients will subsequently develop musculoskeletal related pain in the region of the compensating musculature, often including periscapular region.[1]

Sensory examination of NA patients may reveal a non-specific pattern that is not consistent with localization of pain or regular dermatomal distribution related to the paresis of affected musculature[7], though could show pain with palpation of the affected peripheral nerve. However it is important to recognize that sensory deficits and hypersensitivity may dissipate in weeks to months post-onset.[1]

NA is a clinical diagnosis and does not have a gold standard laboratory, diagnostic, or specific imaging test to give a definitive diagnosis[7] though some studies suggest utilization of electroneuromyography and magnetic resonance imaging (MRI) may be helpful in confirming diagnosis.[4] Previous studies have reported appreciable change in electroneuromyography studies identified as early as three weeks post onset of symptoms.[4,13] These alterations typically entail acute denervation and suggestion of situational axonal degeneration.[4] Though these studies are sensitive for identifying denervation, assuming NA will lead to denervation might only be partially accurate as sampling error leading to a negative study is possible.[7]

Sensory nerve conduction studies have also been shown to be a poor study in assessing for the presence of NA. These studies have been reported to fail to show abnormalities in 80% of patients with NA, even when the affected nerves are examined.[7] Thus, a normal sensory nerve conduction study should not eliminate the inclusion of NA in the differential diagnosis.[7] MRI findings associated with NA include intramuscular edema and muscle atrophy, which may show associated fatty infiltration.[4,14,15] It is important, though, to emphasize the notion that diagnostic studies indicating these findings should be viewed as only one piece of the entire clinical picture. These diagnostic studies results should not be used to rule out the clinical diagnosis of NA, but can be used as additional rationale for the confirmation of the diagnosis.[16]

In this case, the patient reported prior diagnostic studies, though could only recall the use of electrocardiogram, computed tomography, and magnetic resonance studies. It is not known if an electroneuromyography study was administered. It appears that diagnostic studies utilized in this case provided ability to aid in confirmation of NA diagnosis.

In spite of the many conditions that may be considered part of the differential diagnosis, a meticulous history and physical exam should help to distinguish NA from other considerations.[7] Nonetheless, NA and its diagnosis seem

to be relatively foreign to many health care providers[7] and delayed diagnosis, misdiagnosis and mismanagement are not uncommon. In this case, the patient completed multiple treatment options for several months with minimal relief. The patient in this case identified as presenting with common features associated with NA and responded well to a subsequent course of chiropractic treatments and self-care treatments for ongoing management of symptoms.

Management and Prognosis

Failure to properly identify neuralgic amyotrophy, particularly in the acute phase, can lead to substantial mismanagement and potential for suffering for several weeks. Approaches to care may focus primarily on conservative treatment options including manual and rehabilitation therapy, as well as traditional medical treatment options including long acting non-steroidal anti-inflammatory medications, opioids, and corticosteroid injection.[7,17,18] During the initial unrelenting pain presentation there is only pharmaceutical options and corticosteroid injection that have been shown to potentially manage symptoms and hasten recovery.[1,7,17,18]

Manual and rehabilitation therapy may be indicated due to the biomechanical changes that ensue in the latter phase of NA. The objective of these treatments is to stabilize the musculoskeletal system about the area of insult. Often NA presents in the lower neck and shoulder region and thus typical therapy involves stabilizing the scapula by strengthening the various muscles around the shoulder girdle.[1] The serratus anterior muscle is frequently a site of local paresis and presents a hurdle for therapy creating an inability to produce and maintain proper shoulder mechanics and muscular endurance. Thus, a graded progression must be utilized to allow for strengthening while not fatiguing the muscles to the point that they contribute to further shoulder and scapular dysfunction. Improving stabilization about the shoulder girdle and reducing the presence of scapular winging is important in the long-term success of patient suffering from NA. Potential goals of treatments aim to restore faulty movement patterns and reduce biomechanical imbalances that may have resulted from adaptive alterations from NA.

Various other treatment options have shown some indication for continued study to further assess for their ability to aid in the management of NA patients. There is some thought of autoimmune influence in the manifestation of NA and thus some treatment efforts have been focused on associated management with immunomodulants such as prednisone, intravenous immunoglobulins and other prophylactic immunotherapies.[7] However, few studies have been conducted in this area of NA management and to date there is no conclusive evidence to recommend this mode of intervention. Surgical intervention for NA patients suffering from substantial nerve injury, consisting of hourglass constriction (shown by intraoperative visualization or nerve ultrasound), has shown some preliminary success.[7,19,20] Future studies are still needed, though, to determine if surgical intervention is a viable routine treatment option.[7]

Patients generally regain strength in affected paretic muscles, though roughly one-third of NA patients still report some form of dysfunction or symptom even six years post initial presentation.[1,7] Previous studies have shown no well-defined link between neurological considerations and functional outcomes or a specific natural course; though studies have identified a strong association between persistent pain, fatigue and the presence of scapular instability.[7,21,22]

Limitations

This is a case report which only describes the findings of this individual case. The findings of this study cannot be generalized to other patients or the general public. Resolution of symptoms in this case may not have been related to chiropractic care and may have been due to the natural progression of NA. In this case there was no availability of past medical records or diagnostic studies for review. This case relied heavily on communication with the patient and obtaining a thorough patient history, which is subject to potential recall bias.

Summary

This case features the importance of timely recognition and proper diagnosis of NA. Recognition of NA can be difficult due to the nature of NA as a clinical diagnosis which does not have a gold standard laboratory, diagnostic or specific imaging test to establish a definitive diagnosis, and the fact that it mimics so many other etiologies. Prompt recognition of common features associated with NA and differentiation from other diagnostic considerations can be appreciated with a thorough history and examination, which identifies the classic criteria for a

diagnosis of NA. Prognosis is commonly characterized by fragmented recovery from symptoms associated with NA, with a potential for an extended length of time for resolution and recurrence and continued reports of some degree of residual dysfunction are common even up to several years after initial onset.

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Selecting and training opinion leaders and best practice collaborators: experience from the Canadian Chiropractic Guideline Initiative

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Objectives: *To describe the process for selecting and training chiropractic opinion leaders (OLs) and best practice collaborators (BPCs) to increase the uptake of best practice.*

Methods: *In Phase 1, OLs were identified using a cross-sectional survey among Canadian chiropractic stakeholders. A 10-member committee ranked nominees. Top-ranked nominees were invited to a training workshop. In Phase 2, a national e-survey was administered to 7200 Canadian chiropractors to identify*

Objectifs : *Décrire le processus permettant de choisir et former les leaders d'opinion (LO) et collaborateurs des pratiques d'exemplaire (CPE) en chiropratique dans le but de favoriser l'adoption des pratiques d'excellence.*

Méthodologie : *Lors de la première phase, on a désigné les LO au moyen d'une enquête transversale parmi les intervenants canadiens de la chiropratique. Un comité composé de dix membres a classé les candidats. Les candidats les mieux classés ont été invités à un atelier de formation. Lors de la deuxième phase, 7 200 chiropraticiens canadiens se sont soumis à une enquête nationale en ligne visant à désigner d'autres LO et CPE. Les noms recommandés ont été présélectionnés par les LO et le choix final s'est fait*

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additional OLs and BPCs. Recommended names were screened by OLs and final selection made by consensus. Webinars were utilized to train BPCs to engage peers in best practices, and facilitate guideline dissemination.

Results: *In Phase 1, 21 OLs were selected from 80 nominees. Sixteen attended a training workshop. In Phase 2, 486 chiropractors recommended 1126 potential BPCs, of which 133 were invited to participate and 112 accepted.*

Conclusions: *OLs and BPCs were identified across Canada to enhance the uptake of research among chiropractors.*

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KEY WORDS: chiropractic; change agents; opinion leaders; survey; selection; training

d'un commun accord. On s'est servi de webinaires pour former les LO à encourager leurs pairs à adopter des pratiques d'excellence et faciliter la diffusion des lignes directrices.

Résultats : *Lors de la première phase, on a choisi 21 LO parmi 80 candidats. Seize d'entre eux ont assisté à un atelier de formation. Lors de la deuxième phase, 486 chiropraticiens ont recommandé 1 126 LO potentiels, parmi lesquels 133 ont été invités à participer et 112 ont accepté.*

Conclusions : *On a désigné des LO et CPE à l'échelle du pays pour favoriser l'adoption de la recherche parmi les chiropraticiens.*

(JCCA. 2017;61(1):53-64)

MOTS CLÉS : chiropratique, agents de changement, leaders d'opinion, enquête, choix, formation

Background

Clinical practice guidelines (CPGs) are widely recognized as a foundational tool to inform clinical decision making.[1] When followed, CPGs have the potential to improve health outcomes, as well as the efficiency of the health care system.[2,3] Low adherence to CPGs for the management of musculoskeletal disorders and spine care in particular contributes to a wide variation in services seen across several health disciplines including chiropractic.[4-7] Implementing guidelines typically requires change at multiple levels, including attitudinal and behavioural change by clinicians and promoting use of CPGs by stakeholders (e.g., governing bodies and professional associations).[8]

The Canadian Chiropractic Guideline Initiative (CCGI) was launched over a decade ago by the national chiropractic professional organizations in Canada in order to develop CPGs to improve quality care[9] and decrease the burden of musculoskeletal disorders[10]. The mission of the CCGI is to develop, disseminate and help implement CPGs among Canadian chiropractors.[11]

Prior work explored the determinants of guideline adherence among health care professionals using the Theoretical Domain Framework (TDF)[12], a framework previously applied in a wide range of disciplines, settings and contexts[13]. Interviews of chiropractors and professional leaders in Canada[14,15] suggested that guideline adherence is potentially influenced by the theoretical domains of social influence and social/professional role and identity. In other words, the set of behaviours and personal qualities displayed in social or work settings (social influence) and the processes existing between people that have the potential to influence thoughts, feelings or behaviours (social/professional role and identity) can lead to behaviour change.[16] Mapping of Behaviour Change Techniques (BCTs)[17] on to these theoretical domains suggested that social processes of encouragement, pressure, support, and modeling/demonstration of behaviour are important techniques for changing professional behaviour[15]. Change agents (people who, by the nature of their position or abilities are particularly capable of promoting change) are well suited to accomplish these BCTs. This is partly because peer pressure to conform to social norms affects behavioural intention, an important predictor of individuals' behaviour.[18]

Implementation research supports the use of change agents, including practitioners, to deliver evidence-based recommendations and programs to improve the quality of care.[19,20] Opinion leaders (OLs) are individuals who have formal or informal influence on the attitudes, beliefs and

behaviours of their colleagues and stakeholder organizations.[21,22] Generally viewed by their peer group as likeable, trustworthy and influential, OLs play an important role in promoting health care initiatives, in leveraging established relationships to create access points within a target community, in communicating key messages[23], and in demonstrating and reinforcing desired behaviour[24]. As respected members of a community, their spheres of influence provide an opportunity for long-term subsistence of an initiative, long after active intervention has concluded.[25] Reviews on the effectiveness of OL interventions suggest that a 12% absolute increase in compliance with an intervention may be expected when using OLs to promote evidence-based practice.[26]

By extension, best practice collaborators (BPCs) can also be seen as important change agents. Here BPCs are defined as individuals who are also seen as caring, knowledgeable and good educators and who assist the OLs in their role. Recognizing the use of change agents as an important strategy to influence professional behaviour change, the current paper outlines the strategy used by the CCGI to identify and train OLs and BPCs to promote the use of best practice within the Canadian chiropractic profession broadly (i.e., practicing chiropractors and leaders of national and provincial associations, regulatory boards, liability insurance carriers, and other stakeholders).

Methods

Phase 1: Opinion Leaders

The aim of Phase 1 was to appoint OLs to assist the CCGI with the dissemination and implementation of CPGs among Canadian chiropractors and support professional leaders engaged in the process of guideline implementation.

Study design

A cross-sectional research design was employed to identify OLs in the chiropractic profession in all 10 provinces across Canada.

Participants and recruitment

CCGI stakeholders, professional leaders of national and provincial chiropractic associations and regulatory boards in Canada (n=50) who attended an annual meeting in February 2014 were asked to complete a survey questionnaire.

Survey questionnaire

The questionnaire asked participants to provide up to three names of Canadian chiropractors they felt to be suitable to serve as OLs as well as their reasons to nominate. Nominations were based on the chiropractors' skills and attributes, specifically, whether they were educationally influential, knowledgeable and humanistic, along with their sphere of influence (i.e., clinicians and/or professional leaders/decision makers)(Appendix 1).[27]

Data collection

For each nominee, general demographic and practice data were collected from internet searches on publicly available search engines such as Google and social media, the practitioner's clinic website and provincial/regulatory websites. Data gathered from these searches were complemented by information provided by the members of the selection committee based on knowledge of the candidate through prior work (described below). A candidate profile was established in an Excel spreadsheet for each nominee, including their gender, the number of years in practice, their participation (or not) in continuing education activities, presentations given to their peers, academic and publication record, and the presence/absence of prior liability issues or regulatory complaints.

Data analysis

A 10-member selection committee of CCGI stakeholders was established to review the candidate profiles. To obtain a wide range of views, perspectives and professional experience, the committee was composed of a purposive sample from diverse geographical settings including members of a chiropractic specialty college (n=2), a field practitioner (n=1), academics (n=2), leaders from provincial associations and regulatory boards (n=3), and researchers (n=2).

To guide the selection process, committee members considered pre-established criteria adapted from Rycroft-Malone[27] to help inform their selection, including geographical location, past and current level of engagement with the profession, availability, attitudes and beliefs toward evidence-based practice and CPGs, and prior teaching experience. Other desirable attributes included

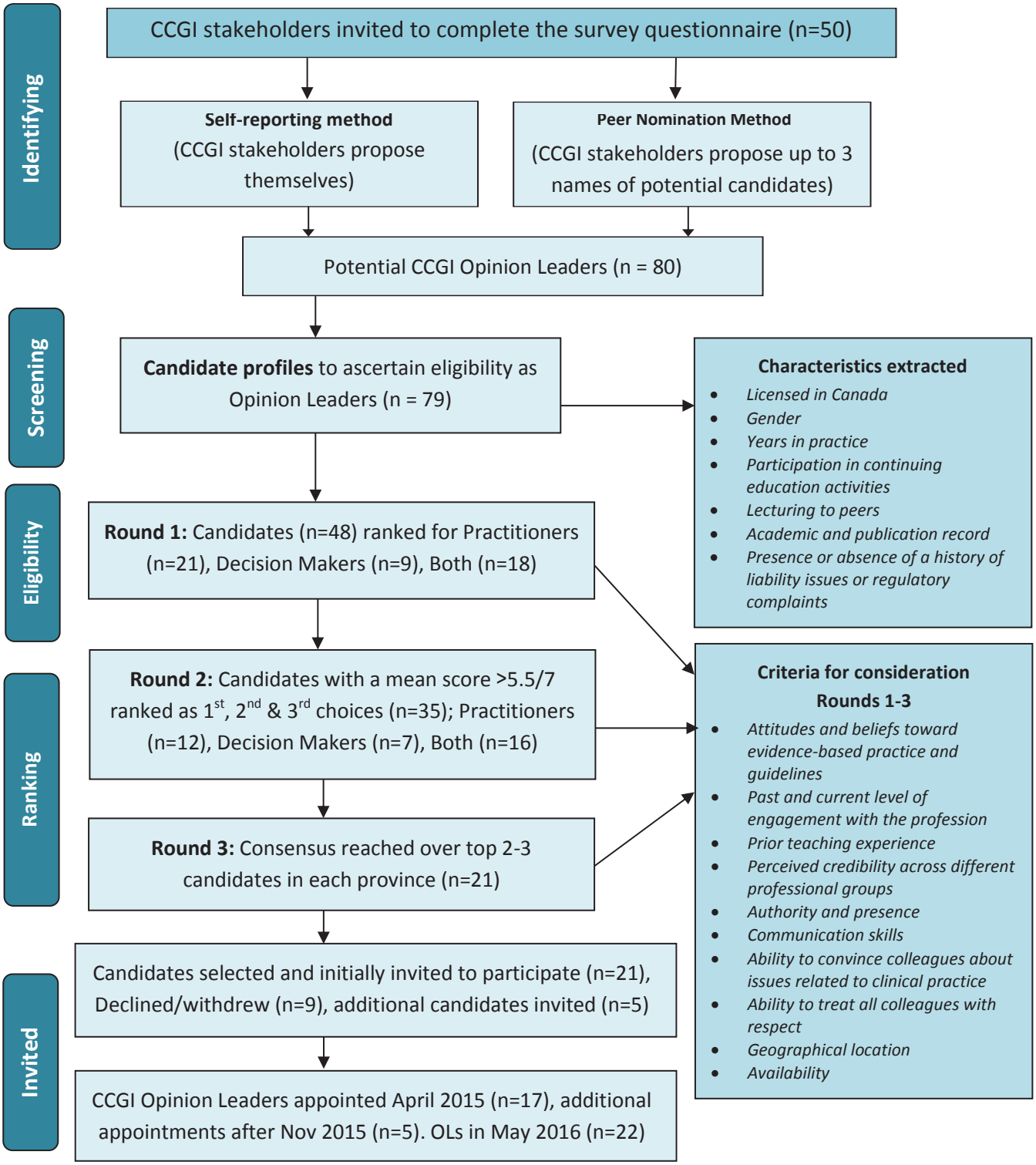

Figure 1.
Flowchart illustrating the systematic process used to identify Canadian chiropractic OLs.

being perceived as being credible and/or as an authority figure by their peers, having good communication skills, treating all colleagues with respect, and being capable of influencing colleagues about issues related to clinical practice (Figure 1). Potential OLs needed to have experience dealing with a range of practicing chiropractors (e.g. working in solo vs. multidisciplinary practices, those with an evidence-based vs. alternative philosophy, and non-specialist vs. specialist chiropractors) and different professional groups.

The committee formally met online on three occasions between June and August 2014 to undertake a two-round consensus process to identify nominees that would be invited to become OLs. In round 1, members of the selection committee considered the above criteria to rank candidates using a Likert scale from 1-7 ("1" = strongly disagree and "7" = strongly agree) on their likelihood of being influential toward practitioners and/or stakeholders. Mean scores were calculated and candidates with scores over 5.5 out of 7 were considered in the next round. In round 2, names retained were grouped by province and ranked by committee members as first, second and third choices. In round 3, committee members reached consensus over the top 2-3 candidates. These were then invited by e-mail to serve as OLs. A follow-up call was made by the project lead (AB) to provide detail about the OL program and answer any questions they had about the program. Other nominated individuals were kept in the retained list.

Results

CCGI stakeholder survey response rate was 38% (19/50), providing names of 80 potential OLs (Figure 1). One candidate was from the US and was excluded. In round 1, median scores across identified potential OLs were 5.19 (0.73) for 'Practitioners' and 5.44 (0.75) for 'Leaders/decision makers'. To retain 40% of potential OLs, candidates with scores of 5.5 or above (n=48) were considered in the next round, including OLs for 'Practitioners' (n=21), 'Leaders/decision makers' (n=9) or nominated in both categories (n=18). In round 2, 35 candidates ranked as either first, second and third choices were retained for the following round, including potential OLs for 'Practitioners' (n=12), 'Leaders/decision makers' (n=7) and 16 for both 'Practitioners' and 'Leaders/decision makers' roles. In round 3, the selection committee made final recommendations for 21 OLs, including two in each province with the exception of a larger province (three in Ontario and Quebec) and a smaller province (one in Prince Edward Island). Of the 21 clinicians and professional leaders/decision makers in the profession who received an invitation letter to become a CCGI OL, 5 declined due to time constraints or lack of interest. Five alternate candidates were invited from the retained list and, of these, 4 withdrew for similar reasons, leaving 17 OLs. Because some new OLs admitted to having limited availability for this project, additional appointments were made from the retained list in November 2015 for Nova Scotia (n=1), and in March 2016 for Saskatchewan (n=1) and Alberta (n=3), bringing the total number of OLs in place to 22 by May 2016. The names of OLs in each province are available at: http://www.chiropractic.ca/guidelines-best-practice/about-us/meet-the-team/opinion-leaders/.

Training workshop for Opinion Leaders

Sixteen OLs were available to attend a one-day workshop in Toronto, Ontario in February 2015. While participation in the OL program is voluntary, traveling expenses were reimbursed. The session was co-developed and delivered by a Certified Executive Leadership Coach with the assistance of three academic researchers with clinical training in chiropractic (AB, MM, DG) and one chiropractor and medical student (SB) and a research manager. Content of the workshop was informed by the literature and addressed five essential activities of the implementation process: engaging, planning, reflecting, executing and evaluating.[28] The workshop objectives and agenda can be found in Appendix 2.

Two weeks prior to the workshop participants received an online invitation to complete the Strength Deployment Inventory (SDI®), a tool aimed at assessing self-awareness, conflict resolution and team functioning strategies.[29] During the workshop, the Certified Executive Leadership Coach presented the results of the self-assessments, aiming to raise the self-awareness of participants and forming the basis for enhancing their ability to communicate more effectively, handle conflict more productively, and improve relationships. This was further explored in the context of the roles and personal qualities of effective OLs.

Participants were asked to identify stakeholders who they could directly or indirectly influence. Participants

were then divided into three groups to identify potential audiences they had access to regionally (e.g. patients, decision-makers, clinicians, multidisciplinary teams) and determine those upon which they had the most/least influence.

After a brief overview of the content of the CCGI website (www.chiroguidelines.org), participants were given time to explore its resources and tools. Comments received in the end-of workshop feedback questionnaire suggested that this activity successfully addressed an important need of OLs to become familiar with CCGI tools and resources on CPGs and EIP.

To provide insight about the OLs' expectations about their participation in the workshop, attendees were asked to do a '3-2-1 exercise', listing three important things they had learned during the workshop, two questions they felt remained unanswered, and one suggestion for next steps. Results from the exercise indicated a need for additional resources to help with their tasks, such as summaries of key guideline recommendations, PowerPoint presentations for board meetings or continuing educational events, a Question and Answer sheet to address potential questions by clinicians, and patient handouts and posters. Participants were invited to draft an 'Opinion Leader Action Plan' to identify upcoming opportunities of influence and to outline the perceived needs for resources from the CCGI.

A detailed summary of the workshop was forwarded to the participants with an invitation to attend a follow-up teleconference call. During periodic follow-up teleconference calls, OLs provided updates on their progress and their plans for dissemination in their respective provinces.

Phase 2: Best Practice Collaborators

The aim of phase 2 was to confirm the additional OL selection and appoint additional OLs and BPCs to complement and assist trained OLs.

Study design

A descriptive cross-sectional survey was conducted online 20 months after phase 1 (REB Approval: 1507X01, Canadian Memorial Chiropractic College).

Participants and recruitment

An invitation to complete a 10-minute national online survey was sent by the Canadian Chiropractic Association (CCA) by e-mail to all members with a valid e-mail address (n=7200). It included a description of the study and a link to access the survey. Those who returned their completed survey were eligible to win one of two $100 Indigo gift cards.

Survey questionnaire

The survey was adapted from Hiss' sociometric questionnaire administered to care providers[30,31] and was divided into four sections (Appendix 3). Section I contained eight questions to find out how respondents give/receive information from colleagues (e.g. In general, do you talk to other chiropractors about clinical or professional issues in chiropractic practice?). They had to indicate, on a 5-point Likert scale, the answer that best represented their behaviour ("1" = Never and "5" = Very often). In section II, respondents were asked to provide the names of three chiropractors in their province who best fit the following roles: educator, knowledgeable practitioner, and caring professional. In section III, the survey asked respondents to suggest up to 18 names of colleagues they would turn toward for: 1) their ability to give good advice, 2) discussing challenging cases, 3) information on referrals resources, and 4) socializing. Section IV asked 10 demographic questions about participants and their practice.

Data collection

Data collection took place over a three-week period in the fall of 2015. The survey was available in English and in French and delivered on FluidSurveys (www.fluidsurveys.com). Data was submitted by respondents electronically immediately after completion and a list of all the proposed names of CCGI collaborators were entered into an Excel spreadsheet by province.

Data analysis

To further refine the list of names proposed by clinicians, OLs selected in phase 1 were asked to indicate if they considered the individuals nominated as potential BPCs had the skills and attitudes required to help accomplish their tasks to promote EIP, guidelines and best practice. They were asked to classify the nominees in one of three categories: 1) In my opinion, this candidate carries influence over their peers in the area of evidence-informed practice; 2) In my opinion, this candidate does not carry influence over their peers in the area of evidence-informed practice;

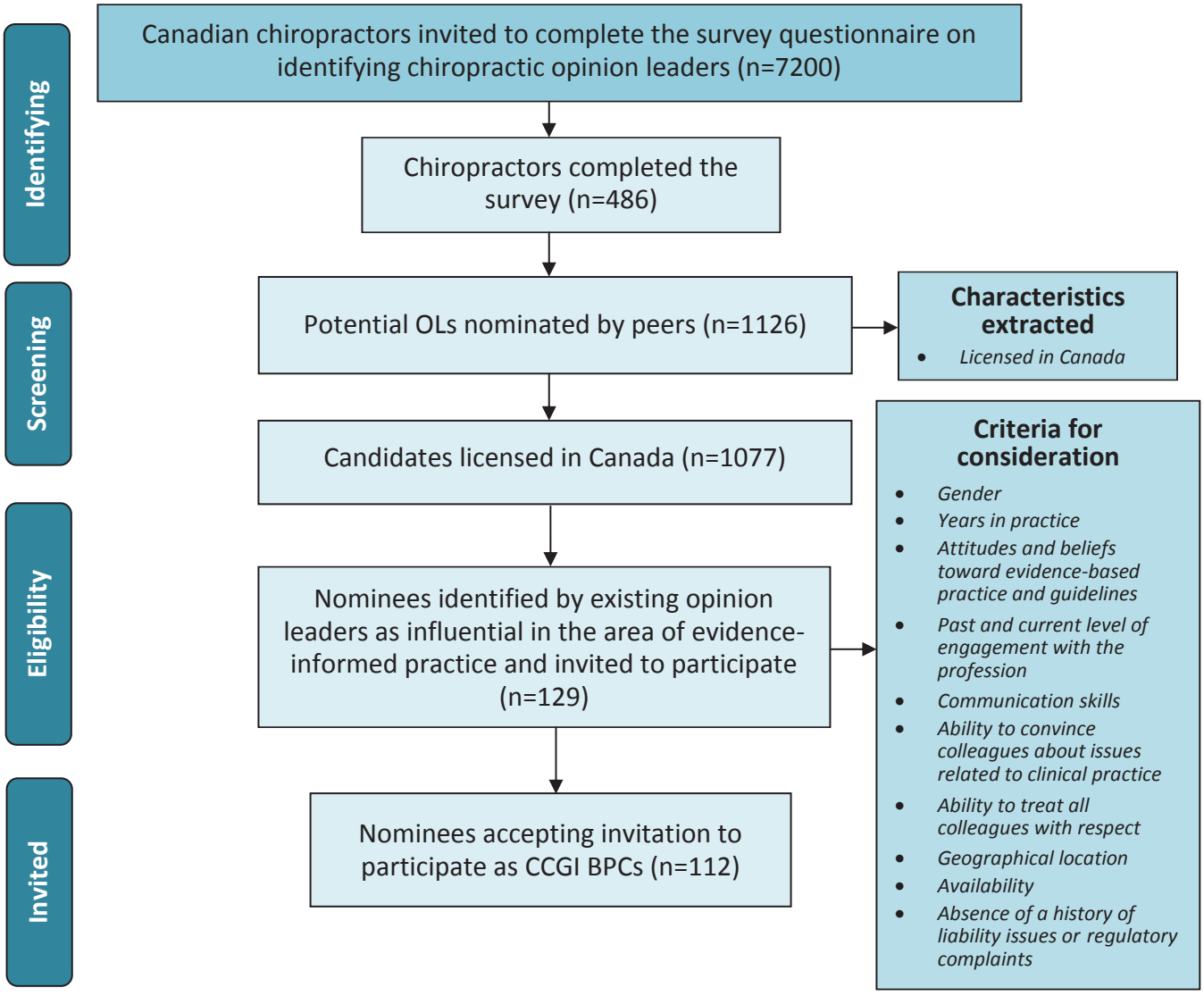

Figure 2:
Flowchart illustrating the systematic process used to identify CCGI BPCs

or 3) I do not know this person. Individual opinion leaders in each province then independently rated the nominees who they knew in their region, and who they classified in the first category mentioned above. Best-rated candidates were placed on a short list based on personal knowledge of OLs and Phase 1 criteria. Final selection of short-listed nominees was made by consensus by the existing team of OLs in each province during a teleconference. The number of nominees selected varied according to context (e.g. size of the province) and perceived local needs (e.g. distance between communities).

Results

A total of 486 Canadian chiropractors submitted their completed survey, providing a response rate of approximately 6% (Figure 2). Results indicate that a majority of respondents were male (53.7%), between the age of 25 and 45 years (66.0%), and in full time practice (86.4%)

Table 1:
Profile of survey participants (November 2015)

Characteristics	Proportion n (percentage)
Gender (n=339)	
Male:	182 (53.7%)
Female:	157 (46.3%)
Work Status (n=339)	
Part-time (< 12 hrs/wk):	46 (13.6%)
Full-time:	292 (86.4%)
Age (n=339)	
25-45:	224 (66.0%)
46-65:	115 (18.9%)
Practice location/Province (n=347)	
Ontario:	154 (44.3%)
Quebec:	59 (16.7%)
British Columbia:	46 (13.3%)
Alberta:	46 (13.3%)
Manitoba:	17 (5.0%)
Saskatchewan:	9 (2.6%)
Nova-Scotia:	9 (2.6%)
New-Brunswick:	5 (1.4%)
Newfoundland/Labrador:	2 (0.5%)

(Table 1). The largest percentage of participants was from Ontario (44.3%). Survey respondents volunteered names of 1077 colleagues from Canada, 47 individuals from the US and 2 from the UK. Among these, 338 were nominated between 2-3 times, 132 between 4-7 times and 36 people over 8 times. All but one of the OLs selected in phase 1 were nominated within the top five choices in their province. OLs in place helped reduce the list to 129 names they believed had favourable attitudes and skills to assist them with their tasks as CCGI OLs. The potential BPCs received a letter informing them of the results of the survey and were asked if they were interested in collaborating with OLs in their respective province. A total of 112 chiropractors accepted the invitation to become BPCs. The list of names is available at: https://www.chiropractic.ca/guidelines-best-practice/about-us/meet-the-team/best-practice-collaborators/.

Training of Best Practice Collaborators

BPC nominees in each province were invited to attend a 45-minute webinar describing the mission and related strategies of the CCGI, the current role of OLs, and their potential contribution as BPCs (Table 2). BPCs were asked to help OLs promote the use of best practices using their own network of colleagues. OLs were encouraged to engage with new BPCs to discuss respective views about the CCGI mission and strategies, possible roles and contribution of collaborators and their availability for future guideline dissemination projects, as well as to ensure that they have access to and become familiar with the CCGI bilingual website, available tools (e.g., online learning modules on EIP and guidelines) and resources. Participation in these various activities aims to provide BPCs with a baseline understanding of the work of the CCGI and to help them perform their new role. A Competency Development Program was developed for OLs and BPCs along with associated performance indicators, including topics such as demonstrating adequate knowledge, effective communication and ability to develop networks with colleagues to help disseminate best practice (Appendix 4).

Discussion

Chiropractors across Canada occupying key positions within provincial, national and international organizations and academic institutions were identified and trained to serve as OLs or BPCs. In addition to facilitating the uptake and application of guidelines to improve chiropractic patient care within their networks, these individuals will help raise the credibility and visibility of the CCGI.

Engaging team members tasked with implementing best practice and guidelines is often-overlooked.[32] It is vital that members be carefully and thoughtfully selected or allowed to rise naturally, especially those considered to be 'implementation leaders' and 'champions'.[22] The decision about who to invite as OLs and BPCs for this project was informed by the scientific literature[27,30,31] and group consensus. There are different conceptualizations of OLs[21,33], one of which proposes that there are two types of OLs: experts and peers. Expert OLs exert influence through their authority and status, while peer OLs exert influence through their representativeness and credibility.[34] CCGI OLs and BPCs include a mixture of these types, and results from the stakeholder survey undertaken in phase II affirmed the committee's selection.

Table 2:
Roles and activities of CCGI Best Practice Collaborators

Canadian Chiropractic Guideline Initiative
ADVANCING EXCELLENCE IN CHIROPRACTIC CARE

Roles and activities of CCGI Best Practice Collaborators

Education

- **Discuss key guideline recommendations** with clinicians;
- **Support the implementation of best practice** among the profession in their own area, in collaboration with existing local CCGI opinion leaders;
- **Participate in or lead activities, groups or events.** (e.g. make presentations or assist with workshops on EIP at continuing education events or conferences in partnership with the local CCGI OL/BPC team);
- **Have a presence on social media** (e.g., LinkedIn, CCGI YouTube) to encourage awareness of available CCGI resources;
- **If teaching, introduce learners to EIP** by including it in coursework and highlighting the importance of EIP for clinicians in practice.

Advancing the profession

- **Raise awareness of the most recent research and encourage clinicians to use it in practice.**

Relationship building

- **Build relationships** through regular communication with various stakeholders (e.g.: clinicians, fellow BPCs/OLs);
- **Create networks** to encourage clinicians and stakeholders to follow CCGI;
- **Share your own experiences with other BPCs and OLs** regarding knowledge translation (KT) strategies used within respective context and setting;
- **Encourage clinicians** to learn about and discuss EIP principles and guideline recommendations;
- **Encourage clinicians to use CCGI tools and resources**;
- **Inform on how/where to access reliable information** on CPGs or EIP principles;
- **Address concerns clinicians express** about EIP principles and guideline recommendations.

Table 3.
CCGI Opinion Leader and Best Practice Collaborator activities since 2015

Province	Event	Date
Ontario	OLs presented EIP to chiropractic students in different contexts at the Canadian Chiropractic Memorial College and showed where and how to access information, tools, resources on the CCGI website. OLs also presented the CCGI mission, strategies, and website to CMCC board members to raise awareness of the benefits for future chiropractors.	Sept 2015-ongoing
Québec	OLs presented the concept of EIP to clinicians at provincial meeting.	Sept 2015
Prince Edward Island	Workshop was held for clinicians to show them how to navigate the CCGI website and access numerous tools and resources, such as CPGs.	Sept 2015
Newfoundland & Labrador	OL meeting with provincial and national politicians to explain how chiropractic could be used more efficiently in a primary care setting and how guidelines can be used to promote best care. OLs explained to insurance company representatives the guidelines development process and how these may be used to increase guideline adherence.	Sept 2015
New Brunswick	Letter sent to family doctors to raise awareness of the chiropractic guidelines and encourage them to either refer to chiropractors when deemed appropriate and to use the guidelines when managing patients with musculoskeletal disorders.	Jul 2016
British Columbia	OLs reviewed the essential components of an evidence- based spine care pathway, which practice-based research network (PBRN) practitioners are expected to follow when receiving referrals from the local hospital- based spine program.	Nov 2016
Manitoba	Presentation to Alberta College and Association of Chiropractors, Red Deer AB	Sept 2016
Nova Scotia	OL and BPC presentation to Annual Maritime Chiropractic Convention and Tradeshow, Halifax NS	Sept 2016
	OL presentation to Collaborative Care Conference, Halifax NS	Nov 2016

Early accomplishments of the OL/BPC program

Although this program is still in its infancy, several activities have already taken place across Canada, including presentations of the EIP approach and CCGI resources to clinicians and chiropractic students, communications with physicians and presentations to insurance companies to raise awareness of the chiropractic guidelines (Table 3).

Next steps

Monitoring the success of this program will be accomplished in multiple ways. For instance, evaluations will be conducted on the implementation process. Process indicators will include the frequency, type and quality of OL and BPC encounters with practitioners and leaders/decision makers, and whether OLs are appropriately supported/equipped/trained to complete their task. Social Network Analysis will be used to map and measure the relationships between actors, the patterns of these relationships, and the flow of resources (e.g., knowledge, support) between actors.[35]

OL and BPCs' roles and activities will be revisited, expanded, refined, and re-evaluated throughout the course of implementation of the program. For instance, the selection committee agreed that the list of OLs should be reviewed every 2 years. Based on achieved outcomes, we may elect to update the selection process and offer tailored training programs to new OL and BPC participants.

The CCGI OL/BPC program has a number of strengths, including a structured process to identify and train chiropractic OLs. Since the context and opportunities for structuring dissemination of CPGs can vary greatly between geographical settings (e.g.: population size, culture, environment – urban vs. rural, professional structures) each region remains independent in the conduct of its activities, the local context being at the core of change implementation, nonetheless promoting the same guideline recommendations.[36,37] This however represents a chal-

lenge in terms of systematic assessment of success. While every attempt was made to maximize the response rate in the survey administered to chiropractors, we are unable to determine the generalizability of our findings to the total population of Canadian chiropractors; this is partly because our sample was a convenience sample of members of the CCA limited to those with e-mail addresses who did not previously opt-out from receiving these. Importantly, it remains to be shown whether this long-term investment strategy will significantly increase uptake of EIP and CPGs in chiropractic and improve chiropractic care and patient health.

Conclusion

The CCGI identified OLs and BPCs across Canada as a strategy to enhance the uptake of best practice and guideline recommendations among clinicians, decision-makers/professional leaders and patients. Respected and influential individuals have been tasked to leverage their spheres of influence to reach out to field clinicians and other stakeholders. This initiative stands to improve the use of research evidence in practice by chiropractors and key leaders in Canada and, ultimately, patient care.

Acknowledgements

We wish to acknowledge stakeholders of the CCGI as well as the OLs and BPCs for their dedication and valuable time devoted to improve patient care in Canada. We also wish to give a special thanks to Alison Dantas, MA, CEO of the CCA, for her valuable contribution to the training workshop, Darquise Lafrenière, PhD, CCGI Knowledge Broker, for co-leading the OL and BPC program, and Heather Owens, MSc, research manager, for all her help in coordinating the activities of this program and for revising this manuscript.

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Pathological burst fracture in the cervical spine with negative red flags: a 12-year follow-up

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Erik Klein, DC[3]

In 2004, a 61-year-old male presented to a chiropractic clinic complaining of neck pain after hearing a 'crunch' when getting out of bed that morning. The initial history intake and physical examination identified no red flags or indications for the patient's pain, with the exception of traction being pain-provoking. Conventional radiographs were ordered, which identified a pathological burst fracture of the fourth cervical vertebra. This Imaging Case Review (ICR) is to provide clinicians with a follow-up to the patient's care and current state.

(JCCA. 2017;61(1):65-67)

KEY WORDS: chiropractic, red flags, multiple myeloma

*En 2004, un homme de 61 ans se présente à une clinique de chiropratique en se plaignant de douleur cervicale après avoir entendu un craquement en se levant du lit le matin même. Au début, les antécédents et l'examen physique n'ont pas permis de déceler de signal d'alerte ou d'indication expliquant la douleur du patient, sauf pour la traction qui provoquait de la douleur. On a procédé à des radiographies traditionnelles qui ont décelé une fracture-*éclatement *pathologique de la quatrième vertèbre cervicale. Cet examen de cas d'imagerie a pour but de fournir aux cliniciens un suivi des soins prodigués au patient et de son* état *actuel.*

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MOTS CLÉS : chiropratique, signal d'alarme, myélome multiple

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Informed consent was obtained from the patient for the publication of this manuscript. All efforts to ensure anonymity have been attempted.

Figure 1.
Anterior-poster open mouth plain film image: read as osteopenic, otherwise normal.

Figure 2.
Anterior-posterior cervical spine: decreased vertebral body height of C4 (arrow), moderate degenerative joint disease of the Lushka and facet joints at C4-5, C5-6, and generalized osteopenia, deviation of the tracheal air shadow to the right.

Figure 3.
Lateral cervical spine plain film image: severe pathologic compression fracture of C4 vertebral body, increase in the AP dimension (arrow) with focal anterior displacement of the retropharyngeal soft tissue, posterior displacement of the posterior wall of the vertebral body compromising the spinal canal, moderate to severe generalized osteopenia, with a decrease in cervical lordosis.

Case Presentation

This case is a follow up on the care the patient received after being sent to hospital by the chiropractor in January 2004 (Figures 1-3).[1] The patient was referred to the local hospital where he underwent a computerized tomography (CT) scan that afternoon. The report identified extensive osteolytic destruction of the vertebral body with extension into the pedicles and superior articular processes. The fracture appeared chronic and included retropulsion of the bone and 50% spinal canal compromise. The radiologist suggested multifocal osteolytic lesions with a chronic pathologic fracture of C4. On the same day, an abdomen and pelvis CT was ordered which showed no intra-abdominal metastasis. For a week following admission to the hospital, the patient received chest radiographs, which identified lobar atelectasis. After two weeks in hospital, his liver enzymes increased, though no cause was found on abdominal ultrasound. By February 4th 2004, he was stable and able to begin chemotherapy through a peripherally inserted central catheter line, which was inserted in the cavoatrial region. On the same day, the patient underwent a cervical and thoracic spine CT to assess for further bony destruction, which revealed that the pathologic fracture had not yet healed. The severe spinal canal stenosis had progressed to 9mm width at its narrowest[2]. The osteolytic lesions had expanded into the ribs and there was greater than 50% bone destruction at C6, and near complete replacement of bone in T5 with erosion through the posterior cortex into the spinal canal. Although the T5 vertebral body height was preserved, the radiologist warned of imminent pathological fracture at that level.

In March 2004, a cervical spine CT with contrast was ordered. The C4 pathological fracture had further collapsed with increased retrolisthesis of C3 on C4. Mild cord compression was noted. By April 2004, these findings had stabilized, and no further progression of findings was noted on monthly monitoring follow-ups. In late August 2004, a cervical spine CT without contrast revealed min-

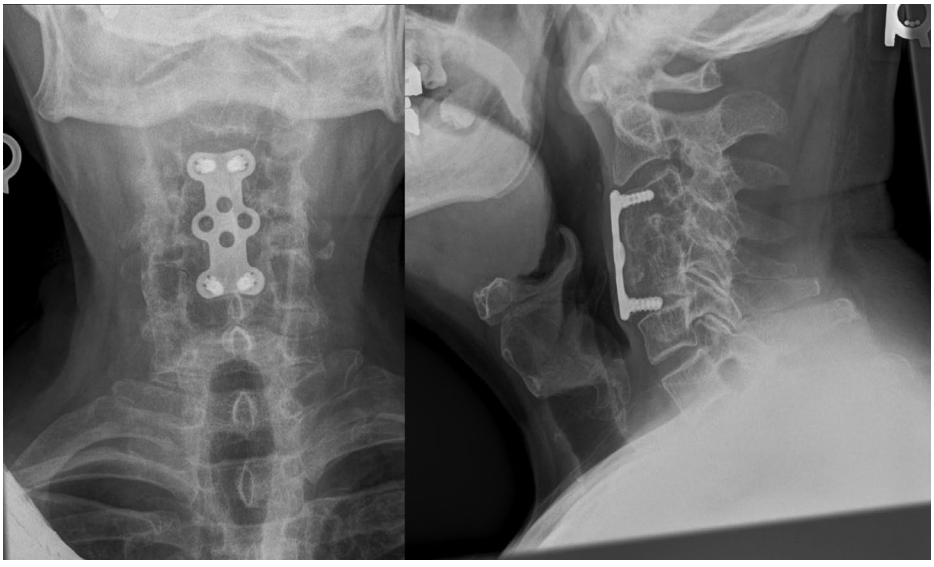

Figure 4.
Stable fusion C3-5, mild degenerative joint disease C5-6, moderate facet arthrosis C2-3, mild facet arthrosis C5-T1, mild osteopenia.

Table 1.
Key imaging features and aetiologies of pathological burst fractures.[2]

Key imaging features:
• Loss of vertebral height on AP and lateral views involving both anterior and posterior vertebral body wall • Interpediculate widening • Possible retropulsion of vertebral body into spinal canal
Aetiologies: metastatic carcinoma, multiple myeloma, Langerhan histiocytosis

or healing had occurred. In September 2004, the patient elected to undergo an internal reduction-fixation with partial corpectomy. The surgery was performed with a metal plate and screws bridging C3-C5. On post-surgical follow up imaging, there remained mild retrolisthesis of C3 on C4 but with marked improvement in alignment and stenosis. Final radiographs performed in late October 2004 confirmed that the fusion was stable without subluxation on flexion-extension views.

The case report on this patient was published in March 2016.[1] The patient is currently receiving follow up assessments every six months from his oncologist and has ceased chiropractic management. The most recent radiographs are shown in Figure 4. The key imaging features and aetiologies for pathological burst fractures are listed in Table 1.

As discussed previously[1] this case serves to emphasize that it is pertinent to recognize the limited accuracy of many orthopaedic tests. In this case, clinical examination failed to reveal a pathologic fracture of the cervical spine that was ultimately identified radiographically. This case further illustrates the need for practitioners to be diligent in their clinical assessment of patients, to be aware of subtle signs of disease processes, and to utilize diagnostic imaging when appropriate in ruling out possible sinister differential diagnoses. These rare cases do present in chiropractic offices and with diligent and attentive care, the likelihood of a positive outcome increases.

Key Messages

- Diligence is essential in the clinical assessment of subtle signs of disease processes
- Although rare, cases of pathologic spinal fractures do present to chiropractic offices
- Radiographic intervention is the diagnostic tool of choice to confirm a pathological fracture

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Grade V acromioclavicular joint separation in a 57-year-old mountain biker

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Patients rarely present to a chiropractic office setting during the acute stage of a high-grade (i.e. Rockwood types IV-VI) separation of the acromioclavicular (AC) joint. Moreover, such cases are non-existent in the peer-reviewed chiropractic literature. Some controversy exists over the optimal (surgical vs. non-surgical) treatment of severe AC joint injuries. Published reports of nonoperative management for grade V injuries of the AC joint are also scarce. This case review highlights the plain film imaging and conservative management of a 57-year-old patient diagnosed with an acute Rockwood type V AC joint separation. Radiographs with nine years of follow-up are presented.

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KEY WORDS: acromioclavicular joint, sprain, dislocation, chiropractic

Les patients se présentent rarement à une clinique de chiropratique pendant la phase aiguë d'une séparation de haut grade (c.-à-d., types IV à VI de Rockwood) de l'articulation acromio-claviculaire(AC). En outre, ces cas n'existent pas dans la littérature sur la chiropratique examinée par les pairs. Le traitement optimal (chirurgical vs non chirurgical) des lésions graves de l'articulation AC ne fait pas l'unanimité. Les rapports publiés sur la prise en charge non chirurgicale des lésions de grade V de l'articulation AC sont également *peu abondants. Cet examen de cas met en lumière l'imagerie par radiographie et la prise en charge conservatrice d'un patient de 57 ans souffrant de séparation aiguë de l'articulation AC de type V de Rockwood. Les radiographies avec neuf ans de suivi sont présentées.*

(JCCA. 2017;61(1):68-71)

MOTS CLÉS : articulation acromio-claviculaire, entorse, dislocation, chiropratique

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The patient has given written consent to have his personal health information, including radiographs, published.
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Case Presentation

A 57-year-old male presented with acute pain, swelling, and noticeable "clunking" in his left shoulder two days after crashing from his mountain bike while cross-country trail riding. The injury occurred when he landed awkwardly from a jump and somersaulted over the handlebars of his bike, jamming his left shoulder hard into the ground. He felt immediate excruciating pain, but did not seek medical attention. He applied ice to his shoulder multiple times at home over the next two days before presenting to the chiropractic clinic. The pain severity at the time of presentation was graded as a nine out of a possible 10. On examination, there was notable swelling and deformity of the left acromioclavicular (AC) joint with elevation of the left clavicle. Manual palpation revealed extreme laxity along with complete separation of the distal clavicle from the acromion process. Upper limb neurological and vascular examination was normal. Left shoulder joint radiographs, including an anteroposterior view of the left AC joint, revealed widening of the AC joint and an increased coracoclavicular (CC) space (measuring 32 mm), along with marked elevation of the clavicle (Figure 1). The patient was diagnosed with an acute grade V separation of the left AC joint.

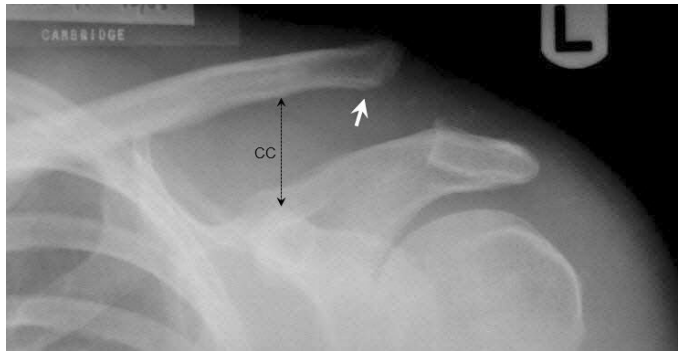

Figure 1.
Initial anteroposterior radiograph reveals superior elevation of the left clavicle (arrow) and marked widening of both the AC joint space (22 mm) and CC (coracoclavicular) space (32 mm).

According to the Rockwood classification[1], there are six types of AC joint injuries (Table 1). Types I and II are typically treated conservatively while types IV to VI are often treated surgically.[1-3] The optimal (i.e. surgical versus non-surgical) management of Rockwood types III and V AC injuries nevertheless remains controversial.[2-5] For instance several studies have shown equally good clinical outcomes in patients treated non-surgically, versus surgically, for these types of AC joint dislocations.[2,4-6] However, radiographic and/or cosmetic outcomes tend to be better in such patients with surgical intervention.[2-4,7] Given the potential for risks and complications with surgery[2-7], some authors continue to advocate for a 'conservative-first' approach to managing severe AC joint injuries[8]. For the clinician, patients with these types of injuries are advised to have both surgical and non-surgical consultations. In each individual case one has to consider the benefits and risks associated with surgical and non-surgical conservative management. Presently the outcomes with both plans of management are highly variable and require further study.

The patient in this case was referred to his family physician to evaluate the need for orthopedic surgical consultation. Based on the patient's preference as well as the absence of 'red flags', such as neurovascular or pulmonary compromise, non-surgical conservative therapy was recommended. The patient subsequently returned to the chiropractor and was treated as follows: ultrasound therapy (3.0 MHz, 1.0 W/cm^2, 50% pulse, eight minutes) was

Table 1.
Rockwood classification of AC joint injuries[1]

Type	Description
I	AC ligament sprain; AC joint intact; CC ligaments intact; Deltoid, trapezius intact
II	AC joint disruption; Slight vertical separation of AC joint; CC ligament sprain; CC distance is widened; Deltoid, trapezius intact
III	AC ligament disruption; AC joint dislocated; CC ligaments torn; CC distance is 25-100% > than normal side; Deltoid, trapezius may be detached
IV	AC ligament disruption; AC joint dislocated; Clavicle displaced posteriorly into trapezius; CC ligaments completely torn; Deltoid, trapezius detached from distal clavicle
V	AC ligament disruption; AC joint dislocated; CC ligaments completely torn; CC distance is 100-300% > than normal side; Deltoid, trapezius detached from distal half of clavicle
VI	AC ligament disruption; AC joint dislocated; CC ligaments completely torn; Clavicle in subcoracoid position; Deltoid, trapezius detached from distal half of clavicle

Legend: AC = acromioclavicular, CC = coracoclavicular

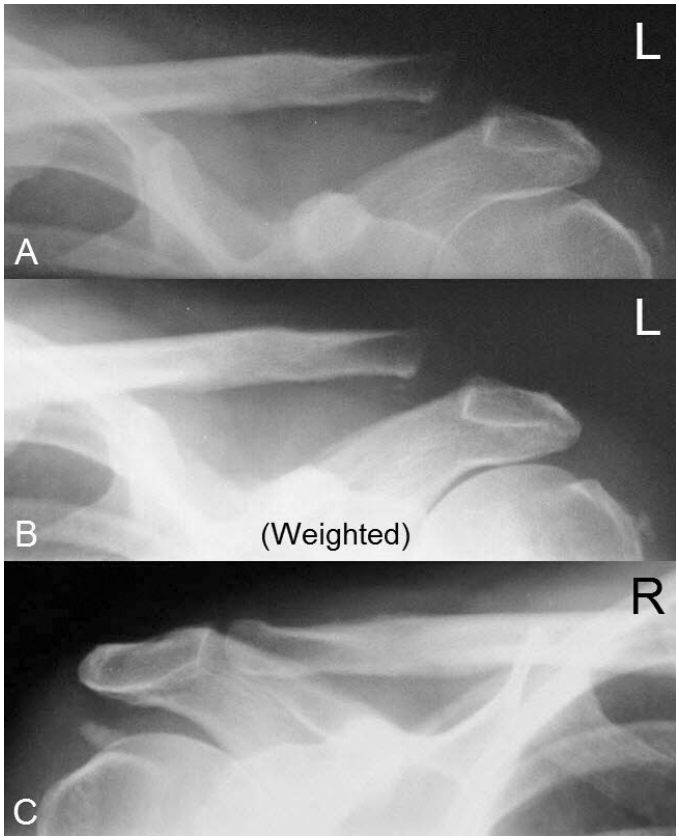

Figure 2.
Follow-up radiographs of the left shoulder without (A) and with (B) weights, obtained nine years later at age 66 years, reveal persistent widening of the AC joint, but no appreciable increase with weights. A radiograph of the normal right side (C) is provided for comparison.

applied to the left AC joint, home-based rotator cuff isometric and Thera-Band™ isotonic strengthening exercises were prescribed (i.e. internal and external shoulder rotation and triceps extensions, performed to tolerance; three sets of 10 reps, 2-3 times/day), home ice therapy was recommended (i.e. 15-20 minutes, every 1-2 hours for the first 2-3 days, then as needed), and the patient was advised to purchase an AC joint shoulder splint (to be worn 24 hours/day, seven days/week, except for showering and icing). After 12 visits (over eight weeks), the patient's left clavicle was still superiorly displaced but his shoulder range of motion was normal and his AC joint was pain-free. With the inherent limitations of a single case study, it is unknown if these clinical outcomes were as a result of the treatment or the natural course of the injury.

Radiographs taken nine years later (at age 66) revealed that there was still moderate elevation of the left clavicle and widening of the AC and CC joints (Figure 2). Despite these findings, the shoulder range of motion remained full and pain-free and the patient had continued to participate in competitive cross-country trail riding with no limitations. These results are consistent with those found in a recent randomized controlled trial comparing operative versus nonoperative treatment of grades III and V AC joint dislocations.[4] Although patients treated nonoperatively ended up with more prominent or unstable and radiographically wider AC joints, clinical outcomes were equally good between the operative and nonoperative groups at long-term (18- to 20-year) follow-up.[4] Good functional outcomes in non-surgically (versus surgically) treated patients with severe AC joint injuries have also been shown by others.[6,7] As in the current case this suggests that in the absence of clinical 'red flags', nonoperative treatment may be a viable option in managing some patients with Rockwood type V AC joint dislocations. However, larger studies are still needed.[4] For more information and additional examples of AC joint injuries, visit Radiopaedia.org.[9]

Key Messages

- Based on the Rockwood classification, AC joint injuries are divided into six categories
- Rockwood types I and II typically respond well to conservative therapy, whereas surgery is usually recommended for types IV to VI
- Patients treated non-surgically for types III and V AC joint separations may achieve a good clinical outcome despite a poorer radiographic and/or cosmetic outcome
- Reports of nonoperative management with long-term follow-up for type V injuries of the AC joint nevertheless remain scarce
- Patients with grades III and V separations are advised to have both surgical and non-surgical consultations; however at present the outcomes with both plans of management are highly variable and need further study

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Chiropractic History

David C. Drum, DC, FCCS(C): an accomplished, multi-faceted individual

Douglas M. Brown, DC[1]

Pablo Picasso (1881-1973) is quoted as saying, "The meaning of life is to find your gift. The purpose of life is to give it away." With these few words Picasso captures the essence of David Drum's existence. From his birth in Moncton, NB, through his formal education in Toronto, ON, to his so-called "retirement" in Crystal Beach, ON, this paper spans 72 years, unveiling the broad range of opportunities for growth David Drum has encountered in his life's journey and documenting his acceptance of the obligations for proud philanthropy that accompany them. Dr. Drum's many accomplishments, gifts, and contributions to the profession and world of art are discussed.

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KEY WORDS: chiropractic, history

Pablo Picasso (1881-1973) aurait déclaré : « Le *sens de la vie est de trouver son don. Le but de la vie est de le partager. » Par ces quelques mots, Picasso saisit l'essence de la vie de David Drum. De sa naissance à Moncton, au Nouveau-Brunswick en passant par ses* études *à Toronto, en Ontario jusqu'à sa prétendue retraite à Crystal Beach, en Ontario, ce document couvre 72 ans et dévoile la vaste gamme d'occasions de croissance vécues par David Drum pendant son périple de vie, en plus d'indiquer sa fière acceptation des obligations de philanthropie qui les accompagnent. Le grand nombre de réalisations, dons et contributions du Dr Drum envers la profession et le monde artistique sont discutés.*

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MOTS CLÉS : chiropratique, histoire

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Growing pains

David Clayton Drum was born 20 minutes after his twin sister Lana, in Moncton, NB, August 9, 1944. This surprised his 20 year old mother, Barbara Phyllis, who was expecting just one bundle of joy, while his father, Wilfred Clayton, a pilot in the Royal Canadian Air Force (RCAF) Coastal Command, was overseas and would not see his babies for the first 2 years of their lives. Coming home in 1946, Wilfred rejected a job with Air Canada to become sales manager of a printing and lithography business in downtown Toronto. "Dad was a fine artist, superb athlete, loved jazz and played the piano. In 1954 he built me a studio and taught me how to use oil paints. When I was nine, my mother left the Anglican Church to become a Jehovah's Witness. She enrolled me in their public speaking school and hoped I would become a boy evangelist. I did my best but my heart was never in it and I resigned after 10 years of growing dissatisfaction, to attend anatomy and human dissection courses, to improve my drawing of the human figure." (Drum CD, old unpublished CV)

David painted every day in grades 10 through 13 under the guidance of Alex Fraser, a wonderful teacher at Gordon Graydon Secondary School. Summers were spent painting landscapes at his uncle's Gatineau cottage, in the Québec Laurentians and in 1961, at age 17, he won the Canadian National Exhibition (CNE) mural competition and was hired by several companies to illustrate their catalogues.

The Canadian Memorial Chiropractic College (CMCC)

Graduating from high school as class valedictorian in 1963, David intended to embark on a career in art, however a misplaced application to the Ontario College of Art dashed his chances for a scholarship that year so he enrolled at CMCC, where he had a full bursary to attend anatomy and human dissection courses. Moving into the original college at 252 Bloor Street West, David was given free reign of the anatomy-pathology museum and library. Lyman C. Johnston, CMCC's Director of Research, commandeered him on the first day.[1] Soon David was illustrating Dr. Johnston's and other professors' papers, along with the text of "Segmental Neuropathy."[2] As well, he illustrated every undergraduate course for the student note service and served as coordinator of special occasions such as seminars, dances and "Practichiro," a minstrel show, named and created by Dr. Rich Luck, during his college years (CMCC 1950-54). After winning the J.M. Wallace Award for the highest marks in the freshman year, David decided to stay at the College. "I was just having too much fun." That summer he prepared sets of histological and pathological slides under instructor Dieter Reschka. In his third year, David met Diane Strickland, a ballet dancer who took him to see "Swan Lake" on their first date. He had never experienced a production that beautiful and fell deeply in love with Diane. "Marriage followed swiftly in 1966." In his final year, David developed a course in chiropractic biomechanics and wrote and illustrated the text of, "An Introduction to the Study of Spinal and Postural Mechanics."[3] David termed the study an introduction because he believed chiropractors had just begun to understand the part we have "to play in the restoration of the human spirit and movement, by correcting faulty body mechanics." Some of the chapter headings are: Gravity the Constant Stressor; A Brief History and Review of Principles of Kinesiology; The Pyramidal System of Three-Dimensional Postural Analysis; Radiographic Investigation of Functional Spinal Scoliosis; Studies of Abnormal A/P Spinal Curvatures and The Compression Subluxation, which David co-authored with Scott Haldeman, DC, PhD, MD.[4] This chapter is divided into two sections. Section A, The Patho-Physiology of Peripheral Nerve Compression, summarizes Dr. Haldeman's original research, as recorded in his master's thesis, on the microscopic effects of nerve compression and describes its six main sequelae. Section B, covers the various ways nerve roots can be compressed at the spinal level and details nine ways this can occur.

David passed his Ontario and American board exams prior to graduating in 1967 with intern of the year honours, which he shared with Edward Demchuk (CMCC 1967). His large practice was mainly composed of dancers referred to the school clinic by his wife. In 1968, Dr. Drum joined the faculty, teaching Histology and Principles of Practice and published his first paper in the Journal of the Canadian Chiropractic Association (JCCA): "The Posterior Gravity Line Syndrome."[5] This article was co-authored by Dr. Johnston, with whom he partnered for 20 years, clarifying ideas, designing equipment, writing papers and travelling widely to hold post-graduate seminars. Drum observed that Johnston was an outstanding educator and inventor who "conceived theories, con-

ducted research, built prototypes of his creations, then marketed and sold them."

In 1968, David was privileged to meet Glenn Gould, one of the best-known and most celebrated classical pianists of the 20th century. David was then living and practising in a home on Bathurst Street. Gould heard that David owned Liberace's Heintzman concert grand piano #100,000 and wanting to try it out, arrived there unannounced one auspicious day. David did not hesitate to abandon his patients in the waiting room, for the private concert of a lifetime and was not disappointed. No one dreamed that Canada's foremost musician would expire prematurely from a cerebral hemorrhage at the age of 50, just 14 years later.

In December 1969, Part 1 of Drum's 2 part treatise "Disc Regeneration: The Rationale for a Positive Therapeutic Approach," appeared in the JCCA.[6] The author asserts his material is limited to intervertebral disc degeneration of the lumbar spine, NOT frank herniation or prolapse of a nucleus pulposus. Under the first main heading, Variable Disc Stressors, Drum identifies posture, physical fitness, occupation, obesity and pregnancy, as possible sources of lumbar disc degeneration. Fortunately, many of these factors are amenable to change by the patient or doctor. Under Anatomical-Physiological Disc Stressors, Drum discusses seven factors that contribute to the inherent instability of the low back region and asserts: "While it behooves us to be aware of their existence... there is little practical therapeutic significance in this section." That is because there is nothing we can do to alter them.

In April 1970, Part 2 of Drum's document on Disc Regeneration was published in the JCCA.[7] Drum declares one of the by-products of injured disc repair to be fibroblastic production of tough, collagenous scar tissue. Although enzymes involved in a homeostatic system of collagen birth and destruction had been identified in some mammalians, they had yet to be found in human beings. Regardless, Drum lists four other factors that govern repair's effectiveness. 1. Physiological Condition of the Host: Young patients have a far greater capacity for repair than the aged. 2. Nutritional Status: Protein depletion prejudices tissue repair. Patients require nourishing diets rich in Vitamin C, which is essential for collagen formation. 3. Endocrine Function: Endocrine secretions may modify the reparative process. Adrenal steroids such as cortisone depress the rate and adequacy of repair and should be avoided. 4. Blood Supply: Adequate circulation is crucial to the healing process. Most orthopedic authorities agree that exercise is valuable. What TYPE of exercise is left to the reader's imagination.

Under Therapy, Drum puts "Prevention" of recurring traumatic episodes to the lumbar spine at the top of his list, including physical and emotional factors among the offenders. Because his prescription for regular athletics is seldom obeyed, Drum advises Johnston's "Posturizer," which exerts a pumping action on the lumbar discs. Even here, Drum warns against its use in the presence of acute inflammatory exacerbations such as rheumatoid arthritis or nucleus pulposus herniation. Drum concurs with James Cyriax when he states: "The first measure to be considered in all disc lesions is manipulation."[8] The form of manipulation Drum refers to is a "chiropractic adjustment" and because that has many connotations he details the rationale and protocol for handling: Fibrocartilage Hinge; Disc Bulge; Disc Thinning; Hypermobile Subluxations; Root Compression without Herniation and Posterior Facet Abnormalities. As for corsets and belts, Drum champions Johnston's "Spine Power Belt," which is fitted over the patient's greater trochanters and limits motion at the L4-L5 and L5-S1 motor units. One year Drum utilized an intermittent, motorized traction table and found the results disappointing in treating disc bulge. On the other hand, practically the entire weight of the abdominal cavity impacts on the spine and its discs, so the loss of 10 to 15 pounds can contribute substantially to the management of these problems. Drum affirms our profession is in the best position to provide conservative therapy for injured and degenerating discs, "now that we possess a credible rationale behind our therapeutic approach."

With the cooperation of its editor, Donald C. Sutherland (CMCC 1950), Dr. Drum prepared four "series of investigative case histories that will contribute to the formulation of a comprehensive concept of the pathogenesis and conservative treatment of the injured and diseased lumbar disc."[9] Cases are chosen for their instructional value, not because they make our profession "look good." In the First Series, Case 3 reveals the value of the "health-team concept." The team consisted of a chiropractor, gynecologist, neurologist and psychiatrist; all of whom were necessary for this patient's return to normal living. The Second Series was released in March 1971.[10] Case 7 was a patient Drum suspected of having ankylosing spondylitis. X-rays

confirmed this diagnosis and Drum referred his patient to a neurologist who sent him to a rheumatologist where he received Phenylbutazone. One week later he was pain free and able to resume his job. In the early stages, it is difficult to differentiate ankylosing spondylitis from lumbar disc disease. Drum quotes DePalma and Rothman in their text, "The Intervertebral Disc," as stating that "many such errors have been made and many patients with ankylosing spondylitis have been subjected to disc surgery and fusion operations on the lower lumbar spine." The Third Series came out in July 1971.[11] On Page 13, Drum provides a handy "Summary of Lumbar Disc Herniation: Its Diagnosis & Treatment." Acute herniation is usually "soft" and associated with trauma. Chronic herniation is "hard," more amenable to manipulative reduction and accompanied by multiple motor unit degenerations. Warning: Protracted presence of contralateral leg pain, bladder, bowel or sexual dysfunction, or signs of cauda equina syndrome, require consultation with a neurosurgeon. Drum says one of the most frustrating factors in dealing with disc lesions is their proneness to relapse and tells his patients this in advance, to avoid their loss of confidence. "To my knowledge, no long range studies have been conducted on this problem within our profession."

February 2-4, 1975, the National Institute of Neurological Diseases and Stroke (NINDS) held a workshop in Bethesda, Maryland, to discuss "The Research Status of Spinal Manipulative Therapy." Participants included 16 chiropractors, 24 medical doctors, 7 osteopaths and 11 basic scientists.[12] This marked the beginning of inter-professional dialogue on the "neutral" issues of science and research. Inter-professional rivalries were deemed unacceptable bases for scientific exchange.[13]

David Drum was invited to attend this conference and present his thoughts. The subject he chose was "The Vertebral Motor Unit and Intervertebral Foramen." The concept of a vertebral motor unit had been created by Prof. H. Junghanns, in 1950. "It gave manipulating spinal therapists a functional concept of subluxations by stressing the relationship between the morphological features of the motor unit and its dynamics." It also hastened the evolution of clinical procedures to discover altered mechanics before they became visible on x-rays and redirected attention from the osseous confines of the intervertebral foramen to the function of the structures passing through it.

Drum describes the intervertebral foramen as "an ellipsoid aperture that gives exit to the segmental spinal nerves and entrance to the vessels and nerve branches that supply the bone and soft tissues of the vertebral canal." Although its neurovascular components may be influenced by spinal discs, the foramina themselves remain anatomically unchanged. Related areas Drum covers are: The Intervertebral Disc and Other Vertebral Motor Unit Ligaments; Vertebral Motor Unit Innervation; The Posterior Spinal Articulations; The Occipito-Atlanto-Axial Atypical Vertebral Motor Units; The Vertebral Motor Unit with Congenital Variations and The Pelvic Motor Unit.

Dr. Drum buttresses his thesis with 209 specific references and closes with these remarks on the "Limitations of the Motor Unit Concept – Areas for Additional Research."

> *A limitation of the vertebral motor unit concept is its emphasis on segmental analysis and yet, Junghanns certainly never intended his model to be autonomous. In the introduction to his text he refers to the 'organ system spine' as appearing 'no longer, as in the past, as an isolated, segmental, skeletal organ. Today the spine appears in the light of many mutual relationships with the total body; with its equilibrium it exerts influences and also receives forces all of which are interwoven with the far-reaching chain of motion. In addition, the spine is able to exercise considerable influence upon neighbouring structures as well as upon remote organs by its action upon nerves and blood vessels. 'To fully exploit Junghanns' and other anatomical-mechanical concepts in clinical practice, will require the continuation of interdisciplinary dialogue enhanced greatly by this conference.*

Expanding horizons

In 1971, David Drum opened a clinic specializing in dance-related injuries in Toronto at 2 Bloor Street East, where he was joined by his favourite student, Jean A. Moss (CMCC 1970). Dr. Moss stayed for three years, before leaving to get her MBA and rise through the ranks to assume the College presidency (1990-2014). In 1974 she was replaced by Dr. Victor Celeste, who graduated from the New York Institute of Chiropractic in 1967. He came to live with David to avoid the Vietnam war draft

and study for his Canadian board exams. "He was the best diagnostician I ever met, possessing a sixth sense that could discern clinical problems. Tragically, he inherited a rare neurological disorder that carried him off after dealing with it magnificently for 20 years." John Beal (CMCC 1972) and his wife Veronica, a registered nurse, soon became team members, as did James Matthews (CMCC 1961). In 1973, Drum began supervising interns in the CMCC outpatient clinic, teaching principles of practice to all four years and teaming with the institute's postgraduate faculty to conduct seminars in Canada and the United States. This year, Drum moved his facilities to 100 Wellesley Street, between the Wellesley and Orthopaedic and Arthritic Hospitals. "Dr. Brian Nelson (National CC 1964) moved in while his new office was being renovated and we combined our talents as art dealers in 19th Century European paintings." John Colwell, MD, a renowned orthopaedic surgeon, invited David to observe his operations and administer spinal manipulative therapy to his patients. "We were able to introduce Dr. Lyman Johnston's concepts into the Department of Biomedical Engineering at the Hospital for Sick Children with Jan Koreska, PhD." Dr. Koreska developed Johnston's models in a paper on orthogonal projection, where the spine could be visualized looking down from above. In February 1975, Dr. Drum had travelled to the NINDS conference accompanied by Dr. Charles Godfrey, as head of physical medicine at Wellesley Hospital, along with the director of epidemiology at the University of Toronto and the Editor of the Canadian Medical Journal. Together, they obtained a substantial grant from NINDS for a paper they coauthored on protocols and therapeutic goals of spinal manipulation. The year ended with CMCC conferring fellowships in the newly formed College of Clinical Sciences on Drs. Drum, Johnston, Vear, Haldeman, Ron Gitelman (CMCC 1961) and Adrian Grice (CMCC 1959). By then, Dr. Vear was administrative dean. He asked Drum to liaise between CMCC and the medical profession so David was making frequent trips to address department chairs in hospitals throughout North America. Vear also encouraged him to organize interdisciplinary postgraduate seminars for Canadian chiropractors, at our alma mater.

Constantly on the go and rapidly running out of space, in 1974 Dr. Drum purchased two adjoining townhouses, in the heart of Cabbagetown, at 115-117 Winchester Street and immediately began renovations that provided 10,000 sq. ft. of prime real estate for his clinic/art gallery/residence. "Finally, with the space we needed, Lyman Johnston brought his Posture Research Foundation on board and was a constant presence with his 'Tension Release Therapy,' training and certifying chiropractors, three of whom stayed on staff." Howard Marcus, a retired National Ballet Principle Dancer, moved in as coach and exemplar of the Alexander Technique and Feldenkrais Method. Although the systems differ, they are considered comparable, because they train those in the limelight to perform with greater ease and less effort. Ada Mueller, a saintly German medical doctor who had struggled with women in the prison system for decades, came out of retirement and was joined by Karen Kain's sister Sandra, who was a registered nurse, a Tai Chi master, four massage therapists and a kinesiologist. "We were swamped!" When Karen Kain, Prima Ballerina of the National Ballet of Canada, followed by purchasing the townhouse next door, "the whole Canadian ballet world seemed to tag along."

In 1974, Victor Celeste's brother Anthony, a massage therapist, was employed exclusively by David to direct the operation of his co-joined clinic for treating dance injuries and art gallery, at 55th St. and 3rd Ave., New York, in the heart of Manhattan. "Art was always displayed on the clinic walls and available for purchase and we held several exhibits a year in the evening after clinic hours, with wine, food and live music." Every second Thursday night, David flew out of the Toronto Island Airport into Newark, New Jersey and returned Monday morning. On alternate weekends, he soared to San Francisco to interact with the San Francisco California Dance Theatre and the Marin Civic Ballet, with the inspiring Jodie White. "Her son David, a National Ballet dancer, was living in my home helping me comprehend the demands on male ballet dancers and Nadia Potts spent hours demonstrating the rigours of pas de deux lifts." Drum's wife Diane, cooked for entire ballet companies such as the Royal Winnipeg and Les Grands Ballets Canadiens, when they were in town and attending the clinic. Dance Canada asked for lectures as did George Brown College, Ryerson and York Universities in Toronto and Michigan State, Texas Christian, Pacific Lutheran and Brown College in the USA. "Our clinic was on standby for all Toronto live theatre, thereby we met lots of legends including famous actors, comedians, sports celebrities, musicians, conductors, composers and impresarios."

As mentioned, 1970 ushered in a decade of rapid expansion for Dr. Drum, who demonstrated financial acumen equal to his clinical and artistic skills. His first step was to apply for money from the Canada Council for the Arts, to study the prevention and treatment of dance- related injuries. "I was subjected to both written and oral examinations and awarded a $5,000 grant, which was a lot of cash back then." His next move was to approach the National Endowment for the Arts in the United States. "This independent federal agency graciously funded my lecturing and research in the departments of dance at Brown, Penn State, Texas Christian and Pacific Lutheran Universities, for an entire season." These contacts gave Drum access to the Life Bliss Foundation, a worldwide movement for meditation and healing, that sponsored him to work with the Joffrey Ballet, a professional touring dance company, founded in 1956 and based at that time in New York City. Dr. Drum's Manhattan clinic cared for the health care and physical training needs of the Joffrey Ballet and in turn, the Ballet covered most of the clinic's operating costs. Dancers paid the usual fees to licensed therapists when in New York but in Toronto, OHIP (Ontario Hospital Insurance Plan) paid for our Ontario dancers and there was a surcharge of $10. Drum's expenses were covered when he was in Montréal and Winnipeg by the respective companies but he did not charge the dancers nor those visiting from other countries. Instead, they gave Drum tickets to their concerts and shared their expertise with his staff. "Basically we broke even but I kept re-mortgaging my Cabbagetown properties when we ran short and was fortunate to have purchased them in a depressed market. Without the continuing escalation in downtown Toronto property values and the lowering of interest rates, I could not have sustained the clinic."

David enjoyed teaching. "I would have stayed my whole life in academia, but my political relationship to the college was becoming strained by my attitude toward adhering to the party line." David often crossed swords with Lyman Johnston. "Lyman would be furious with me when I went off topic during my post graduate lectures. He had his own agenda and wanted me to follow it strictly. I started having similar difficulties in faculty meetings when I began advocating for interdisciplinary seminars and lectures." Without approval, Drum brought in bioengineers, physical medicine specialists, orthopaedic and neurosurgeons at the under- and post-graduate levels. The students found this enlightening and his classes enlarged with all four years attending, to the dismay of other staff who were missing students. "I never took attendance nor failed a single student. If they were having problems I gave them after hours tutoring in my clinic and did not request remuneration at the undergraduate level."

Hard times hit in the early 1980s, with the onslaught of the AIDS epidemic, which killed Anthony Celeste and decimated their dancer clientele. "Too many funerals and too many creative geniuses lost too young. I retreated to Toronto and welcomed a retired National Ballet dancer, Julie Houle (who would graduate from CMCC in 1998) and her husband, Donald Dawson, also of the National Ballet, onto the staff." Dr. Barbara Pike (CMCC 1982) joined in 1985 and the Cabbagetown clinic busied itself with dancers, musicians, actors and athletes. David and Diane toiled in tandem for most of their marriage, however in 1974, when David began flying to New York and San Francisco on alternate weekends, Diane found herself spending more time in the Canadian dance milieu. Although David cancelled these junkets in 1986, this was the traumatic year Diane's career was cut tragically short, when she succumbed to malignant melanoma.

Moving on

In 1987, David met Barbara Vance, a registered nurse with an extensive background in oncology clinical trials. One of the trials she was monitoring involved a medical doctor in private practice. "He was being paid by a pharmaceutical company for his participation but was forging the results to avoid the time and effort involved in collecting data." David recalls that, "Barbara became exasperated with Lyman Johnston's attitude toward the protocol of proper clinical trials. Discussions carried on into the night, instilling the discipline that helped me avoid premature decisions." At this juncture David's career took off because Barbara did everything for him, so he could practice part time and paint in his off days (4 days a week). After taking a six-month course in custom framing Barbara bought the framing business. Then, in 2006, she picked up the brushes and with no fear of painting, quickly developed a personal style with a daring use of colour and freshness that appeals to young and old. "Now we paint our large format abstracts at the same time, without fighting."

David divides his painting techniques into three per-

Figure 1.
Barbara Vance and Dr. David Drum.

iods. The first is realism, an artistic movement that began in France, after the 1848 Revolution. David uses this method to draw medical illustrations such as those he produced by the dozen, during his early tenure at the school. The second is impressionism, which he employs for landscapes. In the 1980s, David became immersed in the techniques of Claude Monet. Barbara took him to France to experience the famous Monet gardens at Giverny and tour the Monet Museum in Marmottan, Paris. "In those days I sported a straw hat and large beard. Japanese tourists thought I had been hired to impersonate Monet. I spent so long in the Monet Museum that the curator opened a case and let me try on his glasses. The man could hardly see when he was creating those monumental water lily panels!" The third period is abstract expressionism. This post World War II art movement was spawned in New York City in the 1940s. David never blew glass but in 2011 created a series of 20 paintings from exploded shards of glass from a friend's studio. "There was danger in just brushing against finished works but this experiment led to reverse glass paintings, where luminosity can be maintained without sharp protrusions and they can be placed in humid atmospheres. Because the pigments are sealed within layers of glass, the colours do not oxidize and remain fresh." Drum informs us that the Chinese had figured this out 2.000 years ago and a number of their antique reverse glass paintings still survive in museums. Unlike Picasso, Drum "never abandons one era for another but rotates between all three as my mood and my client's wishes dictate."

In 1986 David downsized, selling the Cabbagetown properties and moving to 226 Carlton Street. In January that year, Ian Coulter, PhD, CMCC's President (1983-90) formed an Alumni Affairs Committee associated with the College Governors' Club.[14] Its objectives were to unite our graduates and friends by providing them with an entertaining evening and to raise money for the institution. From 1986 through 1994, Barbara and David collaborated in the production of nine gala's, in a variety of locations. The most memorable event was the last; held in Toronto's elegantly appointed Granite Club. On this beautiful evening, 295 revellers devoured a delicious dinner, played games of chance, danced to the Murray Alter Orchestra and headed home in the wee hours of the morning, bearing 400 door prizes and 300 gifts obtained at auction. Net proceeds of these nine dinners to CMCC were $153,000. Their success was assured by Barbara and David who, with their patrons and friends, donated hundreds of art objects with an assessed retail value of $250,000. In addition, they trucked a load of equipment to each venue and set the paintings up for easy access and visibility. Of course, David was always the accomplished and irrepressible auctioneer, even in 1992 and 1993 when he had to compete with the Toronto Blue Jays, who could be seen on large-screen TV, winning the World Series twice in succession.

Crystal Beach

In January 2006, the Drums "moved to the outskirts of town, where somebody ain't always hangin' around," purchasing an abode at 293 Oxford Avenue, in Crystal Beach, ON. Now a stable community of 3,800 on the northeast shore of Lake Erie, across from Buffalo, NY, from 1888 to 1989, it held an immense amusement park

Figure 2.
Women's Hockey Gold (Permission for publication of image granted by Dr. David Drum).

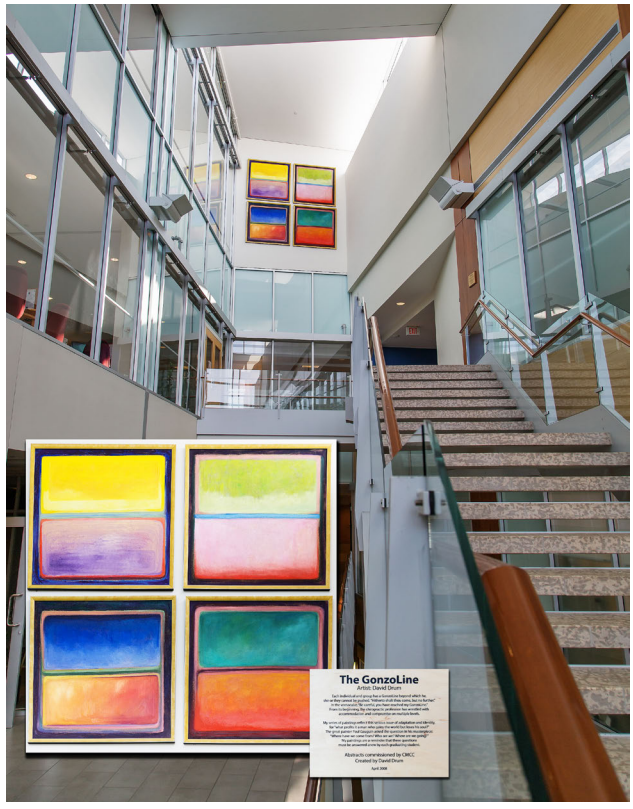

Figure 3.
The Gonzo Line (Permission for publication of image granted by Dr. David Drum).

attracting 20,000 visitors daily, throughout the summer. Barb and Dave's dwelling had been designed and built by Arthur Lafferty of Buffalo, a colleague and admirer of another Buffalo architect, Frank Lloyd Wright. It appeared on the cover of a 1945 edition of Popular Mechanics as the "home of the future."

2007 marked the 40th anniversary of Barbara and David's involvement in health care and they decided to "retire from the healing arts to concentrate on art of a different nature." Since then they have opened Le Bateau Gallery of Fine Art in their own lodging. Previously, Drum exhibited annually with the National Ballet in the O'Keefe Centre for the Performing Arts and provided paintings for many American and Canadian feature films. Currently, Barb and Dave show their paintings in Queenston at the RiverBrink Art Museum, at the Art Gallery in Jordan, in Ridgway at the Sanctuary for the Arts, in St. Catharines in the Veffer Gallery, in Buffalo at the Dana Tillou Gallery and in Toronto at Waddingtons and the Consignor Art Auctions. They also sold numerous works at the George Enns Gallery (now King Street Gallery) and the Pumphouse Gallery in Niagara-on-the-Lake.

When commissioned by then President, Dr. Jean Moss, to provide artwork for a particular wall at CMCC's new Leslie Street Toronto campus, Dr. Drum complied, finishing and hanging 4 abstract paintings by the summer of 2008, see Figure 3. (E-mail, M. McCallen to the author, Aug 5, 2016) The Leslie Street list of Drum's paintings, commissioned or donated, now (2016) stands at 10, see Figure 2 for another example.

Memories of things past

John Taylor (CMCC 1979) enrolled at CMCC in 1975 and remembers this "as a time of major turmoil." In 1976, Dr. Vear resigned as Administrative Dean and was quickly supplanted by Dr. Sutherland, who was named President/

CEO. Almost immediately, Sutherland fired his Academic Dean, Thomas Maxwell (CMCC 1955). This move reverberated throughout the school yet Drum, who was teaching all 4 years, appears to have been untouched, watching calmly from the sidelines. Perhaps his extraneous sources of income left him with no desire to scramble up the executive ladder. Later it was disclosed that David was quietly donating his salary back to the college. "David was a breath of fresh air and very popular among the classes. Comparatively young yet experienced and savvy in chiropractic, he knew the subject well, had cooperated with others in developing chiropractic scientific theories and could link the art, science and philosophy of chiropractic in a way that was understandable to students with a science background." Dr. Taylor confirms that David warmed his students with the glow of enthusiasm, at a time when they desperately needed it. (Email J. Taylor to the author, Aug 15, 2016)

Upon graduation, Dr. Taylor established a practice in North Vancouver, BC. In 1991, Taylor became a Diplomate of the American Chiropractic Board of Radiology (DACBR) through the Los Angeles College of Chiropractic, completed a postdoctoral research fellowship at the University of California at San Diego in 1993 and was hired by the Western States Chiropractic College, Portland, OR, as an associate professor of radiology. John stayed there until 2000, when he became a professor at the New York Chiropractic College, in Seneca Falls and in 2008, was offered his current position as a professor of radiology and coordinator of diagnostic imaging, at D'Youville College in Buffalo, NY.

Perched on Canada's West coast, John heard little about David for decades. "Fast forward about 35 years and I discover that David is retired in Crystal Beach, ON. In 2013 and now living just across the Peace Bridge in Buffalo, I made a point of visiting David and his lovely wife Barbara Vance. Since then, we have become good friends and I take great pleasure from this relationship." February 2014, Taylor coaxed Drum into becoming the first speaker in the D'Youville chiropractic students' "Mentors Series" program. David calls it "a 90 minute presentation on the good the bad and the ugly... highlights from 40 years of clinical experience." John says David's theme was to make the students feel good about themselves and their futures, emphasizing, "he had a great career because he made his own opportunities rather than waiting for opportunities to come to him." David addressed his interdisciplinary relationship with doctors at the Orthopaedic and Arthritic Hospital in Toronto, talked about how he treated dancers from the Canadian National Ballet and how he kept his clinic open all night to attend to the visiting Bolshoi company from the USSR. He also spoke at length about his friend and mentor Lyman Johnston and their achievements. "All the students left feeling much better about their careers."

John Taylor is nothing if not persistent. Sunday, May 22, 2016, he cajoled David Drum into delivering the keynote address at the Hooding and Pinning Ceremony, for the Class of 2016 Chiropractic Program at the D'Youville College. Held in the Bauer Family Academic Center, it was attended by 17 graduates and 150 faculty and guests. The following excerpts are taken from Dr, Drum's remarks. (E-mails D. Drum to the author May 25, 2016)

> *I discovered chiropractic through illustrating Dr. Lyman Johnston's papers at the Canadian Memorial Chiropractic College. He was director of research and his favourite expression was, 'If you can't measure it, it does not exist.' I wondered where this left intuition, inspiration, hope and love. Lyman told us the profession was too vitalistic, needing mechanical and electrical instruments to measure what we were doing with results that could be quantified. He said this was science.*
>
> *But when we are truly sick, we are not wholly ourselves. We require a healer, a relationship we can trust, not just a provider of goods and services. Every new patient represents a case history of one. The case history is the patient's story. Listen carefully for they are telling you what is wrong. The doctor-patient relationship is further enriched by the intimate hands-on nature of our therapy. You are not alone but part of a system rigged toward health and greater complexity. So even though you are skillfully performing closed surgery by altering joint topography and restoring motion or decompressing tissues, the procedures are not as difficult as you may think.*
>
> *Dr. Johnston often hinted about introducing a 'perturbation' into a biological system that needed a kick start to a higher level of functioning. I recall a patient on the way to my clinic with chronic neck*

pain I was ineffectually treating, phoning to say her cab had dropped into an excavation which threw her against the ceiling. She arrived with a full range of painless neck motion. That was a perturbation but difficult to reproduce. Get your patients into that wonderful, continuous passive motion machine – a rocking chair. Use an antigravity device – the swimming pool. Employ a stationary bike with hands dangling, for spinal mobilization. Embrace the unexpected and never lose a holy curiosity in your clinical interactions. When you are free of self-doubt you will still fail but in more useful ways.

Dr. Johnston personified the motto 'carpe diem' and taught me to live life where the action is right NOW! One morning a call came in from the Orthopaedic Hospital half a block away. Could I come immediately to help a visiting surgeon who was teaching a new spinal procedure and found himself in extremis on his hands and knees half under the operating table? Thinking perhaps prolonged flexion may have triggered a rib subluxation, I was ushered into the surgical theatre. The gods were with me, the standing anterior thoracic dorsal lift adjustment worked and he was able to complete the surgery.

The following day I was back in surgery observing a patient having his frozen sacroiliac joint manipulated after copious injections of cortisone. It seemed appropriate to demonstrate what every chiropractor does daily without the danger of general anaesthesia and the expense of a full surgical team. Not to be left out, the hospital physiotherapists asked for a course in sacroiliac adjusting. This lead to the head of physical medicine in an associated hospital sharing his techniques. His father had been a 'bonesetter' in Scotland and taught him well. One has no idea where staying connected to your community health practitioners will lead. We are all in this together! At this point you are relatively inexperienced and have not seen many of the conditions you will be treating. But do not fret. You are embarking on an awe-inspiring open-ended adventure. The experience will be bigger and more exciting than you can imagine. How could it be otherwise when we are all made of stardust?

Welcome to the profession, Class of 2016!

February 17, 2016, it was announced that four large, framed artworks had been donated to D'Youville College and would soon grace the Chiropractic Department area in the Bauer Family Academic Center. After many years decorating the walls of CMCC with energetic and colourful paintings, Barbara Vance and David Drum decided to fill the bare walls of the chiropractic facility in the same spirit as their donations to the Canadian college. "We hope the spirit and energy that so impressed us in the faculty and student body, is reflected in our paintings."

As of August 30, 2016, 15 of their original paintings had been hung, beautifying the halls and eliciting complimentary remarks. A number of the works are multimedia abstracts incorporating themes that range from "The Hand of God," to respectful tributes to Muhammed Ali and David Bowie. "Moreover, the presence of this art in our little area has visibly improved the entire mood of the campus community."

Barbara and David's commitment to and support of the chiropractic profession is both boundless and borderless.

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