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Commentary

What is your research question? An introduction to the PICOT format for clinicians

John J. Riva, BA, DC[†] Keshena M.P. Malik, BSc, DC^J Stephen J. Burnie, BSc, DC, MSc[‡] Andrea R. Endicott, LLB, MPPAL£ Jason W. Busse, DC, PhD§*

Introduction

Clinicians often witness impressive treatment results in practice and may wish to pursue research to formally explore their anecdotal experiences. The potential to further new knowledge both within the profession and to the greater healthcare system is compelling. An obvious next step for a practitioner considering research is to connect with experienced researchers to convey their idea for a study, who may in turn ask, "What is your research question?" With limited understanding of how to respond, this interaction may result in the first and last experience these clinicians will have with the research community.

It has been estimated that between 1% and 7% of the chiropractic profession in Canada is engaged in research.^{1,2} Arguably, this low engagement could be the result of practitioners' perceived importance of research and levels of research literacy and capacity. However, increasing demands for evidence-based approaches across the health system puts pressure on all clinicians to base their decisions on the best available scientific evidence. Lack of clinician representation in research has the probable effect of limiting growth and new developments for the profession. Furthermore, lack of clinician involvement in research complicates the transfer of study findings into practical settings.

The Canadian Institutes of Health Research describes integrated knowledge translation as a process that involves collaboration between researchers and knowledge users at all stages of a research project.³ This necessitates involvement of clinicians to help in forming a research question, interpreting the results, and moving research findings into practice. This shared effort between clinicians and researchers increases the likelihood that research initiatives will be relevant to practice.³ Conversely, it has been reported that there is a growing communication gap between clinicians and academics in chiropractic.⁴ Clinicians have important practice-related questions to ask, but many may lack the ability to map out their research strategy, specifically in communicating their question in a manner required to develop a research protocol.

David L. Sackett, Officer of the Order of Canada and the founding Chair of Canada's first Department of Clinical Epidemiology & Biostatistics at McMaster University, highlights the importance of mapping one's research strategy in exploration of the research question: "onethird of a trial's time between the germ of your idea and

Competing Interests: None.

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its publication in the New England Journal of Medicine should be spent fighting about the research question." (personal communication, November 30, 2011) We describe a randomized controlled trial (RCT) example to highlight how clinicians may use existing literature and the PICOT format to formulate a research question on treatment efficacy.

PICOT Defined

The PICOT format is a helpful approach for summarizing research questions that explore the effect of therapy:⁵

 (\mathbf{P}) – Population refers to the sample of subjects you wish to recruit for your study. There may be a fine balance between defining a sample that is most likely to respond to your intervention (e.g. no co-morbidity) and one that can be generalized to patients that are likely to be seen in actual practice.

(I) – Intervention refers to the treatment that will be provided to subjects enrolled in your study.

(C) – Comparison identifies what you plan on using as a reference group to compare with your treatment intervention. Many study designs refer to this as the control group. If an existing treatment is considered the 'gold standard', then this should be the comparison group.

(**O**) – Outcome represents what result you plan on measuring to examine the effectiveness of your intervention. Familiar and validated outcome measurement tools relevant to common chiropractic patient populations may include the Neck Disability Index⁶ or Roland-Morris Questionnaire.⁷ There are, typically, a multitude of outcome tools available for different clinical populations, each having strengths and weaknesses.

(T) – Time describes the duration for your data collection.

RCT Design Example Using PICOT

Dosage effects of spinal manipulative therapy for chronic neck pain

Neck pain is second in frequency only to low back pain among musculoskeletal complaints reported in the general population and among those presenting to manual therapy providers.^{8,9} Chronic neck pain (i.e. neck pain lasting longer than 90 days) is a common reason for presenting to a chiropractor's office, and such patients often receive spinal manipulation or mobilization.¹⁰ Recent systematic reviews of RCTs and prior observational studies have shown increases in cervical range of motion,^{11,12} and decreases in self-rated neck pain^{13,14} following cervical spine manipulation. In 2010, the Cochrane systematic review concluded, "Optimal technique and dose need to be determined."¹⁴

Despite evidence of benefit, there is a limited understanding of the optimal dose for neck manipulation; as such, frequency and duration of this treatment varies greatly between clinicians. Although patient characteristics and clinicians' beliefs likely account for some of this variation, it seems likely that many cases of mechanical neck pain will require a minimal number of spinal manipulative therapy (SMT) treatments to derive benefit and that no further benefit will result after a certain upper threshold is reached. To properly examine the dose effects of manipulation for neck pain, it is necessary to consider three treatment factors:

- 1) frequency
- 2) intensity
- 3) total number of manipulations

A factorial design RCT allows investigators to consider more than one treatment factor at a time and examine possible interactions between them. This trial design allows for determination of, not only, the effects of frequency and duration, but also whether it is more effective to provide a certain number of manipulations over shorter or longer durations (i.e. an interaction between the two factors). Considering a 3x4 factorial design, patients would attend 1, 2, or 3 sessions per week (i.e. the first 'factor' of frequency) with manipulation provided over a duration of 2 weeks, 4 weeks, 6 weeks, or not at all (i.e. the second 'factor' of duration). To improve generalizability of findings, neck manipulation could be performed using standard rotary or lateral break diversified technique, which is the most common manually applied neck manipulation in chiropractic practice. Pain relief is a common concern among patients presenting with neck pain and detection of a resulting difference of 13 mm on the 100mm Visual Analog Scale (VAS) line is considered a clinically important change in intensity for patients with chronic pain.¹⁵

Research Question: In adults with chronic neck pain, what is the minimum dose of manipulation necessary to produce a clinically important improvement in neck pain compared to supervised exercise at 6 weeks?

(P) – Population: Adults 18 to 60 years of age, with a clinical diagnosis of chronic mechanical neck pain who have not received cervical SMT in the past year. Patients with non-mechanical neck pain or contraindications to cervical manipulation will be excluded.

(I) – Intervention: Subjects randomized to have manipulation would receive standard rotary or lateral break diversified technique once, twice, or three times per week over a period of 2, 4, or 6 weeks (see Table 1). These subjects would also receive the same exercise regimen given to the control group to eliminate exercise as a second variable affecting outcomes.

(C) – Comparison: A standardized supervised exercise regimen would be used as an active control group. All subjects, regardless of group assignment, would perform a standardized exercise regime at each session over a period of 6 weeks. Using this strategy, we will be able to minimize the non-specific effects due to attending a clinic.

(O) – Outcome: Changes in neck pain, measured using the 100mm VAS for pain.

(T) – Time: The outcome would be measured weekly for 6 weeks.

	Frequency of SMT		
	1x/week	2x/week	3x/week
No SMT	0	0	0
2 weeks SMT	2	4	6
4 weeks SMT	4	8	12
6 weeks SMT	6	12	18

Table 1	Frequency	and Duration	of	SMT
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Clinician input, assuming expertise in the 'gold standard' standard rotary or lateral break diversified technique and an ability to teach it, would be helpful during the planning of patient recruitment. Specifically, in leading training initiatives to calibrate each treating chiropractor to deliver his/her manipulation in a similar way (i.e. load, force, angle) and to assist in normalizing communication with study subjects. This standardization, through structured training sessions for those rendering treatment, will help ensure no additional interventions were inadvertently applied (i.e. education, extra advice).

Other Study Designs Amenable to PICOT

The PICOT format example described above represents a factorial RCT methodology that has been informed by the existing literature. While a well-conducted RCT is appropriate for answering many questions on treatment efficacy, they are typically costly, time-consuming and challenging to conduct. Not all research questions that clinicians wish answered are feasible using this research methodology and the use of a PICOT format is also applicable to other study designs.

The clinical research question being asked ideally determines the best research design for a study. A prospective or retrospective cohort design may be an easier methodology to administer in comparison to a RCT; but study results can by affected by confounding due to the comparison of non-randomized groups. Another methodology, used to look for associations between respondent characteristics and outcomes of interest, is a crosssectional survey. This methodology is faster and less expensive to do in comparison to a RCT since it considers one time-point of individuals in various spectrums of the variables of interest. However, this design can also can be prone to recall problems by respondents who self-report information if investigators ask about events in the past. A case-control study is most appropriate when attempting to identify associations between patient characteristics and outcomes that take a long time to occur or are very rare. For example, the study by Cassidy et al. (2008) looking at risk of vertibrobasilar artery stroke following chiropractic care, whilst more complex in the design approach, used aspects of a case-control methodology.¹⁶

While these study designs are common in clinical research today, they are not exhaustive of all designs available. Systematic reviews will be familiar to most as a study design aimed at summarizing bodies of studies; but other less familiar individual patient focus designs, such as N-of-1 RCT,¹⁷ also exist which are amenable to the PICOT format depending on the research question that is being posed.

Discussion

Many considerations need to be contemplated in the PICOT formulation: How detailed should the literature search be in breadth and quality level? What study design best fits the research question? Should the patient population include very similar types of patients or will there be more of a real-world wide variety of participants? Will the intervention be very specific and rendered by a clinical expert or will there be a combination of tailored interventions rendered by a non-clinician with a more general skill set? Will the comparison be against usual care (i.e. 'gold standard') or a sham placebo procedure? Will the outcomes measured be from validated instruments on a form or more from direct patient verbal communication and will these results be presented in a way most important to clinicians, patients or policy-makers? And if so, what amount of difference and how many patients would be required to both statistically and clinically conclude the intervention was effective? Will measurement of outcomes occur at multiple times or once at 5 days, 6 months or 10 years?

While these considerations are clearly complex and not inclusive of the entire process, to develop a strong research question framed in the PICOT format, it is an important basis to understand both the clinical area of investigation and the current literature that exists. As highlighted by the example above, it is necessary to review the type and quality of research that has already been performed in the area of interest to guide development of a question. When initially synthesizing the literature, some key entry questions to examine include:

- what are the important research questions in the field?
- what has been found?
- what areas need further exploration?
- would the proposed study fill a gap and better an understanding?

In our example design, the literature search identified existing knowledge in the respective area. A recent highquality Cochrane review reported on previously completed RCTs in the area, strengths and weaknesses of these studies and offered direction as to gaps in current understanding that would benefit from further research exploration.¹⁴ As research is a time consuming and often costly endeavour, building on the best available existing knowledge rather than "re-inventing the wheel" is favourable.

Only after a thorough literature synthesis and investigation into these answers should a research question be formulated – in some instances a systematic review methodology may actually align best with the PICOT frame-

work for your research question. Turning an idea into a good research question requires it to be feasible, interesting, novel, ethical and relevant.¹⁸ This feasibility refers to, not only, resources (time and money), but also to whether there is agreement on the meaning of the research question and to whether everything that needs to be measured can be measured by the study design. The question should be of interest to many in the clinical area to drive both team momentum for the project and dissemination of the results. Generating new knowledge in large existing gaps of healthcare provides the opportunity to help large volumes of patients who previously may have had poorer clinical outcomes. Practically, ethical considerations have to be accounted for in related study designs to ensure subjects are not harmed by the study. Finally, reflection is required on how well the study design will apply to the real world.

A strong research question should always pass the 'so what?' test. Who will the research help? What is the benefit? There should be a definitive and strong rationale for the purpose of the research. A well-thought-out focused research question leads directly into hypotheses; the predictions about the nature and direction of the relationship between the variables under study. Hence, the question acts as the foundation of the study.

The importance of moving from studies to empirically supported treatments to evidence-based practices may very well rest on whether or not a clinician views the research as relevant to their daily practice. It is common for clinicians to express frustration that researchers are not asking questions that are of most relevance to practice. Similarly, researchers often find that clinicians have difficulty distilling the important concepts they would like investigated in a way that can be feasibly researched.

To support both clinical and academic interests, an important clinical research question should therefore be one that is developed in conjunction with a diverse team. This expertise should align with the best research methodology available and propose a project feasible to complete through study that will adequately answer the research question asked. In Canada, the Canadian Chiropractic Research Foundation has reported that there are currently 12 university-based research chairs, 15 PhD candidates and 14 Masters students.¹⁹ An opportunity exists to engage these researchers, as well as those from chiropractic schools, in helping to formulate important clinical research questions.

Conclusion

Clinicians interested in research pursuits, related to patient care, should consider the use of a literature search and the PICOT format when engaging clinical researchers. This approach will provide clinicians and researchers an initial basis for mutual understanding, communication and direction to help answer clinical study questions of most relevance.

Key Points

- Clinicians should frame practice-based research questions in the PICOT format
- Look to existing literature for guidance in the formulation of a research question
- Clinicians have an important role in contributing to the integrated knowledge translation of research studies
- Framing of a research question offers a common language between clinician and researcher discourse

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JCCA Appointment Associate Editor

The JCCA is delighted to announce the recent appointment of Dr. Kent Stuber DC, MSc to Associate Editor



Dr. Kent Stuber DC, MSc*

Dr. Kent Stuber graduated from the University of Calgary with a Bachelor of Science degree in Cellular, Molecular & Microbial Biology in 1998, and from the Canadian

Memorial Chiropractic College in 2002. He subsequently completed a Master of Science degree in Health and Social Care Research from the University of Sheffield in 2008. He received the CCA's Young Investigator Award in 2008 and was the co-recipient of a CIHR peer-reviewed award to support the "Workshop to Advance the Canadian Chiropractic Research Agenda." He was a member of the Program Development Committee for the 2011 workshop entitled "Advancing the Canadian Chiropractic Research Agenda" held in Toronto in September of 2011. Dr. Stuber is currently an Adjunct Professor in CMCC's Division of Graduate Education and Research where he is currently co-supervising several student research projects in addition to conducting his own research. His research interests include the treatment of pregnancy-related musculoskeletal conditions, sports injuries, vertigo, and spinal stenosis as well as the psychometric properties and use of orthopaedic testing, and the use of nutraceuticals in clinical practice. His preferred research methods include qualitative methods, online surveys, and systematic reviews.

Dr. Stuber's research has been presented at major conferences internationally and published in over half a dozen different peer-reviewed journals including Spine and the Journal of Manipulative & Physiological Therapeutics. Dr. Stuber serves on the JCCA Editorial Board and has peer-reviewed for several other journals and scientific conferences. Dr. Stuber maintains a clinical practice in Calgary, Alberta.

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Acute sciatica and progressive neurological deficit secondary to facet synovial cysts: A report of two cases.

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Objective: To describe two patients with lumbar facet synovial cysts causing sciatica and progressive neurological deficit.

Clinical Features: A 52-year-old female with bilateral sciatica and a neurological deficit that progressed to a foot drop; and a 54-year-old female with worsening sciatica and progressive calf weakness were seen at a major tertiary care centre. Diagnostic imaging studies revealed the presence of spinal nerve root impingement by large facet synovial cysts.

Interventions and Outcomes: Activity modification, gabapentinoid and non-steroidal anti-inflammatory medications were unsuccessful in ameliorating either patient's symptoms. One patient had been receiving ongoing lumbar chiropractic spinal manipulative therapy despite the onset of a progressive neurological deficit. Both patients eventually required surgery to remove the cyst and decompress the affected spinal nerve roots. Objectif : Description de deux patientes ayant des kystes synoviaux facettaires lombaires leur causant de la névralgie sciatique et un déficit neurologique progressif.

Caractéristiques cliniques : *Deux femmes ont été* examinées à un grand centre de soins tertiaires. La première, âgée de 52 ans, est atteinte de névralgie sciatique bilatérale et d'un déficit neurologique qui a progressé jusqu'au pied tombant; la deuxième, âgée de 54 ans, souffre d'une névralgie sciatique qui s'empire et d'une faiblesse progressive au mollet. L'examen de l'imagerie diagnostique a révélé un coincement de la racine du nerf rachidien, causé par de grands kystes synoviaux facettaires.

Interventions et résultats : La modification de l'activité et les médicaments gabapentinoïdes et anti-inflammatoires non stéroïdiens n'ont pas réussi à améliorer les symptômes des patientes. Une des patientes suivait une thérapie continue de manipulation rachidienne chiropratique malgré l'apparition d'un déficit neurologique progressif. En fin de compte, les deux patientes ont eu besoin de chirurgie pour extraire les kystes et décomprimer les racines du nerf rachidien affectées.

Conclusion : Les patients atteints de névralgie sciatique aiguë qui développent un déficit neurologique progressif alors qu'ils reçoivent des soins doivent, sans

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Acute sciatica and progressive neurological deficit secondary to facet synovial cysts: A report of two cases.

Conclusion: Patients with acute sciatica who develop a progressive neurological deficit while under care, require prompt referral for axial imaging and surgical consultation. Primary care spine clinicians need to be aware of lumbar facet synovial cysts as a possible cause of acute sciatica and the associated increased risk of the patient developing a progressive neurological deficit. (JCCA 2012; 56(3)173-178)

KEY WORDS: synovial cyst; facet joint; progressive neurological deficits, radiculopathy; chiropractic

délai, être orientés pour une imagerie axiale et une consultation chirurgicale. Les cliniciens de premiers recours traitant la colonne vertébrale doivent être mis au courant que les kystes synoviaux facettaires lombaires peuvent causer une névralgie sciatique aiguë et, en conséquence, un accroissement du risque que le patient développe un déficit neurologique progressif. (JCCA 2012; 56(3)173-178)

MOTS CLÉS : kyste synovial; facette vertébrale; déficits neurologiques progressifs, radiculopathie; chiropratique

Introduction

The etiology of lumbar facet joint synovial cysts (SC) is thought to be associated with vertebral segmental hypermobility and/or segmental instability.¹ Patients with lumbar facet joint SC typically present with acute sciatica, rather than lower back pain. When the cysts are large in size or atypical in morphology they can cause focal radiculopathy, neurogenic claudication and even cauda equina syndrome.^{1,2} However, unlike patients in whom spinal nerve root trauma is secondary to lumbar disc herniation, the natural history of acute sciatica secondary to a SC is generally unfavourable and any associated neurological deficit can become progressive.³

Previous reports of the clinical management of acute radiculopathy secondary to SC have described a wide variety of therapeutic approaches. These include the use of differing forms of chiropractic spinal manipulative therapy⁴⁻⁶, image-guided injection therapies including aspiration or distension/rupture⁷⁻¹² and surgical treatments such as either excision and fusion or excision alone^{2,13,14}.

This paper describes the diagnosis, clinical course and treatment of two patients with atypical forms of SC, one associated with an anterolisthesis and the other with SC calcification.

Case 1

A 52-year-old female presented to the Combined Neurosurgical and Orthopaedic Spine Program (CNOSP) outpatient clinic with a six week history of progressive numbness and

weakness in both lower extremities and a two week history of "floppy-feet" with poor balance and several falls. She denied any associated bowel or bladder dysfunction or saddle paresthesia. Her past medical history was remarkable for several prior episodes of lower back pain and bilateral buttock pain and numbness. She had received passive therapy and core strengthening exercises from a physiotherapist, which had not been helpful. Most recently she had been treated by a chiropractor who had administered side posture lumbosacral spinal manipulative therapy at a frequency of 2-3 times a week for 4 weeks. She denied or could not recall any other history of spine-related pain or other orthopaedic ailments. Her initial physical examination findings were a shuffling gait with a left-sided positive Trendelenberg test, grade 1/5 L4 and grade 3/5 L5 motor strength, and normal lower extremity sensation all on the left side. Her MRI scan showed a left-sided L3-4 synovial cyst (Figure 1a) and a Grade 1 anterolisthesis of L3 on L4 (Figures 1b), which was also visible on the lateral x-ray (Figure 1c). The patient underwent urgent L3-4 decompression and fusion surgery (Figure 2). She did not suffer any complications postoperatively. At hospital discharge, she was mobilizing independently. Her left L4 motor strength had improved to 4/5. She was transferred to the transitional care unit for further rehabilitation. The 6-week and 3-month postoperative follow-up assessments showed no evidence of persisting nerve root tension signs, and normal lower extremity motor and sensory testing. There were no surgical complications noted.







Figure 1a

Figure 1b

Figure 1c

Case 2

A 54 year-old woman presented to the CNOSP outpatient clinic complaining of progressively worsening left-sided buttock, posterior thigh, lateral calf and lateral foot pain. She further reported the recent onset of fatiguing of her left leg with walking for more than 10 minutes, and in the last month, collapsing of her right heel. She denied any associated cauda equina-like symptoms. Her past medical history was unremarkable for prior episodes of sciatica, lower back symptoms, and other spine or orthopaedic problems.

She reported that her symptoms began approximately seven months previously, initially with "nagging" leftsided lower back and buttock pain the morning after weight-training exercise in a gym. On the following day she experienced the onset of excruciating left-sided sciatica. She was seen initially by her family physician who detected positive straight leg raising, but no motor or sensory deficit in the left lower extremity. An urgent lumbar CT scan was arranged, which revealed the presence of a large, left-sided partially calcified joint synovial cyst at L5-S1. Moderate bilateral foraminal stenosis at the L5-S1 level was also identified. An acute lumbosacral radiculopathy (neurological level not specified) was initially diagnosed. Initial clinical management was activity modification as well as gabapentinoid and COX 2 class nonsteroidal anti-inflammatory medications.

At the time of her initial assessment in the CNOSP clinic she had strongly positive left-sided nerve root ten-



Figure 2



Figure 3a



Figure 3b

sion signs without cross over features. Reflexes were grade 2/4 at the knees, grade 1/4 at the right ankle, and absent at the left ankle. Motor testing showed mild weakness (i.e. 4/5) of her left foot and ankle everters and some fatiguing during repetitive toe standing on the left. Sensory examination revealed diminished sensation to pin prick and light touch along the left lateral foot, consistent with the distribution of the left S1 nerve root. There were no upper motor neuron signs.

An MRI scan demonstrated a large cystic structure adjacent to the left L5-S1 facet joint causing significant deviation of the thecal sac and traversing S1 nerve root (Figure 3a). The left S1 nerve root was seen to be directly compressed both ventrally and medially by the cyst and was cross-sectionally larger in size than on the right, suggesting swelling (Figure 3b).

Treatment options were discussed, including continuing to follow the natural history, image-guided injectionbased interventions, manual therapies and surgical management. However, in view of the progressive neurological features of her clinical course, the large size and position of her SC, and the presence of significant calcification, the patient elected to undergo laminectomy and cyst excision as recommended by her surgeon. The six-week post surgical follow-up assessment showed mildly positive nerve root tension signs and a mild (4+/5) L5 motor deficit. The 3-month postoperative assessment showed no nerve root tension signs, and normal lower extremity motor and sensory testing. There were no surgical complications noted.

Discussion

Synovial cysts (SC) are classified according to their histopathology, origin and location.¹⁵ They are distinguishable from perineural or extradural arachnoid cysts in that they arise from facet joints, are continuous with the capsule and have a partial or complete synovial lining.¹⁴ The preponderance of facet degeneration, degenerative spondylolisthesis and synovial cyst formation at the most mobile lumbar spinal segment (L4-5) suggests that instability likely plays a major role in SC pathogenesis.^{2,15,16,17} In a recent study of patients with leg pain referred for MR imaging, the prevalence of SC was 2.3%.¹⁵

The natural history of synovial cysts is not well-understood. Spontaneous cyst resolution is known to occur in only a small number of cases.¹⁸ Reported studies of nonoperative treatment outcomes have been limited to case reports and retrospective studies, with no prospective cohort studies or randomized trials being reported. Imageguided percutaneous SC interventions are now widely used as a first-line of treatment.^{10,19} Studies of imageguided SC aspiration, rupture or intra-articular steroid injection suggest that approximately half of treated patients obtain good to excellent long-term benefit (at 1.4 years post-intervention).^{7,8,9,11} However, in the subgroup of patients with synovial cysts that are either partially or extensively calcified, percutaneous procedures are less efficacious as the joint capsule cannot be effectively penetrated.

There are few published reports of lumbar SC cases

treated by chiropractors. Cox, reported two cases that benefitted from non-thrust manipulative techniques (flexion distraction) combined with physical therapy modalities. However, long-term outcomes were not reported.⁴ Taylor, using Cox's methods, reported similar benefits in a single case, but the patient's symptoms recurred and then necessitated ongoing visits and exercise therapy over a follow-up period of 4.5 years.⁵ In a third chiropractic case report, the patient received fifteen adjustments with only temporary benefit and eventually underwent surgical excision with good benefit.⁶

Surgical cyst excision is considered the gold-standard treatment for successful long-term outcomes and is recommended in all cases of neurologic deficit.^{13,20} Concomitant lumbar fusion is required in cases with spondylolisthesis and radiographically demonstrable segmental instability. In this regard, a systematic review of 82 studies showed that a substantial majority of surgically-treated SC patients obtained symptomatic resolution over the long-term (mean follow-up 25.4 months).²⁰

The presentation of a patient with an acute radiculopathy accompanied by a progressive neurological deficit should raise concern for all spine clinicians. As primary spine healthcare providers, chiropractors may well be the portal of entry into the healthcare system for many of these patients. With the recent trend towards standardized treatment pathways in mainstream spine patient management, the diagnostic acumen of chiropractors is facing ever-increasing scrutiny, and in this environment the minimum standard of care for spine patients must include diligent clinical monitoring and thorough record keeping.

The two cases that have been presented highlight the importance of considering the presence of a SC in the differential diagnosis of patients with acute sciatica. In particular, the spine clinician's index of suspicion for the presence of a SC should be raised when assessing a patient with a neurological deficit in combination with a degenerative spondylolisthesis and/or significant facet joint degeneration on plain film x-ray.

Summary

Primary care spine clinicians treating patients with acute sciatica need to be aware of the possibility of a synovial cyst as an underlying cause. Careful monitoring of the patient's lower extremity neurological function is prudent as the patient's clinical course unfolds. In patients whose symptoms are not improving or are progressively worsening, axial imaging and prompt surgical referral is indicated.

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Fascia: a morphological description and classification system based on a literature review

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Fascia is virtually inseparable from all structures in the body and acts to create continuity amongst tissues to enhance function and support. In the past fascia has been difficult to study leading to ambiguities in nomenclature, which have only recently been addressed. Through review of the available literature, advances in fascia research were compiled, and issues related to terminology, descriptions, and clinical relevance of fascia were addressed. Our multimodal search strategy was conducted in Medline and PubMed databases, with other targeted searches in Google Scholar and by hand, utilizing reference lists and conference proceedings.

In an effort to organize nomenclature for fascial structures provided by the Federative International Committee on Anatomical Terminology (FICAT), we developed a functional classification system which includes four categories of fascia: i) linking, ii) fascicular, iii) compression, and iv) separating fasciae. Each category was developed from descriptions in the literature on gross anatomy, histology, and biomechanics; the category names reflect the function of the fascia.

An up-to-date definition of fascia is provided, as well as descriptions of its function and clinical features. Our Le fascia est pratiquement inséparable de toutes les structures du corps, et il sert à créer une continuité entre les tissus afin d'en améliorer la fonction et le soutien. Il a déjà été difficile d'étudier le fascia, ce qui a donné lieu à des ambiguïtés dans la nomenclature, qui n'ont été abordées que récemment. Grâce à un examen de la documentation disponible, les avancées dans la recherche sur le fascia ont été compilées, et les problèmes relevant de la terminologie, des descriptions et de la pertinence clinique du fascia ont été traités. Nous avons adopté une stratégie de recherche multimodale pour nos recherches dans les bases de données Medline et PubMed, avec des recherches ciblées dans Google Scholar et manuelles, au moyen de listes de références et de comptes rendus de congrès.

Dans le but d'organiser la nomenclature des structures du fascia fournie par le Federative International Committee on Anatomical Terminology (FICAT, traduction libre : comité fédératif international de terminologie anatomique), nous avons mis au point un système de classification fonctionnel qui comprend quatre catégories de fascia : les fascias i) de liaison, ii) fasciculaire, iii) de compression et iv) de séparation. Chaque catégorie a été élaborée à partir de descriptions se trouvant dans la littérature portant sur l'anatomie macroscopique, l'histologie et la biomécanique. Le nom de chaque catégorie se rapporte à la fonction du fascia.

Une définition à jour du fascia est fournie, ainsi que des descriptions de ses fonctions et caractéristiques cliniques. Notre classification emploie la terminologie

*Canadian Memorial Chiropractic College, Department of Anatomy Correspondence should be addressed to: Myroslava Kumka, 6100 Leslie Street, Toronto ON M2H 3J1, Canada Tel: 416-482-240 ext: 175 Email: mkumka@cmcc.ca ©JCCA 2012 classification demonstrates the use of internationally accepted terminology in an ontology which can improve understanding of major terms in each category of fascia. (JCCA 2012;56(3):179-191)

KEY WORDS: fascia, connective tissue, classification, anatomy, histology, terminology, innervations, manual therapy acceptée à l'échelle internationale dans le cadre d'une ontologie qui peut améliorer la compréhension des termes importants dans chaque catégorie de fascia. (JCCA 2012;56(3):179-191)

MOTS CLÉS : fascia, tissu conjonctif, classification, anatomie, histologie, terminologie, innervations, thérapeutique manuelle

Introduction

Fascia is an uninterrupted viscoelastic tissue which forms a functional 3-dimensional collagen matrix.¹⁻³ It surrounds and penetrates all structures of the body extending from head to toe, thus making it difficult to isolate and develop its nomenclature.¹ The Federative International Committee on Anatomical Terminology (FICAT), in the 1998 edition of Terminologia Anatomica, points out significant flaws in the nomenclature system for fascia, largely stemming from the anglocentric nature of the terms used, and lack of formal international applicability.⁴ The usage of the terms superficial fascia and deep fascia is considered incorrect by the FICAT because histological terminology referring to layers of the connective tissue varies too much internationally to be generalized by these two terms.⁴ Common names of certain fascia are also considered to be inaccurate, e.g., Scarpa's, Camper's, and Colles'. It is suggested that they be replaced with subcutaneous tissue of abdomen membranous layer, subcutaneous tissue of abdomen fatty layer and membranous layer of perineum, respectively.4 Terminologia Anatomica gives a long list of terms related to their definition of fascia, and attempts to offer a system for grouping various fasciae based on embryological origins and modes of development. However, clear details on the groupings and justification for this strategy are not given, and it remains difficult to organize and properly use the multiple fascial terms. Furthermore, the application of these terms for communication in research, education, and clinical practice remains difficult and impractical. In light of the contribution made by the FICAT on fascial terminology, it is important to utilize their work on terminology and suggest how it may be further arranged and used in practice. Indeed, a number of experts have called for further development on the description and nomenclature of all fasciae and have made significant contributions of their own.⁵⁻⁷

Recent advances in research within the fields of biomechanics, gross anatomy, and histology, provide the international research community with an opportunity to improve the terminology associated with fascia, thereby improving intra- and inter-professional communications.⁵. ⁸⁻¹⁰ However, discrepancies still exist concerning the official definition, terminology, classification and clinical significance of fascia.⁵⁻⁶

For example, the FICAT broadly defines fascia as sheaths, sheets or other dissectible connective tissue aggregations. The First International Fascia Research Congress (2007) formulated a comprehensive definition of fascia as the soft tissue component of the connective tissue system, emphasizing its uninterrupted, three-dimensional web-like extensions and highlighting its functional attributes.^{1,4} The Congress went on to include joint and organ capsules, muscular septa, ligaments, retinacula, aponeuroses, tendons, myofascia, neurofascia and other fibrous collagenous tissues as forms of fascia, inseparable from surrounding connective tissues.¹ The broad nature of these two definitions is controversial, and not all of the tissues have been widely accepted into common usage. Thus, a consistent terminology to classify and categorize fascia has not been formally established and accepted internationally.5-6 Gray's textbook approach to naming fascia regionally based on the adjacent or overlaying structures is a practical approach, however, this suggests fascia has a beginning and an end, which is not true to its form.¹¹⁻ ¹² Thus, the topographical approach is important when

identifying regional fascia, but it is not used consistently in practice internationally, nor does it help to describe the functional role of the regional fascia.

A more recent ontology highlights the importance of two functional forms of fascia, *connecting* and *disconnecting*, for which fiber orientation and descriptions of fascia's role in proprioception are key justifications for each category.⁷ In support of this principle, there is an extensive body of work demonstrating that significant amounts of force are transmitted amongst multiple antagonist and synergistic muscle groups across joint capsules through various sections of extra- and intramuscular fascia.^{7-8,13-15}

Although the recent ontologies grounded in fascial function represent an advance in classification, the complexities of fascia make it necessary to expand on these two categories (*connecting* and *disconnecting*) to further sort and describe all groups of fascia according to their attributes reported recently in the literature.⁷ These additional attributes include: collagen type ratio, extracellular matrix proteins, nerve fiber types, myofascial force transmitting potential, details on fiber orientation, and influence on the circulatory system.^{8,16-21}

Lack of consistent terminology has a negative effect on communication within health professions, and impedes collaborations in research.²² Since fascia represents a topic of growing interest worldwide, it should be a priority to reduce ambiguity in fundamental terms so that this field of research can properly advance. For example, the lack of common definitions and nomenclature hinders communication between those involved in the process of diagnosis and treatment of pelvic pathologies in everyday practice.²³ One study revealed this by comparing the unofficial/common terms being used in the field and the terms provided by the Terminologia Anatomica, demonstrating how this text can be used to improve consistency in the nomenclature. While we do accept the validity of a topographical approach in naming fascia, it does not take into account the fact that fascia doesn't have a beginning and end like muscle, nor does a topographical approach account for fascia's microscopic features, or diversity of its functional characteristics.5-7,12

Purpose

The aim of the present study is to develop a classification system for fascial structures, based primarily on their functional properties, but also incorporating morphological characteristics identified in the literature, and utilizing internationally accepted terminology from the FICAT.^{4,24}

Methods:

A review of the literature on fascia was conducted with electronic searches of EBSCO databases, PubMed, and Google Scholar, along with hand searches of proceedings from the past two International Fascia Research Congresses (2007, 2009). Search strategies in EBSCO and PubMed consisted of individual and combined MeSH term searches for "Fascia" and "Connective Tissue" using specific limiters for our topic to emphasize anatomy. These search terms were also paired separately with various keywords - "terminology", "extracellular matrix", "collagen", and "function". Results were limited to English, full text peer reviewed journal articles, conference proceedings, and textbooks. Inclusion was limited to articles with abstracts related to morphology, terminology, and/or clinical aspects of fascia. Information was then used to help organize fascia terminology, utilizing terms from two texts: Terminologia Anatomica and Terminologia Histologica.4,24

Results

In section A below, we present the results of our literature review, discussing the anatomical, histological, and biomechanical features of fascia, and its innervation. Then in section B, we outline our resulting proposal for a new classification system (Table 1) incorporating these features of fascia. It is important to first understand the key characteristics and the divergent classifications of fascia at gross anatomical, histological, and biomechanical perspectives before outlining the details of these four categories.

A. Literature Review

I. Overview

The range of research advances revealed in the literature includes observations on imaging, advanced dissection and staining techniques, as well as modeling of tissue deformation, and in vitro cellular processes.^{10,12,25-30} Areas of interest at the past two (2009, 2010) Fascia Research Congresses have included: biomechanics, innervation, vascularisation, molecular structure, clinical relevance, and terminology.³¹ Upon review of the advances in fascia

research, we see that fascia is not a passive structure, but a functional organ of stability and motion, virtually inseparable from all surrounding tissue.

II. Gross Anatomy

Gross anatomical studies of fascia demonstrate an array of characteristics based on location, density, fiber direction, and fascia's relationship to surrounding structures.^{19,26-27} Based on location, the FICAT describes the following fasciae: i) in relation to the body regions: fascia of head and neck, fascia of trunk, and fascia of limbs, ii) in relation to the surrounding structures: subcutaneous fascia, fascia of muscles, visceral fascia, parietal fascia, and fascia extraserosalis which represents any other fascia which lies inside the parietal fascia and outside the visceral fascia.⁴

Fascia's key characteristic, continuity, helps explain concepts such as myofascial force transmission.³ Hunjing describes biomechanical features of extramuscular and intramuscular force transmission in rat specimens where surrounding connective tissues are seen to influence force potential and connect muscle groups.¹³⁻¹⁵ Dissectional observations of the intramuscular connective tissue (IMCT) show this fascia to influence length of sarcomeres to improve force production.¹⁵ Other morphological descriptions of fascia characterize it as being optimally designed to take up tensional forces in the musculoskeletal system.

In the past, classical dissection techniques have essentially ignored fascia, simply removing it to get to muscle and deeper structures.⁵ Subsequently, it was revealed through careful dissection that fascia commonly occurs as an undulating layered system of different connective tissue types.^{19,28-29} Three-dimensional models of the crural and thoracolumbar fasciae demonstrate that the "deep fasciae" are formed of three sub-layers of connective tissue with different densities and orientations.^{19,29} It was discovered that in each sub-layer the collagen fibers are parallel to each other, whereas the orientation between the fibers of adjacent layers changes, forming an angle of approximately 70-80 degrees with each other.²⁹ This allows denser fascial sheets to slide freely over underlying layers, without significant friction, and enhances fascia's ability to take up strain in virtually all directions.²⁹

It is difficult to gain an appreciation for the true appearance of fascia, aside from basic structure, in embalmed cadavers. Direct observation of fascia's appearance and behavior in a living, hydrated body, has been conducted with recent fluoroscopic imaging under the skin of the dorsal forearm, shedding new light on how this sliding collagenous system works.³²⁻³³ These observations demonstrate that fascia incorporates a water dense vacuolar system able to slide independent of the rate of contraction in muscle around it and able to conduct structures like capillaries throughout sections of myofascia.³²⁻³³ The viscoelastic nature of fascia can only be observed in hydrated tissue, and in embalmed tissue we are only observing an artifact of the living tissue. A better appreciation for the true gross appearance of fascia can be gained through fresh body dissections, and in vivo via direct imaging techniques.³⁴

Pathological changes in fascia have been observed with special imaging techniques, such as ultrasonic elastography that displays deformation and the elasticity of soft tissues.³⁴ This technology allows a non-invasive estimation of tissues stiffness based on the fact that soft tissue has greater tissue displacement than hard tissue when externally compressed.¹⁰ By further quantifying the properties of the soft tissues, as with recent 3-D mathematical models of fascial deformation, insight will be gained into the effects of manual treatments beneath the skin and how the body responds to various forces.^{30,35-36}

III. Histology

Fascia has specific cells, ground substance, and fiber types that make it a form of connective tissue proper.^{16,37-38} A better understanding of fascia at the cellular level gives insight into its functional properties.³⁹ Clear changes to the extracellular matrix (ECM) in the form of adhesive sites between microscopic filaments have been studied in "scarred" fascia.⁴⁰⁻⁴¹ Collagen types have also been shown to vary with mechanical forces and strains.³⁹ We hypothesize that the functional properties of fascia are reliant on the composition of the ECM, specific cells, and filaments, including but not limited to the ratio of collagen types.

Collagen, a triple helix glycoprotein, is the key structural fiber that gives connective tissue its ability to resist tension.^{17,37-38} There are twenty five distinct collagen types recognized in the Ross histology textbook and atlas, and twenty eight collagen types recognized in the latest review by Gordon.^{16,37} Although, type I collagen is the main type accounting for 90% of the human body's collagen, fascia contains an array of collagen type combinations including, but not limited to, types I, III, IV, V, VI, XI, XII, XIV, XXI.^{16-17,37-38} Collagen provides resistance to tension and stretch, which commonly occur in fascial tissues, such as ligaments, tendons, sheaths, muscular fascia and deeper fascial sub-layers.³⁷

Collagen type III, also known as reticular fiber, is involved in forming the scaffolding for the cells of the loose connective tissues related to the endoneurium, vascular walls, and smooth muscle.^{1-2,17}A collagen fibril needs the support of not only fibrillar collagen types, but also a mix of non-fibrillar forms known as fibril-associated collagens with interrupted triple helices (FACITs).¹⁶ The functions of FACITs include: i) anchoring to the basement membrane, ii) regulating the diameter of fibrils, iii) forming lattice networks, and iv) acting as transmembrane structures.¹⁶ These fibrils are important to the integrity and function of fascia within the ECM. Elastic fibers within the ground substance give fascia its characteristic stretch.^{29,37-38,42}

A combination of multiple types of collagen within the extracellular matrix forms a unique structure, like a blueprint that reflects the function and compliance of fascia in various regions.¹⁶⁻¹⁷ Without a characteristic fiber arrangement and composition for each fascial region, it is likely that fascia would not withstand stresses or have the same function.

The cells within fascia include fibrocytes (fibroblasts, myofibroblasts), adipocytes, and various migrating white blood cells.^{27,41-42} Fibroblasts are highly adaptable to their environment, and show a capacity to remodel in response to the direction of various mechanical stimuli, producing biochemical responses.^{29,41,43-45} If function changes, as with increased mechanical stress, or prolonged immobilization, deoxyribonucleic acid (DNA) transcription of pro-collagen in the fibroblasts will change types (e.g., collagen type I into collagen type III), or undifferentiated cell types may adapt towards a more functionally appropriate lineage (e.g., chondrocyte).^{42,45-48}

Benjamin et al, studied the morphological changes observable in various tendons and ligaments in response to biomechanical stresses.⁴⁶ It was established that the tissue structure and the molecular composition of ECM are directly correlated with the local mechanical forces.^{46,47} Under significant states of compression, tissue once populated with fibroblasts, becomes invested predominately with chondrocytes and forms specialized connective tissue, cartilage, with further solid mineral deposition.^{46,47} These adaptations have been demonstrated in the supraspinatus tendon, transverse acetabular ligament, transverse ligament of atlas, as well as various other ligaments and tendons throughout the body.^{47,48}

Myofibroblasts within fascia demonstrate contractile properties and contain actin-myosin filaments typically seen in smooth muscle.⁴⁹⁻⁵¹ The significance of these contractile properties remains unclear, however in-vitro observations of autonomous contraction of myofibroblasts harvested from porcine and rat fascia when stimulated with various pharmacological agents (i.e., mepyramine, angiotensine, glyceryltrinitrate) have been repeated in different labratories.⁵²⁻⁵³ An estimation of tension created by contraction of myofibroblasts when extrapolated to a large fascial sheet (i.e., thoracolumbar fascia) may produce tension within the musculoskeletal system between 30-40N.⁵¹ The significance of this contractile property remains hypothetical and reproduction of these contractile forces in-vivo in response to efferent neural stimulus is vet to be done.

Increased concentration of myofibroblasts in pathological fascia has been observed, suspected to create tissue contractures in clinical conditions like palmar fascial fibromatosis (Dupuytren's disease), plantar fascial fibromatosis (Ledderhose's disease), and adhesive capsulitis (frozen shoulder).^{49,54-56} Fascia is also susceptible to the actions of typical cells of inflammation influencing communication, growth, and function.^{37,38}

Fiber orientation in fascia is important to its overall structure and function, and can be viewed with the unaided eye, polarized light, or various microscopic techniques.^{18,27,57} It is a consistent observation that the fibers are oriented parallel to predicted force vectors, and are likely to resist tension.^{18,27,57} Based on certain common characteristics, including the fiber arrangement, connective tissue proper is classified by the Terminologia Histologica as loose connective tissue and dense connective tissue.²⁴ The dense connective tissue is sub-categorized as: i) unidirectional parallel ordered dense connective tissue, ii) multidirectional parallel ordered dense connective tissue, iii) woven connective tissue, iv) irregular fusocellular connective tissue.²⁴

IV. Mechanotransduction

Mechanotransduction entails significant cellular change that occurs in response to biomechanical tension and compression. These stimuli exert their effects within the cells through filaments of the ECM, and so mechanical stimulation leads to a cascade of events which eventually influences the activity in the nucleus.^{48,58,59} Mechanotransduction is produced as cells convert a diversity of mechanical stimuli, transmitted throughout the ECM, into chemical activity to regulate morphology and function of tissues.⁶⁰⁻⁶¹ The cellular responses include the release of interleukins, adhesion kinases and other biochemicals.⁶¹⁻⁶²

Local injury in a tissue can have widespread consequences via mechanotransduction's role in stimulating quiescent cells to form active fibroblasts.62 This mechanism of cellular activation via mechanical force has been hypothesized to play a role in embryological development as part of the induction process of mesenchymal cells throughout the mesoderm.⁶³ Clinically, the effects of mechanotransduction have been observed with the intervention of acupuncture.64 There is evidence to suggest that the insertion of acupuncture needles into the fascia stimulates the activity of fibroblasts, presumably through physical strain exerted on the transmembranous microfilaments in the ECM.65-66 Needles will also cause displacement of that tissue, and twisting of the needle once it is inserted can cause further displacement of the fascia as measured with ultrasonic elastomyography.³⁵ Simple manual pressure has also been demonstrated, through deformation, to cause alterations in the viscoelasticity of tissue.^{30,36} These cellular and filamentous responses may provide a theoretical framework for the therapeutic mechanisms of soft tissue therapies.36,67-68 An understanding of mechanotransduction reveals that for healing and injury it is not only the gross observable reaction of tissues that is of interest, but also the biomechanical response of the ECM within fascia.

V. Innervation

Electron microscopy and special staining procedures demonstrate that fascia is populated by sensory neural fibers, suggesting that fascia contributes to proprioception and nociception, and may be responsive to manual pressure, temperature, and vibration.^{18,26,69,70} Some receptors found within fascia may be responsive to, and influence some autonomic responses, such as lowering blood pressure.⁷¹⁻⁷²

On a structural basis, two classes of sensory receptors are recognized: free nerve endings as terminal branches of

the axons, and encapsulated endings with distinctive arrangements of non-neuronal cells that completely enclose the terminal parts of the axons.73 Some of these receptors function as both a mechanoreceptor and a nociceptor (types III and IV receptors).⁷³ Pain that arises in muscles, tendons, ligaments, and bones is detected by these receptors. There have been conflicting results in the research, but most recent evidence has revealed small diameter free nerve endings in the thoracolumbar fascia of rats and humans.⁶⁹ One investigation has revealed the presence of these fibers on electronmicroscopy¹⁸, meanwhile another group has demonstrated calcitonin gene-related peptide (CGRP) and substance P (SP) within the same fibers, suggesting afferent function, including nociception.⁶⁹ Further work must be done on human specimens as currently the best evidence is heavily reliant on animal models.

Langevin et al, developed a pathophysiological model of low back pain based on connective tissue nociception, after demonstrating on ultrasound the structural alterations of the low back connective tissues.^{34,70} Fascial connections within different motor units, and different functional synergists, can provide an alternative explanation for referred pain distributions, which often do not follow either nerve pathways or the morphology of a single muscle.⁷⁴

Many encapsulated endings found in fascia are mechanoreceptors that respond to mechanical pressure or deformation, and include Golgi receptors, Pacinian corpuscles, and Ruffini's corpuscles.^{18,26,75-76} Different techniques of tissue manipulation may stimulate the above receptors: the high-velocity thrust manipulations and vibratory techniques likely stimulate Pacinian receptors, while slow, deep soft tissue techniques likely target Ruffini's bodies.⁷⁵⁻⁷⁶ Knowing what receptors are more significantly concentrated in a particular target tissue can help a manual practitioner choose the method of stimulus and technique (e.g., deep pressure, light stroke, stretch, tension, or vibration).⁷⁵⁻⁷⁶ Understanding that certain types of fascia are more densely populated with certain particular receptors can aid in the overall understanding of the body and creating more effective approaches to manual treatments.

B. Classification System

In an effort to organize nomenclature for fascia provided by the FICAT, we developed a functional classification system which includes four categories of fascia: i) *link-ing*, ii) *fascicular*, iii) *compression*, and iv) *separating* fasciae.

All fascia-related terminology provided in the Terminologia Anatomica can be subsumed within these four categories (Table 1).⁴ This system is not meant to be a reductionist approach to the fascial system, but a mode of exploring and better understanding the complex interaction of functions that exist within the system. Each region of the body contains multiple categories, suggesting that every region of the body has a complex mixture of different fascial types. To illustrate this concept, the thigh is an example of a body region which contains all four fascial categories: Illiotibial band (*Linking*), perimysium of the quadriceps femoris muscle (*Fascicular*), fascia lata (*Compression*), and subcutaneous tissue (*Separating*).

I. Linking Fascia

The *linking* category is predominantly dense regular parallel ordered unidirectional connective tissue proper with a significant amount of collagen type I.^{16,24} This includes fasciae of muscles, fasciae of regions (head & neck, trunk, limbs), aponeuroses, tendinous arches and neurovascular sheaths.⁴

This category is subdivided into dynamic and passive divisions. The dynamic division includes major fascial groups more significantly related to movement and joint stability, and characterized by higher concentrations of contractile and proprioceptive fibers. The dynamic division is composed of fasciae of muscles (investing layer, fascia of individual muscle), and fasciae of the trunk.⁴ The innervation of dynamic linking fascia functionally differentiates it from other categories, permitting it to contribute to nociception and proprioception. For example, the thoracolumbar fascia (TLF) contributes to spinal stability and makes firm connections between the trunk and limbs.⁷⁷ It is also densely innervated by free nerve endings and Paciniform corpuscles which respond to rapid pressure and vibration.^{2,18,73,78}

The passive division is acted on by other extramuscular tissues to maintain continuity throughout the body or form tunnels and sheaths.⁷ The passive division incorporates fasciae of muscles (muscle sheaths), fasciae of the head and neck, fasciae of limbs, aponeuroses, tendinous arches, and retinaculae.⁴ This group can act as muscular insertion points, such as the epicranial aponeurosis, and as joint linkages and tendinous arches ultimately providing proprioceptive information when tension is exerted.⁷ The passive *linking* fasciae can only transmit force when they are stretched and loaded, while *dynamic* fasciae can theoretically contract more autonomously like smooth muscle, thereby affecting tension in the musculoskeletal system, but not significant enough to be the primary mover of limbs.⁵¹

II. Fascicular Fascia

Fascicular fascia forms adaptable tunnels which bundle vessels as well as fascicles within muscle, tendon, bone and nerves. *Fascicular* fascia plays an important role in organization, transport, strength and locomotion.³⁹ This category is organized as a mixture of both loose and dense regular multidirectional connective tissues.²⁴ Types I and III collagen are the major components of these tissues with lesser amounts of Types V, VI, XII, and XIV.^{16,39,79}

Fascicular fascia of the muscle comprises three distinct layers of IMCT: epimysium surrounding whole muscles, perimysium separating fascicles or bundles of muscle fibers within the muscle, and endomysium covering the individual muscle fibers.³⁹ Forming the muscle architecture, this network of collagen fibers can be seen as an extensive matrix of tunnels that connects and dissipates force within muscle, provides intramuscular pathways and mechanical support for large and small nerves, blood vessels and lymphatics.^{32,39,79} The fascial fascial of the muscle converges into a dense regular connective tissue link at the myotendinous junction to become fascicular fascia of the tendon, comprising endotendon, peritendon and epitendon.^{5,7,79} At this junction, fascicular fascia is richly innervated by Golgi tendon organs which are stimulated by muscle contraction.37,38 Tension in the tendon results in a reflex decrease in tonus in contiguous striated muscle fibers.70

IMCT is essential for myofascial force transmission (as outlined in Results section A I), enhancing the forces produced by muscles.⁸ *Fascicular* fasciae allow forces to be transferred from within muscle to synergistic muscles, and also, via the extramuscular pathway, through the *link*-*ing* fascia, to antagonistic muscles.^{8,13-14} The *fascicular* fascia forms the connective tissue envelope for nerve fascicles and whole peripheral nerves: perineurium and epineurium, respectively.^{37,38} The perineurium serves as a metabolically active diffusion barrier that contributes to

Fas cate	cial gory	Function	(Examples) Terminologia Anatomica ⁴	Terminologia Histologica ²⁴	Histological features ^{16,37}
L i n g	Dynamic	 role in movement and stability critical to myofascial force transmission creates significant pretension in musculature 	Fasciae of muscles (investing layer) & fasciae of individual muscles: Pectoral fascia Supraspinatus fascia Deltoid fascia Fasciae of trunk: Thoracolumbar fascia Diaphragmatic fascia Iliopsoas fascia Fasciae of limbs/membrorum Iliotibial tract Axillary fascia	Dense regular parallel ordered unidirectional connective tissue proper	Collagen types: I, XII, XIV Actin-myosin filaments Pacinian corpsules, Free nerve endings
	Passive	 maintains continuity, passive force transmission proprioceptive communication throughout the body 	Fasciae of muscles (muscle sheath) Rectus sheathHead & Neck Cervical fascia Carotid sheath Ligamentum nuchae Ligamentum flavumFasciae of limbs/membrorum Intermuscular septae Anterior talofibular ligamentAponeuroses Erector spinae aponeurosis Bicipital aponeurosis Plantar aponeurosisTendinous arches Muscular & vascular spaces/lacunae Iliopectineal arch Tendinous arch of soleus	Dense regular woven connective tissue Multidirectional parallel ordered connective tissue	Collagen types: I, III, XII, XIV Elastin Golgi tendon organs, Pacinian & Ruffini's corpuscles
Fa	scicular	 provides myofascial force transmission & proprioceptive feedback for movement control maintains protection for nerves and vessels allows vascular sheaths to be in continuity with adventitia 	Intramuscular & extramuscular fasciae. Neurovascular sheaths Endomysium Perimysium Epimysium Endotendon Peritendon Paratendon Perichondrium Endosteum Periosteum Endoneurium Perineurium Epineurium	Loose connective tissue Dense regular multidirectional parallel ordered connective tissue Dense irregular connective tissue	Collagen types: I, III, IV, V, XII, XIV Golgi tendon organs

 Table 1
 Fascial categories: function, terms, and histological features

Table 1 (Continued)

Fascial category	Function	(Examples) Terminologia Anatomica ⁴	Terminologia Histologica ²⁴	Histological features ^{16,37}
Compression	 provides stocking, compression and tension compartmental effects influences venous return enhances proprioception, muscular efficiency and coordination 	Fasciae of limbs/membrorum Brachial fascia Antebrachial fascia Dorsal fascia of hand Fascia lata Crural fascia Dorsal fascia of foot	Dense regular woven connective tissue Multidirectional parallel ordered connective tissue	Collagen type I Elastin Ruffini's corpuscles
Separating	 compartmentalizes organs and body regions to maintain structural functions promotes sliding and reduces friction during motion responds to stretch and distention provides physical support and shock absorption limits the spread of infection 	 Parietal Fascia Parietal pleura Fibrous pericardium Endothoracic fascia Parietal peritoneum Endoabdominal fascia Endopelvic fascia Visceral fascia Meninges Visceral pleura Serous pericardium Visceral peritoneum Visceral peritoneum Visceral abdominal fascia Visceral pelvic fascia Extraserosal fascia Sternopericardial ligaments Bronchopericardial membrane Pulmonary ligaments Extraperitoneal fascia Investing fascia Subcutaneous tissue of abdomen Membranous layer of perineum	Loose connective tissue Dense irregular fusocellular connective tissue	Collagen types: III, V, VII Extracellular matrix: reticular and elastic fibers Reticular fibers provide a cellular framework Elastin Pacinian and Ruffini's corpuscles

the formation of a blood-nerve barrier.⁸⁰ The blood vessels that supply the nerves travel in the epineurium.⁸⁰ These two layers of the *fascicular* fascia are innervated by the nervi nervorum, which can evoke nociception through the release of CGRP and may create neurogenic inflammation.⁸¹ An inflammation of the nervi nervorum causes the inflammatory reaction of the nerve's fascial envelopes to induce the mechanical sensitivity, which can manifest as local, radicular, or neuropathic pain.^{75,82,83}

III. Compression Fascia

Compression fascia is a mixture of dense regular woven and multidirectional parallel ordered connective tissue layers that ensheath whole limbs to create a stocking effect.^{24,84} This fascial category plays an important role in locomotion and venous return due to its influence on compartmental pressure, muscle contraction and force distribution.^{20,29,84} For example, the crural fascia is composed of two or three layers of parallel ordered collagenous fiber bundles, each layer being separated by a thin layer of loose connective tissue.^{19,29} The spatial orientation of the collagen fibers changes from layer to layer within the *compression* fascia.²⁹ The presence of loose connective tissue interposed between adjacent layers permits local sliding, allowing the single layers to respond more effectively.²⁹

Examples of this type of fascia are observed in the limbs and are observed as fascia lata, crural fascia, brachial fascia, and antebrachial fascia. While there are proprioceptors embedded in this fascia, its role as a sensory organ is less significant than that of the *linking*, or *fascicular* categories.

IV. Separating Fascia

Separating fascia is generally loose connective tissue and dense irregular fusocellular connective tissue.²⁴ The reticular Type III collagen fibers and elastic fibers are the major components of the ECM of *separating* fascia, with small amounts of collagen Types V, VII.¹⁶⁻¹⁷ While the reticular fibers provide a supporting framework for the cellular constituents, the elastic fibers form a threedimensional network to allow *separating* fascia to respond to stretch and distention.^{28,37} *Separating* fascia divides the body in visible sheets and layers of varying fibers allowing it to take up forces and friction in all directions. While its major function is to allow more efficient sliding of tissues over one another, it may still form adhesions from faulty movement patterns or injury.⁵⁴

FICAT's terms for *separating* fascia include: parietal fascia, visceral fascia, extraserosal fascia, investing/subcutaneous fascia, formerly known as fascia superficialis.⁴ This category also includes synovial sheaths and fasciae of limbs.⁴ Parietal fascia lies outside the parietal layer of serosa such as pericardium, pleura and peritoneum, and lines the wall of a body cavity.⁴ Visceral fascia lies immediately outside the visceral layer of the serosa and surrounds the viscera.^{4,85} Extraserosal fascia lies within the space between the visceral and parietal fasciae.⁴

This fascia class is a complex connective tissue matrix, ensheathing everything from body cavities to individual organs. It separates, supports, and compartmentalizes organs and regions in order to maintain proper structural and functional relationships throughout the body. This group of fascia has a unique appearance and texture upon observation, ranging from transparent woven sheets to a fuzzy cotton-like consistency.²⁸

The innervation of *separating* fascia serves primarily to sense distension and compression of tissues. More detailed histological analyses are necessary to reveal with certainty the fascial innervations of these deep layers. However, concentrations of Pacinian corpuscles (detecting deep pressure) and Ruffini's corpuscles, which responding slowly to sustained pressure and tangential forces, are thought to be present in much of *separating* fascia, for example, in subcutaneous tissue.^{28,70,86} Deep sustained pressure may be necessary for manual practitioners to affect this fascial tissue.

Conclusion

Through this article, we have reviewed advances in fascia research and addressed issues related to terminology and classification of fascia. The literature supports defining fascia as an innervated, continuous, functional organ of stability and motion that is formed by 3-dimensional collagen matrices. In an effort to organize the nomenclature of fascia, we devised a functional classification system which includes four categories of fascia: i) *linking*, ii) *fascicular*, iii) *compression*, and iv) *separating* fasciae.

These categories were developed based primarily on the functional properties of fasciae, with further observations from the literature on gross anatomical, histological and biomechanical features, and terms unique to each category. Such a classification system based on functional properties of fasciae may have more relevance to the clinical experiences of manual therapists.

All fascial related terminology provided in the Terminologia Anatomica⁴ can be subsumed within these four fascial categories (Table 1).

Each region of the body contains multiple categories. This suggests that the complex interaction of different fascial types improves the musculoskeletal system's efficiency. It is our hope that this classification system will add clarity, improve diagnostic precision and contribute to manual therapists' understanding of fascia as a target of pathology and treatment.

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Two cases of work-related lateral epicondylopathy treated with Graston Technique® and conservative rehabilitation

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Objective: To chronicle the conservative treatment and management of two work-related cases of lateral elbow pain diagnosed as lateral epicondylopathy.

Clinical features:

Patient 1: A 48-year old female presented with gradual onset of right lateral elbow pain over the course of six weeks related to work activities of repetitive flexion/extension movements of the wrist and finger keying.

Patient 2: A 47-year old female presented with gradual onset of left lateral elbow pain over the course of four weeks related to work activities of repetitive squeezing and gripping.

Intervention and outcome: The conservative treatment approach consisted of activity modification, bracing, medical acupuncture with electrical stimulation, Graston Technique®, and rehabilitative exercise prescription. Outcome measures included verbal pain rating scale (VPRS), QuickDASH Work Module Score (QDWMS), and a return to regular work activities. Both patients attained resolution of their complaints, and at eight month follow-up reported no recurrence of symptoms.

Conclusion: A combination of conservative rehabilitation strategies may be used by chiropractors to treat work-related lateral epicondylopathy and allow Objectif : Documenter le traitement conservateur et la gestion de deux cas de douleur au coude latéral liée au travail, diagnostiquée comme épicondylopathie latérale.

Caractéristiques cliniques :

Patiente 1 : Une femme de 48 ans présente une douleur latérale du coude droit à apparition graduelle sur six semaines. La douleur est liée au travail et due aux mouvements répétitifs de flexion/extension du poignet et de saisie au clavier.

Patiente 2 : Une femme de 47 ans présente une douleur latérale du coude gauche à apparition graduelle sur quatre semaines. La douleur est liée au travail et due aux mouvements répétitifs de serrement et de préhension.

Intervention et résultat : L'approche adoptée pour le traitement conservateur comprenait la modification de l'activité, l'appareillage, l'acupuncture médicale avec stimulation électrique, la technique Graston^{MD} et la prescription d'exercices de réadaptation. Les résultats ont notamment été mesurés au moyen d'une échelle verbale de notation de la douleur (VPRS), du QuickDash Work Module Score (QDWMS) et du retour aux activités de travail régulières. Les deux patientes ont réglé la source de leurs plaintes, et pendant le rendez-vous de suivi, huit mois plus tard, elles n'ont signalé aucune récurrence des symptômes.

Conclusion : Les chiropraticiens peuvent employer une combinaison de stratégies de réadaptation conservatrices afin de traiter l'épicondylopathie latérale

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for individuals to minimize lost time related to this condition. (JCCA 2012; 56(3): 192-200)

KEY WORDS: tennis elbow, lateral epicondylopathy, Graston Technique[®], epicondylitis, epicondylagia

Introduction:

Lateral elbow and proximal forearm extensor pain is a musculoskeletal disorder historically known as tennis elbow, lateral epicondylagia, or lateral epicondylitis. In a seminal 1999 study by Nirschl et al., histopathological examination of over 600 cases of chronic epicondylagia revealed a degenerative process consisting of fibroblastic tissue, vascular hyperplasia, disorganized and unstructured collagen, and a lack of inflammatory cells associated with these cases.¹ The researchers concluded that a more appropriate term for this condition should be "lateral elbow tendinosis". Present-day use of the term tendinosis or tendinopathy implies the absence of inflammatory markers², with the latter name being used to describe overuse injuries without histopathological confirmation.

Recent data suggests that the prevalence of lateral epicondylopathy (LE) in the general population is approximately 1.0% to 1.3% in men and 1.1% to 4.0% in women.³ Prevalence rates as high as 2% to 23% have been reported within occupational populations.⁴⁻⁶ The scientific literature has attempted to identify risk factors associated with LE and the working population (Table 1). The highest prevalence of LE has been reported among subjects 40 to 60 years of age.^{3.5.8} LE appears to occur more frequently than medial-sided elbow pain, with documented ratios ranging from 4:1 to 7:1.⁹ The natural history of symptomatic LE can range from six to twenty-four months.¹⁰

With the dominant arm commonly affected^{4,11,12}, LE can lead to pain and functional limitations with activities such as gripping, carrying, and lifting. As a result, LE has been linked to reduced productivity, lost time from work, and residual disability.^{13,14,15} In the province of Ontario, the Workplace Safety and Insurance Board (WSIB) identified 2576 workers with LE who were treated in the Upper Extremity Program of Care by chiropractors and

liée au travail et de permettre aux personnes de réduire à un minimum le temps perdu en raison de ce trouble. (JCCA 2012; 56(3): 192-200)

MOTS CLÉS : épicondylite, épicondylopathie latérale, technique Graston^{MD}, épicondylite, épicondylalgie

Table 1Work-related Risk Factors associated with
Lateral Epicondylopathy7

Hands bent with precision movements during a part of the working day	Low job control (i.e. little influence on planning, pacing of work, variation, modification)
Handling loads >20 kg at least 10 times/day	Low social support
Handling tools >1 kg	Arms lifted in front of the body
Repetitive hand/arm movements >2 hours/day	

physiotherapists between 2005 and 2008. Thirty-two percent (832) of these cases were classified as having lost time from work.¹⁵ Workers compensation board statistics from the province of Quebec indicate the average length and amount of compensation for cases of LE was 87.8 days and \$5860 respectively in 2008.¹⁶

According to the National Board of Chiropractic Examiners 2005 Job Analysis of Chiropractic, the chief presenting complaint on initial visit of 8.3% of chiropractic patients in 2003 was in an upper extremity.¹⁷ Chronic tendon pathology is a soft tissue condition commonly seen in chiropractic practice¹⁸, and chiropractors often provide a number of conservative interventions used to treat tendinopathy.¹⁹ This case study was conducted to chronicle the treatment and management of two work-related cases of lateral elbow pain diagnosed as LE.

Case report:

Case 1: A 48-year old, right hand dominant female pre-

PHYSICAL EXAMINATION PARAMETER	CASE #1 (RIGHT ELBOW)	CASE #2 (LEFT ELBOW)
Inspection: Elbow, forearm, wrist regions	• Unremarkable	• Unremarkable
Cervical Spine Screen: ROM and Orthopaedic testing	• Within normal limits (WNLs)	• WNLs
Upper Extremity Neurological Screen: (reflex, sensory, motor testing)	• WNLs	• WNLs
Elbow Examination	 Valgus and Varus testing unremarkable Radiohumeral, proximal radioulnar and ulnohumeral joint play WNLs 	 Valgus and Varus testing unremarkable Radiohumeral, proximal radioulnar and ulnohumeral joint play WNLs
Elbow and Wrist ROM testing	 Active elbow ROM WNLs Active wrist flexion and extension limited by pain; passive wrist flexion painful 	 Active elbow ROM WNLs Active wrist flexion and extension uncomfortable at end ranges; passive wrist flexion painful
Resisted testing	• Resisted forearm supination, wrist extension, and middle finger extension produced significant pain at the lateral epicondyle and in the forearm	• Resisted forearm supination, wrist extension, and middle finger extension reproduced pain at the lateral epicondyle
Palpation	 Tenderness with accompanying lumpy tissue texture in the extensor carpi radialis brevis (ECRB), extensor digitorum (ED), and at common extensor origin Tenderness only in the brachioradialis, extensor carpi radialis longus (ECRL), and distal tricep brachii 	 Tenderness with accompanying lumpy tissue texture in the ECRB, ED, and at common extensor origin Tenderness only in the brachioradialis and ECRL

Table 2Physical Examination results for Case #1 and Case #2

sented with gradual onset of right lateral elbow pain over the course of six weeks related to work activities of repetitive flexion/extension movements of the wrist, and finger keying with an electronic scanning device. She reported that her workload had recently increased and likely contributed to the onset of this complaint. Her pain had considerably worsened over the previous two weeks. She indicated that cryotherapy directed at her forearm and elbow, along with over the counter medication use (ibuprofen) provided temporary pain relief.

The patient rated her pain as 7/10 on the Verbal Pain Rating Scale (VPRS) (where 0 is "no pain" and 10 is the "worst pain that she had ever experienced"). Her Quick-DASH Work Module Score (QDWMS) was 95 out of a possible score of 100. She was primarily limited in her ability to perform lifting, squeezing, pushing, and pulling activities. Past medical history revealed carpal tunnel syndrome on the right resolved with surgery six years prior, and no other history of significant right upper extremity injury. A systems review and family health history was unremarkable.

Physical examination findings for this case can be found in Table 2. The patient was diagnosed with LE. A functional report was provided for the employer with a request for the provision of temporary modified duties. The employee was granted modified work duties which entailed supervision responsibilities not requiring any physical use of her right arm. Treatment was initiated and consisted of medical acupuncture (points consisting of physiological tender regions within the extensor carpi radialis brevis, extensor carpi radialis longus, and extensor digitorum) with electrical stimulation (IC-1107+ at 2 Hz frequency). Graston Technique® (GT) was also administered by a certified provider using GT protocols to the

Figure 1 A-C *The eccentric training protocol for lateral epicondylopathy (LE).*



(A) The patient starts with the elbow extended to 180 degrees, dumbbell in hand with the wrist in the extended position.



(B) The extensor tendons are then eccentrically loaded by slowly lowering the hand over the edge of the table into a flexed position.



(C) The patient returns to the starting position using the contralateral unaffected hand to avoid concentric loading (wrist extension). Table 3Overview of the rehabilitative exercisesprescribed for both cases of lateral epicondylopathy

EXERCISE	INSTRUCTIONS
• Forearm flexor and extensor stretches	• 3 sets of 10 repetitions, 15- 20 second holds for each respective stretch, 5 x/wk
 Eccentric wrist extensor training with dumbbell Position: Extension of the elbow to 180° (Figure 1A-C) 	 3 sets of 10-15 repetitions 5 x/wk Assist with other hand during concentric (extension) movement phase to help in returning to the start position Increase weight of dumbbell once functional tolerance for 15 repetitions is attained
• Concentric strengthening exercises with dumbbell: wrist extension (elbow at 90 degrees), wrist flexion, hammer curls, bicep curls, tricep extensions	 2 sets of 10-15 repetitions for each respective exercise, 5 x/wk Increase weight of dumbbell once functional tolerance for 15 repetitions is attained
• Strengthening with theraband: Forearm pronation and supination	 2 sets of 10-15 repetitions for each respective exercise, 5 x/wk Increase resistance on band once functional tolerance for 15 repetitions is attained

symptomatic soft tissue structures following the acupuncture treatment. The patient was initially prescribed exercises consisting of forearm extensor and flexor stretches and eccentric wrist extensor training using a hand held dumbbell (Figure 1A-C). At the beginning of week five, additional strengthening exercises were introduced. A summary of the full rehabilitative exercise treatment protocol can be found in Table 3.

This patient was seen twice a week for two weeks and then once per week for six weeks for a total of 10 treatment visits. Gradual improvement was reported during the entire course of treatment. Medication use was discontinued in week five and a return to regular work duties occurred in week eight. At week 10, the patient reported a VPRS score of 0/10 and a QDWMS score of 0 was calculated. ROM, resisted testing, and palpatory findings were within normal limits at this time. The patient was subsequently discharged from active care and advised to return if her symptoms recurred. At eight month follow-up conducted via telephone, the patient reported no recurrence of symptoms.

Case 2: A 47-year-old left hand dominant female presented with gradual onset of left lateral elbow pain over a four week period related to beginning a new work activity requiring repetitive squeezing and gripping. She reports that she brought this complaint to her family physician's attention during a routine physical visit approximately two weeks prior when the symptoms were relatively mild. The physician recommended over the counter medication (acetominophen) and an elbow bracing device. The patient indicated that the medication did not provide any significant pain relief, however, the brace did allow her to work with less pain. The patient rated her current pain as 5/10 on the VPRS. Her QDWMS was 62.5. She reported pain while performing repetitive gripping and squeezing activities. Although she was able to continue working, she found that approximately four hours into her shift she would develop a feeling of pain in her left forearm. She denied experiencing any weakness, numbness or tingling in her hand. Past medical history, systems review and family health history were unremarkable. She did not report any other previous history of significant left upper extremity injury.

Physical examination findings for this case can be found in Table 2. A diagnosis of LE was communicated verbally to the patient. The patient did not want to pursue the possibility of modified duties, wishing instead to try and work through the pain. As with case #1, medical acupuncture with electrical stimulation and GT was initiated immediately. Unlike case #1, this patient wore a counterforce brace placed just distal to the lateral epicondyle during work activities. This patient completed the same exercise protocol as case #1. She was seen twice a week for three weeks and then once per week for six weeks for a total of 12 treatment visits. Gradual improvement was reported during the entire course of treatment. The patient was able to continue with her regular duties during the entire treatment program. At week 12, the patient reported a VPRS score of 0/10 and QDWMS score of 0 was calculated. The patient was subsequently discharged from active care and at eight month follow-up conducted via telephone she reported no recurrence of symptoms.

Discussion:

Lateral epicondylopathy (LE) is considered to primarily originate from repetitive and sustained loading of the extensor carpi radialis brevis (ECRB) musculotendinous unit^{1,9,20}, though up to one third of patients also have involvement in the origin of the extensor digitorum¹. Jafarian et al. provide an excellent referenced description on the anatomical pathogenesis of LE.²¹ The aponeurosis of the common origin of the wrist extensors at the lateral epicondyle is the area where the maximum tensile force occurs during wrist movements.^{22,23} The ECRB tendon, which is located deep to the origin of the extensor digitorum²⁴, has its insertion located proximal to the elbow axis, causing shear stress, contact stress, and abrasion against the lateral epicondyle during elbow motion.^{22,23,25} The ECRB tendon is repetitively and heavily loaded dur-



Figure 2 *Extensor muscles of the forearm.*²⁸ Drake: Gray's Anatomy for Students, 2nd Edition. Copyright © 2009 by Churchill Livingstone, an imprint of Elsevier, Inc. All rights reserved.

ing many everyday upper limb activities.²¹ It functions as a stabilizer for gripping activities involving pronation and supination, and is a prime mover for wrist extension.^{26,27} The ECRB tendon is also at risk for fatigue and injury as the large volume of work it is capable of performing is not proportional to the vascular supply of the muscle.²¹ The tendon can bear large loads of up to 10 times an individual's body weight, but only receives 13% of the oxygen supply provided to the muscle.^{22,23} The relationship of the ECRB with the extensor surface of the forearm can be seen in Figure 2.

Individuals with LE often report an onset of lateral elbow pain that may coincide with a history of engaging in a new activity or increasing the intensity of an existing activity.²⁹ In the early stages of LE, pain may only be

Table 4	
Differential diagnostic list for lateral elbow p	ain ^{30,31}

C6-C7 radiculopathy	Arthrosis of the radiohumeral joint
Posterior interosseus nerve entrapment	Lateral collateral ligament incompetency
Osteochondritis dissecans	Plica synovialis
Radiocapitellar disorders	

present during activity. As the condition progresses, pain may also be present at rest, and the ability to sustain activity levels is shortened. This often correlates with functional limitations in gripping, pushing, pulling, and lifting activities of the affected upper extremity. Palpation will produce point tenderness over or just distal to the lateral epicondyle, and may also be present in the wrist extensor muscle mass. Pain may be reproduced during the physical exam by testing resisted forearm supination, wrist and middle finger extension, along with hand grip strength. Provocative manoeuvres such as Cozen's and Mill's tests may also be helpful for diagnosis.³⁰

LE is typically diagnosed during the clinical examination without the need for additional diagnostic testing.³¹ Cases resistant to conservative treatment may require further investigation. Radiographic examination, ultrasound, MRI, or electromyophysiological testing may be helpful in identifying other causes of lateral elbow pain.^{32,33} A differential diagnostic list for lateral elbow pain is included in Table 4.

Initial management of LE is focused on eliminating the offending activities that create repetitive loading on the injured soft tissue. Relative rest prevents ongoing injury, allows for healing of the tendon, and decreases pain levels.^{29,34} In clinical practice, health professionals treating LE may be challenged by workers who are unable or unwilling to comply with such instructions due to various reasons. Providing adequate pain relief from LE may be one way to keep an individual functional and able to complete modified activities without further injury. The use of "counterforce" bracing has been advocated to diminish the load on the common extensor tendon and thereby reduce pain.^{21,30,35} Acupuncture may also be used to control pain associated with LE. A 2011 systematic review evaluated acupuncture on the ability to provide pain relief, global and functional improvements. This review identified several studies with evidence supporting the use of acupuncture for LE.³⁶ Medical acupuncture with electrical stimulation was utilized in the two cases presented, and was well tolerated by both patients, with no adverse affects reported.

Deep transverse friction massage (DTFM) is a soft tissue technique that has traditionally been used in the treatment of LE, and has been postulated to realign abnormal collagen fiber structure, break up adhesions and scar tissue, and increase healing with hyperaemia.³⁷ A 2002 Cochrane review determined that there was insufficient evidence to form conclusions about DTFM for the treatment of LE.37 Despite the lack of evidence to support the use of DTFM, the popularity of soft tissue techniques in treating tendinopathy has grown and evolved over the years. Graston Technique® (GT) is a form of augmented soft tissue mobilization (ASTM) in which stainless steel instruments are utilized to apply controlled microtrauma to the affected soft tissues. Studies suggest that the controlled microtrauma induces healing via fibroblast proliferation³⁸, which is necessary for tendon healing^{1,38}. Previous research has explored the use of GT in the treatment of LE with promising results.^{39,40}

The soft tissue healing effect of GT may be augmented with resistance training which has been identified as beneficial in the management of chronic tendinopathy.⁴¹ Specifically, eccentric training has garnered considerable attention in the last decade with respect to the management of tendinopathy, and has shown some application in the treatment of LE. In a study by Croisier et al., 92 patients with LE were randomized to a standard physical therapy protocol with and without an eccentric strengthening program.42 The group completing the eccentric strengthening showed a considerable improvement in pain, strength, and function compared with the control group.⁴² Another study examining a program of eccentric exercises performed at low speed with static stretching showed reduced pain in patients with LE at the completion of the program.43

Various joint manipulation techniques directed at the elbow and wrist as well as the cervical and thoracic spinal regions have been described as beneficial in the management of LE.⁴⁴ Other non-operative alternatives include therapeutic ultrasound, low level laser therapy, and elec-

trical stimulation^{36,45}, along with NSAIDS, extracorporeal shock wave therapy and corticosteroid injections^{30,36}. Although the use of corticosteroid injections for the treatment of tendinopathy has been routinely used for many years, the scientific evidence supporting their use is controversial.⁴⁶ While individuals with LE may experience dramatic short-term relief from corticosteroid injection, long-term results are poor with higher recurrence rates.^{47,48} New injection therapies utilizing polidocanol⁴⁹, autologous whole blood^{49,50} and platelet rich plasma^{50,51} have recently been gaining popularity in the treatment of LE. Surgery may be considered in cases where conservative non-operative strategies fail to relieve symptoms after 6 to 12 months.⁵²

Field practitioners are usually in agreement over the difficulty and challenges of treating long-standing chronic musculoskeletal conditions. Both case #1 and case #2 presented relatively early in the course of their conditions, four and six weeks respectively, which may have made the management of their LE more responsive to conservative interventions. Symptomatic resolution may have also occurred as a result of natural history. The treatment program for both cases was multi-modal, thus several other factors may have influenced the favourable outcomes attained. Initial management for controlling pain in the first case was achieved through a modified work program arranged with the employer, whereas the worker in the second case chose to remain at work and control her pain with the use of a counterforce brace. Additional pain management was likely attained with use of medical acupuncture points treated at every visit. This was further enhanced with the use of ASTM in the form of Graston Technique[®] which was useful in decreasing the soft tissue tenderness and dysfunction and theoretically aiding soft tissue healing. The active exercise conditioning protocol outlined in Table 3 also likely played an important role in the long-term resolution of symptoms in both cases. A review of the chiropractic literature identifies numerous cases involving the management of tendinopathy utilizing a combination of soft tissue therapy and rehabilitative exercise interventions.53-62

Despite the prevalence of LE and the potential substantial loss of work associated with this condition, there is surprisingly little consensus on its management.⁶³ The scientific literature identifies more than 40 treatments for LE.⁴⁵ In 2011, Biset et al. completed a systematic review of the literature on the effectiveness of interventions used in the treatment of LE. This review concluded that there was insufficient good quality evidence to support many of the commonly utilized conservative treatments, including acupuncture, exercise, manipulation, ultrasound, and combination physical therapies.³⁶ This highlights the need for further research with larger sample sizes and controls to evaluate the short and long term efficacy of interventions that focus on returning those afflicted with LE back to work in a timely manner.

Summary:

These two cases demonstrate the management of workrelated LE using conservative interventions that can be employed by chiropractic practitioners. Although favourable results were obtained, it is important to note that the nature of this investigation was that of a case study format, and therefore the treatment protocol used may not be appropriate for all individuals presenting with LE. Practitioners treating this type of injury may consider implementing the conservative treatment strategies utilized in these cases for other patients presenting with work-related LE.

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Rehabilitation and treatment of a recreational golfer with hip osteoarthritis: a case report

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Objective: This case study reviews the conservative chiropractic treatment of hip osteoarthritis (OA) and the prescription of a rehabilitation program for a recreational golfer.

Clinical features: A 49-year-old registered nurse/ college instructor presented with a five year history of left hip OA and pain, recent right hip pain and occasional low back stiffness. Once her symptoms improved, a golf-specific functional rehabilitation program was prescribed in preparation for the upcoming golf season.

Intervention and Outcome: The initial treatment included ultrasound, soft tissue and myofascial therapy, mobilizations, acupuncture and home advice. Rehabilitative exercises included core and scapular stability exercises, general conditioning, golf specific stretches, functional swinging, proprioceptive and strengthening exercises, and referral to a swing coach. The positive outcomes included increased ranges of motion, decreased pain, as well as improvements in golf driving distance and endurance.

Summary: Conservative management and golf-specific

Objectif : La présente étude de cas porte sur le traitement chiropratique conservateur de l'arthrose de la hanche et la prescription d'un programme de réadaptation pour une golfeuse récréative.

Caractéristiques cliniques : Une infirmière et enseignante au collège de 49 ans présente depuis cinq ans de l'arthrose et de la douleur à la hanche gauche, et, depuis récemment, de la douleur à la hanche droite et des raideurs lombaires occasionnelles. Une fois ses symptômes atténués, un programme de réadaptation adapté aux golfeurs lui a été prescrit en prévision de la saison de golf qui approchait.

Intervention et résultat : Le traitement initial comprenait des ultrasons, de la thérapie myofasciale et pour tissus mous, des mobilisations, de l'acupuncture et des conseils sur le domicile. Les exercices de réadaptation suivants ont été, entre autres, prescrits : exercices de stabilisation du tronc et du scapulaire, conditionnement général, étirements adaptés au golf, élans de golf fonctionnels, exercices de proprioception et de renforcement, et orientation vers un entraîneur d'élan de golf. Parmi les résultats favorables se trouvent l'amélioration de l'amplitude des mouvements, une atténuation de la douleur ainsi que l'amélioration de l'endurance et de la distance parcourue par la balle de golf au coup de départ.

Résumé : La gestion conservatrice et la prescription d'une réadaptation adaptée au golf semblent avoir été bénéfiques, dans le présent cas, pour l'arthrose

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rehabilitation prescription appears to be beneficial for hip OA and recreational golf performance in this case. (JCCA 2012; 56(3):201-208)

KEY WORDS: low back pain, hip osteoarthritis, golf, rehabilitation, chiropractic, exercise

de la hanche et le rendement au golf dans un contexte récréatif. (JCCA 2012; 56(3):201-208)

MOTS CLÉS : lombalgie, arthrose de la hanche, golf, réadaptation, chiropratique, exercice

Introduction

The sport of golf has been increasing in popularity in recent years and has been shown to increase in frequency of play with age.¹ Since golf offers a lower intensity sport and lacks the risk of physical contact, it is an ideal physical activity for older adults.² It has been shown that walking 18 holes of golf has been shown to help golfers achieve the recommended 10,000 steps per day, which can lead to associated health benefits.³ Also, golf is a versatile sport that participants can return to after total hip arthroplasty with less pain and high satisfaction, but postoperative rehabilitation is a major contributor to positive postsurgical golf performance.^{4,5}

Common areas of injury in golfers are in the low back (27-30%), the wrist (18%) and the elbow (25%) and are often due to overuse.^{2,6,7} It has been demonstrated in previous studies that the lumbar spine sustains compressive loads of up to eight times one's body weight during a golf swing.^{8,9} Inactivity prior to playing, poor posture, combined with poor physical conditioning and poor swing mechanics (such as over-rotating to surpassing their neutral pain-free backswing axial rotation position; increased trunk flexion at ball strike and excessive side flexion during backswing) have all been shown to predispose golfers to getting low back pain.^{2,5,8} Golfers who have low back pain demonstrate earlier activation (before backswing commences) and less activity of the erector spinae muscles, as well as well as a delay to the onset time in the external obliques with the start of the back swing and a delay and decreased endurance capacity in transverses abdominus activation.^{2,5,6,8,10} A large difference in lateral endurance testing of golfers (more than a 12.5 second difference between sides), a BMI lower that 25.7 kg/m², and shortened hip flexors have also been shown to lead to low back injury in professional golfers in a longitudinal

study.⁸ Types of low back pain reported in golfers include mechanical lower back pain, sacroiliac joint dysfunction, disc herniation, spondylolysis and vertebral compression fractures.^{2,5,9} Hip osteoarthritis or dysfunction has been theorized to play a contributing role in mechanical low back, since it can lead to decreased internal lead hip rotation during the swing phase, leading more forces to overstress the lumbar spine.^{2,8} Restriction of the lead side hip internal rotation and lumbar extension (which may lead to increased force being transmitted to the lumbar spine) have been shown in golfers with a history of low back pain.⁵

Chiropractors reported in 2010 that 25.6% of their patients present with the low back/pelvis as their chief complaint and 9.4% with the lower extremity as their chief complaint.¹¹ Therefore, this case report deals with conditions that are relevant to most chiropractic practices. The purpose of this case report is to describe the successful management of a patient with hip osteoarthritis and to present a rehabilitative program for golfers.

Case report

A 49 year-old registered nurse/college instructor presented complaining of ongoing left hip pain which she reported starting to notice five to six years prior after she started a nightly power walking routine. An MRI was performed of the left hip 2 ½ years prior revealed no evidence of avascular necrosis, mild degenerative irregularity of the acetabulum with mild thinning of articular cartilage in the left hip and mild bilateral insertional tendinosis of the gluteus minimus tendons. Previous therapy included acupuncture and ultrasound years prior. The patient also noted that she had right hip pain in the groin area and occasionally lateral to the hip, which she felt was due to compensations for the left hip. She reported that the left hip pain started deep in the groin region and referred laterally into the gluteal region and was worse at night, with some short term stiffness in the morning. She rated the pain as a 4-7/10 (10 being the worst pain she had ever experienced), depending on the activities she was performing. She described it as constantly stiff and "throbbing" in certain positions. Aggravating factors included getting out of a car, sitting with her knees up, stepping off a curb, stair climbing and after long walks (which resolved after 2-3 days). She reported that rest and ibuprofen relieved the hip pain. She explained that the pain "came and went" depending on her activities. She documented that she took Advair and Ventolin for her asthma. Venlafaxine for her menopause related night sweats and hot flashes, as well as calcium, vitamin D, Omega 3 fatty acid, and a high fiber supplement (PGX) for weight loss. She stated that she was normally active by using an elliptical machine at the gym, as well as playing golf frequently. She reported that her diet was "average", that she was a non-smoker and that she drank alcohol occasionally in moderation. She stated she slept "well" with 6 to 8 hours per night, but that it was interrupted because of her left hip pain. Previous accidents included a bike accident which led to a cervical spine injury and contusions, as well as a motor vehicle collision as a pedestrian which led to knee contusions. Previous surgery included the removal of her left ovary. She had been previously diagnosed with asthma and her relevant family history included breast cancer, thyroid conditions, hypertension and osteoporosis. Her systems review revealed that she wore reading glasses and that she had a history of migraine headaches. The review of red flags was unremarkable. The review of her psychosocial history revealed that she was married and had no children. Other complaints included bilateral foot pain (on the ball of the foot and first metatarsal), occasional low back stiffness and that she was attempting to lose weight.

The physical examination revealed a mild limp and favoring of the right leg. The lumbar ranges of motion were full and pain free. Hip ranges of motion revealed decreased internal rotation bilaterally (more on the left) and decreased external rotation on the left. Active hip extension testing revealed weak deep abdominals bilaterally. Active hip abduction testing revealed weak bilateral gluteal muscles (as well as tight iliotibial bands and tensor fascia lattae). Ranges of motion and joint play in the first metatarsals were reduced bilaterally and the patient re-

ported tenderness at the base and lateral aspect of the first and the base of the second metatarsals bilaterally. Soft tissue palpation revealed tight and tender bilateral gluteal, tensor fascia latta, iliopsoas, piriformis (more left than right sided), hamstrings, gastrocnemius, first metatarsal plantar flexors, lumbar erector spinae and quadratus lumborum muscles. Compression of the left hip aggravated the patient's symptoms and traction relieved it. Positive orthopedic tests include: bilateral Thomas (supine, knee to chest which reproduced the hip pain), Obers (side lying, top leg is abducted and then released to adduct passively with gravity, tight bilateral iliotibial bands cause the thigh not to adduct) and bilateral Hibbs (prone, internally rotate hip; this was reduced bilaterally and reproduced hip pain).^{12,13} The neurological examination lower limbs was unremarkable.

The differential diagnoses included left hip osteoarthritis; right hip bursitis or osteoarthritis; bilateral myofascial strain; bilateral metatarsalgia (secondary to myofascial strain) and myofascial strain of the musculature of the lower back (secondary to muscular imbalance and weakness). The prognosis was rated as moderate, since osteoarthritis is degenerative in nature. The plan of management included ultrasound, soft tissue and myofascial release therapy, mobilizations (of the lumbar spine, and the first and second metatarsals) and hip traction mobilizations (using a Mulligan belt), and acupuncture. Home care recommendations included stretching (see figures 1-3 & table 1), deep abdominal bracing, home heat and icing, topical anti-inflammatory cream (Muscle Care cream®), ibuprofen (recommended by her MD), good supportive shoes (avoiding high heeled shoes and wearing newer running shoes to increase shock absorption), getting up regularly from sitting and increasing her cardiovascular exercise gradually (low weight bearing, such as cycling or swimming). Treatment was rendered on the first visit according to the plan of management.

On the second visit, the patient reported that she was somewhat tender from the soft tissue therapy, but had experienced the same sensation after previous physiotherapy treatments in the past. She also reported taking ibuprofen twice at night and that she had experienced less left hip pain generally even with common aggravating activities. Acupuncture was added on this second visit, since there was not sufficient time to include it on the first visit. On subsequent visits, the patient reported pain relief which



Figure 1 Seated piriformis stretch (front and side views)





Figure 2 Seated gluteal Figure 3 stretch

Standing iliospoas stretch (side and front views)¹⁴

Table 1	Rehabilitative	exercises	prescribed
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Visit #	Prescribed Exercises
1	Stretches: priformis, gluteals and iliopsoas muscles (see figures 1-3) ¹⁴ Deep abdominal bracing ¹⁴ General cardiovascular exercises/conditioning: 3-4 days per week, working up to 30 minutes.
8	Modified curl up, side bridge and modified bird dogs: to be performed daily with a neutral spine, deep abdominal activation and 8-10 second endurance-aimed holds (with adding more repetitions within her tolerance; see figures 4-6). ¹⁴
10	Proprioceptive exercises: progressing from eyes open to eyes closed, two legged to one legged and two- directional rocker to multidirectional wobble board.
12	Scapular stability exercises: external rotation/rotator cuff, push up plus (on the wall since kneeling aggravated her knees) and scapular retractions (standing with a theraband), twice per week, with 10-12 repetitions working up to 2-3 sets (see figures 7-9). ¹⁵ Golf specific stretches: seated torso rotation (to later add a club behind her head) and standing side bends (see figures 10 & 11). ¹⁶
13	Functional swinging and strengthening exercises: bicep curls, wall squats, resisted backswings, downswings and through swings (increasing resistance band tension slowly) with 10-15 repetitions, working up to 3 sets and 2 seconds in each direction. ^{6,16}

Exercise tested	Initial testing (visit 8)	Subsequent testing (visit 15)
Modified curl up	1 minute 37 seconds	2 minutes 47 seconds
Right side bridge	1 minute 2 seconds	1 minute 5 seconds
Left side bridge	51 seconds	1 minute 35 seconds
Modified bird dog: Left arm/right leg	1 minute 54 seconds	2 minutes 27 seconds
Modified bird dog: Right arm/left leg	2 minutes 30 seconds	2 minutes 1 second

Table 2Core exercise testing results



Figure 4 Modified curl up



Figure 5A Side bridge (beginner on knees)



Figure 5B Side bridge (advanced on feet)



Figure 6 Modified bird dog (prone on abdomen)

was only aggravated with long distance walking and prolonged sitting and for one night at a time, and that is was quickly relieved with ibuprofen. The left hip pain eventually dissipated and she was left with occasional right hip pain which she described as "achy". By the sixth visit she reported the left hip was "great" and that she only had very mild morning stiffness in the right hip (related to sleeping on her right side all night). The next visit she reported both hips were "great" and mild lower back tightness. She stated that the recommendation of abdominal bracing really helped her lower back discomfort. At this point she requested a rehabilitation program to strengthen her core for the upcoming golf season. On the eighth visit, she reported that her hips were "good", except for one day after a 9 hour car trip. After demonstration and instruction, initial baseline measurements were taken on this visit for "back safe" core stability exercises (see tables 1 & 2).¹⁴ The bird dog was modified to a prone position because the patient had difficultly kneeling due to previous knee injuries. The patient was then instructed to do these exercises at home.14

The treatments were extended to once every 1.5-2.0 weeks. The patient reported that core exercises were helping her lower back and that her hips continued to maintain the improvement. She reported that she had increased the number of exercise repetitions and that she felt she was getting "stronger". On her tenth visit, she was able to walk longer distances without pain. Proprioceptive rocker board exercises were added. She reported enjoying the balance and "core" exercises since she felt they seemed to decrease her lower back stiffness. On the twelfth visit, she reported her left hip was pain free and the right hip had only lateral muscle pain. She reported progressing to onelegged balance exercises and a multidirectional balance board from a two-directional rocker board. She continued the core exercises daily. At this point, scapular stability exercises and golf specific stretches were also added (see figures 7-11 and table 1).^{15,16}

Visits were staggered to once every two weeks and the patient reported only occasional pain that was relieved by ibuprofen. The patient reported performing the one-legged balance exercises more frequently. Functional swinging and strengthening exercises were added on this visit (see table 1).^{6,16} On the fourteenth visit, she reported that both hips were virtually pain free and that she had also lost five pounds in two weeks after joining Weight Watchers[®] pro-



Figure 7 Shoulder external rotation/rotator cuff exercise



Figure 8 Wall push-up plus



Figure 9 Scapular retraction



Figure 10 Seated torso rotation



Figure 11 Standing side bend

gram online. She reported using the balance board daily on one leg, as well as preforming the upper body and core exercises on alternate days. She stated that the wall squats aggravated her knee pain, but that she had started "cardio boxing" at home 20 minutes daily which she felt was strengthening her upper body. She also reported that she had taken a lesson with a golfing professional. The golfing professional also noted how "balanced" she was and gave her a few corrections for her swing performance (i.e. not shortening at the end range) and a golf "drill" to work on.

Her next visit, $2\frac{1}{2}$ weeks later, she reported no hip pain on the left side and only very low grade "ache" on the right side. She also stated that her low back felt "good". On this visit, the core exercises tests were repeated (see table 2). Due to the outcome, she was given directions to increase her focus on the right sided side bridge and right arm/left leg bird dogs. Overall she reported doing her exercises regularly. She stated that she would be travelling for a golf trip for the following month for 10 days and was then advised to do a 5-10 minute warm up before each game and to stretch afterwards.

On follow-up 6 months later, the patient reported golfing for a week, during which her left hip was pain free and she had improvements in her endurance and driving distance. She later golfed 15 times in the first half of the summer season and reported improvements of 10-14 yards driving distance overall. A referral to her family doctor was suggested to investigate the symptoms in her right hip, since her left hip was now pain free. The patient chose to return for monthly care to maintain her current positive results and get assistance with her exercise progressions.

Discussion

Research has demonstrated that highly proficient golfers have greater hip and torso strength (which provide a solid base of support), increased shoulder, hip and torso flexibility (to help improve driving distance) and balance (allowing the body to adapt to different terrains and maintain good position over the body's base of support) than golfers who do not perform as well on the golf course.^{17,18} Static and dynamic balance (including one leg stance, one leg perturbed stance and lunging) has been shown to be better in older golfers when compared with nongolfing healthy adults, which researchers have associated with walking on uneven golfing surfaces and the transfer from two to one-legged stances that is often required in golf.¹⁹ It has also been documented that better golfers have higher club head velocity, higher ball launch angle, lower standard deviation of ball velocity and faster body-twist angular velocity.¹⁶ Golf specific training programs have been given to athletes and have been shown to improve performance and prevent injuries.¹⁷

It has been shown that strength increases up to one's early 20's, plateaus until their 50's and then starts to decline by 10% per decade (mostly due to a decrease in muscle mass).⁵ Golf performance also has a similar pattern, since recreational golfers tend to peak in their 30's and start to decrease in their performance in their 40's.⁵ This is why a conditioning program is so important for older participants to follow, since previous studies have demonstrated gains in strength and club head speed with relatively short training periods.⁵

Golf-specific functional rehabilitation and proper swing mechanics instruction have been recommended as part of a treatment and prevention plan for golfers with low back pain.^{2,6,16} These recommendations include spinal stabilization exercises to activate the transversus abdominus and multifidus muscles, transitioning to a more classic swing (by shortening their backswing to decrease low back strain without affecting performance or moving to a two-plane swing to minimize hip and trunk separation), aerobic endurance training to reduce fatigue, balance training, resistance exercises, as well as a good warm-up of at least 10 minutes, and flexibility/stretching of affected musculature (which has been shown to decrease injury by up to 60%).^{2,6,7,8,16,20} Slight activation of the erector spinae, biceps femoris and gluteus maximus muscles has been shown to assist the transfer of load from spine to legs, which in turn prevents spinal shear.21 McGill has researched many lumbar spine sparing stabilization exercises using correct techniques and optimal progression.¹⁴ When combined with abdominal bracing the modified curl-up, side bridge and bird dog help to create a "muscular corset" to protect the spine against daily challenges.¹⁴ Functional training has been shown to improve club head speed, ball velocity and driving distance (by increasing upper torso axial rotation velocity), as well as improving functional fitness in the older golfing population.^{7,16} Referral to a professional golf instructor has also been recommended to aid with swing pattern correction.^{5,8,18}

There are many golf-specific training programs that recommend various exercises, such as transversus abdominus conditioning, seated thoracic and lumbar rotation exercises, hip flexor and lumbar extensor stretching, oblique and core stability.⁶ Other programs include a warm up followed by static stretches, spinal stabilization such as: pelvic tilts, floor bridging, floor quadriped, prone abdominals, dynamic abdominal crunches and scapular stability exercises; balance exercises, and strengthening exercises.7 One study recommended bird dog, side planks, crunches/curl-ups, front planks and later hang twist, lunge twist, prone twist, Roman twist, Russian twist, latissimus dorsi pull downs, Kettle bell squats and standing and seated horizontal throws, as well as pylometrics much later on.8 Other authors have also recommended focusing on groups of conditioning exercises, such as stretching, strengthening with elastic tubing (hip abductions and adductions, scapular retractions, resisted backswings and downswings, resisted through-swings) abdominal crunches and balancing.¹⁶ A three phase resistance training program discusses preventing "musculoskeletal injuries, improve strength and power of the golf swing and increase general fitness".¹⁵ It included trunk stability exercises, shoulder exercises, strength and power training, resistance training and flexibility training.14,15 Switching from a "modern" golf swing (large shoulder turn with a restricted hip turn, leading to increased lateral bending and exaggerated hyperextension) to a "classic" golf swing (front heel raised during backswing to increase hip turn, shorten the backswing or a combination of both, decreasing the lumbar spine torque), along with increasing trunk flexibility has also been shown to assist golfers with low back pain.9

Summary

This case report demonstrates positive results for the conservative chiropractic management of hip osteoarthritis related pain and the prescription of golf-specific rehabilitation. As it is only a single patient, it is difficult to extrapolate results to other cases and further investigation is always recommended. Case reports are limited due to many factors, including non-controlled environment and a small sample size, while results could be due to natural history or placebo effect. Future studies should include the use of outcome measures, randomization and larger sample sizes. The results of this case help to support that conservative care and rehabilitation management of hip osteoarthritis and low back pain may help golfers improve their performance and prevent further injuries.

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Spinal infection: a case report

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Objective: To present a case of a patient with spinal infection (SI) and highlight the chiropractor's role in the prevention or minimization of devastating complications of SI.

Background: Recent literature trends suggest an increasing prevalence of SI. Patients with SI most commonly present with unremitting progressive back pain and may or may not have fever or neurological signs. To avoid negative post-infection sequelae, establishing an early diagnosis and treatment is crucial.

Clinical Features: A 29-year-old female diagnosed with L5-S1 disc herniation with impingement of the right S1 nerve root opted for surgical management. Iatrogenic bowel perforation during her spinal surgery resulted in contamination of the spinal surgical site, and findings in keeping with disco-osteomyelitis with epidural and paraspinal phlegmon formation were visualized on contrast enhanced MRI.

Conclusion: Recent trends of increased spinal

Objectif : Présenter le cas d'un patient atteint d'une infection de la moelle épinière (IME) et souligner le rôle du chiropraticien dans la prévention ou l'atténuation au minimum des complications dévastatrices d'une telle infection.

Contexte : Les tendances qui se dégagent des études récemment publiées sur le sujet suggèrent une croissance dans la prévalence des IME. Les patients qui en sont atteints présentent le plus couramment des douleurs lombaires continues et progressives accompagnées ou non de fièvre ou de signes neurologiques. Afin d'éviter toute séquelle indésirable postinfection, il est essentiel d'en effectuer le diagnostic et le traitement précoce.

Caractéristiques cliniques : Une femme de 29 ans, dont on a diagnostiqué une hernie discale L5-S1 avec coincement à la racine nerveuse S1 droite, a opté pour la gestion chirurgicale. Une perforation intestinale iatrogène survenue lors de sa chirurgie spinale a contaminé le champ opératoire de la moelle épinière, et des constats correspondants à une ostéomyélite discale avec formation épidurale et phlegmon paraspinal ont été visualisés sur IRM à contraste amélioré.

Conclusion : Il est impératif que les chiropraticiens soient davantage sensibilisés aux infections de la

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infection urge a heightened awareness by the chiropractor. The chiropractor can provide early diagnosis and supportive multidisciplinary care for such patients. (JCCA 2012;56(3):209-215)

KEY WORDS: spinal infection, disk space infection, discitis/diskitis, vertebral osteomyelitis, pyogenic, outcome

moelle épinière en raison de l'augmentation récente du nombre de cas de celles-ci. Le chiropraticien peut établir un diagnostic précoce et dispenser des soins multidisciplinaires de soutien à ces patients. (JCCA 2012;56(3):209-215)

MOTS CLÉS : infection de la moelle épinière, infection de l'espace intervertébral, discite, ostéomyélite vertébrale, pyogène, résultat

Introduction:

Spinal infection (SI) can be pyogenic or non-pyogenic in nature and involve any anatomical area around the spine, including but not limited to infection of the disc, vertebral body, paravertebral soft tissues and the epidural space. The most common forms include: discitis, vertebral osteomyelitis, septic arthritis, muscular involvement (psoas abscess or paraspinal abscess), pararvertebral, and epidural abscess.⁴ Treatment can vary considerably depending on the type of spinal infection.

Spondylodiscitis, also referred to as spinal or vertebral osteomyelitis (VO) septic discitis, or disk-space infection is a common result of a pyogenic vertebral infection. This infection involves the disc space as well as the adjacent vertebral bodies and accounts for 2-4 % of all bone and joints infections.¹⁻³ The most common microorganism responsible for pyogenic vertebral osteomyelitis (PVO) is Staphylococcus aureus. Non-pyogenic sources of infection include: Mycobacterium and a variety of fungal organisms such as Candida or Aspergillus. Three mechanisms of spinal infection dissemination have been identified. The most common route of spread is via hematogenous dissemination. Direct inoculation from iatrogenic sources is considered to be the next most common route followed by dissemination from an adjacent contamination.^{4,5,6} This case report focuses on pyogenic spinal infection of the vertebral body and disc space and emphasizes the importance of considering infection within the list of differential diagnoses for progressively worsening low back pain. It will also describe the epidemiology, clinical presentation, radiographic features and typical management of spinal infections and aim to heighten the awareness of SI by the chiropractor to assist in the prevention or minimization of devastating complications.

Case:

A 29-year-old female medical researcher presented to an outpatient orthopedic clinic with a 5-month history of sharp right-sided lower back and posterior thigh pain that extended intermittently to the right foot. Her pain was constant and she found it difficult to find a relieving position. She additionally reported decreased sensation in the calf and lateral aspect of the right foot. She denied any lower extremity weakness or change in bladder or bowel function. There was no history of fevers, weight loss, or night sweats. Her past medical history was otherwise unremarkable.

On her initial examination she ambulated well. Her leg pain was aggravated with the extremes of forward flexion. Her lower back pain was aggravated by extension. Neurological examination revealed an absent S1 reflex on the right. Sensation to light and sharp touch were intact, although the region of her paresthesia approximated the S1 dermatome in the posterior calf and lateral foot. Motor power in the lower extremities was graded as 5/5 bilaterally. Straight leg raise testing was negative.

An MRI of her lumbar spine revealed a L5-S1 disc herniation with impingement of the right S1 nerve root. The patient opted for surgical management and a single level unilateral posterior lumbar decompression and discectomy was performed.

On postoperative day number 1 she developed severe abdominal pain and diffuse tenderness. An abdominal xray and CT examination revealed free intraperitoneal gas

Figure 1a

Figure 1b



Figure 1: *a)* Sagital T2 weighted MR image of the lumbar spine demonstrates abnormal high T2 marrow signal intensity within the L5 and S1 vertebral bodies, and abnormal prevertebral and epidural T2 signal. Irregular inferior L5 and superior S1 endplates and loss of L5-S1 disc space are apparent *b*) Sagital T1 weighted image demonstrates corresponding low T1 signal intensity within the vertebral bodies *c*) Sagital contrast enhanced T1 weighted image reveals abnormally enhancing L5-S1 disc space, and prevertebral and epidural soft tissue.

and fluid. She was taken back to the operating room by general surgery for urgent laparotomy for presumed iatrogenic small bowel or rectal injury. Intraoperative findings at the time of the laparotomy included: a loop of proximal ileum that was leaking enteric contents into the abdominal cavity, an iatrogenic hole in the presacral peritoneum through which the L5-S1 disc level could be palpated, and a few fragments of disc material within the intraabdominal cavity. The injured short segment of small bowel was resected. She was started on a course of broad-spectrum intravenous antibiotics. A swab from the presacral space revealed moderate leukocytosis and growth of *Candida albicans*. Her antibiotic care was modified under the direction of the Infectious Disease consult service.

Her back pain continued in the postoperative period although she did report some initial improvement. Her abdominal pain resolved. Her antibiotics were discontinued after a three and a half week course of therapy. By the time of her postoperative 6-week follow-up clinic visit, she was experiencing dramatic increases in her back and leg symptoms, accompanied by nausea and vomiting. She denied any fevers or chills. Examination at this time revealed aggravation of pain with all directions of range of motion testing, and continued paresthesia at the lateral aspect of the right foot. Lower extremity motor power remained normal. She was afebrile with stable vital signs. Blood work revealed an elevated white blood cell count, erythrocyte sedimentation rate, and C-reactive protein. This prompted a follow-up MRI examination of her spine, and CT evaluation of her abdomen and pelvis.

Figure 1c

The MRI revealed endplate irregularity at the L5-S1 level. There was abnormal low T1, high T2 signal intensity and enhancement within the L5 and S1 vertebral bodies. Additional abnormal enhancing soft tissue was noted within the L5-S1 disc space, encasing the L5 and S1 nerve roots, anterior to the vertebral bodies at L5 and S1 and within the epidural space (Figure 1a-c). Imaging findings were in keeping with disco-ostemolyelitis with





Figure 2b



Figure 2: *a)* Follow up sagital T2 weighted image and *b*) contrast enhanced sagital T1 reveal a reduction in both the abnormal T2 signal and abnormally enhancing prevertebral and epidural soft tissue.

epidural and paraspinal phlegmon formation. CT examination of the abdomen did not reveal an additional infectious source.

The patient was restarted on IV antibiotics and symptoms gradually resolved after a second 8 week course of antibiotic therapy. At this point she was referred for physiotherapy for rehabilitation exercises and back education with no leg pain reported, and intermittent back pain. Examination revealed full range of motion, with normal sensation and motor power to the lower extremities. Six-month follow-up MRI examination demonstrated a reduction of both the abnormal vertebral body T2 signal intensity as well as the degree of abnormal epidural and prevertebral enhancement (Figure 2a-b). As she was clinically improved the remaining findings were thought to represent residual of previous infection and post-surgical changes.

Discussion

Epidemiology

Several recent European epidemiological studies examining the incidence of spinal infection suggest an increasing trend of spinal pyogenic infections in adults.^{9,10,11,12,13} These retrospective studies retrieved hospital records of all patients who had an ICD code diagnosis of vertebral osteomyelitis (VO) and reported an incidence range from 0.70 to 2.4 per 100,000.^{9,10,11,12,13} Differences among studies can be partly explained by the different patient populations, with some studies including post-operative cases while others included non-pyogenic cases.

Recent trends also suggest that the diagnosis of both pyogenic and non-pyogenic spinal infection have been steadily on the rise.^{4,7-11,13,15} Most recently, Nagashima et al conducted a 50-year retrospective analysis of patients treated for spinal infection in Japan.⁷ There was approxi-

mately a 6.8-fold increase in diagnosed spinal infection from 1996-2005 compared to 1976-1985.⁷ According to Nagashima et al, the advancement of highly sensitive imaging modalities, such as contrast MRI and CT guided biopsy, create a heightened ability to diagnose spinal infection. As a result, this likely explains some of the recent increase in spinal infections observed. Other authors identify increasing rates of patients with compromised immune systems and IV drug use as culprits to the recent increase in spinal infection as they are associated with increased vulnerability to opportunistic organisms and consequent infection.^{4,7-11,15}

The incidence of spinal infection increases with age.^{1,8,10,14,15} Several studies confirm that those individuals aged 50 to 80 years are the most susceptible.^{7,12,15} Grammatico et al observed an incidence rate of VO of approximately 9 per 100,000 in males aged 70 to 80 years.¹² His colleagues also note that there is a male to female predominance of 1.5 - 3:1, an observation that is widely accepted.^{1,8,10,14,15} Interestingly, Grammatico et al observed an equal incidence rate in male and females up until the age of 20. At the age of 20 there is an increase in incidence rates in males as they progress in age. The authors speculate that one possible explanation to this observation may be the higher frequency of co-morbidities in men aged > 60 years, however, they did not draw any firm conclusions about this potential association.¹² The literature suggests that patients with underlying diabetes, cancer, renal failure requiring hemodialysis or those who have had previous surgery appear to be at most risk for developing SI.^{10,15,16,17,18} Other potential risk factors include coronary heart disease, immunosuppressive disorders, liver disease, long term steroid use, IV drug users, severe trauma and advanced age.^{10,15,16,17,18}

Clinical Presentation

Spinal infection such as vertebral osteomyelitis appears to have a predilection for the lumbar spine. Approximately 58% of cases noted in Mylona et al's recent review¹⁵ occurred in the lumbar region.¹⁵ The extensive lumbar spine anastomosing veins and arteries, which favour infectious seeding via the hematogenous route of spread, offer some explanation for this observation.¹⁶ The thoracic spine (30%), cervical spine (11%) and sacrum (0.1%) are all less common sites for spinal infection.¹⁵

The clinical presentation of patients with early stage

spinal infection varies widely among individuals, and the condition can be difficult to differentiate from other diagnoses. Patients in the sub-acute stage may present with vague symptoms often mimicking other common conditions. Atypical symptoms of chronic chest, abdominal, or hip pain may be present and often mask or overshadow the underlying back pain.^{15,19,20} Back pain and fever are the most common symptoms reported. Back pain at onset has a prevalence ranging from 91 - 100%.¹⁵ The nature of the pain is often unremitting and progressive and may lead to the patient becoming completely bed ridden. Paraspinal muscle spasms are also very common.^{15,16,20} The back pain may be relieved in recumbency and aggravated by activity, a presentation that can be confused with simple mechanical back pain and can lead to a delay in diagnosis.

Reports on the prevalence of fever at onset varies widely and ranges from 16.2% to 79.6%.^{21,22} The large discrepancy in prevalence rates that exists within the literature is believed to be due to variations in definition of what constitutes a fever as well as poor documentation of antipyretic analgesic use.^{15,19} The presence or absence of fever alone is insufficient to rule in or rule out spinal infection. Neurological impairment is also common, but similar to fever its presence varies widely, ranging from 14.3% to 51.7% of cases.^{23,24}

Diagnosis

Establishing an early diagnosis in spinal infection patients is paramount but often difficult to confirm. In fact, Mc-Henry et al noted that only 28% of patients with VO were diagnosed within the first month of onset of symptoms.¹⁴ They also reported that only 24% of attending physicians included VO in their initial differential diagnosis.¹⁴ The importance of establishing a broad differential diagnosis early cannot be overlooked. As with all patients one must always rule out red flags for back pain that could indicate a significant medical illness.

Considering an active broad differential list with repeated careful neurological examination is important. Employing this strategy facilitates early diagnosis and results in prompt appropriate management, both of which are critical in suspected spinal infection.¹⁴

Imaging Features:

When spinal infection is first suspected, baseline conventional radiographs are indicated. Radiographs are relatively easy to access, are cost effective and give good visualization of bone tissue, which provide rationale for their use. In their review, Mylona et al noted that 95% of the included studies used radiography as a baseline and revealed radiographic abnormalities in 89% of the cases.¹⁵ However, Quinones-Hinojosa et al urge clinicians to beware of the 2-3 week lag in the initial presentation of radiographic signs of spinal infection. Radiographs during this 2-3 week latent period rarely exhibit diagnostic clues.²⁰ Typically, the earliest radiographic sign is narrowing of the disc space. Blurring, irregularity and even destruction of the adjacent endplates tends to occur later.^{15,20}

MRI is the imaging modality of choice for early detection and confirmation of spinal infection diagnosis since it closely reflects the pathological changes during the evolution of spinal infection.^{1,15} It has been reported to have 96% sensitivity, 94% specificity with 92% accuracy in correctly identifying spinal infection.¹ Gadolinium contrast-enhanced MRI is considered the imaging gold standard^{1,4} and it has been reported to be capable of detecting spondylodiscitis as early as 48 hours after the initial inoculation 9. Typical MRI findings include, ill defined hypointense T1 and hyperintense T2 vertebral body marrow signal intensity with loss of the vertebral endplate on both sides of the partially or completely destroyed disc with associated loss of disc height. Paraspinal or epidural soft tissue infiltrations of edema, infection and/or fluid collections are often present.

The final diagnosis is a combination of clinical, imaging and biochemical findings.²⁰ In the acute/subacute phase conventional radiographs should be ordered. Laboratory analysis, including ESR, CRP, and WBC is often ordered and may, in some cases be normal.²⁰ Blood cultures should be retrieved preferably during a fever spike to identify the causal microorganism. It should be emphasized, however, that the accuracy of blood cultures to identify such organism varies.^{9,15,19,20} MRI and CT imaging should follow, including CT guided biopsy of the vertebral body or disc to successfully identify the causal organism and thus guide an appropriate antibiotic treatment regimen. In the absence of positive cultures of blood, spine biopsy is critical for the etiological diagnosis of spinal infection.⁹

If the diagnosis is delayed, serious complications are common. Delayed time to diagnosis usually results in greater degrees of neurologic impairment. Neurological impairment is more common in infections of the cervical spine. Acosta et al. reported that in the cervical spine there is a 60% chance of neurological deficit versus a 5-20% chance in the thoracic and lumbar spine.⁴ This is believed to be due to the decreased cross-sectional diameter of the cervical spinal canal in relation to the spinal cord compared with the thoracic or lumbar spine.⁴ The formation of epidural or paraspinal abscess may further compromise the spinal cord, thecal sac or intervertebral foramina which lead to more extensive neurological impairment and the development of these abscesses may require surgical drainage.15,16,25 Treatment can vary considerably depending on the type of spinal infection. For instance, an uncomplicated discitis with an intact neurological system can be treated medically with antibiotics while an epidural abscess causing progressive neurological compromise necessitates urgent surgical intervention.^{15,20}

The mortality rate of spinal infection ranges from 6-20%.^{4,14,15,20,25} Early diagnosis, identification of causative agents, and early initiation of specific treatments dramatically reduces the mortality rate.^{15,20,25} McHenry and his colleagues examined the largest number of microbiologically diagnosed pyogenic VO cases to date, following these patients for a median of 6.5 years (range 2 days to 38 years). In 255 episodes, 146 (57%) recovered fully and 31% had qualified recovery defined as improvement with persistent pain, motor weakness or paralysis, and/ or bowel/bladder dysfunction. The remaining 11% of patients died. For those patients who had qualified recovery, disability caused by pain was the most prevalent longterm poor outcome (66%), followed by motor weakness or paralysis (34%).¹⁴

Lindholm and Pylkkanen reported that up to 50% of patients with postoperative discitis who had been followed for longer periods, had severe chronic back pain and an inability to work or perform the normal activities of daily living.²⁶ It is apparent that effective co-management of these post-infection problems must be important considerations for clinicians.

Summary:

Overall, spinal infection is not a common presentation, but can be devastating and the diagnosis of both pyogenic and non-pyogenic types appears to be increasing over time. Any patient with progressively unremitting back or leg pain with or without fever should receive a comprehensive evaluation for spinal infection. Heightened suspicion should be given to those patients who are elderly males with concomitant chronic illnesses such as immunosuppression, diabetes mellitus Type 2 and IV drug use. In these high-risk patients, clinicians should consider a broad differential diagnosis including spinal infection supplemented with comprehensive repeated neurological testing. Clinicians should also be aware of the high probability of long-term poor outcome and should work in a multidisciplinary fashion to co-manage these patients.

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Conservative management of Achilles Tendinopathy: a case report

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Objective: To chronicle the conservative treatment and management of a 77-year old female patient presenting with chronic pain of 8 months duration in the midportion of the achilles tendon diagnosed as achilles tendinopathy.

Clinical features: The main clinical feature was pain in the midportion of the achilles tendon, 2 to 6 cm proximal to the calcaneal insertion. Symptom onset was gradual and unrelated to any acute trauma or overt injury mechanism.

Intervention and outcome: The conservative treatment approach consisted of medical acupuncture with electrical stimulation, Graston Technique®, eccentric calf training, and rehabilitative exercise prescription. Outcome measures included verbal pain rating scale, lower extremity functional scale (LEFS), and a return to activities of daily living (ADLs). The patient attained long-term resolution of her complaint and at 12 month follow-up reported no recurrence of symptoms.

Conclusion: A combination of conservative rehabilitation strategies may be used by chiropractors to treat midportion achilles tendinopathy and allow an individual to return to pain free ADLs in a timely manner.

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KEY WORDS: achilles, tendinosis, tendinopathy, Graston Technique®, eccentric training Objectif : Documenter le traitement conservateur et la gestion d'une patiente de 77 ans qui présente de la douleur chronique depuis 8 mois dans la partie du milieu du tendon d'Achille, diagnostiquée comme une tendinopathie du tendon d'Achille.

Caractéristiques cliniques : La caractéristique clinique principale est la douleur ressentie dans la partie du milieu du tendon d'Achille, à 2 à 6 cm proximal à l'insertion calcanéenne. L'apparition des symptômes s'est produite graduellement et n'est pas associée à un trauma aigu ou à un mécanisme de blessure évident.

Intervention et résultat : L'approche adoptée pour le traitement conservateur comporte l'acupuncture médicale avec stimulation électrique, la technique Graston^{MD}, l'entraînement excentrique du mollet et la prescription d'exercices de réadaptation. Les résultats ont notamment été mesurés au moyen d'une échelle verbale de notation de la douleur, d'une échelle fonctionnelle des membres inférieurs (ÉFMI) et du retour aux activités de la vie quotidienne (AVQ). Une résolution à long terme a été apportée à la plainte de la cliente et, au rendez-vous de suivi, douze mois plus tard, aucune récurrence des symptômes n'a été rapportée.

Conclusion : Les chiropraticiens peuvent employer une combinaison de stratégies de réadaptation conservatrices afin de traiter une tendinopathie de la partie du milieu du tendon d'Achille et de permettre à une personne de retourner à ses AVQ sans douleur et en temps opportun.

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MOTS CLÉS : Achille, tendinose, tendinopathie, technique Graston^{MD}, entraînement excentrique

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Introduction:

The term "*tendonitis*" has traditionally been used to denote overuse injury to the tendon that is chronic in nature. The suffix "itis" implies the presence of an inflammatory condition. However, studies have identified little or no inflammation within tendons exposed to overuse.¹⁻³ *Tendinopathy* is now commonly used to describe overuse injuries in the absence of histological confirmation and includes a range of diagnoses involving injury to the tendon (e.g., tendonitis, peritendinitis, tendinosis).^{4,5}

The pathogenesis of Achilles tendinopathy (ATY) begins when the mode, intensity, or duration of a physical activity changes and places an abnormal biomechanical demand on the achilles tendon.^{6,7} This is followed by an inadequate recovery period and is believed to lead to breakdown at the cellular level.8 What results is an incomplete healing response that can be attributed to ongoing mechanical forces on the tendon, poor blood supply, or a combination of both.9,10 The tendon undergoes microscopic changes, including fibrin deposition, reduction in neutrophils and macrophages, neovascularization, and disorganization of collagen fibers.^{11,12} The neovascularization within the degenerated achilles tendon is accompanied by an in-growth of nerve fascicles.¹³⁻¹⁵ These nerve fibers have both sensory and sympathetic components that may be responsible, in part, for the pain that is associated with ATY.8,14,15

The mean age of those affected by achilles tendon disorders has been reported to range between 30 and 50 years¹⁶⁻¹⁸, with data suggesting males are affected to a greater extent than females¹⁶. ATY is generally more common among individuals who increase their usual activity levels or participate in sports.^{19,20} However, less active individuals may also be affected as a minority of cases have been reported in sedentary groups.^{21,22} In one series of 58 patients, nearly one-third did not participate in vigorous physical activity.²⁰ Onset within the sedentary population may be attributed to physical deconditioning, intrinsic risk factors, or co-morbidities associated with ATY.^{6,22}

The long-term prognosis for patients with acute to sub-chronic ATY has been reported as favourable with nonoperative treatment.^{23,24} Significant decreases in pain and improvement in function have been reported in cases treated with exercise interventions.²⁵⁻²⁷ Long-term follow-up ranging between 2 and 8 years suggests that between 71% to 100% of patients with ATY are able to return

to their prior level of activity with minimal or no complaints.^{24,28,29} It has also been reported that results of both conservative³⁰ and operative treatments³¹ are less favourable in nonathletic populations and in those with insertional tendinopathy versus midportion tendinopathy³².

Chronic tendon pathology is a soft tissue condition commonly seen in chiropractic practice³³, and chiropractors can provide a number of conservative interventions used to treat tendinopathy³⁴. This case study was conducted to chronicle the conservative treatment and management of a 77-year old female patient presenting with chronic pain in the midportion of the achilles tendon, diagnosed as ATY.

Case report:

A 77-year old female presented with chronic pain of 8 months duration in the midportion of the right achilles tendon. The complaint was one of gradual onset and not related to any acute trauma or overt injury mechanism. The patient was a retiree who stated that she maintained a busy schedule looking after her country home. This included outdoor maintenance and management of her large garden. She reported that her pain had progressed to the point of limiting activities of daily living (ADLs) such as walking greater than 15 minutes and descending/ ascending stairs. The patient also reported now occasionally feeling pain at rest. Decreasing her activity levels and cryotherapy provided short term relief. She presented to her family physician's office 5 months prior and a referral was made to another health professional for evaluation of her achilles pain. The patient reported that she was examined and fitted for a pair of custom orthotics. Despite several modifications and three months of use, the custom orthotics did not provide any significant pain relief or functional improvements in her ADLs.

The patient rated her current pain level on the Verbal Pain Rating Scale (VPRS) where 0 is "no pain" and 10 is the "worst pain that she had ever experienced". She reported her pain as ranging from 2-3/10 occasionally at rest, and 6-7/10 with activity (i.e. walking greater than 15 minutes and ascending/descending stairs). Her Lower Extremity Functional Scale (LEFS) score was 48. The LEFS is a subjective outcome measure, comprised of 20 items, that asks individuals to rate their difficulty in performing a variety of everyday activities (where 0 is "unable to perform" and 4 is "no difficulty"). The final LEFS



Figure 1 *Right sided Achilles Tendinopathy resulting in noticeable swelling*



Figure 2 A-C The eccentric training protocol for Achilles Tendinopathy. Illustrations demonstrate the gastrocnemius portion of the program. (A) The patient starts in a single-leg standing position with the knee straight, weight on the forefoot and the ankle in full plantar flexion. (B) The achilles is then eccentrically loaded by slowly lowering the heel into a dorsiflexed position. (C) The patient returns to the starting position using the contralateral unaffected leg to avoid concentric loading of the symptomatic achilles tendon. This protocol was also repeated with the knee flexed at 45 degrees to engage the soleus.

score can vary from 0 (low) to 80 (normal function)³⁵. The patient's past medical history was unremarkable for any right lower extremity injury or condition. A full systems review was normal with the exception of a long-standing history of bronchioectasis and related use of a corticoster-oid inhaler as required.

Upon examination, inspection of the right lower extremity revealed swelling around the right achilles tendon (Figure 1). Hallux valgus was visible bilaterally as was left-sided sub-talar varus. One-legged squat testing revealed bilateral foot over pronation, along with internal femoral and tibial rotation. The patient was able to rise to her toes bilaterally, albeit with some discomfort noted on the right. With repeated heel raises, she reported increasing discomfort in the right achilles tendon and had to stop after six repetitions. Diminished balance was observed on the right with inability to maintain a one-legged stance. Range of motion (ROM) for the right knee and right hip joint was within physiological limits. Active and passive ROM at the right ankle was diminished by 25% in dorsiflexion. Palpation revealed tenderness and soft tissue thickening 3 cm from the heel along the course of the achilles tendon and into the gastrocnemius-soleus complex. Palpation also revealed tenderness in the following soft tissues of the right lower extremity: flexor hallucis longus, flexor digitorum longus, tibialis posterior, distal vastus medialis oblique, and gluteus medius and minimus. Evaluation for achilles tendon rupture was done with the Thompson test¹⁹ and was negative in this patient. Motor, reflex, and sensory testing for the lower extremities was within normal limits bilaterally. Supine straight leg raising was unremarkable for nerve root tension signs bilaterally.

The patient was diagnosed with ATY. Treatment was initiated and consisted of medical acupuncture (points consisting of physiological tender regions within the painful achilles tendon and gastrocnemius-soleus complex) with electrical stimulation (IC-1107+ at 2 Hz frequency). Graston Technique® (GT) was administered by a certified provider using GT protocols to all the affected soft tissues following each acupuncture treatment.

The patient was initially prescribed exercises consisting of static stretching for the gastrocnemius and soleus muscles. In addition, unilateral eccentric heel drops with no concentric component were prescribed for each respective muscle group (Figure 2 A-C). The patient was

Table 1.	Overview of treatment	sessions, in office treatment,	, and rehabilitative exercise in	ntervention(s)
	•			

WEEK(S) SESSIONS	IN OFFICE TREATMENT	REHABILITATIVE EXERCISE INTERVENTION(S)
WEEK-1 • 2 sessions	 Medical acupuncture (points consisting of physiological tender regions within the painful achilles tendon and gastrocnemius-soleus complex) with electrical stimulation (IC-1107+ at 2 Hz frequency) Augmented soft tissue mobilization (ASTM) Graston Technique® (GT) applied to all the tender/dysfunctional soft tissues as per physical examination findings 	 Stretching: Gastrocnemius and Soleus, 15-20 second holds, 8-10 repetitions (reps) for each respective stretch Eccentric heel drops: 3 sets of 10 reps For gastrocnemius: knee fully extended (Figure 2 A-C) For Soleus: knee flexed 45 degrees *Exercise performed 2 times/week in office, 3 times/week at home
WEEK-2 • 2 sessions	• Medical acupuncture and ASTM GT, same as above (SAA)	 Stretching and Eccentric heel drops: SAA *Exercise performed 2 times/week in office, 3 times/week at home
WEEK 3 • 2 sessions WEEK 4 • 2 sessions	• SAA • SAA	 Stretching: Gastrocnemius and Soleus (SAA): Addition of hamstring and quadricep muscle groups Eccentric heel drops: 3 sets of 15 reps Proprioception – 1-legged stance Introduction of lumbopelvic conditioning and lower extremity strengthening: Bridging; side-lying hip abduction; VMO training with quad sets and supine straight leg raise; theraband inversion, eversion, dorsiflexion strengthening for right foot; Exercise prescription = 2-3 sets of 8-10 reps *Exercise performed 2 times/week in office, 3 times/week at home
WEEK 5, 6, 7, 8 • 1 session each week	• SAA	 Stretching and Eccentric heel drops: SAA Proprioception: Rocker board training in office; Home proprioceptive challenge increased by performing 1-legged stance and introducing arm movements Lumbopelvic conditioning and lower extremity strengthening: VMO training advanced to shallow wall squats; addition of theraband hip abduction and adduction in the standing position; Exercise prescription = 2-3 sets of 8-10 reps *Exercise performed 1 time/week in office, 4 times/week at home
WEEK 9 • Discharge	• N/A	• Discharged, encouraged to continue with home program

instructed to assist with the unaffected contralateral lower extremity during the concentric (plantar flexion) movement phase, helping return the affected ankle to the starting position. Exercises were added as the treatment plan progressed. A summary of the full treatment protocol and prescribed exercises is included in Table 1.

The patient was seen twice a week for 4 weeks and then once per week for 4 weeks for a total of 12 treatment visits. Gradual improvement was reported during the entire course of treatment. At week 9, the patient reported a VPRS score of 0/10. Her LEFS score improved from 48 to 80. A change of 9 points or more is considered to represent a clinically meaningful functional change.³⁵ Physical examination at this time revealed only mild tenderness in the midportion of the achilles tendon and into the gastrocnemius-soleus complex. ROM, functional, and palpatory testing was otherwise within normal limits. The patient was encouraged to continue with her exercise program and was subsequently discharged from active care. At 12 month follow-up conducted via telephone, the patient reported no recurrence of symptoms.

Discussion:

The achilles tendon is the largest³⁶ and strongest³⁷ tendon in the body, and serves as the conjoined tendon for the gastrocnemius and soleus muscles³⁸. The achilles tendon does not have a true synovial sheath but instead has a paratenon.^{19,39} The paratenon is a connective tissue sheath that surrounds the entire tendon and is able to stretch 2 to 3 cm with movement, which allows for maximal gliding action.¹⁹ Initial inflammation of this layer with subsequent thickening and adhesion formation can result in diminished tendon flexibility and predispose the achilles to further injury.⁴⁰ The area of the tendon with the poorest blood supply is approximately 2 to 6 cm above the insertion into the calcaneus.^{8,20,41} Blood supply to this region further diminishes with increasing age.¹⁹ This hypovascular region is most commonly implicated in achilles tendinopathy^{19,20,41,42} and rupture⁴¹.

The etiology of ATY appears to be multi-factorial, with both extrinsic and intrinsic risk factors likely contributing.^{6,8,38,43} Extrinsic risk factors include training errors, increased training volume or physical activity, environmental variables, and use of faulty equipment or improper footwear.^{20,38} Intrinsic risk factors to consider include abnormal ankle dorsiflexion range of motion, abnormal subtalar joint range of motion, decreased ankle plantar flexion strength, increased foot pronation, increasing age, and genetic factors.^{6,10,22,38,44} Co-morbidities of obesity, hypertension, hypercholesterimia, and diabetes³⁸ can also contribute, and the presence of systemic inflammatory disease⁴⁵ and the use of antibiotics in the fluoroquinolone class⁴⁶⁻⁴⁹ may play a role as well.

In the absence of acute trauma or overt injury mechanism, ATY will clinically present as gradual pain and stiffness in the midportion of the tendon, 2 to 6 cm proximal to the calcaneal insertion.^{8,20,38,42} There may be a history of different or increased physical activity levels that precipitates injury and symptom reporting. In the early stages, tendon pain may be present following a period of inactivity (i.e. sleep, prolonged sitting), which lessens with a brief bout of activity, only to increase again after sustained activity.^{9,38} As the condition progresses to a chronic state, tendon pain may be present at rest, and exercise or activity durations are shortened due to earlier onset of pain.³⁸

Inspection of a symptomatic achilles tendon may reveal asymmetry, swelling, or abnormal tissue contour. Palpation will reveal tenderness along the tendon, reproducing the patient's pain. If degeneration of the tendon has occurred, a thickened, nodular area may be palpable.^{9,42} To gauge the possible impact on foot kinematics, various ranges of motion at the foot and ankle should be assessed.^{38,50} It is also important to view the biomechanical alignment of the foot and ankle while the patient is standing and throughout the gait cycle.^{9,38,50} A custom foot orthotic may be utilized to correct any aberrant mechanics of the foot and ankle to relieve pain in the Achilles.^{20,22,42} In this case, the patient reported that orthotic prescription as a stand alone intervention was not effective in providing a therapeutic or functional benefit.

Achilles tendon rupture should be suspected if there is a history of acute pain after a popping sound in the posterior aspect of the heel, if there is a positive result on the Thompson test¹⁹, and/or if a gap can be palpated within the achilles tendon⁹. Excluding tendon tear or rupture, the differential diagnostic list in patients with posterior ankle pain should include retrocalcaneal bursitis^{9,38}, insertional achilles tendinopathy³⁸, posterior ankle impingement⁵¹, achilles tendon ossification⁵², and systemic inflammatory disease⁴⁵. Plain radiography may be used as the initial investigative study for suspected achilles tendinopathy. Results are usually normal, but may reveal calcification of the tendon, osteoarthritis, or a loose body.9 Musculoskeletal ultrasonography and magnetic resonance imaging (MRI) may be helpful in cases where the patient fails to respond to conservative management or the diagnosis remains unclear.9,38

Healing of ATY may take several months in chronic conditions¹⁹, and may partially be due to the lack of vascularity to the tendon⁴². Initial conservative treatment measures should begin with relative rest and activity modification to provide pain relief and time for the tendon to heal.^{6,11,20,28,42} Medical acupuncture with electrical stimulation was utilized during the in-office treatment sessions to provide pain relief. This was immediately followed by GT applied to the achilles tendon as well as all the affected soft tissues in the right lower extremity identified as tender or dysfunctional during the initial assessment and subsequent treatment sessions. GT is a form of augmented soft tissue mobilization in which stainless steel instruments are utilized to apply controlled microtrauma to the affected soft tissues.53 Studies suggest that the controlled microtrauma induces healing via fibroblast proliferation.⁵⁴ Additional studies have shown clinical efficacy using GT for the treatment of various soft tissue disorders.^{53,55-60}

Eccentric training has garnered considerable attention with respect to rehabilitation of ATY. Several studies suggest that eccentric strength exercises for the calf can improve symptoms and should be initiated early in treatment.^{1,25,61,62} It has been hypothesized that eccentric training may be beneficial because of its effect on improving microcirculation⁶³ and peritendinous type I collagen synthesis⁶⁴. One particular study demonstrated that a 12-week course of eccentric strengthening exercises was more effective than a traditional concentric strengthening program for treating ATY in recreational athletes.⁶¹ In other studies, imaging of the achilles tendon before and after a 12-week eccentric training protocol showed thinning and normalization of the tendon structure both on ultrasound and MRI.54 Stretching exercises for the gastrocnemius-soleus complex have also been advocated to reduce pain and improve function.^{20,25,38,61} In this case, stretching exercises and eccentric calf exercises for both the gastrocnemius and soleus muscle groups were initiated early and well tolerated by the patient.

Additional conservative modalities commonly utilized in the treatment of ATY include therapeutic ultrasound, low level laser therapy, and taping.³⁸ Other non-operative treatment alternatives include extracorporeal shock wave therapy^{65,66}, topical glyceryl trinitrate patches⁶⁷, and corticosteroid injections^{9,68}. Scientific evidence supporting corticosteroid injections is controversial⁶⁹, and there is evidence that their use around the achilles tendon increases the risk of rupture⁷⁰. As a result, steroid injection is becoming "obsolete" in the treatment of midportion ATY⁷¹ and is being gradually replaced by new therapies utilizing injections of polidocanol⁷², along with autologous whole blood and platelet rich plasma73,74. Surgical intervention may be considered for cases that have failed a comprehensive, nonsurgical treatment program of three to six months in duration.9,20

There are several factors that may have influenced the favourable outcome of this case study. The patient in this circumstance did not demonstrate any significant co-morbidities that would have complicated recovery or limited her participation in an active exercise program. The patient was extremely motivated to recover and compliance to the scheduled office visits and prescribed exercises was excellent. The use of medical acupuncture points appeared to be effective in decreasing initial pain levels, while at the same time allowed active treatment in the form of static stretching and eccentric heel drops to be introduced early in the treatment protocol. Graston Technique® was useful in decreasing the soft tissue tenderness and dysfunction and theoretically aiding soft tissue healing. To ensure the likelihood of a positive therapeutic outcome, this practitioner also included gluteal and lumbopelvic conditioning, lower extremity flexibility and strength training, and proprioceptive exercises to address the functional deficits in the right lower extremity.

Summary:

Much has been written in the scientific literature about the conservative management of ATY. However, there is no high level of evidence that exists to conclusively support the use of any particular modality for treatment. Interventions that address extrinsic and intrinsic risk factors and focus on returning the patient back to work, sport, and ADLs in a timely manner require further investigation. This should include study in clinical trials with large sample sizes and controls to evaluate short and long term efficacy of various therapeutic modalities. This case demonstrates the successful management of midportion ATY using a variety of conservative interventions that can be employed by chiropractic practitioners. Although favourable results were obtained, it is important to note that the nature of this investigation was that of a case study, and therefore the treatment protocol utilized may not be appropriate for all individuals presenting with ATY. Practitioners treating this type of injury could consider implementing the conservative treatment strategies utilized in this case for other patients presenting with midportion ATY.

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Conservative management of a 31 year old male with left sided low back and leg pain: a case report

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Objective: This case study reported the conservative management of a patient presenting with left sided low back and leg pain diagnosed as a left sided L5-S1 disc prolapse/herniation.

Clinical features: A 31-year-old male recreational worker presented with left sided low back and leg pain for the previous 3-4 months that was exacerbated by prolonged sitting.

Intervention and Outcome: The plan of management included interferential current, soft tissue trigger point and myofascial therapy, lateral recumbent manual low velocity, low amplitude traction mobilizations and pelvic blocking as necessary. Home care included heat, icing, neural mobilizations, repeated extension exercises, stretching, core muscle strengthening, as well as the avoidance of prolonged sitting and using a low back support in his work chair. The patient responded well after the first visit and his leg and back pain were almost completely resolved by the third visit.

Summary: Conservative chiropractic care appears to reduce pain and improve mobility in this case of a L5-S1

Objectif : La présente étude de cas porte sur la gestion conservatrice d'un patient qui présente une douleur du côté gauche au bas du dos et à la jambe, diagnostiquée comme une hernie discale (ou un disque saillant) L5-S1 gauche.

Caractéristiques cliniques : Un homme de 31 ans qui travaille dans le domaine récréatif ressent depuis 3-4 mois une douleur du côté gauche au bas du dos et à la jambe, qui a été exacerbée par des périodes prolongées en position assise.

Intervention et résultat : Le plan de gestion était composé de l'administration de courant interférentiel, d'une thérapie myofasciale et des points déclics des tissus mous, de mobilisations par traction manuelle à basse vitesse et de faible amplitude en position allongée sur le côté et, au besoin, du blocage pelvien. Les soins à domicile comprenaient : l'application de chaleur et de froid, des mobilisations neurales, des exercices d'extensions répétées, des étirements, le renforcement des muscles du tronc, éviter de rester assis pendant des périodes prolongées et utiliser un dispositif de soutien pour le bas du dos dans sa chaise de travail. Le patient a bien réagi après la première visite et la douleur qu'il ressentait à la jambe et au bas du dos avait presque entièrement disparu au troisième rendez-vous.

Résumé : Les soins chiropratiques conservateurs semblent réduire la douleur et améliorer la mobilité dans ce cas de la hernie discale L5-S1. Il est conseillé de

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disc herniation. Active rehabilitative treatment strategies are recommended before surgical referral. (JCCA 2012; 56(3):225-232)

KEY WORDS: low back pain, rehabilitation, exercise, chiropractic, disc herniation/bulge

procéder à des stratégies de traitement de réadaptation active avant d'orienter le patient pour une chirurgie. (JCCA 2012; 56(3):225-232)

MOTS CLÉS : lombalgie, réadaptation, exercice, chiropratique, hernie discale

Introduction

Low back pain has been reported as the chief complaint for 23.6% of patients presenting to chiropractic offices.¹ Disc herniations that lead to nerve-root compromise account for less than 15% of chronic low back pain cases.² Over 95% of lumbar disc herniations occur at L4-5 or L5-S1 levels, and only 2% of herniations require surgery, 4% have compression fractures, 0.7% have spinal malignant neoplasms, 0.3% have ankylosing spondylitis and 0.1% have spinal infections.^{2,3} Leg pain is estimated to be found in 25-57% of all low back pain cases and accounts for large costs, disability, chronicity and severity.^{4,5,6} Many conservative treatments have been shown to be effective in the management of this condition and are favorable to pursue before considering any surgical interventions, such as: modalities, soft tissue therapy, spinal manipulations or mobilizations, pelvic blocking, McKenzie/endrange loading exercises, lumbar stabilization exercises and neural mobilizations, patient education, reassurance, short-term use of acetaminophen, and nonsteroidal antiinflammatory drugs.^{2,3,7-24} The purpose of this case report is to describe the successful management of a patient with low back and leg pain.

Case report

A 31-year-old male recreation centre worker presented complaining of left sided low back, gluteal and leg pain that travelled down to his posterior calf for the previous 3-4 months after playing sports at his workplace. He rated the pain as a 3/10 on the visual analogue scale (VAS) and 7-8/10 at its worst (where 0 was no pain and 10 was the worst pain ever experienced). He recalled that when the pain started a few months prior that it had left him "bedridden", but that his mobility had improved since. He stated that the low back pain "came and went" and was constantly "stiff". He identified the left sided leg pain

as constantly "dull" and occasionally "sharp". The aggravating factors included prolonged sitting at work (after 20-30 minutes) and slouching. The relieving factors included stretching, walking and getting up from sitting. He reported taking no medications or supplements. He was a non-smoker, who walked regularly, had an average diet and slept well. He reported no previous traumas, surgeries, illnesses or medical conditions. He recalled a previous incident of mild back pain without leg pain in high school. The organ systems and red flags reviews were unremarkable. He had never seen a chiropractor, but did see his medical doctor annually for check-ups.

The physical examination revealed that the visually estimated lumbar ranges of motion were limited in flexion (by 75%), lateral bending (by 50%) and extension (by 25%). Extension was found to be a relieving position, especially when it was repeated. Postural observation demonstrated increased anterior head carriage and thoracic kyphosis. Motion and static palpation illustrated restricted motion at L2-4. Soft tissue palpation revealed tight and tender bilateral lumbar erector spinae and quadratus lumborum, left sided gluteal, piriformis, iliotibial band and lateral gastrocnemius muscles. The neurological examination was unremarkable in the lower extremities. Gait and heel/toe walking were normal. Positive orthopedic tests that reproduced his pain included Valsalva (patient holds breath and bears down), left sided straight leg raise/ SLR (seated and supine) at approximately 45 degrees and Braggard's (SLR plus ankle dorsiflexion) which all reproduced his leg and low back pain.^{25,26} Negative orthopedic tests included right sided SLR and Braggard's, and bilateral Bowstring's (palpation of the popliteal fossa for the sciatic nerve), Thomas (supine, flex one knee to the patient's chest), Patrick/Fabere/Distraction (cross patient's ankle over opposite knee into "figure four" position, supine), Thigh thrust (supine with knee bent to 90 degrees and thrust down into table/patient's SI joint), Gaenslen's (supine, patient's knee to chest and other leg off table and apply overpressure), Obers (side lying, hang top leg off back of table), PA and side SI compression, Ely's (prone, patient's heel to buttock), Hibb's (prone, patient's knee bent to 90 degrees and internally rotate femur), Yeoman's (prone, examiner extends hip and presses down on the ipsilateral PSIS), and Spring/joint mobility tests.^{25,26}

The working diagnosis was a left sided postero-lateral disc prolapse/herniation with referral/compromise of the left L5-S1 nerve root. The differential diagnoses included mechanical low back pain and muscular entrapment/piriformis syndrome. The prognosis was rated as moderate, due to the length of time and type of the injury. The plan of management included 1-2 weekly treatments for 2-3 weeks, followed by a re-evaluation. Treatments included interferential current, soft tissue trigger point and myofascial therapy, side posture traction mobilizations (a manual side posture posterior-anterior mobilization with long axis traction and deep flexion avoided) and pelvic blocking was used as necessary.23,27 Manipulations were not performed due to the patient's request. Home care advice included heat, icing, neural mobilizations/nerve flossing (see Figures 1A & 1B), reassurance, staying active, repeated end range loading extension exercises (10 repetitions every hour, held for 1 second each, see Figure 2), stretching (quadratus lumborum, iliopsoas, gluteal and piriformis muscles), core stabilization exercises, avoiding prolonged sitting by getting up regularly and using a low back support in his chair. A referral was also made to his medical doctor to request imaging.

On his second visit, two weeks later, the patient stated he had no pain for the previous two days, which was the longest period of time for the previous 3-4 months he had been pain free. He reported that the pain was "bad" three days prior because he had done a substantial amount of prolonged sitting at work. He had seen his medical doctor, who requested radiographs and magnetic resonance imaging (MRI). He conveyed that the prescribed stretches felt "good". On this visit deep abdominal activation (during daily activities) and the modified curl-up exercise (to be performed daily with 8-10 second holds and building up the number of repetitions slowly, see Figure 3) were added.^{9,13} On his third visit, two weeks later, he reported being pain free since the previous visit and only a mild "tightness"in his back. He also recounted having no leg



Figures 1A & 1B Sciatic nerve neural mobilizations



Figure 2 McKenzie/end range loading extension exercises



Figure 3 Modified curl-up9

symptoms, that he was able to sit longer at work and that he had an MRI appointment in two weeks. He stated that he had continued to do his stretching, but had not yet started the core stabilization exercises.

He cancelled his next visit, due to an unrelated illness. On the phone, he reported having no pain and was discharged with follow-up advice given (via e-mail) to increase the difficulty and variety of the stabilization exercises (adding bird dogs and side bridges) and to return for subsequent visits as needed.⁹ The MRI report was received a few weeks later and showed mild degenerative disc disease at L4-5 and L5-S1, a mild diffuse L4-5 disc bulge with a central posterior annular tear, a mild to moderate diffuse disc bulge at L5-S1 that touched the left S1 nerve root and mild L5-S1 bilateral neural foraminal stenosis.

Discussion

In this case, the patient stated that prolonged sitting and slouching aggravated his symptoms. He reported relief with the chiropractic treatment, including repeated extension exercises. Lumbar stabilization exercises were added to build strength and endurance of the surrounding musculature. A short review of the literature on these specific topics is summarized.

Disc herniations have been found to be highly prevalent (20-76%) in the normal asymptomatic population and can be detected on MRI, but physical job characteristics and psychological aspects of work are more predictive of the need for low back pain related medical consultation and work incapacity over long term follow-up.28,29 Lumbar disc protrusions have been shown to spontaneously resolve or reduce by 20-70% in size by MRI.²⁹⁻³¹ Keskil et al (2004) found complete, spontaneous resolution of large protruded discs without treatment (while neighboring disc protrusions did not), which the authors related to dehydration and regression within the annulus of disc fragments that had not fully migrated out (see Figure 4 for anatomical review).²⁹ The natural history of disc herniation has been demonstrated as high as 93% resolution in 24 months and from 58-88% in the 10 days to 6 months post injury for lumbar disc herniations with radiculopathy.^{31,32} Muscular atrophy in the lumbar mutifidus and piriformis muscles has been documented following a lumbar disc injury.^{33,34} Hodges et al (2006) reported that 20-60% of chronic low back pain patients have been found to have



Figure 4 Lumbar vertebrae and intervertebral disc

paraspinal muscle atrophy and abnormalities (30% reduction in cross-sectional area, fiber change and increased intramuscular fat).³³ One-year prognosis in low back pain patients with and without radiculopathy is associated with baseline disability and pain, diffuse tenderness, worrying and health anxiety, compensation claim, fear avoidance, and baseline exercises habits.³⁵ In patients with back plus leg pain, duration of pain and forward flexion have shown statistically significant associations with one-year disability.³⁵

Sitting and Slouching

Sitting has been shown to increase intradiscal pressure in the nucleus pulposus by approximately 40% when compared to standing.36-38A slouched posture while sitting has long been discussed as a cause or aggravator for back pain.^{10,36-39} Slouching results in backward rotation of the sacrum (in relation to the ilium), dorsal widening of the L5-S1 disc and strain on the iliolumbar ligaments but the addition of lumbar backrest support eliminates these movements.11 Co-contraction of the deep stabilizing muscles of the spine while sitting has been shown to reduce the lumbar curve and increase the sacral angle.^{36,37} Maigne et al. (2003) found that chronic low back pain sufferers who demonstrated position-related pain onset and relief (pain with sitting and relieved by standing) have higher rates of radiologic instability (loss of the ability of the spine under loads to maintain its displacement pattern so

there are no deficits, deformity or pain) and anterior loss of disc space in flexion when compared to controls.⁴⁰ Patients with discogenic pain have demonstrated increased pain with sitting.¹⁰ Prolonged loading decreases disc hydration, while rapid fluctuations of load (such as between flexion and extension) has not been shown to affect disc hydration.⁴¹ Changes in segmental lumbar motion relate to the degree of degeneration when measured in supine and seated MRI in subjects with discogenic chronic low back pain.⁴² Wilke et al (1999) concluded that constant position change promotes fluid flow in the disc, including leaning forward while seated in a chair increases intradiscal pressures when compared to leaning back or slouching, while sitting with the back consciously straightened increased the pressure by approximately 10%.³⁹ Sleeping for seven hours increased the intradiscal pressure by 240%, which concurs with reports that discs may prolapse more easily after longer periods of sleep.³⁹ Snook et al (2002) reported that discs were more susceptible to intra-annular prolapse when fully hydrated.43 When subjects reduce or eliminate early morning lumbar flexion and maintain a "straight back", they report a reduction in pain intensity, number of "days in pain", as well as improvements in disability, impairment and medication usage.43 Callaghan & McGill (2001) demonstrated that standing allows the passive tissues of the lumbar spine to "rest" from the strain they sustain in a seated position, therefore regularly getting up from sitting and changing positions promotes a favorable clinical outcome.44 It has also been demonstrated that with a greater amount of extension, the load is shifted to the facets which unloads the discs and helps to combat the normal spinal height loss over the course of a day, but that with flexion, there is no such osseous structure to do the same.45,46

Assessment and Treatment

Surgical procedures have demonstrated limited clinical success, but these failures have led to improvements in detection, imaging, diagnosis and treatment of disc injuries.⁴⁷Alternatively, conservative treatment is less invasive and outcomes are comparable to surgery for pain relief, quality of life and return to work for long-term.⁴⁷

This case study focused on two accepted rehabilitation methods that exist for treatment of low back pain. The first includes a lumbar stabilization program that emphasizes maintaining a neutral spine position with daily

activities, trunk muscular endurance training and overall functional capacity.9,11-13,47 This method of stabilization rehabilitation has been shown to be 80-98% effective in patients with herniated nucleus pulposus and extruded discs.48 The predictors of clinical response to stabilization exercises include age, straight-leg raise, prone instability test, aberrant motions, lumbar hypermobility, and fearavoidance beliefs.^{9,27,51} There are two main strategies for abdominal activation (ie/ bracing vs hollowing), but abdominal bracing has been shown to be the most effective for lumbar spine stability.9,13 McGill has researched many lumbar spine stabilization exercises that "spare the spine" by using the correct technique and optimal progression.⁹ When combined with abdominal bracing, the modified curl-up, side bridge and bird dog help to create a "muscular corset" to protect the spine against daily challenges.⁹ Other "low-tech" stabilization exercises for low back pain with leg pain include swiss ball exercises, pelvic tilts with bridging, abdominal crunches, prone extension exercises, side-ups, and wall squats, post-isometric stretching techniques, upper body stabilization exercises, and proprioceptive exercises.11

The second treatment and assessment method recommended in this case report was introduced by McKenzie and depends on the patient's response to end-range lumbar spine movements.^{2,10,12,14,52} A 'directional preference' can sometimes be found when performing endrange movements, where patients can be categorized with centralization of pain (pain receding towards the lumbar spine) or peripheralization (pain spreading into a radicular pattern more distally).^{10,12,13,47,52} Patients are then given exercises in the direction that creates centralization, while peripheralizing movements are taught be avoided.⁴⁷ This method has been shown to be twice as effective as traction and back schools at alleviating pain, while favorable outcomes have been shown in 80-98% of low back pain patients.48 Specific extension movements can cause anterior migration of nuclear tissue, while the neural arch reduces forces on the posterior annulus and therefore relieves pain.⁴⁶ The repetition of the extension movements may also assist in rehydrating and unloading the disc, theoretically causing "centralization" of patient's symptoms.⁴⁶ Rapala et al (2006) concluded that McKenzie assessment could successfully differentiate discogenic from non-discogenic pain.14 Centralization has been shown on MRI to imply an intact annulus and has 89% specificity

in relation to positive discography, while peripheralization or the inability to identify a pain-centralizing movement implies a sequestered, disrupted or extruded.^{15,47-49} Repeated end-range or pain-response based assessment (McKenzie assessment) is supported in the evidence for diagnostic and therapeutic care in patients with low back and leg pain.¹⁰ Wetzel and Donelson (2003) determined that "centralization" predicts successful response to conservative care, aggravation of symptoms with testing predicts a poor response to conservative/non-surgical care and those who are unaffected by testing are likely to have pain that is nondiscogenic.¹⁰ TheMcKenzie method includes categories of "postural" syndrome, "derangement" syndrome (80% of cases) and "dysfunction" syndrome (3-6% of cases).^{16,30} The author states that adherent nerve root (ANR) is a subgroup of the dysfunction syndrome and includes: recent sciatica history, 6-8 weeks of symptoms, intermittent leg pain, limitation of flexion in standing and consistent relieving movements.³⁰ The successful treatment involved neural stretches (with supine flexion exercises), lumbar extensions, and postural correction in sitting (with a lumbar roll).³⁰ Scannell and McGill (2009) demonstrated evidence of disc prolapse with repeated flexion and re-direction of the displace nucleus with repeated extensions, which they theorized may support the success of the McKenzie derangement syndrome.⁵⁰

Neural mobilizations are another possible therapy for lumbar disc herniations with referral.¹⁶ A literature review found limited evidence in the number and quality of studies for this treatment modality, but with further research it may show promise.¹⁷ It has been proposed that neural mobilizations help to "…restore the dynamic balance between the relative movement of neural tissues and surrounding mechanical interfaces, thereby allowing reduced intrinsic pressures on the neural tissue and thus promoting optimum physiologic function…" which helps to facilitate "…nerve gliding, reduction of nerve adherence, dispersion of noxious fluids, increased neural vascularity, and improvement of axoplasmic flow".¹⁷

Chiropractic therapy, including spinal manipulation, has also been included in many treatment strategies for low back pain. Recommended chiropractic treatment and rehabilitation for patients with disc bulges/herniations or "sciatica" has included spinal manipulative therapy, mobilizations, mechanical traction, interferential electrical stimulation, cold laser, patient education and active care, including stabilization exercises, prone press-ups or McKenzie therapy.^{3,7,11,15,18,20,23,24,51,53} Spinal manipulative therapy (SMT) and mobilization have been found to have moderate evidence acute and chronic low back pain for short-term pain relief, but have similar or better pain outcomes when compared to placebo, sham manipulations and other treatments.54,55 McMorland et al (2010) endorsed manipulation as a first-line treatment when compared to microdiskectomy for the treatment of sciatica secondary to lumbar disc herniation.²¹ Paskowksi et al (2011) reported positive results for a multidisciplinary care of low back pain patients and included recommending patients to remain active, quit smoking, exercise, give them reassurance, minimize unnecessary x-rays and imaging, as well as appropriate timing or surgery and injections.²²

Summary

This case demonstrates positive results for the treatment of a sub-acute lumbar disc injury with conservative care. It should be noted that results cannot be extrapolated to other cases, since this is only a single case report and the rapid resolution of this patient's symptoms could be due to the natural history of the condition or the use of multiple interventions. Sitting and slouching have been shown to aggravate low back pain, especially when a disc injury is involved. Standing and extension exercises have been shown to help combat this. There are many reports of asymptomatic disc herniations and spontaneous resolutions, as well as muscular atrophy associated with this type of injury. The prognosis of disc herniation related low back pain relates to the extent of radiation, duration of pain and other psychosocial factors. Recommended conservative care includes spinal stabilization exercises. McKenzie assessment and treatment, neural mobilizations and chiropractic modalities, including spinal manipulative therapy. Conservative management may decrease pain and increase function for the treatment of lumbar disc injuries. Active patient participation in rehabilitative care is recommended before surgical referral.

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Book Reviews

The Four-Minute Neurologic Exam Stephen Goldberg MedMaster Inc., P.O. Box 640028, Miami, FL, 33164, USA; 2012 49 pages, paperback, \$12.95

The Four-Minute Neurologic Exam, written by Stephen Goldberg, aims to address the issue of neurological exams, which are frequently not performed due to time constraints in private practice settings. This thin paperback was written primarily for physicians who are nonneurologists and focuses on a brief neurological screen that can yield the highest amount of diagnostic information in a limited amount of time.

There is a brief review of neuroanatomy with a focus on localization of central and peripheral lesions followed by a review of common neurologic presentations. The remainder of the book discusses pertinent information to be gathered in the history and examination.

The four-minute exam outlined by the author includes mental status, cranial nerve, sensory, motor, reflex, and coordination tests. There is also a brief discussion on evaluation of the unconscious patient. Although the tests included within the suggested exam do not constitute a complete neurological evaluation as some tests are omitted for the sake of brevity, *The Four-Minute Neurologic Exam* is a useful starting point or screen.

This book is well worth the price. The review section, common presentations, as well as the exam were well explained and practically useful. I would recommend this book as a review for family physicians and chiropractors, however, it would be best suited for on-field or sideline sports injury evaluation.

Cameron M. Marshall, BA(Hons.), DC Sport Sciences Resident Canadian Memorial Chiropractic College Clinical Sports Medicine – Revised Third Edition Peter Brukner and Karim Khan McGraw-Hill Book Company Australia, 2009 Hardcover, 1032 pages, \$109.95 CDN ISBN-13: 978-0-0702-7899-8

This text was written for musculoskeletal practitioners interested in the care of elite, competitive, and recreational athletes. The book covers a wide range of subjects including sports medicine science, injury prevention, nutritional supplementation, and management of special populations. Injuries and conditions are presented in a symptom specific manner (i.e. thoracic and chest pain, buttock pain, anterior knee pain). There is an emphasis placed on assessment, diagnosis, differential diagnosis, and treatment options.

The end of each chapter provides recommendations for further reading and a full reference list. In addition, selected web-based references have also been included which provide the reader an opportunity to access current information. The greatest feature of this text is the color illustrations that compliment the clear and succinct writing style. Numerous charts and tables are also used to present important information.

This book would serve as an excellent resource to chiropractic practitioners with an interest in rehabilitation and sports injury management.

John A. Papa, DC, FCCPOR(C)

Clinical Orthopaedic Rehabilitation: An Evidence-Based Approach – Third Edition S.B. Brotzman and R.C. Manske Elsevier Mosby, 2011 Hardcover, 608 pages, \$84.95 CDN ISBN-13: 978-0-3230-5590-1

The authors of this book have succeeded in providing rehabilitation professionals with a comprehensive resource for managing numerous orthopaedic conditions. The text is divided into chapters that discuss regional problems in depth, including injury assessment, differential diagnoses, and rehabilitation protocols. The chapter on spinal disorders is particularly well done, and covers topics such as whiplash management, core stabilization, McKenzie approach to LBP, and rehabilitation following lumbar disc surgery.

At the conclusion of each chapter, non-operative and post-operative treatment protocols are provided in an easy to follow chart format to help guide the practitioner through the rehabilitation process. The breadth of the information presented in this text can be attributed to the extensive reference list with citations as recent as 2010 presented at the end of each chapter. The book is also accompanied by a bonus expert consult feature that provides online access to the book contents and a video library demonstrating exercises and treatment techniques.

Overall, this text is an extraordinary presentation of material primarily geared toward chiropractors with an interest in exercise and rehabilitation, and would have the greatest utility for those directly involved with patient care.

John A. Papa, DC, FCCPOR(C)

Athletic and Sport Issues in Musculoskeletal Rehabilitation (Musculoskeletal Rehabilitation Series) D.J. Magee, R.C. Manske, J.E. Zachazewski, W.S. Quillen Elsevier Saunders, 2011 Hardcover, 824 pages, \$79.95 CDN ISBN-13: 978-1-4160-2264-0

This text was written for health practitioners with an interest in understanding the complexities of physical performance and injury management beyond the traditional concepts of pathology and treatment intervention. The book is divided into four distinct sections covering a range of topics including psychosocial aspects of youth sports, sports drug testing, medical conditions in sport, sports related concussion, and the care of special populations.

The comprehensive review of biomechanics in sports such as cycling, golf, tennis, soccer, and running allows the reader to understand the implications of less than ideal movement patterns and the role they play in the genesis of injury. The book is generally well organized, with text boxes used to emphasize important points. The illustrations in the book generally support the concepts discussed, however, the presentation would have been significantly enhanced with the inclusion of more colour photos. This is glaringly obvious in the chapter on Dermatologic Considerations in Athletes, where the black and white photos are insufficient to exhibit the subtleties of these conditions.

Overall, this thorough and informative book is highly recommended and can serve as a valuable resource.

John A. Papa, DC, FCCPOR(C)
Physical Therapy for Children S.K. Campbell, R.J. Palisano, M.N. Orlin Elsevier Saunders, 2011 Hardcover, 1104 pages, \$84.95 CDN ISBN-13: 978-1-4160-6626-2

The goal of this text is to provide a comprehensive reference primarily written for physiotherapists working in a setting catering to the special needs of children. A detailed review of the five sections in this book revealed that there are large portions of this text devoted to clinical presentations that are likely foreign to chiropractic practice. This is largely due to the fact that many of these conditions fall outside of the chiropractic scope of practice. This would include topics dealing with developmental rehabilitation, burn management, rare genetic diagnoses, and mechanical ventilation.

The "Management of Musculoskeletal Impairment" section of this text will be much more familiar to chiropractic practitioners. This section discusses conditions such as juvenile idiopathic arthritis, congenital and idiopathic scoliosis, Scheuermann's disease, spondylolisthesis, congenital muscular torticollis, slipped capital femoral epiphysis, and sports injuries in children. Although not all presentations are amendable to chiropractic intervention, chiropractors should have a general understanding of these conditions so that appropriate referral can be made where appropriate.

Overall, this text likely has limited utility for everyday chiropractic practice. Pertinent information regarding pediatric presentations can likely be obtained in other references more geared toward musculoskeletal care.

John A. Papa, DC, FCCPOR(C)

Fascia: The Tensional Network of the Human Body Robert Schleip, Thomas W. Findley, Leon Chaitow, Peter Huijing ISBN-10 0702034258 Churchill Livingstone; Elsevier 1st edition 566 pgs. CAD\$ 65.95

Fascia: The Tensional Network of the Human Body is a collection of the most current and comprehensive information on the topics of fascia. Its editors, leading experts in fascia research, have organized the most qualified contributors from their respective fields. This collective effort represents an international best evidence update on our knowledge of fascia, creating a benchmark for the growing movement of fascia enthusiasts.

With an easy to read style and informative graphics, *Fascia* makes learning about fascia straightforward for any reader. The seven chapters flow smoothly, starting with sections on basic sciences, then clinical applications, ending with future research directions. Although black and white, it has a 12 page colour plate and access to quality content online with the text. The glossary, an essential piece when bringing a body of research together, left this reviewer dissatisfied; it had not expanded from earlier published lists of terminology (LeMoon K. Terminology used in Fascia Research. Journal of Bodywork and Movement Therapies 2008; 12: 204–212).

Advances in the fascia research community are exciting which is in the spirit of this well executed textbook. Chiropractors will find content on assessment and palpation that can be applied in practice along with interesting sections on management from a range of practioners. *Fascia* is useful and worthy for any student or clinician of the human form.

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