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The efficacy of instrument assisted soft tissue mobilization: a systematic review

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Background: *Instrument assisted soft tissue mobilization (IASTM) is a popular treatment for myofascial restriction. IASTM uses specially designed instruments to provide a mobilizing effect to scar tissue and myofascial adhesions. Several IASTM tools and techniques are available such as the Graston® technique. Currently, there are no systematic reviews that have specifically appraised the effects of IASTM as a treatment or to enhance joint range of motion (ROM).*

Purpose: *The purpose of this study was to systematically appraise the current evidence assessing the effects of IASTM as an intervention to treat a musculoskeletal pathology or to enhance joint ROM.*

Methods: *A search of the literature was conducted during the month of December 2015 which included the following databases: PubMed, PEDro, Science Direct, and the EBSCOhost collection. A direct search of known journals was also conducted to identify potential*

Contexte : *La mobilisation des tissus mous assistée par instrument (MTMAI) est un traitement populaire pour la restriction des tissus myofasciaux. La MTMAI utilise des instruments spécialement conçus pour fournir un effet de mobilisation sur les tissus cicatriciels et les adhérences myofasciales. Plusieurs outils et techniques de MTMAI sont disponibles, comme la technique Graston[MD]. Actuellement, il n'y a aucun examen systématique ayant notamment évalué les effets de la MTMAI comme traitement ou pour améliorer l'amplitude articulaire.*

Objectif : *Cette étude visait à évaluer systématiquement les données actuelles évaluant les effets de la MTMAI comme méthode d'intervention pour traiter une pathologie musculo-squelettique ou pour améliorer l'amplitude articulaire.*

Méthodologie : *Une recherche des publications scientifiques a été réalisée au cours du mois de décembre 2015, incluant les bases de données suivantes : PubMed, PEDro, Science Direct, et la collection EBSCOhost. Une recherche directe a également été réalisée dans les*

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publications. The search terms included individual or a combination of the following: instrument; assisted; augmented; soft-tissue; mobilization; Graston®; and technique.

Results: *A total of 7 randomized controlled trials were appraised. Five of the studies measured an IASTM intervention versus a control or alternate intervention group for a musculoskeletal pathology. The results of the studies were insignificant (p>.05) with both groups displaying equal outcomes. Two studies measured an IASTM intervention versus a control or alternate intervention group on the effects of joint ROM. The IASTM intervention produced significant (P<.05) short term gains up to 24 hours.*

Conclusion: *The literature measuring the effects of IASTM is still emerging. The current research has indicated insignificant results which challenges the efficacy of IASTM as a treatment for common musculoskeletal pathology, which may be due to the methodological variability among studies. There appears to be some evidence supporting its ability to increase short term joint ROM.*

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KEY WORDS: chiropractic, Graston®; myofascial; massage

revues connues pour relever les publications possibles. La recherche était basée sur les termes ou combinaisons de termes suivants : instrument; assistée; accrue; tissu mou; mobilisation; Graston^{MD}; technique.

Résultats : *Au total, sept essais contrôlés randomisés ont été évalués. Cinq des études mesuraient une intervention de MTMAI par rapport à un groupe de contrôle ou une intervention différente pour l'évaluation de la pathologie musculo-squelettique. Les résultats des études étaient négligeables (p > ,05) les deux groupes affichant des résultats égaux. Deux études mesuraient une intervention de MTMAI par rapport à un groupe de contrôle ou une intervention différente sur les effets de l'amplitude articulaire. L'intervention de MTMAI a produit des gains à court terme significatifs (P < ,05) allant jusqu'à 24 heures.*

Conclusion : *Les publications scientifiques sur la mesure des effets de la MTMAI sont encore à leur début. La recherche actuelle a indiqué des résultats négligeables qui mettent en question l'efficacité de la MTMAI comme traitement de la pathologie musculo-squelettique courante, ce qui peut être dû à la variabilité de la méthodologie entre les études. Il semble y avoir des preuves soutenant sa capacité à augmenter l'amplitude articulaire à court terme.*

(JCCA. 2016;60(3):200-211)

MOTS CLÉS : chiropratique, Graston^{MD}, myofascial, massage

Introduction

Instrument assisted soft tissue mobilization (IASTM) is a popular treatment for myofascial restriction based upon the rationale introduced by James Cyriax.[1,2] Unlike the Cyriax approach utilizing digital cross friction, IASTM is applied using specially designed instruments to provide a mobilizing effect to soft tissue (e.g., scar tissue, myofascial adhesion) to decrease pain and improve range of motion (ROM) and function.[2] The use of the instrument is thought to provide a mechanical advantage for the clinician by allowing deeper penetration and more specific treatment, while also reducing imposed stress on the hands (Figure 1).[2-4] Using instruments for soft tissue mo-

Figure 1.
Example of IASTM treatment.

bilization is theorized to increase vibration sense by the clinician and patient. The increased perception of vibration may facilitate the clinician's ability to detect altered tissue properties (e.g., identify tissue adhesions) while facilitating the patient's awareness of altered sensations within the treated tissues.[2,5]

The IASTM treatment is thought to stimulate connective tissue remodeling through resorption of excessive fibrosis, along with inducing repair and regeneration of collagen secondary to fibroblast recruitment.[6,7] In turn, this will result in the release and breakdown of scar tissue, adhesions, and fascial restrictions.[6-8] In laboratory studies using a rat model, the use of instruments resulted in increased fibroblast proliferation and collagen repair (e.g., synthesis, alignment, and maturation) in cases of enzyme-induced tendinitis.[9,10] Many of these benefits were also found in a laboratory study on ligament healing using the rat model which further provided supporting evidence that instrument massage produces a significant short-term (e.g., 4 weeks) increase in ligament strength and stiffness compared to the contralateral control limb.[11] While these findings provide initial support for IASTM stimulating connective tissue remodeling, these physiological changes are still being studied and have not been confirmed in human trials.

There are various IASTM tools and companies such as Graston®, Técnica Gavilán®, Hawk Grips®, Functional and Kinetic Treatment and Rehab (FAKTR)®, Adhesion Breakers® and Fascial Abrasion Technique™ that have their own approach to treatment and instrument design (e.g., instrument materials, instrument shape). Anecdotally, the Graston® technique contains a protocol for treatment that contains several components: examination, warm-up, IASTM treatment (e.g., 30-60 seconds per lesion), post treatment stretching, strengthening, and ice (only when subacute inflammation is of concern).[12] Despite the variations in treatment approaches and design, the general premise of IASTM is to enhance myofascial mobility with limited adverse effects such as discomfort during treatment or bruising (e.g. petechiae) after treatment.[13-17]

To date, there have been no systematic reviews appraising the body of IASTM literature. For many years, the efficacy of IASTM was described through case series[2,18-21] and reports[1,6,8,22-32] (level 4 evidence) which are limited due to their subjectivity. Most of the case reports described successful treatment of tendinopathies[8,19,21,22,24-27,30,32] and arthrofibrosis[31,33]. Recently, higher level controlled investigations[14,32,34-38] have been published assessing the efficacy of IASTM treatment for various conditions but have not been appraised. The goal of this systematic review was to appraise the current IASTM literature to provide a current update for the clinician.

Methods

Search Strategy

A systematic search strategy was conducted according the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for reporting systematic reviews.[39,40] The following databases were searched during the month of December 2015: PubMed, PEDro, Science Direct, and the EBSCOhost collection. A direct search of known journals was also conducted to identify potential publications. The search terms included individual or a combination of the following: instrument; assisted; augmented; soft-tissue; mobilization; Graston®; and technique.

The terms Gua sha and ASTYM® were omitted from this search. Gua sha is a popular Asian medical treatment that uses a smooth edged instrument (e.g. water buffalo horn, honed jade, soup spoon) to scrape the skin until a red blemish appears.[41] The red ecchymosis caused by the scraping is believed to be blood stasis. The Gua sha treatment is supposed to relieve blood stagnation and reduce pain.[15] Clinicians may consider the Gua sha approach a form of IASTM but the treatment rationale, goals, and application differs from the other IASTM approaches.[41] Another form of myofascial treatment called augmented soft tissue mobilization (ASTYM®) is often considered a type of IASTM.[42] The creators and proponents of ASTYM® do not consider it a form of IASTM due to their unique treatment approach which uses a combination of instruments, stretching, and strengthening.[32,42,43] Both Gua sha and ASTYM® have their own body of evidence including literature reviews.[15,17,32,41-44] Due to these variations, Gua sha and ASTYM® were not included in this review since the focus of this review was to appraise the literature on IASTM.

Study Selection

Two reviewers (MC and ML) independently searched the databases and selected studies. A third independent re-

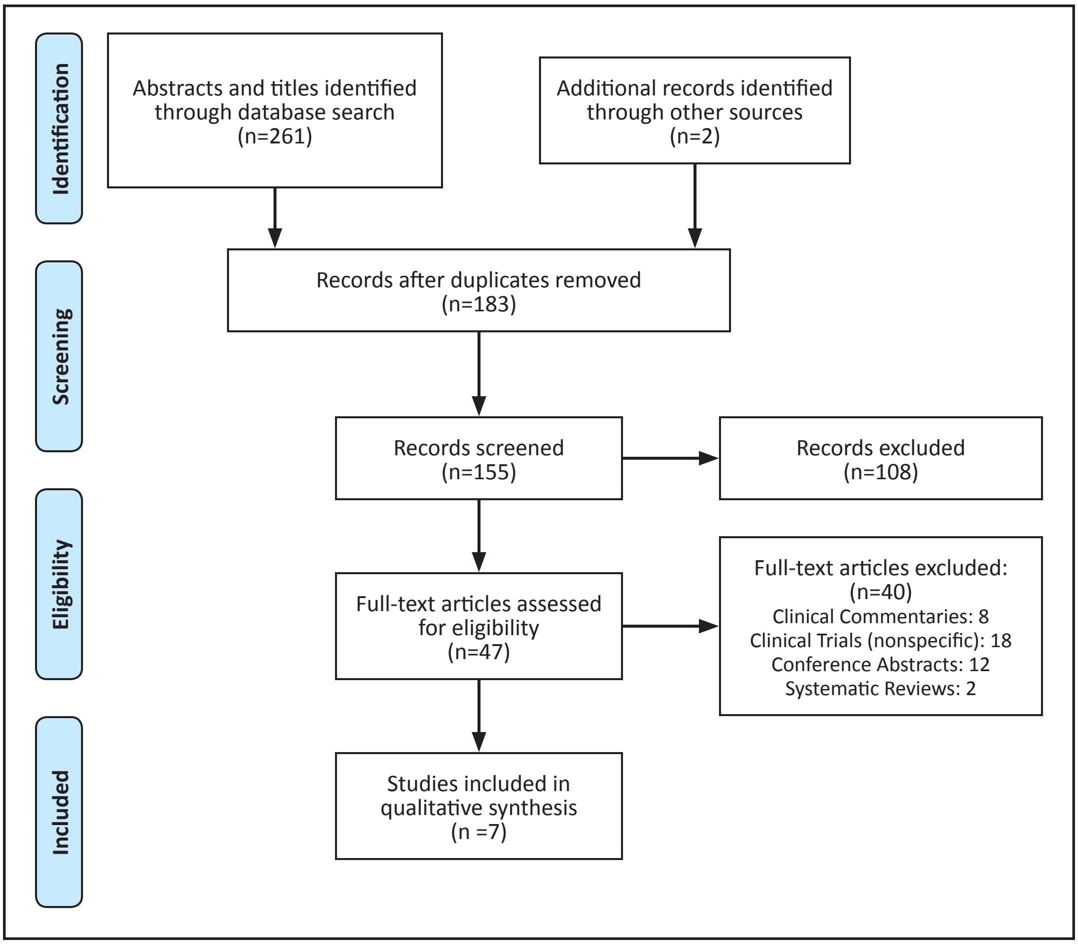

Figure 2.
PRISMA search strategy.

viewer (SC) was available to resolve any disagreements. Studies considered for inclusion met the following criteria:

1) Peer reviewed, English language publications
2) Controlled clinical trials that compared pretest and posttest measurements for an intervention program using IASTM
3) Investigations that compared an intervention program using IASTM
4) Investigations that compared two intervention programs using IASTM.

Studies were excluded if they were non-English publications, clinical trials that included IASTM as an intervention but did not directly measure its effects, clinical trials that included Gua sha and ASTYM®, case reports, case series, clinical commentary, dissertations, and conference posters or abstracts.

Data Extraction and Synthesis

The following data were extracted from each article: subject demographics, intervention type, intervention parameters, and outcomes. The research design of each study was also identified by the reviewers. Qualifying manuscripts were assessed using the PEDro (Physiotherapy Evidence Database) scale for appraising the quality of literature.[45,46] A PEDro score of 6 or more was considered moderate to high level evidence.[47]

Intra observer agreement was calculated using the Kappa statistic.[48] Landis and Koch [49] provided the follow-

Table 1.
PEDro score for the qualified studies.

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Total Score
Blanchette and Normand[32]	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	8
Burke et al[35]	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	8
Gulick[36]	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	8
Laudner et al[37]	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	8
Markovic[14]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	7
Schaefer and Sandrey[38]	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	8
Brantingham et al[34]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	10

Pedro Criteria: Item 1(Eligibility criteria), Item 2 (Subjects randomly allocated), Item 3 (Allocation concealed), Item 4 (Intervention groups similar), Item 5 (subjects were blinded), Item 6 (Therapists administering therapy blinded), Item 7 (All assessors blinded), Item 8 (At least 1 key outcome obtained from more than 85% of subjects initially allocated), Item 9 (All subjects received treatment or control intervention or an Intention-to-treat analysis performed), Item 10 (Between group comparison reported for a least on variable), Item 11 (study provides both point measures and measures of variability for at least one key outcome)

ing interpretation to the Kappa values: <0 poor inter-rater agreement, 0.01 to 0.20 as slight agreement, 0.21 to 0.40 as fair agreement, 0.41 to 0.60 as moderate agreement, 0.61 to 0.80 is substantial agreement, and 0.81 to 1.0 as almost perfect agreement.

Results

A total of 261 articles were initially identified from the search and 106 articles were excluded due to duplication or not meeting the inclusion criteria. A total of 155 articles were screened and a total of 7 randomized controlled trials (RCTs) met the inclusion criteria for this analysis. A summary of the search strategy and reasons for exclusion of manuscripts are outlined in Figure 2. The reviewers Kappa value for the 7 articles was 1.0 (perfect agreement). Table 1 provides the PEDro score for each of the qualifying studies and Table 2 provide a description of each study.

Study Quality and Patient Characteristics

All qualified studies were RCTs and scored a 7 or higher on the PEDro scale (Table 1). This is higher than the reported mean PEDro scores of musculoskeletal studies (5.08 ±1.7) and sports physiotherapy studies (4.46 ±1.61).[50,51] All seven manuscripts yielded a total of 220 subjects (Male-144, Female-76) (Mean age 28.6 ± 4.17 years). Five studies[32,34-36,38] investigated IASTM treatment on subjects with a musculoskeletal pathology and two studies[14,37] measured the effects of IASTM on joint ROM in healthy individuals. None of the studies [14,32,34-38] reported any adverse effects or subject attrition from the IASTM intervention. Three studies[34,35,38] reported subjects (N=24) dropping out for unrelated reasons. The qualifying studies were grouped into two sections: IASTM treatment for pathology and IASTM treatment for joint ROM.

IASTM Treatment for Pathology

Five studies measured the effects of IASTM on subjects with musculoskeletal pathology which included: lateral epicondylitis[32], carpel tunnel syndrome[35],myofascial trigger points[36], chronic ankle instability[38], and patellofemoral pain syndrome[34]. All studies[32,34-36,38] reported using the Graston® technique but varied in their treatment protocol.

For the intervention program, two studies[32,36] compared IASTM with a control group, one study[35] compared IASTM to soft-tissue massage, one study[34] compared two intervention programs that included either IASTM, strengthening exercises, stretching, and chiropractic manipulative therapy, and one study[38] compared three intervention programs that included either IASTM, dynamic strengthening (e.g., single leg hops), or proprioception exercises. The time frame for the all the interventions ranged from 2 to 6 weeks (average 2 sessions per week).[32,34-36,38]

All studies[32,34-36,38] used the Graston® technique but only three studies[34,36,38] reported the treatment time. One study[34] reported a maximum 3 minutes per site and two studies[36,38] reported a total treatment times of 5 and 8 minutes. Two studies[32,35] did not report any specific IASTM treatment times. Only one study[35] followed the recommended Graston® treatment protocol. All other studies[14,32,34,36-38] either modified the protocol or did not include all intervention components. Due to the variations in treatment protocols and the lack of homogeneity in treatment application, it is difficult to utilize the results to assess the effect of the Graston® protocol or IASTM effectiveness in general.

All studies[32,34-36,38] included a combination of patient related outcome measures and clinical tests. The most common patient related outcome measure was the visual analog scale for pain.[32,34-36,38] Three[32,34,35] studies included clinical tests such as joint ROM and muscle strength as part of their outcome measures. All studies measured outcomes pre-intervention and immediately post-intervention.[32,34-36,38] Only three studies[32,34,35] reported a second follow-up assessment that ranged from 2 to 3 months' post treatment. The overall results among studies were insignificant (p>.05) with the IASTM group displaying equal improvement as the control or comparison groups.[32,34-36,38]

IASTM Treatment for joint ROM

Two RCT studies[14,37] measured the effects of IASTM on joint ROM of the shoulder and knee in healthy subjects. One study[37] measured the effects of a single session (40 seconds) of the Graston® technique on glenohumeral ROM and compared it to a non-intervention control group. The Graston® protocol was not followed. Another study[14] compared the effects of one session (2 minutes) of the IASTM Fascial Abrasion Technique (FAT™) to one session of foam rolling (2 minutes) on hip and knee ROM. Subjects performed a comprehensive warm-up prior to the FAT™ intervention and 24-hour follow-up. The warm-up consisted of cardiovascular activity, closed chain movements, and lower extremity statistic stretching. No specific IASTM protocol was used in the study.[14]

Both studies[14,37] used joint ROM as the primary outcome measure and did not use any patient related outcome measures. Both studies[14,37] measured pre-intervention and immediately post-intervention outcomes with only the FAT™ study[14] conducting a follow-up at 24-hours post-intervention. The results of the study[37] using Graston® revealed a significant (p<.05) acute increase in joint ROM when compared to the control group. The study[14] using FAT™ reported equal improvement between groups immediately post-intervention but the FAT™ group preserved the most joint ROM (p<.05) at the 24-hour follow-up.

Discussion

To the authors' knowledge, this is the first systematic review to appraise the IASTM literature. Seven RCTs met the search criteria (Table 2) and were mainly comprised of intervention studies followed by joint ROM investigations. The body of knowledge regarding IASTM is still emerging. The current research has indicated insignificant results which challenges the efficacy of IASTM as a treatment, which may be due to the methodological variability among studies. The clinical implications of the investigations will be discussed in the following sections.

IASTM Treatment for Pathology

Five studies[32,34-36,38] were appraised but varied in their study populations, methodology, and outcomes measures preventing a direct comparison. The common variable among all the studies was the reported use of the Graston® technique; however, there were several potential methodological issues that may have led to the insignificant results among all studies. *First,* only one study[35] followed the recommended Graston® treatment protocol which includes examination, warm-up, IASTM treatment, post treatment stretching, strengthening, and ice.[13] The other four studies[32,34,36,38] either modified or excluded parts of the protocol. It is problematic to compare studies with different IASTM protocols and attempt to draw conclusions regarding its efficacy in clinical practice. The varied protocols also make it difficult to determine the effectiveness of the Graston® technique when their specified protocols are not followed. *Second,* the IASTM treatment times varied among studies. Three studies[34,36,38] reported different treatment times and two studies failed to report any treatment times. *Third,* several of the studies

Table 2.
Summary of qualifying studies.

Author	Type of Study	Subjects	Technique	Pathology or Region	Outcome Measures	Intervention	Results
Blanchette and Normand[32]	RCT	N=27 (12M,15F) IASTM (N=15) Control (N=12)	Graston®	Lateral Epicondylitis	1. VAS 2. Pain rated tennis elbow evaluation 3. Grip strength (painfree)	*IASTM:* received IASTM twice a week for 5 weeks. Dosage time not reported. *Control:* received education about the pathology, computer ergonomics, and stretching flexors and the extensors muscles of the wrist (hold 30 seconds, 6 times a day), ice and generic anti-inflammatory medications.	Post-intervention and at a 3-month follow-up. Both groups showed improvements in pain-free grip strength, VAS, and Patient-Rated Tennis Elbow Evaluation.
Burke et al[35]	RCT	N=22 (3M, 19F) IASTM (N=12) STM (N=10)	Graston®	Carpel Tunnel Syndrome	1. Sensory and motor nerve conduction evaluations of the median nerve 2. VAS 3. Katz hand diagrams 4. Self-reported ratings of symptom severity and functional status 5. Sensory and motor functions of the hand by physical examination.	Both the IASTM and STM groups received the same treatment protocol: 2x/week for first 4 weeks and 1x/week for 2 weeks. Home program included stretching and strengthening the upper extremity. IASTM and STM dosage times not reported. Note: subjects were instructed to refrain from use of wrist splints and anti-inflammatory medications during the intervention period.	Post-intervention and at a 3-month follow-up, both groups showed improvement in all outcomes measures.
Gulick[36]	RCT	*Phase I* (N=27, 13M, 14F) *Phase II* (N=22, 5M, 15F) IASTM (N=14) Control (N=8)	Graston®	Myofascial Trigger points in upper back and	1. Pressure sensitivity with algometer	*Phase I:* Two MTrPS were identified. One treated with IASTM for maximum of 5 minutes the other was control. 6 total treatments (2x/week for 3 weeks) *Phase II:* One MTrPS identified in IASTM and control group. IASTM group received a maximum treatment time of 5 minutes 2x/ week for 3 weeks. Control group did not receive treatment.	Post-intervention, both the IASTM and control groups showed improvement in the outcome measures. intervention. No secondary follow-up was reported.
Laudner et al[37]	RCT	N=35M IASTM (N=17) Control (N=18)	Graston®	Posterior Shoulder Muscles	1. Glenohumeral horizontal adduction Glenohumeral internal rotation	*IASTM:* One treatment to the posterior shoulder musculature for a total treatment time of 40 seconds. *Control*: No treatment.	Post-intervention, the IASTM group demonstrated greater acute improvements in ROM when compared to the control group. No secondary follow-up was reported.
Markovic[14]	RCT	N-20M IASTM (N=10) Foam Roll (N=10)	Fascial Abrasion Technique®	Quadriceps and Hamstrings	1. Passive straight leg raise test 2. Supine passive knee flexion test	*IASTM:* One treatment to the quadriceps and hamstring for a total of 2 minutes to each region. *Foam Rolling:* One session to the quadriceps and hamstrings for 2x/1 minute per muscle group. Note: Both groups performed a warm-up up before each session. They cycled for 5 minutes and did dynamic movements (2-5 sets each leg) of walking lunges, walking knee to chest, side squats, deep squats, and standing toe-touches. Static stretching of quadriceps and hamstring muscles was also done (2 sets of 30 seconds each).	Post intervention, both groups showed improvement in joint ROM At the 24-hour follow-up, the IASTM group preserved the most joint ROM.

Table 2. (continued)
Summary of qualifying studies.

Schaefer and Sandrey[38]	RCT	N=36 (31 M, 5F) Balance/IASTM (N=13) Balance/Sham IASTM (N=12) Balance only (N=11)	Graston®	Chronic Ankle Instability	1. Foot and ankle ability measure 2. VAS 3. Ankle ROM (4 directions) 4. Star Excursion Balance Test (3 directions)	*Balance:* 4-week program based upon the work of McKeon et al. Exercises included: single-limb hops to stabilization, hop to stabilization and reach, unanticipated hop to stabilization, and single-limb-stance activities. *IASTM:* 2x/week for a maximum of 8 minutes	Post-intervention, all groups showed improvement in all outcome measures. No longer term follow-up was reported.
Brantingham et al[34]	RCT	N=31 Group A (N=13) Group B(N=18)	Graston®	Patellofemoral Pain Syndrome	1. Anterior knee pain scale 2. VAS 3. Patient satisfaction scale	*Group A*: chiropractic manipulative therapy, exercise, and IASTM to knee joints only. *Group B*: chiropractic manipulative therapy, exercise, and IASTM to lumbosacral, hip, knee, ankle, and foot Both groups received treatment 1-3x/week for 2-6 weeks for a total of 6 treatments Note: IASTM was performed on both groups for a maximum of 3 minutes at each site. The exercise program included isometrics for hip and knee muscles, supine straight leg raise, short arc quadriceps extensions, double and single leg squats, and stretching of the hamstrings and quadriceps. The home program consisted of similar exercises that that subjects continued until the 2-month follow-up.	Post-intervention and at the 2-month follow-up, both groups showed improvement in all outcome measures.
IASTM: Instrument Assisted Soft-Tissue Mobilization STM: Soft Tissue Massage VAS: Visual analog scale MTrPS: Myofascial Trigger Points ROM: Range of motion							

seem to have methodological issues with their intervention programs. Blanchette and Norman[32] measured the effects of IASTM for lateral epicondylitis in a group of 27 subjects. The researchers randomized the groups into an experimental and control group. The experimental group received IASTM treatment only and the control group received education, forearm stretching, strengthening exercises, ice, and generic anti-inflammatory medication during the intervention phase. Upon completion of the study, the researchers found that both groups improved but no significant difference in outcomes were found. Perhaps, the difference in group interventions (e.g., not including other components of IASTM protocol) may have led to the insignificant treatment outcomes.[32] Schaefer and Sandrey[38] measured the effects of a 4-week dynamic balance program combined with IASTM on subjects with a history chronic ankle instability. The researchers randomized the 36 healthy subjects with a history of ankle instability into 3 groups: balance/IASTM (N=13), balance/sham IASTM (N=12), and balance only (N=11). Upon completion of the study, the researchers found that all groups improved with no significant difference between groups. Perhaps, the IASTM had no effect because the subjects did not have a current injury, the therapy was not provided for a long enough duration to initiate tissue remodeling for chronic scar tissue following injury, or the treatment application was not directed at the appropriate anatomical area. Thus, the dynamic balance training program would have been the only effective intervention.[38] Brantingham *et* al.[34] conducted a feasibility study comparing two chiropractic protocols in the treatment of patellofemoral pain syndrome. Protocol A consisted of chiropractic manipulative therapy, exercise, and IASTM to the knees only. Protocol B consisted of chiropractic manipulative therapy, exercise, and IASTM to lumbosacral, hip, knee, ankle, and foot. The researchers reported that the study was conducted over a 1-year period with several different treating clinicians and blinded assessors (total not reported).[34] The researchers did not report any formal training or reliability measures for these clinicians. The subjects were also instructed to continue with a prescribed home program until a 2 month follow-up. The researchers did not report any procedure to ensure the subjects were following the home program correctly.[34] These variables may have influenced the overall outcomes of the study. Upon completion, the researchers found that all groups improved with no significant difference between groups.

IASTM Treatment for joint ROM

Two studies were appraised that measured the effects of IASTM on joint ROM. Both studies reported favourable outcomes but only applied a one session dose of treatment with a short term follow-up. Both studies contained some potential methodological issues that may have influenced the results. *First,* the IASTM treatment times were different between studies. Laudner *et al*.[37] reported using the Graston® technique which helped determine their treatment time of 40 seconds but the protocol was not completely followed. Markovic[14] used the FAT™ technique, but did not report any specific IASTM guidelines. The treatment time of 2 minutes was based upon the comparison intervention of foam rolling which has been found in the literature to enhance hip and knee joint ROM with shorter intervention times.[52] Perhaps, a more structured IASTM intervention protocol would have enhanced the outcomes. *Second,* both studies[14,37] measured the immediate post-intervention outcomes with only Markovic[14] performing a second ROM assessment 24-hours later which showed that the IASTM group maintained more joint ROM. It is important to note that Markovic[14] performed the comprehensive warm-up prior to the 24-hour follow-up which may have influenced the favourable outcomes found. Perhaps, a longer post-intervention assessment period using pre-established time points and more stringent guidelines may have helped to better determined the lasting effects of the IASTM. In comparison, several studies have measured the effects of self-myofascial release using a foam roll or roller massage bar on lower extremity joint ROM.[52] The studies measured the post-intervention effects at several pre-established time points and determined that foam rolling and roller massage have positive short-term effects (<10 minutes) on joint ROM.[52]

Limitations

The main limitation of this systematic review is the paucity and heterogeneity of evidence surrounding IASTM. For example, it is difficult to compare the results of studies utilizing only IASTM therapy versus those utilizing IASTM as part of a treatment protocol with other adjunct therapies (e.g., ultrasound, stretching, exercise, etc.). This problem is further compounded when the IASTM application is used with patient populations who may theoretically respond to IASTM therapy without adjunct therapy (e.g., tendinopathy) and those who likely require adjunct therapy (e.g., chronic ankle instability). Additionally, it is challenging to assess IASTM treatment effectiveness, even when used in isolation, given the inconsistent methodology (e.g., treatment time variation, application of static versus dynamic IASTM treatment, etc.) used across studies. A second limitation is the search criteria for this review which excluded lower level evidence (e.g., case reports) and focused on higher level clinical trials. A third limitation is the literature search only included English language publications which may not have represented all the available evidence from non-English studies or studies currently submitted for publication. Another potential limitation may be the search criteria focusing on IASTM methods utilizing the most homogenous rationale and treatment approach which led to the exclusion Gua sha and ASTYM® for comparison.

Clinical Implications

The heterogeneity among the current IASTM investigations makes it a challenge when attempting to translate the results into clinical practice. The variability in study protocols including the study population, type of IASTM intervention, dosage time, and outcome measures make it difficult to determine the optimal treatment protocol. Five studies [32,34,36-38] reported using the Graston® technique but modified or excluded parts of the protocol. This creates a challenge for the clinician because the Graston® technique is based upon a sequential protocol and the current evidence failed to use this treatment strategy.[12] Perhaps, future studies should further define the intervention protocol by stating if the Graston® protocol was followed or just the tools were used. To date, the best available evidence for the Graston® technique is the RCT by Burke *et al*.[35] which followed the complete protocol.

Clinicians may also benefit from reading related research on the myofascial system in order to further understand the postulated physiological mechanisms that occur with the different myofascial therapies. Several authors have contributed to the existing body of knowledge through their research. Notable authors such as Findley[53], Stecco[54], Langevin[55], and Schleip[56] have helped to increase our knowledge of this complex system. The reader is referred to the reference section which provides the citations for these authors.

Conclusion

The current evidence of RCTs does not support the efficacy of IASTM for treating certain musculoskeletal pathologies. There is weak evidence supporting the efficacy of IASTM for increasing lower extremity joint ROM for a short period of time. IASTM is a popular form of myofascial therapy but its efficacy has not been fully determined due to the paucity and heterogeneity of evidence. There is a gap between the current research and clinical practice. A consensus has not been established regarding the optimal IASTM program, type of instrument, dosage time, and outcomes measures. Future studies are needed to assess the different IASTM tools and IASTM protocols such as Graston® using strict methodology and fully powered controlled trials. The current evidence seems to lack the methodological rigours necessary to validate the efficacy of IASTM itself or any of the IASTM protocols.

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Neck pain in children: a retrospective case series

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Introduction: *Spinal pain in the paediatric population is a significant health issue, with an increasing prevalence as they age. Paediatric patients attend for chiropractor care for spinal pain, yet, there is a paucity of quality evidence to guide the practitioner with respect to appropriate care planning.*

Methods: *A retrospective chart review was used to describe chiropractic management of paediatric neck pain. Two researchers abstracted data from 50 clinical files that met inclusion criteria from a general practice chiropractic office in the Greater Toronto Area, Canada. Data were entered into SPSS 15 and descriptively analyzed.*

Results: *Fifty paediatric neck pain patient files were analysed. Patients' age ranged between 6 and 18 years (mean 13 years). Most (98%) were diagnosed with Grade I-II mechanical neck pain. Treatment frequency averaged 5 visits over 19 days; with spinal manipulative therapy used in 96% of patients. Significant improvement*

Introduction : *La douleur vertébrale chez la population pédiatrique constitue un important problème de santé, avec une prévalence croissante à mesure qu'ils grandissent. Les patients pédiatriques consultent des chiropraticiens pour des douleurs vertébrales; toutefois, il y a toujours un manque de preuves de qualité pour guider le praticien à planifier des soins appropriés.*

Méthodologie : *Un examen rétrospectif des dossiers a été utilisé pour décrire la gestion chiropratique de la douleur cervicale chez les patients pédiatriques. Deux chercheurs ont extrait des données d'une clinique de chiropratique de la région du Grand Toronto, au Canada, portant sur 50 dossiers cliniques qui répondaient aux critères d'inclusion. Les données ont été saisies dans SPSS 15 et soumises à une analyse descriptive.*

Résultats : *Cinquante dossiers de patients pédiatriques souffrant de douleurs cervicales ont été analysés. La tranche d'âge des patients variait de 6 à 18 ans (moyenne de 13 ans). La plupart (98 %) ont reçu un diagnostic de cervicalgie mécanique de stade I-II. La fréquence de traitement était en moyenne 5 visites sur une période de 19 jours, la thérapie de manipulation vertébrale étant utilisée pour 96 % des patients. Une*

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was recorded in 96% of the files. No adverse events were documented.

Conclusion: *Paediatric mechanical neck pain appears to be successfully managed by chiropractic care. Spinal manipulative therapy appears to benefit paediatric mechanical neck pain resulting from day-to-day activities with no reported serious adverse events. Results can be used to inform clinical trials assessing effectiveness of manual therapy in managing paediatric mechanical neck pain.*

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KEY WORDS: chiropractic, neck pain, pediatric, spinal manipulative therapy, case series

amélioration significative a été enregistrée dans 96 % des cas. Aucun incident indésirable n'a été documenté.

Conclusion : *Il semble que la cervicalgie mécanique chez les patients en pédiatrie soit gérée avec succès par des soins chiropratiques. La thérapie de manipulation vertébrale semble être bénéfique au traitement, chez les patients pédiatriques, de la cervicalgie mécanique survenue à la suite des activités quotidiennes sans signalement d'effets indésirables graves. Les résultats peuvent être utilisés pour informer les essais cliniques évaluant l'efficacité de la thérapie manuelle dans la gestion de la cervicalgie mécanique chez les patients en pédiatrie.*

(JCCA. 2016;60(3):212-219)

MOTS CLÉS : chiropratique, cervicalgie, pédiatrique, thérapie de manipulation vertébrale, série de cas

Introduction

Spinal pain is common amongst the paediatric population (including children and adolescents). It is a significant health issue[1,2], where 52% of paediatric patients report musculoskeletal (MSK) symptoms over a one-year period[3]. Neck pain is the most common spinal pain in paediatric patients[3,4] with 60% reporting neck pain persisting at two years after this study began.[5] A survey of Finnish school children reported neck pain experienced at least once during the week.[3]

Children with neck pain seek complementary and alternative medicine (CAM) interventions, of which the most common is chiropractic care.[2,6,7] Paediatric patients comprise between about 8% and 13% of a chiropractor's practice.[7-10] A recent National Institute of Health report suggested that 3.3% of children in the United States (1.9 million) saw a chiropractor or osteopath between 2002 and 2007.[11] Although surveys report paediatric patients visit chiropractors, little is known why they visit, how often, and whether or not there is a favourable response.

In addition to these unknown variables, there is also a paucity of evidence of effectiveness of spinal manipulative therapy (SMT) in the management of musculoskeletal (MSK) pain in children; what evidence is available is of low quality.[12] This is important to note, as SMT is one of the tools chiropractors use to address and manage MSK complaints. Currently the only standard of treatment for children with MSK pain can be found in a recent consensus-based clinical practice guideline.[13] Unfortunately, due to lack of available quality evidence of treatment effectiveness, consensus led to a generic recommendation of using a therapeutic trial within an evidence based framework. Similarly, systematic reviews[14,15] have reported that much of the evidence into MSK care for the pediatric population is limited due to insufficient sample size, research design and expert opinion.

Much of the evidence on pediatric care for MSK neck pain is exploratory, relying on single case studies and expert opinion.[14-16] Exploratory studies within the IDEAL framework[17] can be used to help identify appropriate trial design and feasibility[18]. They can set the stage for explanatory studies that assess effectiveness, quality assurance and safety of an intervention.[18,19] Given the infancy of the research regarding the management of pediatric neck pain[12], foundational work is required to inform the future design for more robust explanatory studies, e.g. randomized controlled trials. The IDEAL framework provides a guide to inform research when there are gaps in knowledge.[17] This paper aims to contribute to the exploratory stage of the IDEAL framework by documenting the clinical presentation and outcomes of pediatric patients presenting with neck pain to a chiropractic office.

Methods

This study was granted ethics approval by the Institution's Research Ethics Board. We conducted a retrospective patient chart review. Patient charts were included if (i) the patient was between 6-18 years, (ii) had a chief complaint of neck pain, and (iii) received treatment (See Table 1). The first episode of neck pain in the file was selected for data abstraction. Neck pain was defined as pain originating from musculoskeletal tissues in the region from the occiput to the first thoracic vertebrae. Minor injury was described as mild to moderate limitation in physical activity of mechanical origin, i.e. sport participation, roughhousing, motor vehicle collisions, or falls. The definition of Grade I and Grade II mechanical neck pain was adopted from the Neck Pain Task Force.[20] It did not include primary complaints of headaches, shoulder or arm pain; however, subjects with secondary headaches to neck pain were included. Clinical files were sequentially drawn in alphabetical order and the first 50 patient charts meeting our inclusion criteria were selected for review.

Two researchers abstracted records from a general practice chiropractic clinic in the Greater Toronto Area, Canada. The office had three practicing chiropractors. The data were collected using a standardized intake form. The intake form was adapted from a similar form previously used for abstraction in a low back pain study,[21] though it was not validated for neck pain. The intake form was revised by changing related low back pain references to neck pain, including location and examination protocols. Revisions were reviewed for content validity.[22] The data intake forms included patient demographics, information regarding the history and examination, the diagnosis, the treatment(s) used and the outcome of care (see Table 2).

Any discrepancy in the coding of information was dealt with by consensus of the two researchers. If consensus could not be reached, then the senior author (SM) made the final decision. Treatment was considered complete when a patient presented on two consecutive visits with no reported complaint of neck pain or was deemed recovered and discharged from care.

All patient information was coded to prevent any direct identification, thus ensuring confidentiality of the patient records. Information linking the patient ID number and their file was recorded in a reference booklet and stored in a locked cabinet in the practitioners' office. Once all data had been entered and checked for accuracy, the booklet was destroyed.

All data were entered into an Excel spreadsheet, and later exported into SPSS Version 15 for statistical analysis. Data were descriptively analysed.

Table 1.
Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Age between 6-18 years	File was incomplete for data required
Primary complaint of neck pain	Child was under 6 years of age
Patient received treatment	The complaint was not related to the neck
Patient file records were thorough enough to complete the data collection survey	

Table 2.
Patient demographics.

Variable		% Frequency (n)
Age: Mean (sd)		13 years (± 3)
Gender	Males	50 (25)
Age Distribution	6-9 years	14 (7)
	10-12 years	26 (13)
	13-15 years	34 (17)
	16-18 years	26 (13)
Referral	Parents	72 (36)
	Other	8 (4)
	Other Chiropractor	2 (1)
	Family Physician	2 (1)
	Not reported	16 (8)
Mechanism of Injury	Minor injury	54 (27)
Descriptor of Pain	Sharp/Stabbing	46 (23)
	Dull/Achy	20 (10)
	Without specific description	34 (17)

Table 3.
Complaint presentation.

Variable		% Frequency (n)
Previous Treatment Provided	Family Physician	18 (9)
	Neurologist	2 (1)
	Other	10 (5)
	Not reported	70 (35)
Duration of Complaint	Acute (<3 weeks)	72 (36)
	Sub-acute (<3 months)	6 (3)
	Chronic (<6 months)	4 (2)
	Chronic (>6 months)	10 (5)
	Not reported	8 (4)
Associated Symptoms	Headache	58 (29)
Imaging (Plain film, other)	Plain Film Radiographs	12 (6)
Diagnosis	Grade I or II Neck Pain	98 (49)
	Grade III Neck Pain	2 (1)
Region of Restriction	Upper cervical spine (C0-C3)	40 (20)
	Mid cervical spine (C4-6)	56 (28)
	Lower cervical spine (C7-T1)	4 (2)
Affected Muscles (hypertonicity)	Suboccipitals	32 (16)
	Trapezius	56 (28)
	Levator Scapula	54 (27)
	Sternocleidomastoid	10 (5)
	Cervical Paraspinals	70 (35)

Results

The age range of the patients was 6 to 18 years, with a mean age of 13 years. There was an equal distribution of males and females. The majority of patient referrals were from parents, with few from other sources [chiropractor (2%), medical doctor (2%), or other (8%)]. The source of referral was not reported in 70% of subjects. Most patients presented with acute pain following a minor injury. The character of the pain was commonly described as localized sharp/stabbing in 46%, dull/achy in 20%, and without specific description in 34% of cases. Associated referred pain was reported in 30% of patients either to the head (10%), upper back (10%), or one or both arms (10%). Headaches were reported in 58% (See Table 3).

First incidence of neck pain was reported in 64% of cases. Prior neck complaints were present in 28% of patients, while no data were available for 8%. Only 14% of patients reported previously receiving SMT. Plain film imaging was reported in 12% of charts. About 30% reported receiving prior treatment for their neck pain (e.g. analgesics, muscle relaxants, and bed rest) with no reported relief.

Examination findings were positive for primarily Grade I or Grade II mechanical neck pain (i.e. joint restrictions with localized tenderness on palpation of the facet or apophyseal joints of the neck with no distal radiation) (See Table 3). The most frequently reported level of painful dysfunction was the mid-cervical spine (C4-C6) (56%). Associated muscle tenderness on palpation was primarily found in the cervical paraspinal muscles (70%) and trapezius (56%). Ranges of motion were visually assessed to be mildly to moderately reduced in all directions. Neurological examination was unremarkable, except in one case where unilateral diminished biceps reflex was found and attributed to a previous upper limb surgery.

The most common treatment provided was manual therapy (see Table 4). SMT provided was high-velocity, low-amplitude thrust manipulation, delivered supine with a rotary thrust directed at the painful segments. The most common form of adjunctive therapy was soft tissue therapy (STT), followed by the use of passive modalities.

The average number of patient visits was 5 (sd=3) with a range between 1 and 15 and a median of 3 visits. The patient visits were distributed over a range of 2 to 80 days, with the average being 19 days (±15 days, median 17). In 96% of cases, patients were discharged after self-reporting feeling very much improved or deemed recovered by the chiropractor. There was no recorded worsening of symptoms nor adverse events.

Discussion

In our study, the typical patient was 13 years old and presented with acute neck pain with associated headaches

Table 4.
Treatment techniques and reported response.

Treatment Techniques			% Frequency (n)	
Spinal Manipulative Therapy			96 (48)	
Soft Tissue Therapy (massage, trigger point therapy, etc)			94 (47)	
Passive Modalities (interferential current or transcutaneous electrical nerve stimulation)			48 (24)	
Education			26 (13)	
Time to Resolution	<3 weeks		72 (36)	
Number of Visits to Resolution (% frequency, n=50)	2 visits	14%	7 visits	0%
	3 visits	30%	8 visits	4%
	4 visits	14%	9 visits	6%
	5 visits	12%	10 visits	0%
	6 visits	10%	>10 visits	10%

due to minor injury. This age range is similar to that reported in other studies where spinal pain was common amongst those between the ages of 11 and 15 years.[5] The frequency of reported headaches was interesting but consistent with findings of a cross-sectional study of Swedish preadolescents.[23] About 54% of these cases reported minor, unintentional childhood injuries.

Children typically sustain unintentional childhood injuries in their daily lives while developing, learning and growing (e.g. riding a bicycle, running and playing, participating in sports).[24] It is not uncommon for a child to experience pain after a fall and then to not perceive such an incident as an injury. Despite neck pain being attributed to an injury, this association may not necessarily be causal as suggested in an observational study by Hellstenius *et al*.[23], wherein no significant relationship was found between occurrence of trauma and neck pain and/or headaches. A similar conclusion was reported in another study that identified only 3% (9 of 264) of adolescents with neck pain had a previous injury to the neck.[25]

In our study, examination findings were generally considered to be uncomplicated and mechanical in nature. The most frequent examination findings suggested localized, painful intersegmental joint movement restrictions and muscle tenderness on palpation. Although ranges of motion were visually assessed, we did not consider this a concern given that visual assessment has been reported to be reliable and valid when quantifying ranges of motion.[20] The most commonly reported level of cervical joint pain was the middle cervical region; unlike Hellstenius *et al*.[23] who indicated the upper cervical region was more commonly reported. In consideration of the uncomplicated nature of the pain, imaging amongst our sample was uncommon (12%).[23] Such a low rate suggests radiographs are not as commonly requisitioned in children as in adults.[23]

We found that chiropractic treatment primarily included SMT and STT, along with patient education and home exercises. The SMT performed was a supine rotary cervical and was most commonly directed at the painful joint restrictions. This appears to be consistent with other paediatric practices.[26] Follow-up with study chiropractors suggested that modulated manipulative forces were used during the treatment (personal communication). Such modulation is in agreement with Best Practice Guidelines that suggest forces and loads used during SMT be relative to the patient's size and modified to address the development of the immature skeleton.[27,28] Similar conclusions were noted in a survey where the majority of chiropractors reported modifying their therapeutic techniques for children.[25]

We found relatively few treatments were provided for an episode of care. The average frequency of visits was five over the course of 19 days. Of these patients, 96% reported a favourable outcome. A similar frequency was reported by Marchand (2012), who found the length of treatment varied by patient age and condition treated; however, for those between 13 and 18 years, the average number of treatments was 4.6 for neck pain.[28] For context, Hurwitz *et al*.'s[29] retrospective analysis of chiropractic treatments for neck pain and headaches for adults reported the average number of visits for adults with neck pain, per episode of care was 10 visits (median 6 days). Another study suggests that adults improved in pain after three weeks of treatments.[30] Based on our work, children with neck pain appear to respond favourably and quickly to chiropractic care.

There were no adverse events recorded in the patient charts. While minor adverse events such as transient increased soreness are commonly reported after manual therapy[31], serious adverse events are exceedingly rare. One study reported nine adverse events published in the literature over 100 years of publications[32], of which six were related to delayed or mis-diagnosis, rather than to the intervention. Studies exploring the safety profile of chiropractic care (spinal manipulation, soft tissue therapy, passive modalities, exercise, and education) have reported minimal risk in the management of musculoskeletal complaints.[13, 28,33-35]

Our study supports findings in other studies that have found the majority of pediatric patients are referred to CAM providers by parents[36] but few are referred by physicians[37]. This may be due to the strongest predictor of the use of complementary health approaches by children is use by their parents[38] or it may be due to medical physicians being hesitant to refer to a chiropractor[39]. Such hesitation may be related to limited exposure to the roles and understanding of the requirements and indications for chiropractic care.[40,41] Results from exploratory studies may provide preliminary evidence supporting the use of chiropractic care in the management of common pediatric MSK conditions to help support the role of interprofessional collaboration.

Limitations

There are a number of limitations of our study. The study is a retrospective case series that has inherent design limitations[42], including small sample size, subjective coding, relying on documented findings, inability to collect missing/unreported data, and no randomization nor blinding. However, the results can help inform inclusion, frequency and duration of care, and outcome criteria for future explanatory studies. Further, the assessment of patient self-rated improvement was subjective, including the use of terms 'better' and 'much improved'. The term 'better' implied recovery but was not pre-defined; however, we considered it a reasonable proxy given patient discharge and evidence of clinical improvement. Asking patients to self-rate their recovery is increasingly being used as a valid and reliable measure of their progress.[43] We are also aware that low quality studies tend to present an overly optimistic view of effectiveness compared to larger assessment and evaluation studies.[44,45] Furthermore, given no control group, the results may have been due to the placebo effect, therefore more rigorous studies are needed. Finally, we did not track the total number of files reviewed during abstraction, thus we're unable to estimate the percentage of files searched in order to achieve our total sample.

This study provides exploratory data suggesting mechanical neck pain in paediatric patients responds favourably and quickly to chiropractic care. It also provides a developmental frame from which to progress the field of pediatric MSK pain management research. Our data can be used to design more robust controlled trials providing more realistic measures of the effectiveness of SMT in the management of neck pain in paediatric patients.

Conclusion

In our study, 50 paediatric patients between 6 and 18 years (average 13 years) were found to have evidence of mechanical neck pain. Treatment was provided on average of 5 visits over an average of 19 days. These patients were successfully managed primarily using SMT. There were no worsening of symptoms nor adverse events recorded.

This exploratory study provides data to help inform the role, indication and dose of manual therapy in the management of paediatric mechanical neck pain. It highlights a treatment option with minimal risk and reported successful pain management for a commonly experienced MSK condition by many paediatric patients. The results can be used in designing more robust explanatory studies.

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A narrative review of new trends in the diagnosis of myofascial trigger points: diagnostic ultrasound imaging and biomarkers

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Myofascial pain syndrome (MPS) is one of the most common conditions of chronic musculoskeletal pain encountered by primary healthcare practitioners on a daily basis. It is generally accepted amongst the broad profile of healthcare practitioners treating MPS that the presence of discrete, palpable and tender nodules within the muscle, known as myofascial trigger points (MTrP), is necessary to confirm the diagnosis of MPS. Manual palpation is currently the most common technique used to detect MTrP, however, previous research has shown that the reliability of manual palpation for detecting MTrP is poor, and in our opinion unacceptably poor, leading to inconsistent diagnosis of MPS and poor patient outcomes. There are currently no objective accepted diagnostic criteria for the clinical detection of MTrP, nor are there standardized diagnostic criteria for MPS. Two promising areas of research with potential

Le syndrome algique myofascial (SAM) est l'une des conditions les plus fréquentes de douleurs musculo-squelettiques chroniques rencontrées par les praticiens de soins de santé primaires tous les jours. Il est généralement admis, parmi un large segment de professionnels de la santé traitant le SAM, que la présence de nodules discrets, palpables et tendres dans le muscle, connus sous le nom de points déclencheurs myofasciaux (PDM), est nécessaire pour confirmer le diagnostic de SAM. La palpation manuelle est actuellement la technique la plus couramment utilisée pour détecter les PDM. Cependant, des recherches antérieures ont montré que la fiabilité de la palpation manuelle pour détecter les PDM est faible, et à notre avis inacceptable, ce qui se traduit par des diagnostics incohérents du SAM et de mauvais résultats pour les patients. Actuellement il n'y a aucun critère diagnostique objectif accepté pour la détection clinique des PDM, ni de critères diagnostiques normalisés pour le SAM. Deux domaines prometteurs de recherche ayant un potentiel

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for enhancing the diagnosis of MPS include the use of diagnostic ultrasound and biomarkers. Further research is needed to advance the development of composite diagnostic criteria employing ultrasound imaging, biomarker assessments and physical assessment to enhance the accuracy and objectivity of MTrP detection and diagnosis of chronic MPS disorder.

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KEY WORDS: chiropractic, myofascial pain syndrome, myofascial trigger point, diagnostic ultrasound, biomarker

pour améliorer le diagnostic du SAM comprennent l'utilisation de l'échographie diagnostique et les biomarqueurs. D'autres recherches sont nécessaires pour faire avancer le développement de critères de diagnostic composites employant l'échographie, l'évaluation des biomarqueurs et l'évaluation physique pour améliorer l'exactitude et l'objectivité de la détection des PDM et le diagnostic de troubles de SAM chronique.

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MOTS CLÉS : chiropratique, syndrome algique myofascial, point déclencheur myofascial, échographie diagnostique, biomarqueur

Introduction

Myofascial pain syndrome (MPS) is one of the most common conditions of chronic musculoskeletal pain[1], with a prevalence of 15% of patients in general medical practice and up to 85% in pain management centres[2,3]. Despite its prevalence in general medical practice, there is very little research describing the prevalence of myofascial pain in general chiropractic practice. A recent study of Australian chiropractors reported that 60% of patient encounters were related to musculoskeletal conditions[4] while recent survey data collected from chiropractors in Ontario, Canada indicate that 97% of chiropractors encounter myofascial pain in their practice on a daily basis.[5] Given the aging societal demographic[6], MPS is poised to become one of the greatest clinical challenges for the chiropractic profession.

A commonly accepted key diagnostic criterion for MPS amongst practitioners in the field of musculoskeletal pain is the presence of one or more hypersensitive nodule(s), referred to as myofascial trigger points (MTrP), within a taut band(s) of skeletal muscle.[7] Prevailing thought amongst practitioners in the field of musculoskeletal pain accepts that active MTrP are defined by the presence of spontaneous pain at rest as well as being associated with the induction of a local muscular twitch response and/or pain referral with manual or intramuscular needle provocation.[8] In contrast, it is also accepted that latent MTrP are typically asymptomatic at rest, eliciting pain only after manual or needle provocation.[9]

The most commonly employed clinical technique used to confirm the presence of a MTrP is manual palpation. Despite this, the sensitivity and/or specificity of manual palpation for detecting MTrP has not been studied because there is presently no known "gold" standard measure for a MTrP locus. Accordingly, the literature has only cited inter and intra rater reliability data. Previous research reports significant inter-observer variability amongst non-expert clinicians in detecting a MTrP, taut band and local twitch response via manual palpation[10,11], whereas elicitation of referred pain during physical examination was only marginally reliable[12]. Hsieh *et al*.[12] further emphasized that training did not meaningfully improve inter-rater reliability, concluding that "among non-expert physicians, physiatric or chiropractic, trigger point palpation is not reliable for the detection of a taut band and local twitch response, and only marginally reliable for referred pain following training."[12] As a result, no consensus or validated guidelines exist for the clinical diagnosis of MPS.

Several key factors appear to influence the poor reliability of the physical assessment and clinical diagnosis of MTrP and MPS, the most prominent of which being the lack of consensus amongst practitioners on their diagnostic criteria.[13] One contributing factor may be the disparity in training between practitioners. Previous literature shows that insufficient training exists amongst medical physicians in the physical assessment of MTrP and pain management[14]; similar studies have not yet been performed with chiropractors. The location of the MTrP site may also be a significant determinant for reliability, given that MTrP often form deep within the paravertebral muscles, making them very challenging to detect using manual palpation alone.[12,15] Even when palpable, manual provocation of tender MTrP regions may elicit reactive tension, spasm and/or withdrawal responses from some patients, adding greater variability in detection between subjects. Indeed, existing studies differ in terms of the anatomic location in which MTrP were studied, bringing to question the reliability of these studies in determining the utility of manual palpation for different anatomic regions.

Given the variation in the clinical presentation of chronic musculoskeletal pain and the challenges in reliably detecting MTrP, chronic musculoskeletal pain is inconsistently diagnosed, resulting in inadequate treatment and poor patient outcomes. To this extent, no objective diagnostic tool(s) or universally accepted diagnostic criteria currently exist for the clinician to objectively assess the the MTrP locus[13], nor is there an accepted list of objective and validated gold standard criteria for the diagnosis of MPS. Two promising areas of research aiming to address this gap include ultrasonography and biomarkers.

Diagnostic Ultrasound

Ultrasound is defined as a sound wave greater than 20,000 Hz.[16] Diagnostic ultrasound specifically employs waveform frequencies within the range of 1-30 MHz which are reflected in varying degrees to form high resolution images, called sonograms.[17] As a result, diagnostic ultrasound is an imaging technique that has been used extensively in musculoskeletal imaging. Although not routinely employed in the clinical assessment of MTrP, the accumulating body of research suggests that diagnostic ultrasound may have the potential to significantly contribute to the identification of MTrP within skeletal muscle.

Several investigators have pioneered the use of diagnostic ultrasound imaging to characterize MTrP and distinguish between active and latent MTrP loci from normal tissues. These studies have employed brightness-modulation (B-mode), elastography and Doppler imaging methods.[15,18-22]

B-mode Imaging

Previous research using B-mode ultrasound has suggested that MTrP present as spherical, elliptical and/or even band-like hypoechoeic (dark gray) regions.[18,21] This presentation contrasts with typical normal muscle appearing as a hypoechoic background of muscle fascicles separated by clearly demarcated linear hyperechoic strands representing fibroadipose septa–perimysium. The unique hypoechogenicity of a MTrP region suggests a difference in local tissue density featuring abnormal reduction in echoes visualized by ultrasonography.[18,19,23] A leading explanation for this may be the accumulation of fluid or local tissue edema resulting from acute inflammatory exudate combined with blood or, in a chronic state, residual inflammatory by-products after the inflammatory process has subsided.[23]

Despite the emerging research suggesting that MTrP may present as distinct hypoechoic loci within muscle tissue, research has yet to resolve the association between ultrasound imaging and manual palpation. A recent pilot study found no correlation between the manual detection of active MTrP and tissue characteristics visualized on ultrasound imaging.[24] In contrast, one case study reported contrasting findings of hyperechoic regions within areas of palpable tenderness in a single patient.[25] These inconsistencies may be explained by the fact that obtaining quality images with ultrasound is highly dependent on technique and operator experience. A significant limitation to the cited studies is that they do not clearly describe where within the muscle the ultrasound images were recorded from, nor do they disclose operator experience. In addition, they do not adequately characterize their samples in the context of clinical acuity, extent of pain, physical examination abnormalities and/or whether the MTrP was palpable, active or latent.

Despite these limitations, the emerging literature suggests that MTrP may present as discrete hypoechoic regions within muscle tissues as visualized by ultrasonography. The next phase of studies should investigate the association between manual palpation and sonography to better understand the characteristics of the underlying tissues detectable via manual palpation within the underlying muscle.

Elastography

Ultrasound elastography is a technique employed to qualitatively and quantitatively assesses the mechanical properties of soft tissues.[26,27] Elastography is based on the principle that local contraction and/or pathology alters tissue elastic properties (Young's modulus) resulting in changes in the velocity of ultrasound propagation through the tissue. This technique has been used to assess local tissue properties of MTrP with the expectation that local contractures lead to greater tissue stiffness relative to surrounding normal tissue.

Spectral Doppler analysis has demonstrated that vibration amplitudes are 27% lower on average within a MTrP region compared with surrounding healthy tissue.[27] A recent study employing elastography supported these findings further by reporting a reduction in local stiffness which correlated with palpable reduction in stiffness at the MTrP site after dry needling.[28] Using elastography, the investigators measured significant reductions in shear modulus post-needling ($p<0.01$), corresponding with a decrease in local palpable hypertonicity.

The reason for the decreased wave propagation velocities measured through localized, hypoechoic regions within the muscle is unclear. Future studies should aim to further elucidate the elastographic features of local contraction vs. inflammation to enhance our understanding of the underlying pathophysiologic mechanisms contributing to these observations.

Doppler Imaging

Ultrasound Doppler flow is an imaging technique used to measure the Pulsatility Index (PI). The PI is calculated as [(peak systolic velocity – minimum diastolic velocity)/mean velocity] and is used as a measure of downstream resistance to blood flow in tissues.[29] An increased PI is physiologically interpreted as increased resistance to blood flow. Previous research has reported higher PI at active MTrP loci versus normal tissue sites, while no differences in PI have been reported between latent MTrP and normal tissue.[19,20] Peak systolic velocities at active MTrP sites are typically greater than latent MTrP or normal tissue sites while, in contrast, minimum diastolic velocities are significantly lower than latent MTrP and/or normal tissue sites.[20]

Retrograde diastolic blood flow has also been reported at the MTrP site. Using Doppler flow waveform analysis and computational modeling to study the vascular environment, the researchers have suggested that these collective observations could be explained by the presence of increased blood volume and stasis within the vascular bed of the MTrP as a result of increased outflow resistance subsequent to vasoconstriction.[20] It has also been postulated by this group that the high pulsatile blood flow at the site of MTrP may be the result of increased compliance and volume of the vascular compartment combined with increased outflow resistance due to local muscle fiber contraction leading to inflammatory-induced vasoconstriction and/or compression of the local capillary bed. Additionally, anatomical determinants and/or external pressure of the ultrasound transducer may have also contributed to these findings, given that the force of the transducer was not reported or controlled for in the methodology and/or analysis. These collective observations point to the possibility that edema and vasoconstriction at the outflow-blood vessels of a MTrP may reduce local perfusion and contribute to the distinctive sonographic features of the MTrP, including the characteristic hypoechoicity.

Post-Acquisition Image Enhancement

Post-acquisition image enhancement techniques have also been used in the evaluation of MTrP. Turo *et al*.[23] introduced the concept of entropy to MTrP image analysis. Entropy is a statistical measure of the probability distribution of grey pixel values on B-mode imaging, creating a score that quantifies the homogeneity of the region of interest within tissue. The lower the score the more homogeneous the tissue, with a score of zero depicting complete homogeneity. Hypoechoic tissues characterized by edema and or hyper-vascularity present with lower entropy scores while tissues containing fat or scar/fibrosis show higher entropy scores. The combination of entropy and vibration elastography has experimentally demonstrated 69% sensitivity and 81% specificity at detecting the MTrP site as determined by manual palpation. A limitation to this technique, however, is that it involves post-image acquisition processing making image results unavailable for immediate clinical decision-making. If found to be useful, developing ultrasound devices in the future with the capability for real-time entropy image analysis would be a valuable addition to the clinician's toolbox for enhancing the reliability of MTrP identification.

Biomarkers

Clinical assessment of biomarkers may also offer an objective tool in the diagnostic workup of MPS. Previous research has shown that an altered biochemical milieu of pain and inflammatory biomarkers exists within a localized palpable MTrP region of the muscle identified using the criteria established previously by Simons and Travell[30,31]. Shah *et al*. reported increased concentrations of interleukin 1b (IL-1b), interleukin 6 (IL-6), interleukin 8 (IL-8), tumor necrosis factors (TNF-a), bradykinin, calcitonin gene-related peptide (CGRP), substance P and norepinephrine within these regions of the muscle[30,31]. Importantly, it is yet unresolved whether patients with active MTrP may also demonstrate elevated levels of inflammatory biomarkers in remote uninvolved sites. It has been hypothesized that a systemic response characterized by elevated systemic levels of IL-6,IL-8, creatine kinase (CK) and monocyte chemo-attractant protein-1 MCP-1[32,33] may be indicative of skeletal muscle injury and/or ischemia-reperfusion mechanisms commonly linked to the pathophysiology of MPS[34]. Currently, no consensus in the literature exists regarding the association between systemic biomarkers and the physical finding of MTrP on manual palpation. Future studies should explore the reliability (sensitivity, specificity) of biomarkers for MTrP detection in the clinical evaluation of the chronic myofascial pain patient.

A current limitation of this technique is that it cannot provide the practicing clinician with immediate results for use in daily clinical practice, given that blood is typically analyzed off-site. Future research should address this by advancing biomarker assay technology that could be implemented in routine clinical practice, enhancing the clinician's decision making and reduce unnecessary delay in therapeutic intervention.

Conclusion

Myofascial pain is one of the most common chronic pain conditions seen daily by chiropractors, however, the lack of consensus amongst primary care clinicians for the diagnostic criteria is a major limitation to appropriate and timely intervention for suffering patients. The primary challenge in the clinical management of MPS is the need for objective, reliable, gold-standard diagnostic criteria for the identification of MTrP.

Although it is not currently used in routine clinical settings for the diagnosis of MPS, diagnostic ultrasound is a safe, non-ionizing, and portable tool enabling high resolution imaging of soft tissue. Although ultrasound may offer important diagnostic insight into the structural and mechanical properties of MTrP, its sensitivity and specificity for detecting palpable nodules has not yet been studied. It may be particularly valuable in resolving smaller and/or deeper MTrP loci less amenable to palpation. Future research should aim to establish the association between manual palpation and sonographic findings in order to validate these techniques for future clinical application.

Biomarker analysis may further contribute to our understanding of the pathophysiologic changes associated with MPS by enabling the objective quantification of pain and inflammatory biomarkers released subsequent acute and/or chronic myofascial injury. This may be especially important in the early or pre-clinical stage of MPS where palpable MTrP may not be clinically evident. Furthermore, biomarkers may be valuable as confirmatory findings in the case where MTrP may not be palpable or when discrepancies exist between assessors.

The relationship between ultrasound imaging, biomarker outcomes and palpable nodules has not been studied. Given the poor interrater reliability of manual palpation, additional objective outcomes are necessary to enhancing the sensitivity and specificity of MTrP detection. Importantly, research should aim to assess the clinical utility of ultrasound and biomarkers to predict future clinical morbidity (i.e. pain). Although biomarker analysis and diagnostic ultrasound imaging have the potential to provide important additional objective insight into the physical assessment of MTrP and diagnosis of MPS, they are not intended to replace manual palpation. Furthermore, if these technologies are shown to be reliable, future research should strive to advance ultrasound and biomarker technologies to enable the clinician with immediate feedback for use in daily clinical decision-making. Given that diagnostic ultrasound and biomarker assessment technologies are presently featured in routine medical practice, it is feasible that these technologies could be easily integrated into daily chiropractic practice to enhance the clinical assessment of chronic musculoskeletal pain.

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A rare cause of chronic elbow pain in an adolescent baseball player: a case report

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Objective: *To present a case of chronic elbow pain as a result of a hidden underlying osteochondral defect.*

Clinical Features: *A 17-year old baseball player presented with chronic lateral elbow pain. Examination revealed swelling of the elbow with signs of possible ligament, muscle, and tendon injury.*

Diagnosis and Treatment: *Although there was apparent soft-tissue injury, the elbow swelling created immediate suspicion of a more serious underlying condition. Examination revealed a swollen and tender elbow, with plain x-ray confirming a subchondral bone disorder (osteochondral defect) of the capitellum. Surgical repair was performed by an orthopedic surgeon using DeNovo NT Natural Tissue Grafts: the implantation of small pieces of juvenile joint cartilage into the affected area, using glue-like fibrin. Rehabilitation of the elbow began immediately following surgery.*

Summary: *Examination and imaging indicated that elbow pain in an adolescent baseball player could be from multiple sources, however, the chronic swelling*

Objectif : *Présenter un cas de douleur chronique du coude résultant d'une anomalie ostéo-cartilagineuse sous-jacente cachée.*

Caractéristiques cliniques : *Un joueur de baseball de 17 ans souffrait d'une douleur chronique latérale du coude. L'examen a révélé un gonflement du coude avec des signes de blessures possibles au ligament, au muscle et au tendon.*

Diagnostic et traitement : *Bien qu'il y ait une blessure évidente des tissus mous, le gonflement du coude a immédiatement indiqué une affection sous-jacente plus grave. L'examen a révélé un coude enflé et douloureux, une radiographie simple confirmant un trouble de l'os sous-chondral (anomalie ostéo-cartilagineuse) du capitellum de l'humérus. Une chirurgie réparatrice a été réalisée par un chirurgien orthopédiste qui a eu recours à des greffes de tissus naturels DeNovo NT : l'implantation de petits morceaux de cartilage articulaire juvénile dans la zone touchée, avec de la colle de fibrine. La réhabilitation du coude a commencé immédiatement après l'intervention chirurgicale.*

Résumé : *L'examen et l'imagerie indiquent que la douleur du coude chez un joueur adolescent de baseball pourrait provenir de sources multiples; cependant, le*

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raised suspicion of a condition requiring immediate and further investigation.

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KEY WORDS: chiropractic, elbow pain, chondroblastoma, osteochondral bone defect, joint swelling

gonflement chronique a éveillé des soupçons d'une condition exigeant un examen plus poussé.

(JCCA. 2016;60(3):226-232)

MOTS CLÉS : chiropratique, douleur du coude, chondroblastome, anomalie ostéo-cartilagineuse, gonflement articulaire

Introduction

Elbow pain in an adolescent baseball player is not an unusual occurrence. The reasons for the elbow pain may at times be due to unusual circumstances such as tumours and undiagnosed fractures. Although most elbow complaints in young baseball players are the result of either traumatic injury or repetitive stress, it is important to recognize that elbow pain may signify the presence of an injury not restricted to the soft-tissues. This is especially true when a red flag such as painful joint swelling is present.

One possible reason for such joint swelling is an osteochondral defect. Such a defect is a progressive stage of osteochondrosis/osteochondritis dissecans. This condition is relatively rare, necessitates different treatment options, and is associated with variable recovery dependent on the stage of the condition's development. Osteochondritis dissecans (OCD) is a commonly used term. However, due to the paucity of inflammatory cells found on the osteochondral articular surface of the bone, a more appropriate term would be osteochondrosis, which does not assume the presence of an inflammatory process.[1,2]

A similar condition commonly confused with OCD is Panner's disease (an osteonecrosis of the capitellum). Although the two conditions appear similar, there are significant differences between them. The most important difference is the age of onset. Panner's disease occurs in children below the age of 12, with some authors stating the upper range to be at 10 years of age. Panner's disease tends to be self-limiting and presents as a focal osteonecrosis of the entire capitellum. OCD on the other hand commonly occurs in adolescence, is laterally located, and is variable in terms of prognosis. Some authors feel that there may be a progressive connection between the two disorders.[1,3]

OCD in the capitellum of the elbow has been described in the literature by numerous authors.[1-9] Although it is considered a rare condition when present, it is most commonly found in the capitellum. The exact incidence of the condition is speculative, with current estimates of 1.3% to 1.6% amongst little league players.[4] It is not uncommon for this injury to be confused with osteonecrosis, Panner's disease, Little Leaguers elbow, and hereditary epiphyseal dysplasia.[5]

This case is of particular interest to chiropractors who treat athletes in general, and most relevant to those who treat baseball players. Elbow injuries from various mechanisms are common in adolescent baseball players. It is important for clinicians to realize that at times musculoskeletal conditions requiring a more thorough investigation may masquerade as sprains and strains and could potentially be missed. The misdiagnosis may result in damaging sequelae such as disruption of the normal endochondral ossification process (disruption of the growth plate).[6] Chronic joint swelling is one such red flag that should not be overlooked.

Case Presentation

A 17-year-old baseball player presented with right elbow pain of approximately one year in duration. The pain was diffuse throughout the elbow, and had progressively worsened. The elbow was aggravated with throwing, particularly on the follow-through and the player did not recall any specific trauma or injury to the elbow. He had been previously diagnosed and treated for a suspected chronic lateral epicondylitis. Regrettably for the patient there had been no relief from any of the treatment received. He reported that the treatment consisted of muscle stimulation, Graston technique, massage, and "strong" stretching.

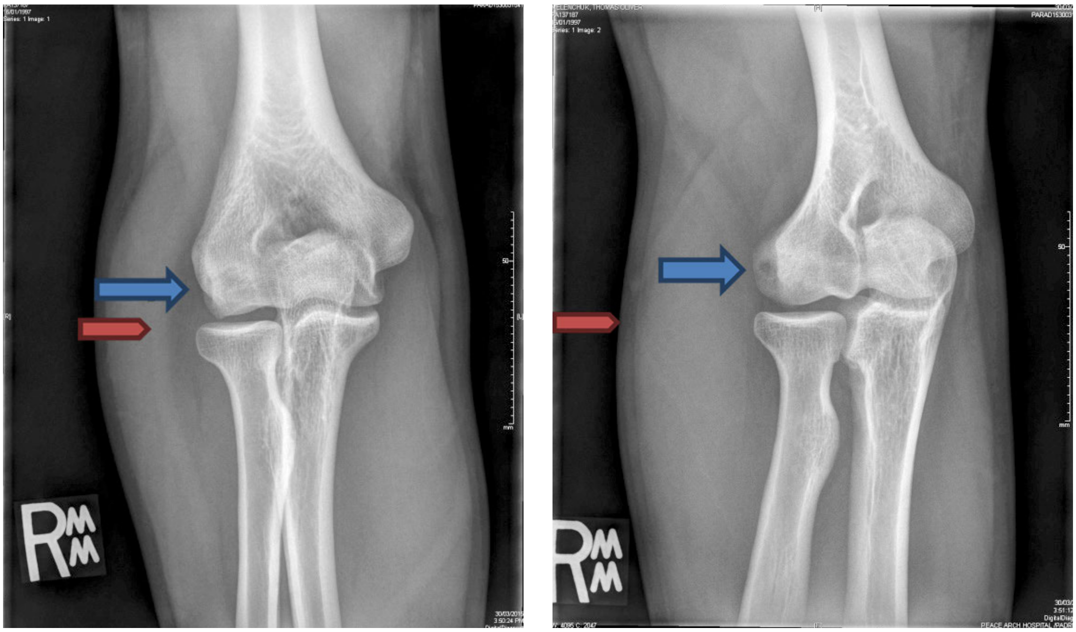

Figure 1.
Plain radiographs of the elbow prior to surgical intervention.
Blue arrow: Osteochondral defect; red arrow: Soft tissue swelling. Left: AP view; Right: oblique view.

Clinical Findings

Inspection of the elbow revealed significant swelling on the lateral aspect of the joint. Range of motion was limited in extension to approximately 150° with discomfort. Flexion of the elbow was minimally limited. Varus and valgus stress on the medial and lateral holding elements respectively did not induce any excessive movement due to ligamentous laxity. The ulnar collateral ligament, although tender, appeared intact. Digital percussion of the epicondyles produced pain on the lateral epicondyle. There was also soft-tissue swelling and tenderness to palpation over the lateral aspect of the elbow.

Strength testing of the elbow resulted in pain-related weakness in flexion, extension, pronation, and supination. Palpation revealed multiple tender areas around the elbow joint, particularly over the distal aspect of the brachialis and lateral head of the biceps muscles. Similar tenderness was found on the lateral forearm extensors, common extensor tendon, and pronator teres muscle. Notwithstanding an absence of ligamentous laxity, pain was elicited during palpation of the ulnar collateral ligament and annular ligament. The shoulder joint revealed a significant decrease in external rotation. All other ranges, strength, upper limb reflexes, and sensation appeared to be normal.

Differential Diagnosis and Follow-up

The physical examination indicated that this could have been an atypical or complicated case of soft-tissue damage. Soft-tissue differentials included a mild sprain of the ulnar collateral and annular ligaments, and strains of the pronator teres, biceps, brachialis, and elbow extensor group.

The presence of swelling with progressively worsening pain was potentially ominous and indicated a need to refer for plain x-ray imaging and subsequent medical evaluation. In the initial stages of the evaluation, benign tumours such as osteoid osteoma, giant cell tumour, or chondroblastoma were considered. Of these, chondroblastoma was most consistent with both the age of the patient and presence of swelling. Malignant tumours that required consideration in order of incidence were osteosarcoma, Ewing sarcoma, and synovial sarcoma.[7]

The radiographs revealed an osteochondral defect in the right lateral capitellum of the elbow (Figure 1). Fol-

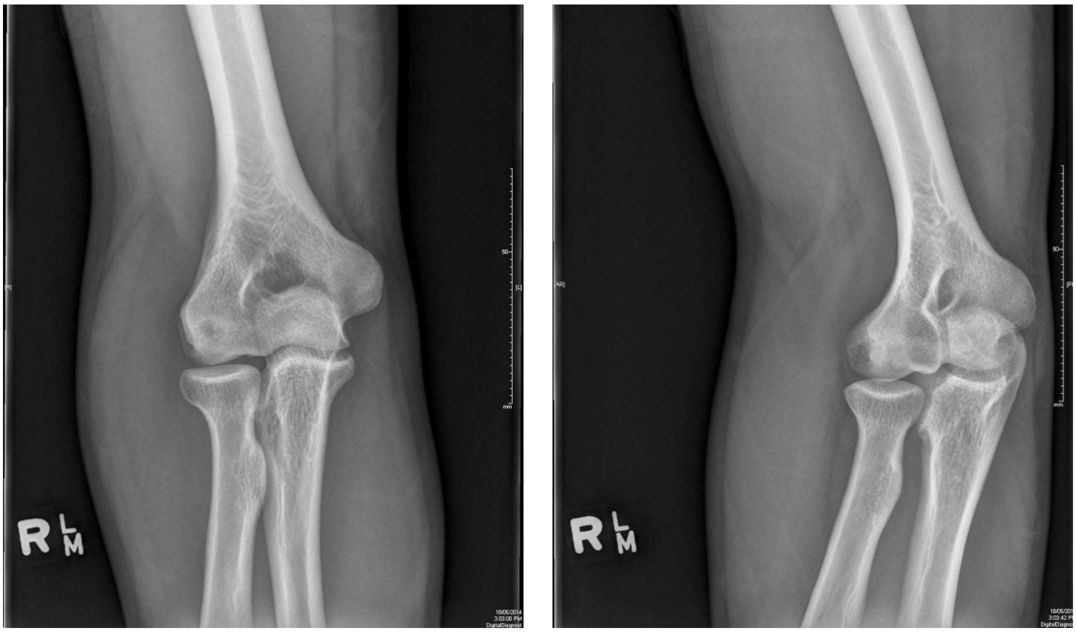

Figure 2.
Plain radiographs of the elbow 7 months post-surgical intervention.
Left: AP view, 8 months post-surgery; Right: Oblique view, 8 months post-surgery.

lowing confirmation of the diagnosis, the patient consulted an orthopedic surgeon where a De Novo NT allograft procedure was performed. At approximately 7 months post-surgery and rehabilitation, the patient was able to begin light throwing. Post-surgical radiographs were reported as normal with no focal or suspicious abnormality noted. In addition, there was no evidence of joint effusion identified (Figure 2).

Discussion

Etiology

It is generally accepted that the etiology of OCD of the elbow is largely unknown. A review of the literature indicates that there appears to be some common ground amongst most authors as to the most likely origins of the condition.[1-9] The most obvious suspicions for the development of an osteochondral defect are repetitive microtrauma, and compromised blood flow to the elbow. OCD is found primarily in throwing athletes and gymnasts due to the excessive compressive and shearing forces on the lateral compartment of the elbow.

During the late cocking and early acceleration phases of throwing a significant valgus stress occurs at the elbow, producing abnormal compressive forces across the radiocapitellar joint. This is especially significant in a developmentally immature elbow. The continued stresses result in a localized injury to the subchondral bone in the form of fatigue fractures and diminished support for the overlying articular cartilage. Consequently, this combination of events results in a breakdown and potential fragmentation of the cartilage and bone. It is believed that 60% of axial compression forces across the elbow are transmitted to the radiocapitellar joint.[5,9]

According to Yadao *et al*.[5] the vascular supply to the distal humerus may be considered marginal, which suggests that the lack of blood (ischemia) may play a part in the development of OCD. Further to this, the small blood vessels enter posteriorly to the capitellar epiphysis and extend over the epiphyseal cartilage, which is a site of significant contact and compression. It is therefore conceivable that repetitive stress in this area may lead to the development of OCD. If this injury is left untreated, symptomatic degenerative change appears to be inevitable, leading to damage and fragmentation of the articular cartilage.[5] There is some belief that a genetic component to the disease may exist based on reports of OCD occurring in generations of families.[5]

OCD may initially be asymptomatic in the early stages but with continued overuse, will progress to a symptomatic state that can potentially end an athlete's career.[10] Takahara *et al*.[9] described the early development and detection of OCD utilizing MRI. They observed capitellar abnormalities while screening adolescent baseball pitchers and noted that those individuals developed OCD over time. Early changes in the capitellum were identified by low signal intensity on T1-weighted images, while T2-weighted images displayed no abnormalities. They also found that diagnostic ultrasound revealed a localized flattening of the subchondral bone with a normal outline of the articular cartilage. Plain radiographs with the elbow at 45° of flexion displayed a slight flattening and sclerosis of the superficial aspect of the capitellum.[9]

As noted by Krych *et al*.[10], many bone and soft-tissue tumours present disproportionately in young and active patients who are often involved in athletic activities. In such instances the clinician may misdiagnose these rare tumours as more common sports injuries.[10] Walker *et al*.[11] emphasize that both joint-related tumours and sports injuries often afflict young, active patients, and the symptoms may overlap significantly. In these cases, lack of adequate imaging studies may result in either a significant delay in diagnosis or an inappropriate and unnecessary arthroscopic procedure.[11]

Therapeutic Intervention

Many authors have discussed the treatment options available for OCD. Although conservative treatment may be effective in certain circumstances, there is general agreement that a variety of surgical options tend to provide better outcomes.[12-17]

The therapeutic protocols for OCD are somewhat dependent on the stage of the condition. If caught early in the process, conservative management may be effective. Matsuura *et al*.[13] produced a retrospective paper on 176 individuals with osteochondrosis of the humeral capitellum. Of the 101 patients that received conservative care, healing occurred in 90.5% of stage I lesions (radiolucent areas on plain radiograph) and 52.9% of stage II lesions (non-displaced fragments). On average, stage I required 14.9 months to heal, while the stage II patients resolved in 12.3 months. According to that study, treatment consisted of refraining from heavy use of the elbow for six months.[13] In contrast, Takahara *et al*.[14] found that there was only a slight chance of the capitellum healing with conservative care, regardless of stage.

In this particular case the condition had been progressing for 12 to 18 months and required surgical repair. Although different surgical techniques have been developed to repair chondral and osteochondral lesions, the literature demonstrates only fair to good results when performed, even in the appropriate circumstances. Additionally, there is significant controversy in regards to the indications and outcomes of these various procedures.[13] The specific procedure utilized in this case was a DeNovo NT allograft. This particular technique has not been used often in the elbow but has been administered with empirically good success in the knee. Therefore, its application for the elbow was largely untested. Additionally, rehabilitation of the elbow following this specific surgery was done without the benefit of previous cases, but was guided simply by general basic principles of rehabilitation for other post-surgical orthopedic conditions. According to Tompkins *et al*.[15] "most surgeons develop personal treatment preferences guided by training, published literature, outcome data, education conferences, expert opinion, and personal experience. As a recently developed cartilage-repair technique, the role of DeNovo NT has not been clearly defined".[15] This is especially true with regards to the capitellum.

The DeNovo NT (natural tissue) repair process inserts juvenile articular cartilage into the damaged bone. The particulated allograft chondral fragments are attached to the bone defect and held in place with adhesive fibrin. The fibrin has been shown *in vitro* to support chondrocyte overgrowth, thereby assisting in the healing process. The juvenile chondrocytes are used due to their greater potential for cell division and matrix production.[13]

Rehabilitation of the elbow by the chiropractor in this case began immediately following surgery and was guided by general principles of rehabilitation for other post-surgical orthopedic conditions. The protocol initially involved pain-free passive movement, which continued for 10 weeks, producing approximately 175° of extension. Following the passive movement stage, light resisted motion was introduced. Minimal dumbbell weight (2-3 lbs) and stretch tubing was utilized to strengthen flexion, extension, pronation, and supination. The volume of work consisted of one to two sets of 20 repetitions initially, progressively increasing the number of sets and weight as tolerance to the exercise increased. The patient also developed general fitness, utilizing an exercise bike, and maintained core strength and upper and lower limb strength where possible without aggravating the repaired elbow. The general fitness program was supervised by an athletic therapist who included left arm goblet squats, left side back rows, plyometric boxes, weighted sit-ups and agility drills. At 16 to 20 weeks weighted wrist pronation was performed with 5 lbs, progressing by 24 to 28 weeks to 10 lbs. The volume remained consistent at 10 reps for 3 sets. Dumbbell biceps curls and triceps extension were performed with 5 to 15 lb weights (15 reps/3 sets) progressing from 16 to 28 weeks. At week 24, light push-ups were introduced.

By 28 weeks post-surgery, the patient began light throwing in the form of wrist flicks and light hitting off a tee at 40-50% of maximum. He continued to strengthen the arm with his normal workout routine, while increasing general fitness under the supervision of the team trainer. By 32 to 36 weeks, the goal of rehabilitation was achieved with a return to non-competitive play.

Clinical Significance

OCD of the capitellum is rare, but is most often found in adolescent overhead athletes, and was therefore a condition requiring a high degree of suspicion in the current case.[6] More importantly to clinicians is the awareness of the multiple implications of chronic joint swelling. In this case the patient claimed to have been assessed and treated by numerous different practitioners for the aforementioned signs and symptoms. That so many different individuals failed to recognize a condition more significant than a soft-tissue injury highlights the need to understand the many reasons for chronic joint swelling.

The treatment for OCD, particularly when chronic, is surgical intervention. If the condition is recognized early, prior to frank symptoms, but in the presence of the typical mechanism of injury and age of the athlete, development of more serious sequelae may be prevented. According to Kida *et al*.[4] introduction to the game at an early age may be a risk factor for OCD of the humeral capitellum. Additionally, the duration of competitive play, a history of current and prior elbow pain when throwing, and position played may also be considerations.[4] Generally in regard to the latter, one would expect a higher incidence of OCD in pitchers and catchers, due to the high number of throws executed. In this particular case, the patient was a first baseman, which simply exemplifies the fact that playing position may not be a reliable proxy measure of volume of throwing activity.

Summary

Chronic swelling within a joint should always be considered suspect, particularly in young athletes, and not dismissed as simply an atypical soft-tissue sprain or strain. Serious conditions are rare but when present, may masquerade as a common athletic injury. Conditions that are unresponsive to initial therapy should be investigated further. OCD is an example of a potentially serious condition that can mimic a common athletic soft-tissue injury, yet if diagnosed early, may resolve simply with rest. Conversely, if misdiagnosed and mismanaged, OCD can potentially become a career-ending injury.

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Differences in hip range of motion among collegiate pitchers when compared to youth and professional baseball pitcher data

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The purpose of this study was to measure passive hip internal (IR) and external rotation (ER) range of motion (ROM) in collegiate baseball pitchers and compare to published youth and professional values. Measures were taken on the bilateral hips of 29 participants (mean age 20.0±1.4, range 18-22 years). Results identified no significant differences between the stance and stride hip in collegiate right handed pitchers for IR (p= 0.22, ES 0.23) and ER (p=.08, ES= 0.25). There was no significant difference in left handed pitchers for IR (p= 0.80, ES= 0.11) and ER (p= 0.56, ES= 0.15). When comparing youth to collegiate, IR increased in the stance (2º) and stride (5º) hip and an increase in the stance (5º) and stride (5º) hip were present for ER as well. From collegiate to professional, IR increased in the stance (4º) and stride (3º) hip whereas a decrease

Le but de cette étude était de mesurer l'amplitude de mouvement passif de la hanche en rotation interne (RI) et en rotation externe (RE) chez les lanceurs de baseball au niveau collégial et la comparer aux valeurs publiées chez les jeunes et les professionnels. Des mesures ont été prises sur les deux hanches de 29 participants (moyenne d'âge de 20,0 ± 1,4, tranche d'âge de 18 à 22 ans). Les résultats n'ont révélé aucune différence significative entre la posture et la foulée de la hanche chez les lanceurs droitiers collégiaux pour la RI (p = 0,22, AE = 0,23) et la RE (p = 0,08, AE = 0,25). Il n'y avait pas non plus de différence significative chez les lanceurs gauchers pour la RI (p = 0,80, AE = 0,11) et la RE (p = 0,56, AE = 0,15). Lorsque l'on compare les jeunes aux joueurs collégiaux, la RI a augmenté dans la posture (2º) et la foulée (5º) de la hanche, et une augmentation était également constatée pour la RE : posture (5º) et foulée (5º) de la hanche. Par rapport aux professionnels, la RI a augmenté pour la posture (4º) et la foulée (3º) de la

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in the stance (9º) and stride (12º) hip was present for ER. The data suggests an increase in passive ROM from youth to collegiate and a decrease from collegiate to professional. Understanding passive hip ROM values among the different levels of pitchers may assist clinicians in developing time dependent interventions to prevent future injury and enhance performance.

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KEY WORDS: hip joint, range of motion, baseball, collegiate

hanche, alors qu'une diminution de la posture (9º) et la foulée (12º) de la hanche était constatée pour la RE. Les données indiquent une augmentation de l'amplitude de mouvement passif des joueurs de niveau collégial par rapport aux jeunes et une diminution par rapport aux joueurs professionnels. La compréhension des valeurs d'amplitude de mouvement passif de la hanche chez les différents niveaux de lanceurs peut aider les cliniciens à développer des interventions ponctuelles pour prévenir les blessures futures et améliorer la performance.

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MOTS CLÉS : articulation de la hanche, amplitude de mouvement, baseball, collégial

Introduction

Hip injury among baseball pitchers has become an evolving area of study. Baseball pitchers may be at risk for injury due to the high volume of repetitive motions involved in pitching and comprehensive training schedules.[1] It has been reported that approximately 30% of all injuries in professional baseball pitchers occur in the lower extremity.[2] Emerging research suggests that the hip joint has a major influence on pitching performance at higher speeds, since the hip muscles are primary generators of power.[3-6] Thus, compulsory motions among pitchers are not limited to the throwing arm and the hip presents a viable region to consider from both a prevention and performance perspective.

Evidence suggests that in the presence of limited hip mobility, throwing mechanics are altered and may lead to both hip and shoulder pathology.[6,7] Specifically, baseball pitchers are susceptible to groin injuries, femoral acetabular impingement, and sports hernias as a result of limited hip mobility.[7-10] Limited hip mobility can also affect the shoulder by compromising normal pitching biomechanics, forcing the abdominal core and shoulder to work harder or compensate, due to the loss of range of motion (ROM) and muscle force generated by the hip musculature.[11] This may induce excessive forces through the glenohumeral joint which can affect the velocity of the pitch as well as increase the potential risk for upper quarter injury.[5,6,8,12,13]

The hip's influence on pitching mechanics needs to be considered when assessing professional, collegiate, and youth pitchers with a suspected shoulder pathology since movement of the lower extremity is part of the throwing motion and contributes to the generation of power.[14] Understanding hip ROM trends among the various levels of pitchers may help to recognize risk factors and develop time dependent mobility-based interventions to prevent injuries and mitigate impairments. A search of electronic databases that included: PubMed, CINAHL, SPORT Discus, ProQuest, Cochrane Database, and Google Scholar® revealed selected studies among baseball pitchers. Hip ROM studies have been reported for professional pitchers[8,11,15-17], youth pitchers[18,19], and one study for collegiate pitchers[12]. The majority of hip ROM studies have been in professional pitchers. Hip ROM trends in youth and collegiate pitchers are important to study given the relatively large proportion of pitchers compared to professional players. To date, there has been no comparison of existing data from professional, collegiate, and youth level pitchers. This leaves a gap in our knowledge of how hip ROM develops as pitchers mature from youth to collegiate and professional levels. Thus, the purpose of this investigation was to report passive hip internal and external ROM values in collegiate pitchers and compare to published values of youth and professional pitchers.

Methods

This cross sectional study involved the measurement of

Table 1.
Subject Demographics; m, meters; BMI, Body mass index; kg, kilograms

	Age (years)	Height (m)	Mass (kg)	BMI (kg/m^2)
Subjects (N=29) (mean $\pm$ SD)	20.0 ± 1.4 (Range 18 to 22)	1.9 ± 0.6	89.3 ± 10.7	25.3 ± 2.5

collegiate baseball pitchers. Each pitcher was assessed for bilateral passive seated hip internal rotation (IR) and external rotation (ER) ROM. Data were collected as part of a larger study investigating descriptive characteristics of collegiate pitchers. Comparisons were made between right and left handed pitchers and pooled data from all participants in this study were compared to the published passive hip ROM values for professional and youth pitchers.[17,19]

Participants

A convenience sample of 29 collegiate baseball pitchers (58 hips) were recruited from Azusa Pacific University and California State University San Bernardino (Table 1). Of the participants, 23 were right-handed pitchers and 6 left-handed pitchers. Participants had to be asymptomatic in both hips at the time of testing and free of any known hip pathology. Exclusion criteria included previous hip surgery or any other medical problem that would have limited their ability to participate in full activity during the regularly scheduled 2013-2014 baseball season. This study was approved by the University Institutional Review Board (IRB). All participants who qualified were adults and received detailed information of the study requirements. All participants completed the university approved consent process and signed a university approved consent form prior to participation.

Instrumentation

Bilateral passive hip IR and ER ROM was performed with a wireless micro*FET*3 hand held digital inclinometer (Hoggan Health Industries., Salt Lake City, UT, USA). The manufacturer reports accuracy for ROM within 1° when using this device. Hand held digital goniometers have shown good reliability in measuring hip ROM[20,21]

Prior to data collection, a three session intrarater reliability analysis was conducted, over 1 week, using one examiner. The examiner was a licensed physiotherapist with over 12 years of experience and board certified in orthopedics. The examiner was blinded to the recording of the data outcomes. The measurements were performed on 29 independent participants chosen for this portion of the study. The intrarater reliability was calculated using the Intraclass Correlation Coefficient (ICC model 3, k).[22] There was good intrarater reliability for both passive IR (ICC= 0.91) and ER (ICC= 0.92) ROM. These coefficients are in accordance with the minimum threshold of ≥ 0.90 for ICC values postulated to be acceptable for clinical decision making.[22]

Data Collection

For all measurements, the participants were examined in their collegiate training facility and all procedures were explained in detail and demonstrated by the examiner. Measurements were performed seated based on previously described measurement procedures.[17,19] For each hip, two measurements were recorded for both passive IR and ER and the average was used for data analysis.[17]

For the measurement of hip IR, the participants were sitting on an athletic training table with their unsupported knees flexed to 90°. The examiner stood along the lateral side of the limb being measured and placed one hand behind the distal tibia above the malleoli. The examiner used the other hand to hold the digital inclinometer on the lateral malleolus. The examiner passively moved the participant's hip into IR by moving the foot laterally to the end of the available range when an "unyielding" endfeel was felt and then took the measurement (Figure 1).[17] The measurement for passive hip ER was then performed. The examiner stood along the medial side of the limb being measured and placed one hand behind the distal tibia above the malleoli. The examiner used the other hand to hold the digital inclinometer on the medial malleolus. The examiner passively moved the participant's hip into ER

Figure 1.
Passive hip internal rotation measurement.

by moving the foot medially to the end of the available range when an "unyielding" end-feel was felt then took the measurement.[17] The examiner monitored the participant during testing to prevent any excessive movement of the test leg or lumbopelvic region.

Data Sources: Youth and Professional

For the data comparison, we used two prior publications for our analysis with similar methods to our current investigation. These were the only known published studies that could be directly compared. Oliver et al[19] measured bilateral passive seated hip ROM in 26 youth pitchers (mean age of 11.3 ± 1.0 years) and Sauer et al[19] measured 50 professional pitchers (mean age of 22.6 ± 2.8 years) using the same methods. Data from these studies were compared to the pooled data obtained in this investigation.

Statistical Analysis

Statistical analysis was performed using SPSS version 22.0 (IBM SPSS, Chicago, IL, USA). Participant descriptive data was calculated and reported as the mean and standard deviation (SD) for age, height, mass, and body mass index (Table #1). A two tailed independent *t*-test was used to compare mean passive hip IR and ER ROM differences between the stance (*back*) and stride (*forward*) hip for left and right handed pitchers. A two-way factorial ANOVA (mixed general linear model) was conducted to compare the variables IR and ER passive hip ROM measures with handedness as a between factor and stance and stride hips as within factors between right and left handed pitchers.[21] Effect size (ES) was also calculated using Cohen's d ($d=(M_1-M_2)/SD_{pooled}$) from the available data.[21] Effect size of 0.50 was considered large, 0.30 was moderate, and 0.10 was small.[23] Statistical significance was considered as $p< 0.05$.

Results

Collegiate Pitchers

The calculated values among collegiate pitchers can be found in Table 2. For *right handed pitchers*, there was no significant difference in passive seated IR (p= 0.22) and ER (p= 0.08) ROM between the stance and stride hips. For the *left handed pitchers*, there was no significant difference in seated IR (p= 0.80) and ER (p= 0.56) ROM between the stance and stride hips. When comparing *right*

Table 2.
Comparison of seated hip PROM in collegiate baseball pitchers.

	Stance: IR	Stride: IR	P	ES		Stance: ER	Stride: ER	P	ES
Right Hand Pitchers	33.6 ± 9.4°	35.6 ± 8.1°	P= 0.22	0.23		36.9 ± 9.8°	39.4 ± 10.3°	P= 0.08	0.25
Left Hand Pitchers	33.0 ± 9.5°	32.1 ± 7.4°	P= 0.80	0.11		43.2 ± 13.6°	45.2 ± 13.6°	P= 0.56	0.15
Right versus Left Hand Pitchers	P= 0.90	P= 0.34				P= 0.20	P= 0.26		

IR: internal rotation; ER: external rotation; P=statistical significance using t-test; P<0.05 = statistically significant; data reported as mean ± SD; ES= effect size

Table 3.
Comparison of collegiate pitchers seated hip PROM to published values for youth and professional pitchers.

	Youth Pitchers [19] (N=26)	Collegiate Pitchers (N=29)	Effect Size (CI)		Collegiate Pitchers (N=29)	Professional Pitchers[17] (N=50)	Effect Size (CI)
Stance: IR (degrees)	31.3 ± 8.3°	33.3 ± 9.4°	-0.22 (–0.75, 0.31)		33.3 ± 9.4°	37.2 ± 5.7°	-0.54 (–1.00, –0.07)
Stance; ER (degrees)	35.0 ± 6.2°	40.0 ± 11.7°	-0.53 (–1.06, 0.02)		40.0 ± 11.7°	30.9 ± 5.9°	1.07 (0.58, 1.55)
Total Hip ROM (degrees)	66.4 ± 10.6°	73.3 ± 10.5°	-0.65 (–1.19, –0.10)		73.3 ± 10.5°	68.1 ± 7.7°	0.59 (0.12, 1.05)
Stride: IR (degrees)	28.5 ± 6.1°	33.8 ± 7.8°	-0.75 (–1.29, –0.19)		33.8 ± 7.8°	37.0 ± 5.6°	-0.49 (–0.95, –0.02)
Stride: ER (degrees)	37.0 ± 6.6°	42.3 ± 11.9°	-0.54 (–1.07, 0.00)		42.3 ± 11.9°	30.1 ± 5.4°	1.46 (0.93, 1.95)
Total Hip ROM (degrees)	65.7 ± 8.4°	76.1 ± 9.8°	-1.13 (–1.69, –.055)		76.1 ± 9.8°	52.0 ±8.3°	2.71 (2.06, 3.30)

**IR: internal rotation; ER: external rotation; data reported as Mean ± SD; CI: Confidence Interval*

and left handed pitchers, there were no significant differences in the stance hip for seated IR ROM [F (1, 27) =0.16, p= 0.90] and ER ROM [F (1,27) =1.72, p= 0.20]. There was no significant difference in the stride hip for seated IR ROM [F (1,27) =0.94, p= 0.34] and ER ROM [F (1,27) =1.33, p= 0.26].

Comparison of Collegiate Data with Youth and Professional Pitcher Data

All data from this investigation were pooled (right and left handed pitchers) for this comparison analysis and presented in Table 3. For the *stance hip* passive seated IR ROM, there was a 2° increase (ES= –0.22) from youth to collegiate level and a 4° increase (ES= –0.54) from collegiate to professional. For the *stance hip* seated ER ROM, there was an approximate 5° increase (ES= –0.53) from youth to collegiate level and a 9° decrease (ES= 1.07) from collegiate to professional. For the *stance hip total ROM*, there was an approximate 7° increase (ES= –0.65) from youth to collegiate level and a 5° decrease (ES= 0.59) from collegiate to professional.

For the *stride hip* seated IR ROM, there was an approximate 5° increase (ES= –0.75) from youth to collegiate level and a 3° increase (ES= –0.49) from collegiate to professional. For the *stride hip* seated ER ROM there was an approximate 5° increase (ES= –0.54) from youth to collegiate level and a 12° decrease (ES= 1.46) from collegiate to professional. *For the stride hip total ROM*, there was an approximate 10° increase (ES= –1.13) from youth to collegiate level and a 9° decrease (ES= 2.71) from collegiate to professional. A graphical comparison of the three groups is provided in Figure 2.

Discussion

This investigation measured bilateral passive seated hip rotation ROM in 29 collegiate pitchers and found no statistical significance between right and left handed pitchers for both stance and stride hip IR and ER (p≥ 0.31). These findings were consistent with Sauer et al [17] who reported similar findings of no significant difference of right and left passive seated hip ROM in a group of professional pitchers (N= 50) tested with similar methods. These results suggest that within each population there is similar values of passive hip ROM for the stance and stride leg among pitchers. Clinically, bilateral examination of both hips is warranted since loss of ROM in either hip can have an effect on the throwing motion.[12]

When comparing the data of the collegiate pitchers to published youth and professional values there were moderate differences in ROM. From youth to collegiate, IR ROM showed an increase in both the stance (2°) and stride (5°) hip. For ER ROM, there also was an increase in the stance (5°) and stride (5°) hip. For total change in ROM, there was an increase in the stance (7°) and stride hip (10°). The increase in ROM could be due to many factors such as the population sampled, maturation and growth

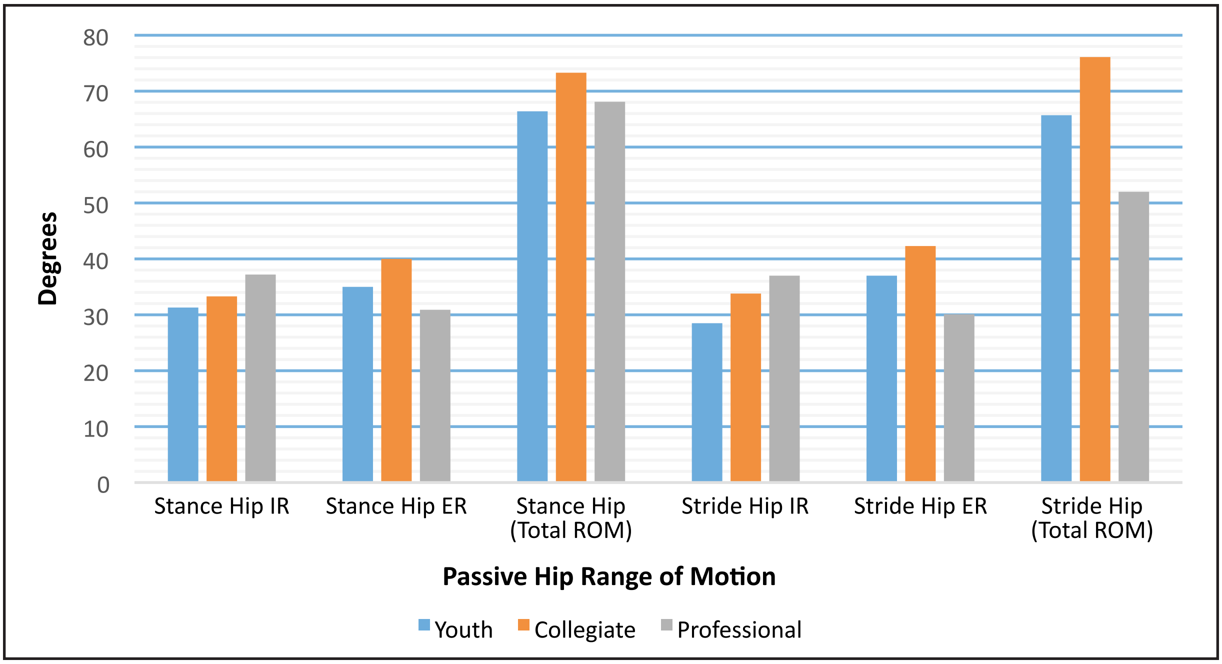

Figure 2.
Comparison of Youth, Collegiate, and Professional Pitchers.

of the athlete, number of game and practice exposures, physical conditioning, and sports specific training. Nevertheless, it seems there is an increase in hip mobility from youth to collegiate levels when considering hip IR and ER ROM. From collegiate to professional, hip IR ROM showed an increase in both the stance (4º) and stride (3º) hip. For ER ROM, there was decrease in the stance (9º) and stride (12º) hip. For total change in ROM, there was a decrease in the stance hip (5°) and stride hip (9°). These findings are similar to Lauder et al [12] who found that decreased ER ROM of the stance and stride hips increased horizontal adduction of the throwing shoulder during the pitching motion. Decreased stride hip IR and ER also created a significant increase in torque across the throwing shoulder. It appears that a total loss of hip ROM from the collegiate to professional levels may exist. The data also suggests that changes in ER ROM may contribute the most to this loss of motion.

Limitations

The main limitation of this investigation was the comparison of data from studies with similar methods which only represented a portion of the available literature. All the studies analyzed, tested pitchers' bilateral passive hip ROM (IR and ER) in the seated position which provided a direct comparison. Previous studies have tested pitchers in seated but used different testing methods such as active ROM thus results cannot be extrapolated to passive ROM.[24] Several other investigations have measured hip ROM in collegiate and professional pitchers in the prone position making it difficult for a direct comparison to this investigation.[12,25,26] Due to the variability in results among studies, future comparisons should be made using similar methodology. A second limitation was the small sample of pitchers, specifically left-handed pitchers. Future studies should include larger samples of left handed pitchers. A third limitation was the absence of data from all the age groups in youth pitchers. To date, there is only one study that has evaluated hip ROM among the various age groups of youth pitchers. Beckett et al[27] measured hip ROM in youth players using two age groups: preadolescents (players aged 7-12 years) and adolescents (players aged 13-18 years). The authors did not use this data for comparison since they tested all the players in the prone position. A fourth limitation was that other hip motions such as flexion or extension or abduction or adduction were not measured. Future studies should attempt to measure these motions to determine their influence on the pitching motion.

Despite limitations, these data are a starting point for researchers to analyze how passive range of hip motion changes through the various levels of play. The clinical relevance of these findings is that passive hip IR and ER ROM increases from youth to collegiate and then decreases from collegiate to professional. Knowing time points for change may allow appropriate staging of interventions to enhance performance or prevent future injuries. We chose to collect data from collegiate pitchers since there are fewer studies published versus youth and professional. Future research should attempt to use larger sample sizes and similar methodology of testing subjects in one standard position or in both seated and prone in order to provide means for a direct comparison.

At this point, there is not enough evidence to determine if this increase in ROM impacts performance or increases the risk of injury. Future studies will need to determine if these ROM changes are just growth trends or adaptation from playing. Possible causes of joint ROM loss could be adaptations from the high volume of throwing and rigorous training schedules. Further research is needed to confirm these hypotheses.

Conclusion

The hip joint has an important biomechanical role in the pitching motion since it is a primary generator of power, plays a major role in pitching performance at higher speeds, and is related to shoulder injuries.[3-6] This study measured passive hip IR and ER ROM in collegiate baseball pitchers and compared to published youth and professional values. This study provides a starting point for clinicians and researchers to look at hip ROM in pitchers from youth to collegiate to professional. Understanding hip ROM trends in this population may provide insight into injury patterns among the different levels of play and may assist clinicians in developing time dependent interventions to prevent future injury (e.g. hip and shoulder) and enhance performance. The data presented are limited by the small samples size, limited access to normative data, and passive testing in the seated position. The results of this study suggest that a loss of total passive hip ROM may occurs from the collegiate to professional level. The data also suggest that changes in ER ROM may contribute the most to this loss of motion. The reasons for these occurrences are still unknown. Future studies are needed to confirm these findings and determine plausible factors.

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The meaning of it all: evaluating knowledge of Minimal Clinically Important Difference (MCID) among chiropractic students

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Introduction: *Patient-reported outcome measures are frequently used to monitor patient progress during chiropractic care, yet student interns utilizing such assessments are unfamiliar with what magnitude of change (MCID) is considered beneficial to the patient.*

Objective: *This work seeks to determine chiropractic intern knowledge of MCID.*

Methods: *A five-item survey was administered to 104 chiropractic student interns.*

Results: *Nearly one-third of the interns correctly defined the MCID acronym, and approximately one-third of the interns knew at least one MCID value for the outcome assessments in the EHR. Surprisingly, 20% of the interns reported knowledge of at least one MCID value, but answered incorrectly pertaining to the MCID acronym.*

Conclusion: *Student interns value patient perception, but have limited knowledge of MCID values. Addressing*

Introduction : *Les mesures de résultats rapportés par les patients sont fréquemment utilisées pour suivre les progrès du patient pendant les soins chiropratiques, mais les stagiaires qui utilisent ces évaluations ne sont pas familiers avec l'ampleur des changements (différence minimale cliniquement importante – DMCI) considérée comme bénéfique pour le patient.*

Objectif : *Cette étude vise à déterminer les connaissances, chez les stagiaires en chiropratique, de la DMCI.*

Méthodologie : *Une enquête comportant cinq points a été menée chez 104 stagiaires en chiropratique.*

Résultats : *Près d'un tiers des stagiaires ont correctement défini l'acronyme DMCI (MCID en anglais), et environ un tiers d'entre eux était au courant au moins d'une valeur de DMCI pour les évaluations de résultats dans le DSE. Étonnamment, 20 % des stagiaires ont indiqué connaître au moins une valeur de DMCI, mais n'ont pas su reconnaître l'acronyme DMCI.*

Conclusion : *Les stagiaires accordent de l'importance à la perception des patients, mais ont une connaissance*

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this gap will improve their understanding of patient progress and inform their treatment decisions both in the outpatient clinic and in their practices following graduation.

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KEY WORDS: chiropractic, education, minimal clinically important difference, MCID

limitée des valeurs de DMCI. Combler cette lacune permettra d'améliorer leur compréhension des progrès des patients et d'informer leurs décisions de traitement tant en consultation externe que dans leurs pratiques après l'obtention du diplôme.

(JCCA. 2016;60(3):241-251)

MOTS CLÉS : chiropratique, éducation, différence minimale cliniquement importante, DMCI

Introduction

The ultimate goal for any chiropractic treatment plan is favorable patient outcome. Towards this end, outcome assessments (OAs) are utilized to establish baseline deficiencies in patients, and to monitor progress during the course of care. Outcome assessments are defined as tools used to measure and report patient perceptions during observational studies.[1] These semi-objective and quantifiable assessments can be useful for the clinician to plan future therapeutic strategies and for a patient to realize the benefit (or lack thereof) of care.[2,3] Of great importance is identifying what amount of change is indicative of clinical response in a patient. This can be challenging since traditional definitions of statistical significance may not always correlate to clinical relevance (e.g. p-values).[3] For instance, the meaningfulness of an identical numerical change on an outcome assessment varies among different patient populations.[4] Further, statistical significance is integrally linked to sample size; thus, significant changes observed in a large population may be clinically irrelevant.[5] In 1989, Jaeschke *et al*.[6] defined a measure of health status referred to as the minimal clinically important difference (MCID). MCID is defined as the smallest improvement considered worthwhile for a patient.[7] Not to be confused with similar terms such as MID (minimally important difference), MCD (minimal clinical difference) or MCSD (minimal clinically significant difference) which all refer to changes outside the standard variations of the outcome assessment of interest; MCID specifically relies on patient perception (with the exception of Delphi method-calculated values, discussed below).[3,8] Importantly, calculating the MCID value of a given outcome assessment allow clinicians to follow patient progress by quantifying subjective measures.

Methods for calculating MCID values can be divided into three categories: distribution-based, anchor-based, and the Delphi method.[7] Distribution-based methods are derived from statistical measures of the spread of data, and compare a change in score to measures of variability. These approaches include standard error of measurement (SEM), standard deviation (SD), effect size, minimum detectable change (MDC), reliable change index (RCI) or standardized response mean (SRM).[7-14] Underlying each of these methods are a number of general concepts; these methods and concepts are summarized in Table 1.

Table 1.
Methods used to calculated MCID.

SEM	an MCID value smaller than the SEM likely results from error[8, 9]
SD	the MCID value corresponds to one-half the standard deviation[6]
Effect size	MCID is equal to the smallest calculated effect size and a function of standard deviation of baseline values[10]
MDC	an MCID value must be at least equal to the smallest detectable change (MDC)[11]
RCI	closely related to the concept behind MDC, MCID is a function of the SEM[4]
SRM	similar to the concepts underlying effect size, except the MCID and effect size values are a function of the standard deviation across change values.[12]

Anchor-based methods compare the change in OA score to a second global measure of change. As an example, the MCID value for an outcome measure specifically designed to assess the level of chronic musculoskeletal pain intensity might be calculated by comparing scores to a Patient Global Impression of Change score.[15] Approaches falling into these methodological categories are reviewed in greater detail in Wells et al, 2001.[8]

Dissimilar from the distribution and anchor-based methods for calculating MCID, the Delphi method is an opinion-based technique in which, a panel of experts in a given field and with extensive familiarity with the health disorder and with the specific outcome assessment are repeatedly queried until a consensus on the minimum clinically significant change is reached.[16] Consensus methods have been commonly used in the development of clinical guidelines, and provide great value for evaluating patient progress. The challenges of using this method, however, include implied cues within the questionnaire, selection of the panel members, selection and presentation of scientific knowledge, and methods of finalizing the consensus (e.g. defining agreement, addressing outliers).[17] One example of a commonly used outcome assessment is the Visual Analog Scale (VAS).[18] This scale attempts to measure a characteristic which occurs across a continuum (here, the continuum referred to is pain) that is not easily measure or described.[19] As depicted in Table 2 MCID values for VAS differ between acute[20-24] and chronic lower back pain[20,25-27], two related yet different conditions, and even within the same condition across multiple studies[20,25]. These discrepancies highlight a challenge of using MCID value: lack of standardization; however, MCID remains a reliable tool for evaluating clinically relevant changes in patient populations.

Anecdotally, chiropractic students have both an interest in identifying significant improvements in patient well-being and a lack of knowledge of the term MCID and relevant MCID values for the outcome assessments that they regularly administer. Although a recent article summarizes MCID comprehensively[28], there are no reports addressing use of MCID in chiropractic and no work addressing the value of MCID as an educational topic in chiropractic colleges. As a first step towards determining chiropractic intern knowledge of MCID, this work seeks to query students about what the MCID acronym represents and whether students are familiar with MCID values for the outcome assessments commonly used in our outpatient clinic. Gathering such preliminary information will identify strengths and areas for improvement, to provide a basis for increasing instruction and developing novel tools on the topic.

Table 2.
Representative MCID values for the Visual Analog Scale (VAS).

Population	MCID Score (mm or units)
Acute Lower Back Pain (< 2 weeks)	20 – 35[18-22]
Chronic Lower Back Pain (> 12 weeks)	18 – 19; 20 – 25[18, 23-25]

Table 3.
Student knowledge and attitudes about MCID.

KNOWLEDGE
Which phrase is represented by the acronym MCID?
Have you administered either of the following outcome assessments using the HER system, Future Health Smart Cloud™?
Rank the top FIVE assessments you currently use.
For which of the following outcome assessments do you know the MCID values
ATTITUDE
Do you think it is important to have a tool with which to compare a patient's outcome assessment score(s) and thus have a sense of patient response to treatment?
Which of the following do you think is most relevant as it relates to a patient's overall outcome?

Methods

An anonymous questionnaire was administered to chiropractic interns. Participation was strictly voluntary, and sampling was based on student availability. The study was reviewed and approved by the University's Institutional Review Board.

Participants

Chiropractic interns were recruited by a peer (who was excluded from completing the questionnaire) when passing in the hallway. Of a total 104 eligible student interns enrolled at the time the instrument was administered, 58 interns completed the survey with a response rate of 55.8%.

Survey Instrument and Procedure

The questionnaire instrument included two demographic questions (gender and trimester in chiropractic program) and six survey items (*Appendix A*). Gender was recorded to determine whether respondents were representative of all student interns on campus (Figure 1). The trimester of study was used to confirm that only student interns completed the study. The purpose of the instrument was to determine student intern knowledge of MCID, use of outcome assessments, and use of MCID values in their outpatient clinic practice (Table 3). Further, two survey items were designed to evaluate student intern attitudes concerning need for objective patient response and relevance of the patient and/or clinician perspective to a patient's overall outcome (Table 2). Although formal validity of this piloted survey instrument was not evaluated (discussed further in Limitations), face validation by two independent clinical instructors was performed. These independent reviewers evaluated the goals and objectives of the survey, the readability of the survey items, and whether the instrument appropriately addressed the intended audience. During the independent review, both instructors found that the survey items matched the stated goals and objectives of the research study and that the instrument was written to address its intended audience. Further, they found the questions were clear and concise, suggesting easy readability; a Flesh reading ease score of 59.5 and a Flesch-Kincaid Grade Level of 9.3 supported this finding.[29,30] Student interns were verbally consented to completing the anonymous questionnaire, and questionnaires were not administered during class time.

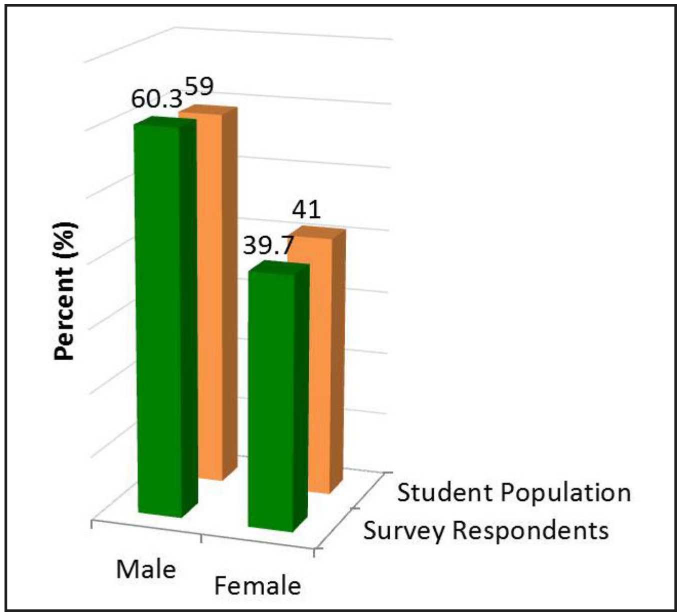

Figure 1.
Gender distribution of survey respondents and student population.

Statistics

All descriptive statistical observations were calculated using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Released 2015, Armonk, NY). Frequencies were calculated and reported as percent (%) of total responders. Where indicated, cross-tabulation was performed to compare variables. The histogram plot was generated by calculating the frequency. Cross-tabulation data were reported as frequency, with percent (%) of totals calculated within groups and across the entire population of responders in parentheses.

Results

To address the goal of evaluating our student intern knowledge and understanding of how to identify clinical relevance of a change in score on an outcome assessment, we queried the interns to identify what percentage could define the acronym MCID. Based on the demographic question, the gender of our study population was comparable to the total study population (respondents: 60.3% male, 39.7% female; student population: 59% male, 41% female; Figure 1). Nearly one-third (32.8%) of the respondents correctly identified the phrase "minimum clinically important difference" (Figure 2). The outpatient chiropractic clinic currently utilizes 14 outcome assessments (OAs) through its EHR software. Every responder had used at least two of the OAs, and histogram analysis revealed an expected bell-shaped plot (median = 6 outcome assessments used; Figure 3); however, 70.7% of respondents did not know MCID values for any of the 14 OAs in use in the clinic (Table 4). Using a simple cross-tabulation calculation, student intern knowledge of the MCID acronym was compared with knowledge of actual MCID values for the 14 outcome assessments available in the EHR system. Interestingly, 17.2% of respondents did not know the MCID acronym but knew one or more MCID values (Table 4).

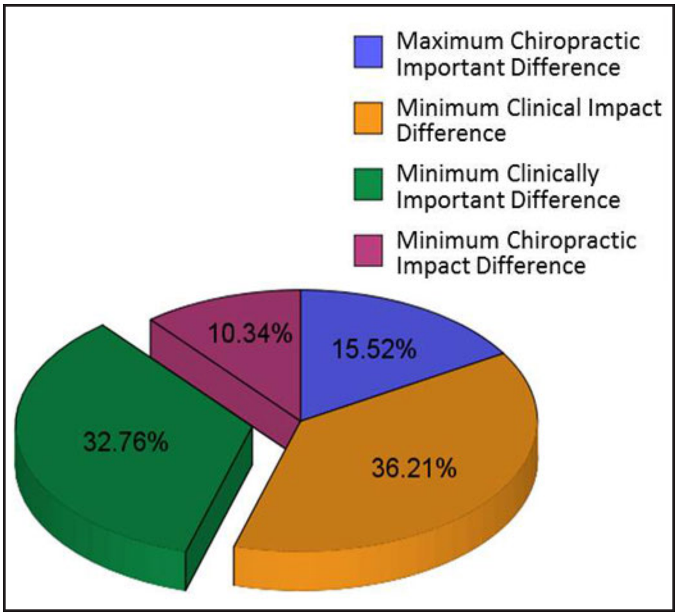

Figure 2.
Response distribution for meaning of MCID acronym.

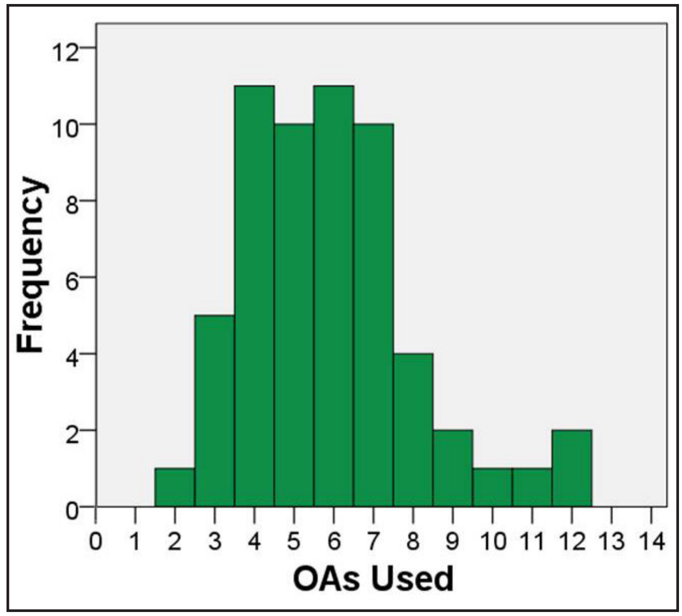

Figure 3.
Number of different outcome assessments (OAs) employed.

Discussion

The overall goal of this preliminary study was to gain insight into whether chiropractic interns know the MCID acronym, whether they know MCID values associated with the OAs currently in use, and their general perception of both the value of patient perception and importance of quantifying changes in such perceptions. Our results suggest that approximately one-third of student interns enrolled at the University know the phrase represented the MCID acronym. Further, approximately one-third of these interns report knowing one or more actual MCID values for the commonly used outcome assessments used in the outpatient clinic. These data may suggest a gap in knowledge between assessing a patient (at baseline and subsequent visits) and recognizing the clinical significance of observed changes in the patient.

It is important to note that since there are a number of methods for calculating MCID values (up to nine published)[8], there are inconsistent reported MCID values for

Table 4. *MCID acronym.*

	Maximum Chiropractic Important Difference	Minimum Clinical Impact Difference	Minimum Clinically Important Difference	Minimum Chiropractic Impact Difference	No Response	**Total**
Do Not Know MCID Values	6	16	14	4	1	**41 (70.7%)**
Knows One or More MCID Values	3	5	5	2	2	**17 (29.3%)**
Total	**9 (15.5%)**	**21 (36.2%)**	**19 (32.8%)**	**6 (10.3%)**	**3 (5.2%)**	**58 (100.0%)**

many patient-reported outcome assessments (e.g. Health Status SF-36)[8,27,31-33]. Other challenges presented when calculating MCID value for a given outcome assessment include recall bias of patient (response more reflective of current health status versus comparison between current and baseline reported values), variability of the health status across a patient population leading to wide standard deviations (particularly in distribution-based methods), and, pertinent to anchor-based methods, inherent flaws in the tools used as the anchor measure.[32,34-36] Thus, it is important to carefully weigh the use of calculated MCID values with the knowledge and experience of the clinician. However, we maintain that use of MCID is a valuable tool for integrating subjective, patient centered research into evidence based literature.

Currently, chiropractic interns at our institution receive didactic instruction (Introduction to Research course) on the difference between statistical significance and clinical difference over the course of 1-2 lectures, during the third trimester of the program. In the future, we seek to address this problem by integrating the concept of clinically important difference more frequently during the Research Methods course (often taken during the 8th trimester) while students are completing their clinic internship responsibilities. Additionally, we plan to develop a MCID reference guide for the OAs found within our EHR system; copies will be available in the clinic for use. Further, follow-up studies will validate the current survey instrument and subsequently administer to chiropractic students in various stages of study including prior to and following completion of each of the two research courses in our curriculum and following the first year of employment after matriculation. We hypothesize those students' attitudes towards the importance of patient perception of improvement and their knowledge of tools (namely, MCID) to measure the clinical significance of patient-reported improvement will increase greatly.

In a larger context, patient-reported outcome measures are increasingly used to inform evidence-based clinical practice, and complete documentation of patient outcomes is more often expected documentation for third-party payers.[28,37] Necessarily, standardization of such subjective measures has arisen as a potential tool for use in the development of evidence, and as a means to eliminate costly treatments with no measureable benefit. In fact, an editorial published in Science Magazine highlights the importance of enhancing practical use of outcome measures in terms of clinical significance through increasing practitioner familiarity and by implementing technological tools to lessen the time burden that consistent use of such measure may cause.[38]

An increase of the scientific literature to support evidence-based chiropractic practice supports both the intra-professional perception of chiropractic as an integrative health care approach and the expansion of payer coverage for care, both of which are contemporary challenges in the field.[39-41] As chiropractic student interns represent the future of chiropractic, it is important both to engage students in the research that supports scientific literature and to equip them with tools that allow them to pursue evidence based clinical practice in their independent careers. In fact, recent research has demonstrated that at one chiropractic college 99% of students surveyed agree that research is necessary for positive professional growth.[42] A second study of students representing 12 North American chiropractic colleges found that chiro-

Table 5. *Summary of literature search – MCID in chiropractic education.*

Search Terms	**Results in PubMed**	**Relevant to Topic**	**Results in Index to Chiropractic Literature**	**Relevant to Topic**
"Education" AND "MCID"	20	0	1335	0
"Education" AND "Minimum Clinically Important Difference"	12	0	1336	0
"Chiropractic Student" AND "MCID"	0	–	50	0
"Chiropractic Student" AND "Minimum Clinically Important Difference"	0	–	51	0

practic students either agree (34.8%) or strongly agree (52.2%) that is important that practicing chiropractors are educated in evidence-based practice. The majority of these students also responded affirmatively (agree or strongly agree) when asked if it's appropriate to update and enrich chiropractic theories based on scientific advancement and if scientific evidence is more important than traditional chiropractic theory, 86.8% and 51.9% respectively.[43] Taken together, these data emphasize the growing interest in research and evidence based clinical decision making among chiropractic students.

Limitations

The survey instrument used in this study was only subjected to face validation, which is a subjective assessment of the measurements. We acknowledge that more stringent validation techniques should be employed were responses to be used as a basis for major curriculum decisions. The sample size of this study was small, and limited to the number of interns who were readily available to complete the survey over the course of 3 days. It is worthy to note, however, that based on the number of total eligible interns our response rate (55.8%) was comparable to what has been observed using paper surveys in the past.[44]

Conclusion

To the best of our knowledge, this work represents the first peer-reviewed discussion of chiropractic student intern knowledge of MCID. Searches of either PubMed or Index to Chiropractic Literature (performed during February 2016; Table 5) revealed no research on the topic. Here, we sought to initiate a pilot study to determine basic intern knowledge of MCID, and attitudes towards perception of patient improvement (patient versus clinician perspective) among interns at out institution. While these data are limited, they serve as an early measure of MCID knowledge among our interns and can be used to justify more extensive study on the topic. Our future goal is to use a combination of quantifiable and consensus-based methods to develop a standardized method for calculating MCID values, and to subsequently develop and integrate a guideline for evaluating patient progress for use in the outpatient clinic. Ultimately, we seek to give student interns the tools to implement an evidence-based course of treatment for patients in their care, both during training and in their individual practices upon matriculation.

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Appendix A.
MCID Survey Instrument.

MCID Questionnaire

Please take a few minutes to fill out this survey on issues related to MCID and outcome assessments in chiropractic practice. Participation in this survey is voluntary, and your answers will be kept anonymous. Mark the box to the left of the chosen response. Thank you for your participation.

General Information

1. Gender

☐$_1$ Male ☐$_2$ Female

2. Trimester

_____/12 _____/10

Knowledge

1. Which phrase is represented by the acronym MCID?

☐$_1$ Minimum Clinically Important Difference ☐$_2$ Minimum Clinical Impact Difference
☐$_3$ Maximum Chiropractic Important Difference ☐$_4$ Minimum Chiropractic Impact Difference

2. Have you administered either of the following outcome assessments using the EHR system, Future Health Smart Cloud™ (please check all that apply)?

☐$_1$ Quadruple Visual Analogue Questionnaire
☐$_2$ Pain Intensity
☐$_3$ Patient Progress
☐$_4$ Health Status (SF-36)
☐$_5$ Headache Questionnaire
☐$_6$ Neck Disability Index (Vernon Mior)
☐$_7$ Oswestry Back Pain - Modified
☐$_8$ Roland-Morris Disability Questionnaire
☐$_9$ Copenhagen Neck Functional Disability Scale
☐$_{10}$ Functional Rating Index
☐$_{11}$ Shoulder Injury
☐$_{12}$ Boston Carpal Tunnel Syndrome Questionnaire
☐$_{13}$ Anterior Knee Pain
☐$_{14}$ Zung Depression Index
☐$_0$ None of the above

3. Rank the top FIVE assessments you currently use (please only select five assessments, ranking them 1 – 5 where 1 is the most commonly used assessment)?

☐$_1$ Quadruple Visual Analogue Questionnaire
☐$_2$ Pain Intensity
☐$_3$ Patient Progress
☐$_4$ Health Status (SF-36)
☐$_5$ Headache Questionnaire
☐$_6$ Neck Disability Index (Vernon Mior)
☐$_7$ Oswestry Back Pain - Modified
☐$_8$ Roland-Morris Disability Questionnaire
☐$_9$ Copenhagen Neck Functional Disability Scale
☐$_{10}$ Functional Rating Index
☐$_{11}$ Shoulder Injury
☐$_{12}$ Boston Carpal Tunnel Syndrome Questionnaire
☐$_{13}$ Anterior Knee Pain
☐$_{14}$ Zung Depression Index
☐$_0$ None of the above

4. For which of the following outcome assessments do you know the MCID values (please check all that apply)?

☐$_1$ Quadruple Visual Analogue Questionnaire
☐$_2$ Pain Intensity
☐$_3$ Patient Progress
☐$_4$ Health Status (SF-36)
☐$_5$ Headache Questionnaire
☐$_6$ Neck Disability Index (Vernon Mior)
☐$_7$ Oswestry Back Pain - Modified
☐$_8$ Roland-Morris Disability Questionnaire
☐$_9$ Copenhagen Neck Functional Disability Scale
☐$_{10}$ Functional Rating Index
☐$_{11}$ Shoulder Injury
☐$_{12}$ Boston Carpal Tunnel Syndrome Questionnaire
☐$_{13}$ Anterior Knee Pain
☐$_{14}$ Zung Depression Index
☐$_0$ None of the above

Attitude

5. Do you think it is important to have a tool with which to compare a patient's outcome assessment score(s) and thus have a sense of patient response to treatment?

☐5 Strongly Agree
☐4 Agree
☐3 Neutral
☐2 Disagree
☐1 Strongly Disagree

6. Which of the following do you think is most relevant as it relates to a patient's overall outcome?

☐1 Outcome based on the patient's perspective
☐2 Both of these
☐3 Impression of change from the clinician's perspective
☐4 Neither of these

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Multiple seizure-induced thoracic vertebral compression fractures: a case report

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Background: *Musculoskeletal injuries stemming from forceful muscular contractions during seizures have been documented in the literature. Reports of multiple seizure-induced spinal fractures, in the absence of external trauma and without risk factors for fracture, are rare.*

Case Presentation: *A 28-year-old male, newly diagnosed with epilepsy, presented to a chiropractic clinic with the complaint of mid-thoracic pain beginning after a tonic-clonic seizure with no associated external trauma. Radiographs revealed the impression of five new vertebral compression fractures from T4 to T8.*

Discussion: *This report highlights the importance of a complete history and examination of patients with a history of tonic-clonic seizures and back pain, especially when considering spinal adjustments.*

Contexte : *Des études sur les blessures musculo-squelettiques résultant de contractions musculaires forcées pendant les crises épileptiques ont déjà été publiées dans les revues scientifiques. Les rapports de fractures vertébrales multiples causées par des crises épileptiques, en l'absence de traumatismes externes et sans facteurs de risque de fracture, sont rares.*

Exposé de cas : *Un homme de 28 ans, qui a reçu un diagnostic récent d'épilepsie, s'est présenté à une clinique de chiropratique se plaignant d'une douleur mi-dorsale débutant après une crise de grand mal sans traumatisme externe associé. Les radiographies révèlent l'impression de cinq nouvelles fractures vertébrales par compression de T4 à T8.*

Discussion : *Ce rapport souligne l'importance d'un historique complet et de l'examen des patients ayant des antécédents d'une crise de grand mal et de douleurs dorsales, en particulier si l'on envisage des ajustements vertébraux.*

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Summary: *This case report presents an argument that a tonic-clonic seizure, in the absence of external trauma or significant risk factors for fracture, resulted in multiple vertebral compression fractures.*

(JCCA. 2016;60(3):252-257)

KEY WORDS: chiropractic, seizure, back pain, thoracic, compression fracture, spinal manipulation

Résumé : *Ce rapport de cas présente l'argument qu'une crise de grand mal, en l'absence de traumatismes externes ou de facteurs de risque significatifs pour fracture, a donné lieu à de multiples fractures vertébrales par compression.*

(JCCA. 2016;60(3):252-257)

MOTS CLÉS : chiropratique, crise épileptique, douleur dorsale, thoracique, fracture par compression, manipulation vertébrale

Background

Musculoskeletal injuries stemming from forceful muscular contraction during seizures and associated external trauma (e.g. due to falls), have been documented in the literature.[1-8] Early electroconvulsive therapy studies documented spinal fractures secondary to induced convulsions.[9,10] However, epileptic seizure-induced fractures of the spine, in the absence of external trauma, are rarely reported in the literature.[11-14]

Powerful seizure-related abdominal and paraspinal muscle contractions create compressive flexion forces that induce significant vertebral axial loading[15], which can lead to vertebral compression fractures[9,16]. These compression fractures are most commonly found in the upper and middle thoracic spine, compared to external trauma-induced compression fractures, which are more often found in the lower thoracic and lumbar spine.[9,16] Although very rare, seizure-induced burst fractures resulting in neurological compromise (e.g. cauda equina compression) have also been reported, highlighting the extent to which muscular contractions can induce injury.[17,18] The following report describes a case of seizure-induced vertebral compression fractures from T4 to T8, in the absence of external trauma or known risk factors for vertebral fracture.

Case Presentation

Clinical History

A 28-year-old, otherwise healthy male, presented to a chiropractic clinic with a ten-day history of mid-thoracic discomfort the onset of which was immediately following a tonic-clonic seizure. This was his second known seizure. His first was 15 months prior, with no known associated injury. Investigation (brain computed tomography (CT), magnetic resonance imaging (MRI), and electroencephalogram (EEG)) after his first seizure led to treatment for primary generalized epilepsy with lamotrigine, which has not been found to significantly affect bone mineral density in the short term.[19,20] No other risk factors for osteopenia/osteoporosis were identified, including excessive alcohol consumption or tobacco use. The more recent seizure was observed by his wife, who described the convulsion posture as trunk forward flexion with rotation while sitting on a couch. There was no associated fall or other external trauma. Since this seizure he reported suffering mild to moderate back discomfort aggravated with prolonged lying and standing, taking deep breaths, and coughing. Night pain was also reported. Relieving factors included: ice, heat, and sitting in a chair with lumbar support. There were no radicular symptoms or signs identified.

Examination

Tenderness was present over the mid-thoracic spinous processes. Spasm of the thoracic paraspinal musculature was noted, especially on the left. All thoracic spine active ranges of motion (ROM) were mildly uncomfortable and described by the patient as "tight", especially on the left. Specifically, active thoracic spine ROM was decreased especially in right rotation and right lateral flexion, due to increased left thoracic pain. Right and left active thoracic spine extension combined with ipsilateral rotation and lateral flexion produced mild mid-thoracic discomfort. Prone posterior-anterior compression over the costotransverse joints was unremarkable. When the patient

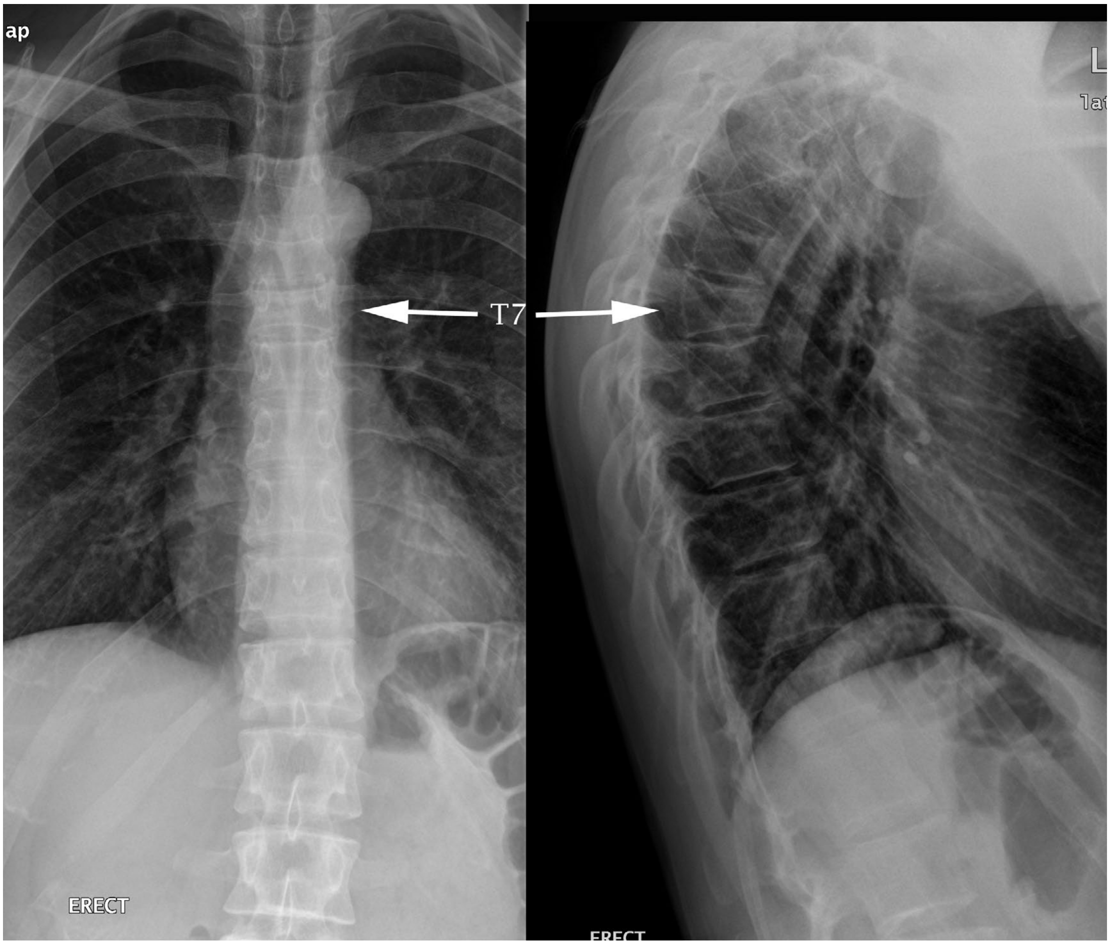

Figure 1a.
AP and lateral views of the thoracic spine demonstrated moderate anterior wedged deformity of T7 vertebral body with approximately 50% loss of vertebral body height.

transitioned on and off the examination table he exhibited significant guarding, beyond what was expected in a patient with typical mechanical back pain.

Imaging

Based on the clinical assessment, the differential diagnosis included thoracic spine fracture(s). Plain radiographic examination was conducted. The AP and lateral radiographs of the thoracic spine (Figure 1a) revealed a 50% anterior compression fracture at T7 with a slight convex posterior vertebral body margin. Accentuated superior endplate concavities (white arrows) with 20% loss of central vertebral body heights of T6 and T8 are depicted on the close-up lateral view (Figure 1b). Hazy zones of condensed trabeculae (arrowheads) were noted subjacent to the T6 and T7 superior endplates (Figure 1b). Anterior wedging and slight superior endplate concavity were demonstrated at T4 and T5 on the swimmer's view (Figure 2).

Diagnosis and Management

The clinical impression was that of acute seizure-induced mid-to upper thoracic spine compression fractures (T4-T8). While there are clinical practice guidelines for the

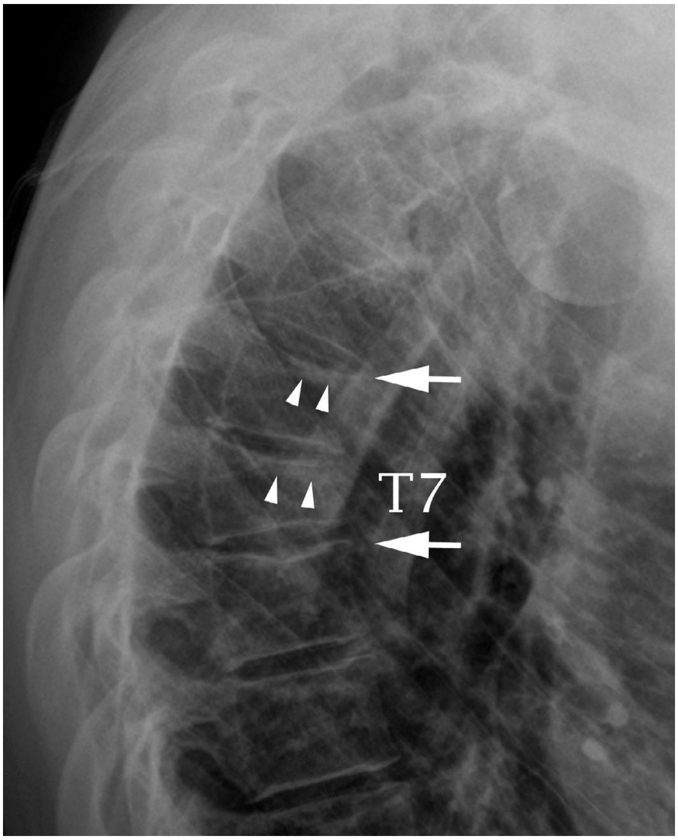

Figure 1b.
Close-up lateral view of the upper thoracic spine revealed the convex deformity of the posterior vertebral body of T7 as well as the accentuated superior endplate concavities of the T6 and T8 (white arrows). Zones of impacted trabeculae (arrowheads) were evident subjacent to the T6 and T7 superior endplates.

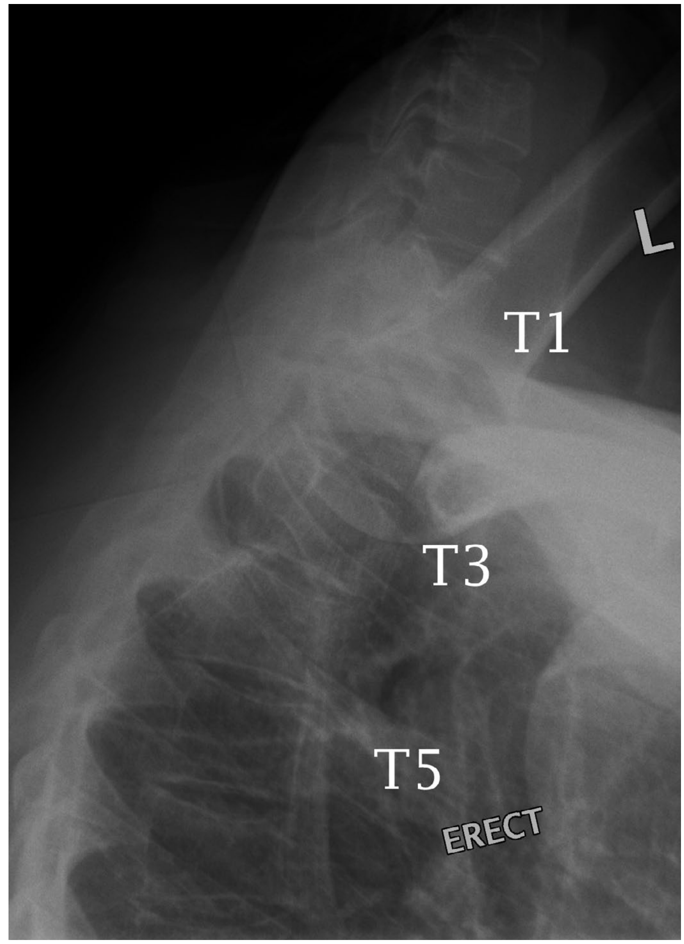

Figure 2.
Swimmer's view revealed the accentuated superior endplate concavities at T4, T5 and T6 when compared to the T3 superior endplate.

management of osteoporotic vertebral compression fractures[21], only a small body of low-level evidence was available focusing on the management of younger individuals presenting with seizure-induced spinal fractures[11-14]. The patient was referred to his family medical doctor for further investigations and to discuss the utility of bracing and pain medications. Dual-energy x-ray absorptiometry (DEXA) was found to be normal and the patient did not feel the need to pursue bracing or invasive treatment options. Conservative management was multimodal, including advice regarding: relative rest, cryotherapy, and gentle thoracic extension exercises to be performed at home. During a follow-up approximately six-weeks post-seizure, he stated that he was "doing very well". During a three-month post-seizure follow-up, he noted a gradual reduction in his discomfort over time and was only occasionally uncomfortable when standing for long periods. During a fourteen-month post-seizure follow-up, he noted that he has continued to do very well and rarely feels any back discomfort.

Discussion

Compression fractures from T4 to T8 are suggestive of a muscular-induced mechanism, such as an epileptic seizure or electroconvulsive therapy.[22] Seizure-induced thoracic compression fractures in our case are differentiated from Scheuermann's disease based on the location in the upper thoracic vertebrae. Scheuermann's disease occurs in the middle thoracic and thoracolumbar spines commonly and not in the upper thoracic spine.[22] Furthermore, compression fractures do not usually demonstrate the characteristic irregular endplates/Schmorl's nodes and disc narrowing found in Scheuermann's disease. Upper thoracic compression fractures can be found in the elderly population with osteoporotic spines. Our patient is young with a normal bone density imaging finding. These upper thoracic compression fractures are easily differentiated from old healed compression fractures by the appearance of impacted zone of trabeculae subjacent to the deformed endplates. The compression fractures in this case are also differentiated from pathological vertebral compression fractures, which can have decreased anterior and posterior vertebral body heights (uniform collapse), which should prompt further investigation.[22]

The literature on compression fractures is focused on the osteoporotic population, as poor bone density is a significant risk factor for vertebral compression fractures.[23] Although most osteoporotic vertebral compression fractures are stable and managed conservatively[23], they may not always be obvious during the clinical encounter or on plain radiographs. Evidence suggests this is also true of seizure-induced vertebral fractures.[15] This is important, as a delay in diagnosis and the delivery of inappropriate treatments may be detrimental to the patient. Youssef *et al*.[15] describe the case of a tonic-clonic seizure-induced burst fracture in a 35 year old male who initially presented with mild paraspinal pain and a normal neurological exam. This seizure occurred while he was sitting on a couch and similar to our case, suffered no external trauma. This man was treated using a Risser cast; however, this was not successful. He subsequently underwent posterior spine fusion with Cotrel-Dubousset segmental instrumentation with iliac crest bone grafting.[15] The potential for subtle spinal fractures to be mistaken for a simple musculoskeletal sprain/strain, in the absence of external trauma, in patients who have suffered a tonic-clonic seizure, is highlighted in this previous case report.[15]

The potential for further complications may arise, as discussed by Youssef *et al*.[15] in patients presenting in a post-ictal state with this requiring the attending health care practitioner (likely an emergency department physician) to perform a careful examination of the shoulders, hips, pelvic girdle, as well as the entire spine[14]. Youssef *et al*.[15] suggest that the presence of mild paraspinal pain after a seizure should still provoke suspicion of spinal fractures and prompt radiographic evaluation. Plain radiographs can have a significant false-negative rate when attempting to detect spinal fractures, especially unstable spinal fractures (e.g. burst fractures), suggesting the need for advanced imaging such as CT or MRI to provide an accurate diagnosis and optimal patient management.[24-26] In particular, advanced imaging (MRI) is required to rule out spinal cord or nerve root compromise.[23] MRI can also help confirm the age of compression fractures, as it can show bony edema in acute fractures.[23]

The current case could have been misdiagnosed as acute mechanical back pain originating from a sprain/strain injury where spinal imaging may not be indicated.[27] Mechanical back pain is often treated by chiropractors and other manual health care providers with spinal mobilization and/or adjustments. However, these interventions are considered to be absolute contraindications in the presence of new spinal compression fracture(s), highlighting the potential risk of missed spinal fracture(s).[28,29]

Haldeman and Rubinstein[30] published four cases where patients were noted to have compression fractures following chiropractic spinal manipulation. Although a causal relationship between the spinal manipulation and the fractures in these four cases was unclear, the authors noted that failure to identify compression fractures with the subsequent application of spinal adjustments into the fractured area can increase pain and prolong disability.[30] Furthermore, the potential to cause iatrogenic spinal cord injury is of great concern.

Summary

This case highlights the possibility that the compression fractures identified were likely the result of a recent seizure. This suggests that severe muscular contractions secondary to tonic-clonic seizures, in the absence of secondary trauma/external forces, can result in spinal fractures. The report highlights the importance of obtaining an appropriate history and undertaking a musculoskeletal and neurological examination, as indicated, in patients presenting with spinal pain following a tonic-clonic seizure. The symptoms and signs of epileptic seizure-induced spinal fractures may be mild and resemble simple acute mechanical back pain. Health care providers should consider radiographic evaluation when a tonic-clonic seizure results in spinal pain, especially before delivering spinal mobilization or adjustments.

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Imaging case reviews

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Recent surveys have shown that a perceived "lack of time" is one of the main reasons why chiropractic clinicians do not read research literature.[1-3] Case reports[4], which are typically shorter in length (1,500 to 2,500 words) than most scholarly papers, can also be judged by busy practitioners as too long to read and or irrelevant to clinical practice. The notion of researching and writing up a case study for peer-review and publication, especially for the inexperienced author and/or busy clinician, can be even more daunting.

The purpose of this editorial is to introduce a new type of case report to the chiropractic literature, the *Imaging Case Review (ICR)*. Similar to the case studies published in the Journal of Radiology Case Reports[5], ICRs are intended to give chiropractic radiologists and clinicians a professional forum in which to showcase interesting or novel diagnostic imaging cases from clinical practice, written in an abbreviated format. Because of their brevity and relevance to 'real-world' clinical practice from where they originated, it is believed that these short articles are ideal for busy practitioners and researchers alike.

ICRs are brief, easy-to-read, descriptive case reports where the primary focus is on the visual diagnostic image(s). The images should be relevant to chiropractic clinical practice and may include, but are not limited to, radiographs, computed tomography (CT), magnetic resonance imaging (MRI), diagnostic ultrasonography, and scintigraphy (i.e. bone scan). High quality images (e.g. JPEG, TIFF, PNG, or EPS format) will be accompanied by a brief case presentation (of 500 words or less), one or two tables listing the key clinical / imaging features and differential diagnoses of the disorder, figure captions, a few key messages, and one to eight reference citations (see author template in Appendix 1).

ICRs are not intended to replace the traditional case report[4] or the evidence-based case report[6-8], but to give prospective authors an additional format in which to present their clinical cases. To be considered for publication, ICRs should be educational and present interesting, novel, rare, or unusual imaging cases from clinical practice. Cases with clinical 'pearls' are also encouraged.

We hope that readers of the JCCA, and clinicians in particular, will find these short case presentations interesting and informative. Both seasoned and first-time authors including radiologists, clinicians, educators, and students are invited to compose and submit ICRs to the JCCA for publication.

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Appendix 1.
Author template for Imaging Case Reviews (ICRs).

Title Page:
- Short, informative title
- Statement about patient consent
- Brief abstract
- Key words

Case Presentation (500 word limit):
- Case history
- Clinical examination findings
- Diagnostic imaging findings, with reference to Figure(s)
- Intervention and outcome
- Brief discussion about the clinical disorder (supported by 1-8 reference citations)
- Long term follow-up of patient (if any)
- Table(s) listing key clinical / imaging features and or differential diagnoses
- Key message(s)
- Online reference for further reading and other case examples (e.g. Radiopaedia.org) (*optional*)
- Figure legends
- References

Advanced hip joint degeneration associated with femoroacetabular impingement in a retired chiropractor

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Femoroacetabular impingement is a relatively new clinical entity only recently described in the orthopedic literature. In this report, we document a severe case of hip joint osteoarthritis associated with cam-type impingement in a retired chiropractor.

(JCCA. 2016;60(3):260-262)

KEY WORDS: chiropractic, femoroacetabular impingement, osteoarthritis, hip joint

Le conflit fémoro-acétabulaire est une entité clinique relativement nouvelle, récemment décrite dans les revues orthopédiques. Dans ce rapport, nous documentons un cas grave d'arthrose de l'articulation de la hanche associée à un conflit de type à came chez un chiropraticien à la retraite.

(JCCA. 2016;60(3):260-262)

MOTS CLÉS : chiropratique, conflit fémoro-acétabulaire, arthrose, articulation de la hanche

Case Presentation

A 67-year-old retired chiropractor (of 42 years) presented with a chief complaint of chronic and worsening right-sided hip pain of five years' duration. The pain was described as a deep "burning" sensation in the right buttocks that occasionally referred to behind the right knee. Daily activities such as prolonged standing, getting in and out of a car, climbing stairs, and right side-lying were provocative. Lying supine with a pillow behind the right knee and or taking over-the-counter pain medication (Acetaminophen, Tylenol) were palliative. While still working as a chiropractor, the pain was also exacerbated when flexing the right hip to perform a 'side-posture' lumbar spinal adjustment, particularly if using a "shin to knee" contact.[1] The patient had been retired from clinical practice for two years at the time of presentation. His hip pain had become increasingly debilitating over the past 12 months and was now graded with a severity of eight out of a possible 10.

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The patient has consented to having his personal health information including radiographs published.

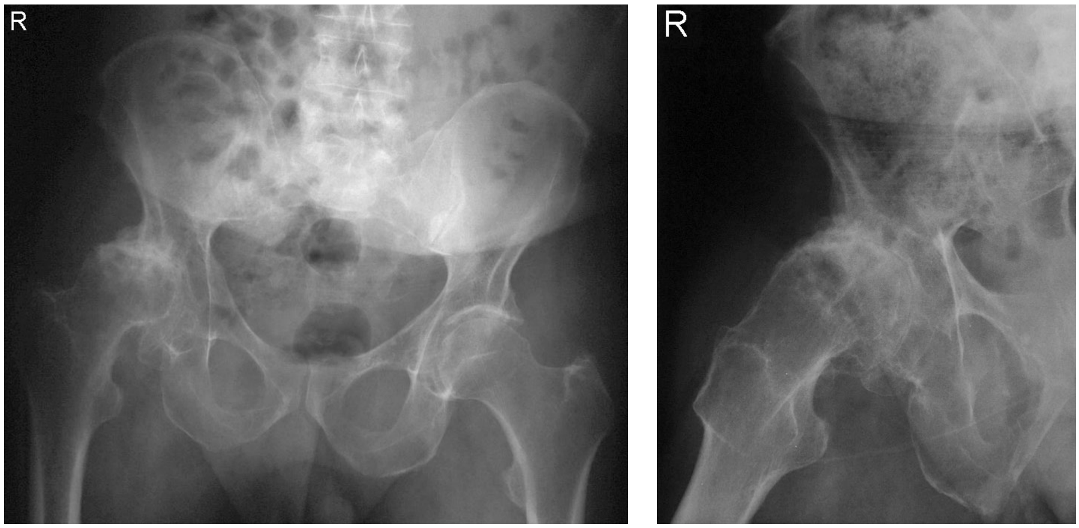

Figure 1.
a) *Anteroposterior pelvis and* b) *frog-leg projection of the right hip reveal complete obliteration of the hip joint space with associated subchondral sclerosis, osteophyte formation, and subchondral cyst formation. Superolateral subluxation of the femoral head is also present. Both femoral head/neck junctions reveal a prominence on the lateral surface consistent with a "pistol grip" deformity typical of cam-type FAI. The left hip joint exhibits only minimal degenerative changes compared with the right.*

On examination, he walked with a noticeable limp. Range of motion testing of his right hip joint revealed pain and limited mobility in all ranges, but there was severe pain and 80% restriction with flexion, adduction, and internal rotation. The combination of those three movements (i.e. Hip Impingement Test[2]) provoked his hip complaint. Moving the right hip joint into extension, abduction, and external rotation provided some relief. Anteroposterior (Figure 1a) and right frog-leg (Figure 1b) radiographic projections revealed bilateral cam-type (or 'pistol-grip') femoral deformities[2,3] with severe advanced degenerative joint disease of the right hip. Based on these findings, the patient was diagnosed with right anterior hip joint impingement with severe underlying osteoarthritis. Table 1 lists the key imaging features[2,3] and etiologies[4] for cam-type femoroacetabular impingement (FAI) syndrome.

FAI is a relatively new clinical entity only recently described in the orthopedic literature and has been implicated as an important contributor to hip pain in adults and idiopathic osteoarthritis of the hip later in life.[2-5] Notably, however, not all patients with radiographic evidence of FAI will present with clinical symptoms or develop progressive hip joint degeneration.[2,6,7] Further, the prevalence and the incidence rates of FAI with or without hip joint osteoarthritis in practising and/or retired chiropractors are unknown. The patient in this case was referred for orthopedic surgical consultation and underwent successful total right hip joint arthroplasty four months later. For

Table 1.
Key imaging features and etiologies of cam-type FAI.

Key imaging features
• Asphericity of the femoral head with osseous 'bump' formation at the anterolateral femoral head-neck junction • Morphology of the proximal femur resembles a pistol handle (i.e. 'pistol-grip') • Alpha angle measures > 55° • Decreased or absent femoral head-neck offset
Known etiologies: malunion of a femoral neck fracture, slipped capital femoral epiphysis, developmental dysplasia of the hip, or Legg-Calvé-Perthes' disease

more information and additional examples of FAI, visit Radiopaedia.org.[8]

Key Messages

- Cam-type deformities of the femoral neck often have a 'pistol-grip' appearance
- FAI has been associated with hip pain in young adults and osteoarthritis of the hip joint later in life

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Sciatic neuralgia associated with a perineural (Tarlov) cyst

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Perineural (Tarlov) cysts are rare and are usually asymptomatic and an incidental finding on routine spinal imaging. Presented here is a case of sciatic neuralgia in a 56-year-old patient whose clinical symptoms correlated with a lower lumbar perineural cyst.

(JCCA. 2016;60(3):263-265)

KEY WORDS: chiropractic, perineural cyst, Tarlov cyst, sciatica

Les kystes périneuraux (Tarlov) sont rares, et sont généralement asymptomatiques et une observation fortuite d'une imagerie routine de la colonne. Nous présentons ici un cas de névralgie sciatique chez un patient de 56 ans dont les symptômes cliniques correspondaient à un kyste périneural lombaire.

(JCCA. 2016;60(3):263-265)

MOTS CLÉS : chiropratique, kyste périneural, kyste de Tarlov, sciatique

Case Presentation

A 56-year-old man presented with a 2-year history of severe and progressing left-sided low back and leg pain, described as "sharp" and "pinching" when either walking or arching his lower back. The pain severity was rated as a nine out of 10, and his overall Bournemouth Questionnaire[1] score totalled 39 out of a possible 70, where zero equals no disability and 70 equals complete disability. The low back and leg symptoms were most intense in the evening. Flexing his left leg at the knee joint and or taking non-steroidal anti-inflammatory medication (Ibuprofen, Advil) provided relief. On physical examination, the Straight Leg Raise test[2] (at approximately 30° of hip flexion), the Hibb's test, and the Yeoman's test each elicited pain and parasthesia down the patient's left leg; the Double Leg Raise, seated Kemp's, and Nachlas' tests were negative. Lower limb neurological examination (including motor, reflex, sensory, and vibratory testing) was normal.

Lumbar spine magnetic resonance imaging (MRI) had been performed at a hospital one month earlier. In the attending radiologist's report, there was a left-sided

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The patient has provided written consent to having his personal health information, including diagnostic images, published.

Figure 1.
Left parasagittal T2-weighted MR image reveals a high signal lobulated mass within an enlarged left L4-5 neural foramen. The mass is compressing and displacing the L4 nerve root into the undersurface of the L4 pedicle (arrow).

Figure 2.
An axial T2-weighted MR image shows the high signal, fluid-filled, lobulated mass resulting in a focal scalloped erosion of the left posterolateral aspect of the L4 vertebral body and marked lateral displacement of the left exiting L4 nerve root. The mass abuts and minimally compresses the thecal sac adjacent to the descending L5 and S1 nerve roots.

perineural/arachnoid cyst (measuring 1.1 cm) noted at the L4-5 level in addition to degenerative changes at L4-5 and L5-S1. However, no clinical correlation or recommendation for further investigations or treatment was given. Copies of the patient's MR images were subsequently obtained and these clearly revealed that the perineural cyst was displacing the left L4 nerve root and had resulted in posterior vertebral body scalloping and enlargement of the left L4-5 neural foramen (Figures 1 and 2). Based on these findings, the patient was diagnosed with sciatic neuralgia resulting from a left-sided L4-5 perineural cyst.

Perineural cysts were first described by Tarlov in 1938.[3] Tarlov cysts are rare and arise from the perineurium membrane surrounding the spinal nerve root, near the dorsal root ganglion. Most are asymptomatic and are an incidental finding on routine spinal imaging. Symptomatic cases are typically treated by surgical excision, needle aspiration, or steroid injection, although some cases resolve spontaneously.[4-6] The key imaging features and differential diagnoses for Tarlov cysts are listed in Table 1.

The patient in this case was referred back to his primary care physician with a recommendation for neurosurgical consultation. A conservative approach was taken, however, and after four months the patient's sciatic symptoms spontaneously resolved. Because a second MRI was not obtained, it is possible that the patient's imaging findings were coincidental to his clinical symptoms. Regardless,

Table 1.
Key imaging features and differential diagnoses of Tarlov cysts.

Key imaging features
• Circular or ovoid lobulated, fluid-filled (CSF) mass within the spinal canal or neural foramen • Hyperintense on fluid-sensitive (T2-weighted) MR images • May exhibit stenosis with nerve root and/or thecal sac compression • May result in adjacent erosion of pedicles or vertebral bodies • May accompany adjacent disc herniation
Differential diagnoses: facet joint synovial cyst, intraspinal neoplasms

CSF = cerebrospinal fluid

his improvements were still maintained at follow-up (via telephone) one year later. For more information on Tarlov cysts visit Radiopaedia.org.[7]

Key Messages

- Perineural (Tarlov) cysts are rare and are usually asymptomatic
- Symptomatic cases can be treated surgically although some cases resolve spontaneously

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