Case Reports

Manipulative and Multimodal Therapies in the Treatment of Osteoarthritis of the Great Toe: A Case Series

James W. Brantingham DC, PhD^a, Tammy Kay Cassa DC^{b,*}

^a *Adjunct Faculty, Logan University, Chesterfield, MO*

^b *Private Practice, Cassa Family Chiropractic, Erie, PA*

Received 12 September 2014; received in revised form 20 July 2015; accepted 20 July 2015

Key indexing terms:

Osteoarthritis;
Hallux;
Hallux rigidus;
Chiropractic;
Manual manipulation

Abstract

Objective: The objective of this case series is to describe manual manipulative therapy with exercise for 3 patients with mild to moderate osteoarthritis of the great toe.

Clinical Features: Three patients, a 32-year-old man, a 55-year-old woman, and a 49-year-old woman, had great toe pain of 8, 1, and 2 years, respectively. Each had a palpable exostosis, a benign outgrowth of bone projecting outward from the bone surface, and decreased dorsiflexion with a hard end-feel.

Intervention and Outcome: Manual manipulative therapy with exercise, the Brantingham protocol, was used with patients receiving 6, 9, and 12 treatments over 6 weeks. Specific outcome measures for hallux rigidus and the foot were chosen to document the effects of this intervention including digital inclinometry, the lower extremity functional scale, the foot functional index, overall therapy effectiveness and Visual Analogue Scale (VAS). Each patient had an increase in range of motion that surpassed the minimal clinically important change, an increase in the overall therapy effectiveness and a decrease in the foot functional index that surpassed the minimally clinically important difference. Most importantly for the patients, each reported a decrease in both usual and worst pain on the VAS that exceeded the minimally clinically important difference of 20 to 30 mm.

Conclusion: The 3 patients reported decreased pain measured by the VAS, increased range of motion and minimally clinically important difference in 3 other outcome measures.

© 2015 National University of Health Sciences.

Introduction

Osteoarthritis is the second most common great toe disorder, exceeded only by hallux valgus, and is a

leading cause of disability and chronic pain in the elderly.^{1–3} Since 1887 painful osteoarthritis (OA) of the great toe has most often been labeled hallux rigidus (HR).¹ Up to 10% of those 20 to 34, 44% over 80, and

* Corresponding author at: 4510 Peach Street, Erie, PA 16509. Tel.: +1 814 923 6024; fax: +1 888 795 0726.

E-mail address: drcassa@gmail.com (T. K. Cassa).

42.4% 62 to 94 years old show signs of OA of the great toe with men being affected at a higher rate than women.^{4,5} Multiple etiologies have been posited, but repetitive or traumatic toe-off or other severe trauma in sports is most commonly recognized for unilateral HR, and a familial history is associated with bilateral HR.^{5,6} Hallux limitus is sometimes used to denote a painful but lesser restricted motion, but the orthopedic literature more commonly uses HR for mild to severe grades of the disorder.^{1,2} Recent research suggests that the full within-normal limits of range of motion (ROM) of the great toe is unclear; however, it is universally acknowledged that loss of ROM of the great toe in dorsiflexion may be the most serious functional deficit suffered in HR.^{1,2}

Osteoarthritis is classified into 3 categories: mild – maintained joint space, minimal changes, moderate – some narrowing, cysts and sclerosis and severe – severe changes with loose bodies via radiology findings.⁷ The Kellgren-Lawrence grade (K-L system) is a scoring tool used to assess the severity of osteoarthritis on a plain radiograph.⁷ The osteoarthritis is scored 0 through 4. The scoring ranges from no radiographic features to large osteophytes, marked joint space narrowing, severe sclerosis, and definite bony deformity.⁸

Residual pain and or stiffness, after sprains such as “Turf Toe” (hyper-extension sprain) has been documented as producing symptoms five years post diagnosis.⁹ DD Palmer, the founder of chiropractic, recognized this disorder and recommended repetitive high velocity low amplitude (HVLA) thrust manipulation for great toe “ankylosis”.⁴ Interestingly, only the last decade has seen any research into conservative treatments for HR by randomized controlled or clinical trials (RCTs).^{1,2,6}

There is no conservative therapy that has been demonstrated superior to placebo in the treatment of HR.^{1,2,4,10–12} Conservative treatments such as exercise, orthotics, steroid injections, felt padding, various rocker bottom casts or shoes, braces, splinted insoles, specialized foot orthotics, or a “punched out, stretched or split” canvas or leather toe box remain traditional, empirical, untested, or failed treatments.^{1,2,10,13,14} A recently published RCT of hyaluronic acid injection was not superior to sham saline injection for HR.¹² A newly designed RCT comparing “off-the-shelf” rocker bottom shoes to an “off-the-shelf” specialized orthotic is underway but not yet complete.¹⁵

It is recommended that prior to surgery, manipulation should be tried for grades I and II HR and only after protracted, severe pain when all empirical,

traditional treatments having failed, is surgery justified; with the only supportable evidence based surgery agreed upon by all as arthrodesis.^{8,16–21} In addition to the recent Cochrane review of interventions for HR that supports only one physical therapy RCT with manual therapy, there are other reviews, case series, reports, peer reviewed papers and texts supportive of manual manipulative therapy (MMT) for HR.^{1,12,19–26}

There is a very small subset of non-OA HR in which passive MMT is contraindicated; such as ischemic or avascular necrosis. Generalized rheumatoid arthritis, systematic inflammatory arthritides, seronegative spondyloarthropathies, Reiter’s syndrome, enteropathic arthritis, psoriatic arthritis, gout, systemic lupus erythematosus (SLE), juvenile idiopathic arthritis, diabetes type 1, and infection must be ruled out.^{14,27–30} In the United States, these and similar disorders should be referred to the appropriate MD or DO. Certainly an individual can have painful HR concurrently with painful hallux abducto valgus (HAV) and other non-musculoskeletal disorders named above, but an HAV angle greater than 20° rules out treatment for HR.^{1,2,12}

The purpose of this case series is to document the reported effect specific MMT with exercise had on 3 patients with mild to moderate osteoarthritis of the great toe.

Case Series

This case series was completed at Cleveland Chiropractic College in Los Angeles with approval from the college institutional review board. Along with informed consent by participating patients regarding the proffered chiropractic care (mobilization, manipulation, exercise, advice, and education), all care was provided without charge. A diagnostic algorithm and differential diagnosis to rule out systemic disease with first ray predilection with radiology and blood tests was used to diagnose mild to moderate HR for this series.^{30,31} Specific outcome measures for HR and the foot were prospectively chosen. The full diagnostic and treatment protocol, known as the Brantingham protocol (manual and adjunctive therapy), used in this case series is published elsewhere.^{16,17} In the original paper the soft tissue treatment was open to modification based upon functional assessment, age, fitness and special needs.¹⁷ See Tables 1 and 2 and Figs 1 to 5.

Specific outcome measures for HR were taken at baseline and the end of treatment. Digital Inclinator was used to measure ROM of the great toe. Digital inclinometry has acceptable intra-rater reliability, with

Table 1 The Brantingham Protocol (2007)^{16,17}

Intervention	Notes
1. Radiographic examination ^{1,16}	Grades 0 through 4, traditionally grades 3+ have not been treated; however, these x-ray grades have not been standardized and in fact grade 3 in the past encompassed grades 3 and 4 as per the Kellgren-Lawrence OA designations. Rule out fracture, avascular necrosis (AN) and HAV.
2. Laboratory ¹⁷	Rule out metabolic disease; gout, severe degenerative joint grade 3 or 4 OA, rheumatoid arthritis, diabetes (particularly type 1), etc.
3. No contraindications ^{19,20} Grade 3 oscillating mobilization (mbl) axial elongation for the 1st MTPJ When suitable, a grade 5 HVLA axial elongation thrust, or tractive impulse pull (the “thrust”) usually with very slight plantar flexion of about 5° (pulling the great toe forcefully into plantar flexion “or down” toward the floor (as is commonly done with the lesser toes) is strictly contraindicated	2 sets of 20 reps w/ an increase or decrease as appropriate. 1-3 times See Figs 1, 2, and 4
4. Sesamoid mbl prox to dist; grade 3 to 4. ¹¹	2 sets of 10 mbl; increase or decrease as appropriate. See Fig 3
5. Adjustive technique: 1st cuneiform...plantar to dorsal prone “snap move” like a “cuboid snap” grade 5 2nd and 3rd cuneiform ^{8,17}	2 sets of 10 mbl followed by grade 5 HVLA
6. Intermetatarsal glide mbl 2nd-5th MTPJs ^{8,17}	2 sets 10 rep w/ 10 s rest in between at a 1 s grade III to IV mbl See Fig 5
7. Plantar flexion of the 2nd-5th MTPJs w/ concurrent dorsiflexion of the metatarsal head ⁸	If not too stiff, painful or both—carefully assess before application; can aggravate or injure patient
8. Assess ankle for ↓ dorsiflexion, from a right angle which is essentially 0°, the ankle should be passively able to dorsiflex 20° or more ²³	Axial pull/thrust known as the “mortice separation” to increase A to P talar motion or “scoop” done concurrently with axial elongation grade 5 manipulation to ↑ dorsiflexion.
9. FKC manipulation or mbl as indicated for reasons such as significant (sig) loss of ROM, function and or sig pain. ¹²	The authors are in full agreement w/ an earlier writer that there should be no mbl of the great toe into dorsiflexion, even grades III but especially through IV, IV+ or IV++ and above all grade V thrust manipulation. ¹⁵ However this does not rule out very gentle, very light stretch into dorsiflexion just <i>gently</i> up to the “barrier” (or gently up to the point at which all “slack is removed”) 2 × for a 30 s stretch, 2-3 times per day.
10. Exercise and gentle stretch protocol ^{19,20}	Modify based upon functional assessment, age, fitness and special needs. See Table 2
11. Apply soft tissue therapy (ST), pressure point therapy or petrissage especially to the plantar muscles proximal to sesamoids and to tender points or tight fascia including any mm such as the gastrocnemius soleus mm too as is indicated. ^{9,19,20}	Shamus used ultrasound to heat the tissues and relieve pain.

HAV, hallux abducto valgus; HVLA, high velocity low amplitude; MTPJ, metatarsal phalangeal joint; OA, osteoarthritis; ROM, range of motion.

intra-class correlation coefficients of 0.88, CI 95%.^{32,33} A minimal clinically important change (MCIC) in dorsiflexion has been determined to be an increase of 10° to 20° and an increase of 20° to 40° is associated with high levels of decreased pain, increased function, and quality of life.^{2,8,12,17} Lower Extremity Functional Scale is valid and reliable for lower extremity disability.³⁴ Foot Functional Index is valid and reliable for foot disability.³⁵ A patient rated satisfaction scale or global rating of change score was used: the valid and reliable Overall Therapy Effectiveness scale (OTE).³⁶ Visual Analogue Scale (VAS) was obtained at baseline

and follow up as usual pain and worst pain (0-100mm).^{37,38} In the event a serious adverse reaction was reported in the SOAPE (subjective, objective, assessment, plan, education) note then the Numerical Pain Rating Scale would be used.^{37,38}

Patient #1

A 32-year-old man presented with left great toe pain 8 years in duration with a general and essentially unremarkable history. A regional examination was performed on his left foot and great toe. He first injured

Table 2 Protocol Exercises^{9,19}

Exercise	Set/repetitions
Isometric resistance to 1st MTPJ flexion	Hold 10 seconds 10 times for the first 1 or 2 tx
1st MTPJ isotonic flex	5 sets of a 5 s hold; if no undo strengthening off of a step so that the 1st MTPJ can flex slightly below the step
Towel curls: using a real towel on a hard, smooth floor or pretend by using carpet.	2 sets of 20-25 toe flex to curl towel followed by toe ext to flattened towel w/ 20-s rest.
Heel raises ^b : Flat surface to begin...if no ↑ pain progress to a slow lowering of heel on step.	5 sets of 5 s hold; ^a if no pain, stiffness, cramping or swelling then 5 sets of 10 s hold w/ 10 s rest between sets.
A light dorsiflex stretch of the great toe, other toes and related fascia can be added with the addition of slight eversion over time, but the stretch should be below any sig discomfort.	2 sets 30 s stretch 2-3 times per day; increase or decrease as needed.

MTPJ, metatarsal phalangeal joint.

^aIf cramping or pain ↑ modify as needed....begin by reducing reps by half and build up to above as tolerated by patient.

^b Use a sturdy table, wall, or banister for support.

Fig 2. HVLA manipulation or thrust of hallux if no adverse reaction to mobilization. The patient is placed in the supine position. The doctor's thumbs cross and grasp the proximal phalanx, with slight plantar flexion and light traction applied in a proximal to distal or superior to inferior direction. After applying tension to remove tissue slack (1-3 mm), a pull-thrust into or towards the doctors' chest is applied. If there is joint cavitation, then the patient is reassessed to see if there is an apparent improvement in motion palpation in axial elongation. If no improvement then the procedure is repeated up to 3 times per visit. A cavitation is not needed for a good or even excellent outcome. **Do not thrust into plantar flexion. (Color version of figure appears online.)

Fig 1. Motion palpation and mobilization of the great toe (proximal phalanx at the first MTPJ). The patient is in the supine position. The doctor's distal hand grasps the proximal hallux while the proximal hand holds the forefoot with the thumb just proximal to metatarsals. One to four oscillations into axial line of drive. Mobilization is performed in the same manner as an oscillation, 2 sets of 20 repetitions, increasing or decreasing as appropriate. The mobilization is used to assess if this type of physical treatment is possible, it should not be painful; at most a slight discomfort is acceptable. If 2 to 4 treatments of mobilization are performed over 2 to 3 weeks with no unacceptable side effects a high velocity low amplitude thrust may be performed. (Color version of figure appears online.)

Fig 3. Sesamoid mobilization. Sesamoid mobilization is an oscillation grade III or IV mobilization, as tolerated, but moving toward grade IV. The doctor performs 2 sets of 20 repetitions and increases or decreases, as appropriate. A brief rest of 5-10 seconds is used between each set. The proximal aspect of both sesamoids is contacted by the thumb (while the great toe is simply held passively in a neutral position). The left thumb (per the picture) then performs an oscillating grade 4 mobilization (or grade 3 mobilization if too tender at first) from proximal to distal 2 times 20 mobilizations with 10 seconds rest between sets. The doctor can increase or decrease these sets, as appropriate. (Color version of figure appears online.)

Fig 4. No forced dorsiflexion mobilization grade III or IV or HVLA grade V thrust manipulation. Do not perform repetitive mobilization (grades III or IV) or grade V HVLA thrust into dorsiflexion. This is contraindicated but does not rule out mobilization in axial elongation or other possible accessory motions at the first MTPJ.^{2,3,16,17} (Color version of figure appears online.)

his toe 8 years ago doing martial arts, and it has hurt intermittently with an increase in pain around August of 2009, which he attributes to a general increase in sporting activity and exercise, although the specific activity most aggravating is unknown. Inspection and palpation elicited pain and easily palpated exostosis. He had decreased dorsiflexion of his left great toe, pain in his first metatarsal phalangeal joint (MTPJ) with occasional cramping in his foot and arch; the toe pain and stiffness is made worse by

Fig 5. Other accessory motions at the first MTPJ. Careful dorsal to plantar, plantar to dorsal, lateral to medial, medial to lateral and rotational mobilization is applied. Many of these may not be necessary and certainly for any that cause pain on strong provocation or after mobilization or manipulation; it is suggested that cryotherapy be applied to the affected toe and this procedure is not repeated. However, there may be a patient on occasion that gets a significant amount of additional relief from adding in other accessory motions. (Color version of figure appears online.)

increased activity and exercise. A full chemistry panel was within normal limits and radiographs (DP, oblique, lateral) of the great toe showed a slight HAV with very minimal loss of joint space and early mild exostosis, but no significant osteophytes visible at the first MTPJ; otherwise unremarkable.

Patient #2

A 55-year-old woman in good general health presented with right great toe pain 1 year in duration. No trauma regarding the right great toe was reported or remembered. General systems review and full chemistry blood panel were unremarkable. A regional examination was performed of her right foot and great toe. There was loss of axial elongation of the ankle as well as the second MTPJ. There was subtalar joint restriction in eversion with a hard end feel. There was decreased dorsiflexion of the great toe to 26° with a hard ROM end feel, as well as a decrease in internal and external rotation accessory glide motions of the great toe. In addition, the sesamoids lacked spring in a proximal to distal direction. Radiologist report notes loss of joint space; superior osteophytic lipping; or a dorsal osteophyte and subungual exostosis, OA at the distal phalanx and on the fibular side, and subchondral sclerosis. Radiologists' impression: degenerative osteoarthritis of the first MTPJ indicative of HR early stage.

Patient #3

A 49-year-old woman presented with left great toe pain 2 years in duration and denied any trauma or accidents, with pain increasing over time. A regional examination was performed on her left foot and great

Table 3 Diagnostic Rule for Determining Hallux Rigidus With Added Modification¹⁸

Description	Subject
1 Pain in the great toe, with a duration just over 2 years	1,3
2 A hard end-feel to dorsiflexion ROM overpressure (rather than a more normal spring)	1,2,3
3 Decreased ROM less than 64°. (We note that PROM ^a has normally been described as being anywhere from 60° to 75° in the normal healthy foot)	1,2,3
4 Palpable dorsal exostosis	1,2,3
5 Grating and popping or crepitus on movement of the 1st MTPJ	

MTPJ, metatarsal phalangeal joint; ROM, range of motion. Three out of 5 signs and symptoms have a sensitivity of 88% and specificity of 71%, accuracy of 84%, a positive likelihood ratio of 3.07, and negative likelihood ratio of 0.17.⁴⁵

^a Passive ROM.

Table 4 A Broader Grading System Outlined for Hallux Rigidus^{1,18}

Grade	Dorsiflexion ^a	Radiographic Findings	Clinical Findings
0	40-60° of and/or 10%-20% loss ROM	No findings	No pain only stiffness and loss of motion
1	30°-40° of and/or 20%-50% loss ROM	Dorsal osteophyte is main finding w/ minimal joint space narrowing, peri-articular sclerosis, flattening of meta-tarsal head ^b	Mild, occasional pain and stiffness, pain at extremes of dorsiflexion and/or plantar flexion
2	10°-30° of and/or 50%-75% loss ROM	Dorsal, lateral, and possibly medial osteophytes, (flattening of metatarsal head) < 1/4 of dorsal joint space involved (lateral) radiograph and sclerosis, sesamoids not involved	Moderate to severe pain and stiffness that may be constant, pain just before maximum dorsiflexion and plantar flexion
3	≤ 10° and/or 75-100% loss ROM ie, plantar flexion	Same as in grade 2 but w/ substantial narrowing and sclerosis, possible periarticular cyst, greater than 1/4 dorsal joint space involved (lateral radiograph), sesamoids enlarged and/or cystic/irregular	Pain and substantial stiffness at extremes of range of motion but not at mid-range
4	Equivalent grade 3	Equivalent grade 3	Equivalent grade 3 w/ pain at mid-range of passive ROM

ROM, range of motion.

^a Compared to unaffected side.

^b Not associated with avascular necrosis.

toe. The ankle was restricted in axial elongation, and the subtalar joint was restricted in eversion with a hard end feel. Dorsiflexion of the left great toe was 24° with a hard ROM end feel and decreased axial elongation and plantar flexion to 49°. Other accessory joint dysfunctions were foot or ankle joint hypomobility. Adding to and/or aggravating her problem was decreased axial elongation at the second, third, and fourth MTPJs and decreased plantar to dorsal glide of the first, second, and third cuneiforms and the cuboid intertarsal joints. In addition, the sesamoids lacked spring in a proximal to distal direction. Radiologist

reports an ungual exostosis, OA at the first distal phalanx and at medial side, and a slight loss of the joint space at the first MTP; early OA was suspected.

The 3 patients were diagnosed with chronic mild to moderate hallux rigidus. The Brantingham protocol was applied to each patient who received 6, 9, and 12 treatments, respectively, over 6 weeks.

The 3 patients in this series had a significant loss of great toe dorsiflexion ROM—35%, 65%, and 68%, respectively. For these patients, this MMT plus exercise increased dorsiflexion ROM in the great toe—12°, 12°, and 14°, respectively, with an average

Table 5 Outcome Measure Results for the 3 Cases

Case	VAS ^a	ROM ^b	Grades ^c	FFI ^d	LEFS ^e	OTE ^f
1	↓ 60mm usual ↓ 33 mm worst	↑ 12°	1	↓3.0	↑0	>1.5
2	↓ 62mm usual ↓ 59 mm worst	↑ 12°	2	↓26	↑26	>1.5
3	↓ 75 mm usual ↓ 87 mm worst	↑ 14°	2	↓40	↑19	>1.5
Average	↓65.7 mm usual ↓59.7 mm worst	↑ of ~13°		↓23.0	↑15.0	>1.5

FFI, Foot Functional Index; LEFS, Lower Extremity Functional Scale; OTE, Overall Therapy Effectiveness scale; ROM, range of motion; VAS, visual analogue scale.

^a A decrease of 20 to 30 mm is the MCID.^{25,26}

^b An increase of 10° is the MCIC.¹

^c Grades of HR: All 3 fit the clinical rule and were retrospectively graded using a newer 0 to 4 Grading system.^{1,11}

^d A decrease of 7 points is the MCIC. FFI, Foot Functional Index.²³

^e An increase of 9 points is the MCID. LEFS, Lower Extremity Functional Scale.²²

^f Differences greater than 1.5 represent large, statistically significant, changes.²⁴

of 13°. End-of-treatment outcome measure values are detailed in Table 5.

Patient 1's OTE improved in section one to a 'good deal better' and in section two to a 'very important' overall improvement of 78%. Patient 2's OTE improved in section 1 to a 'very great deal better' and in section 2 to an 'extremely important' improvement and, the patient verbally reported that she felt almost 100% better. Patient 3's OTE improved in section 1 to a 'great deal better' and section 2 to 'extremely important', for an overall improvement of 92%. At 1 year post final treatment, each subject was contacted to answer a simple verbal rating scale (0 worst through 100% healed). This was not one of the original outcome measures as it is a follow-up; each subject was contacted via phone. Patient 1 moved with no forwarding information provided. Patient 2 stated the pain returned about 4 months after treatment stopped; she still had over 40% relief of her great toe pain and stiffness. Patient 3 stated she still had over 90% relief of the pain and stiffness in her left great toe.

Side-effects were mild and self-limiting; patients 2 and 3 experienced slight general soreness the morning after the first treatment, which lasted for a few hours. There were no serious adverse reactions; defined as causing persistent severe pain or disability in regards to the 3 subjects.

Discussion

The results of this case series are similar to the results of a manual and multimodal RCT that was carried out in 2004 by physical therapists and appeared clinically effective for HR^{6,16–18} Described as merely "standard physical therapy" when in fact, manual therapy was a key component including multimodal care emphasizing first MTPJ flexion strengthening and gait retraining.

The implication of the outcomes in this series is that clinicians may consider MT as a viable treatment in the treatment of HR. With cost-containment in mind, a logical approach would be to begin care with a 6-visit treatment plan, followed by additional visits if satisfactory results are not achieved. As "satisfactory" is a matter of opinion, a suggestion of greater than 50% reduction in pain and a 10° increase in dorsiflexion is being put forth.

The take away from the simple 1-year follow-up may be that clinicians consider scheduling the patient for a 6 month follow-up/maintenance visit to assess the

amount of relief from the pain and stiffness still being attributed to the treatment.

The combined subjective and objective findings show the promise of benefit of MMT. The need for future research and randomized controlled trials of chiropractic, manual and multimodal therapy in the treatment of osteoarthritis of the great toe versus placebo, sham, and/or "wait and see" is needed.

One type of joint dysfunction, the loss of involuntary axial elongation accessory motion of the first MTPJ, is not commonly discussed per orthopedists or podiatrists, but it is suggested that 1° to 3° is common and should exist in a healthy great toe when distracted or dorsiflexed.^{14,39} It is possible that loss of axial elongation may develop prior to significant pain, or loss of significant dorsiflexion ROM in the first MTPJ with a history of injury or prolonged repetitive strain to the great toe joint.⁴⁰ These patients often show concurrent loss of ankle dorsiflexion, which may be due to a secondary compensation for the loss of first MTPJ dorsiflexion. Assessing axial traction and or dorsiflexion are used in treatment of hallux rigidus and other foot and ankle disorders and are prominently noted in chiropractic, osteopathic and physical therapy literature and should not be discounted as secondary aggravating components of this disorder.^{41,27}

A newly developed diagnostic rule may be useful in the treatment of HR and to help in the identification of radiographic OA of the first MTPJ in people with HR pain.⁴² One hundred eighty-one people with great toe pain, demonstrating apparent OA at this joint were confirmed, with radiographic evidence, using plain film radiography. Diagnostic test statistics assessing the correlation of symptoms, clinical observations and association with visible radiographic OA degenerative changes were carried out. Two diagnostic models were developed by multivariate statistical analysis: a statistically optimal model and a simplified clinical model. Multivariate logistic regression suggested that subjects with pain duration greater than 25 months, the presence of a dorsal exostosis, a hard-end feel to dorsiflexion ROM, and crepitus on movement less than 64° at the first MTPJ dorsiflexion significantly associated these signs and symptoms with visualized radiographic OA. The statistically optimal model and clinical model correlated strongly with clinical symptoms (95% CI, 0.81-0.93) and effect size of 0.87 (95% CI, 0.80-0.93), respectively, with the percentage of cases correctly classified 86.2% to 85.6%, respectively. A cut-off score of greater than or equal to 3 of these 5 resulted in a sensitivity of 88%, specificity of 71%, accuracy of 84%, and a positive likelihood ratio of 3.07 and

negative likelihood ratio of 0.17. These 5 findings appear to accurately identify the presence or absence of radiographic OA greater than 3 times better than previous studies. If this diagnostic rule (Table 3) is demonstrated to be accurate by additional future repetitive studies it may assist clinical decision making, reducing un-needed radiography.⁴³ We have retrospectively compared the findings of our patients to this clinical rule; subjects presented with 3 or 4 of the 5 signs and symptoms per the “diagnostic rule”, respectively. Therefore it may have been appropriate to begin care prior to a radiology diagnosis of the first MTPJ (Table 3).⁴³

Table 4 is a more recently developed hallux rigidus Diagnostic Scale by Coughlin and Shurnas in 2003.^{1,18} Furthermore, there is a move away from the older system of grading by numerical listing of 1, 2, and 3 (used for greater than 50 years) to broader definitions based on history, ROM findings, pain, radiologic abnormalities, and common outcome measures.^{1,44} Looking at this scale with a “0-4 grading of diagnostic categories”, this too has been retrospectively applied to the 3 patients in this case series. In terms of the newer hallux rigidus grading system the subjects would probably be listed as a “grade 1”, “grade 2”, and “grade 2”, respectively.⁸

Limitations

This case series presents only 3 patients and no control arm; therefore, efficacy or effectiveness cannot be established. Only 1 treatment has yet been demonstrated in an RCT and Cochrane review to help this condition, physical therapy which included manual therapy, consequently no claims may be extrapolated from this case series to the general population suffering from HR. The natural history of fluctuating signs and symptoms of osteoarthritis may account for some of the improvement. As a case series a blind assessor was not utilized for the outcome measures; the treating clinician without intentionally setting forth may have veered the subjects with the explanation of the outcome measures to answer more positively. As the protocol allowed for modification of the treatment in regards to number of visits and soft tissue treatment the average improvement noted is not truly an average. These limitations would easily be resolved with a full scale RCT.

Conclusion

In this case series the 3 patients reported relief of pain and stiffness from hallux rigidus after receiving

chiropractic care, specifically the Brantingham protocol with outcome measures, meeting or exceeding MCID or MCIC.

Funding Sources and Conflicts of Interest

The authors were awarded a grant by NCMIC to complete this manuscript for publication. The authors have no other conflicts of interest to declare.

References

1. Polzer H, Polzer S, Brumann M, Mutschler W, Regauer M. Hallux rigidus: Joint preserving alternatives to arthrodesis—a review of the literature. *World J Orthop* 2014;5(1):6–13.
2. Zammit GV, Menz HB, Munteanu SE, Landorf KB, Gilheany MF. Interventions for treating osteoarthritis of the big toe joint. *Cochrane Database Syst Rev* 2010;9.
3. Menz HB, Munteanu SE, Landorf KB, Zammit GV, Cicuttini FM. Radiographic evaluation of foot osteoarthritis: sensitivity of radiographic variables and relationship to symptoms. *Osteoarthritis Cartilage* 2009;17(3):298–303.
4. Brantingham JW, Bonnefin D, Perle SM, et al. Manipulative therapy for lower extremity conditions: update of a literature review. *J Manipulative Physiol Ther* 2012;35(2):127–66.
5. Coughlin MJ, Shurnas PS. Hallux rigidus: demographics, etiology, and radiographic assessment. *Foot Ankle Int* 2003;24(10):731–43.
6. Shamus J, Shamus E, Gugel RN, Brucker BS, Skaruppa C. The effect of sesamoid mobilization, flexor hallucis strengthening, and gait training on reducing pain and restoring function in individuals with hallux limitus: a clinical trial. *J Orthop Sports Phys Ther* 2004;34(7):368–76.
7. Kellgren JH, Lawrence JS. Radiological assessment of osteoarthritis. *Ann Rheum Dis* 1957;16(4):494–502.
8. Clar C, Tsertsvadze A, Court R, Hundt GL, Clarke A, Sutcliffe P. Clinical effectiveness of manual therapy for the management of musculoskeletal and non-musculoskeletal conditions: systematic review and update of UK evidence report. *Chiropractic Man Ther* 2014;22(1):12.
9. Clanton TO, Ford JJ. Turf toe injury. *Clin Sports Med* 1994;13(4):731–41.
10. Rao S, Riskowski JL, Hannan MT. Musculoskeletal conditions of the foot and ankle: assessments and treatment options. *Best Pract Res Clin Rheumatol* 2012;26(3):345–68.
11. Hoskins W, McHardy A, Pollard H, Windsham R, Onley R. Chiropractic treatment of lower extremity conditions: a literature review. *J Manipulative Physiol Ther* 2006;29(8):658–71.
12. Munteanu SE, Zammit GV, Menz HB, et al. Effectiveness of intra-articular hyaluronan (Synvisc, hylan G-F 20) for the treatment of first metatarsophalangeal joint osteoarthritis: a randomised placebo-controlled trial. *Ann Rheum Dis* 2011;70(10):1838–41.
13. Menz HB, Frescos N, Munteanu SE. Effectiveness of off-the-shelf footwear in reducing foot pain in Australian Department

- of Veterans' Affairs recipients not eligible for medical grade footwear: study protocol for a randomized controlled trial. *Trials* 2013;14:106.
14. Yee G, Lau J. Current concepts review: hallux rigidus. *Foot Ankle Int* 2008;29(6):637–46.
 15. Menz HB, Levinger P, Tan JM, Auhl M, Roddy E, Munteanu SE. Rocker-sole footwear versus prefabricated foot orthoses for the treatment of pain associated with first metatarsophalangeal joint osteoarthritis: study protocol for a randomised trial. *BMC Musculoskelet Disord* 2014;15:86.
 16. Brantingham J, Wood T. Case report: hallux rigidus. *J Chiropr Med* 2002;1(1):31–7.
 17. Brantingham J, Chang M, Gendreau D, Price J. The effect of chiropractic adjusting, exercises and modalities on a 32-year old professional male golfer with hallux rigidus: a case report. *Clin Chiropr* 2007;10(2):91–6.
 18. Manral D. Hallux Rigidus: a case report of successful chiropractic management and review of the literature. *J Chiropr Med* 2004;3(1):6–11.
 19. Nawoczenski DA. Nonoperative and operative intervention for hallux rigidus. *J Orthop Sports Phys Ther* 1999;29(12):727–35.
 20. Lorimer D, French G, O'Donnell M, Burrow JG, Wall B. Neale's common foot disorders diagnosis and management. 7th ed. New York: Churchill Livingstone Elsevier; 2006:91–326.
 21. Talarico LM, Vito GR, Goldstein L, Perler AD. Management of hallux limitus with distraction of the first metatarsophalangeal joint. *J Am Podiatr Med Assoc* 2005;95(2):121–9.
 22. McNeil DS, Baumhauer JF, Glazebrook MA. Evidence-based analysis of the efficacy for operative treatment of hallux rigidus. *Foot Ankle Int* 2013;34(1):15–32.
 23. Erdil M, Elmadag NM, Polat G, et al. Comparison of arthrodesis, resurfacing hemiarthroplasty, and total joint replacement in the treatment of advanced hallux rigidus. *J Foot Ankle Surg* 2013;52(5):588–93.
 24. Dos Santos ALG, Duarte FA, Seito CAI, Ortiz RT, Sakaki MH, Fernandes TD. Hallux rigidus: prospective study of joint replacement with hemiarthroplasty. *Acta Ortop Bras* 2013;23(2):71–5.
 25. Mann RA, Clanton TO. Hallux rigidus: treatment by cheilectomy. *J Bone Joint Surg Am* 1988;70(3):400–6.
 26. Dawson-Bowling S, Adimonye A, Cohen A, Cottam H, Ritchie J, Fordyce M. MOJE ceramic metatarsophalangeal arthroplasty: disappointing clinical results at two to eight years. *Foot Ankle Int* 2012;33(7):560–4.
 27. Magee D. *Orthopedic Physical Assessment*. 4th ed. Philadelphia: Saunders Elsevier; 2006:599–672.
 28. McMaster MJ. The pathogenesis of hallux rigidus. *J Bone Joint Surg (Br)* 1978;60(1):82–7.
 29. Regule D. An update on inflammatory arthropathies including pharmacologic management and preoperative considerations. *Clin Podiatr Med Surg* 2010;27(2):183–91.
 30. Schlesinger N. Diagnosis of gout: clinical, laboratory, and radiologic findings. *Am J Manag Care* 2005;11(15 Suppl):S443–50 [quiz S465–448].
 31. Brantingham CR. Military chiropody today. *Mil Med* 1956;119(1):33–5.
 32. Kolber MJ, Fuller C, Marshall J, Wright A, Hanney WJ. The reliability and concurrent validity of scapular plane shoulder elevation measurements using a digital inclinometer and goniometer. *Physiother Theory Pract* 2012;28(2):161–8.
 33. Michaud TC. *Human locomotion. The conservative management of gait-related disorders*. Newton, MA: Newton Biomechanics; 2011:200–1.
 34. Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. *North American Orthopaedic Rehabilitation Research Network. Phys Ther* 1999;79(4):371–83.
 35. Landorf KB, Radford JA. Minimal important difference: Values for the Foot Health Status Questionnaire, Foot Function Index and Visual Analogue Scale. *Foot* 2008;18(1):15–9.
 36. Juniper EF, Guyatt GH, Willan A, Griffith LE. Determining a minimal important change in a disease-specific Quality of Life Questionnaire. *J Clin Epidemiol* 1994;47(1):81–7.
 37. Price DD, Bush FM, Long S, Harkins SW. A comparison of pain measurement characteristics of mechanical visual analogue and simple numerical rating scales. *Pain* 1994;56(2):217–26.
 38. Farrar JT, Young Jr JP, LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain* 2001;94(2):149–58.
 39. Zammit GV, Menz HB, Munteanu SE. Structural factors associated with hallux limitus/rigidus: a systematic review of case control studies. *J Orthop Sports Phys Ther* 2009;39(10):733–42.
 40. Reid C. *Sports Injury Assessment and Rehabilitation*. New York: Churchill Livingstone; 1992:217–50.
 41. Menz H. Manipulative therapy of the foot and ankle: science or mesmerism? *Foot* 1998;8:68–74.
 42. Zammit GV, Munteanu SE, Menz HB. Development of a diagnostic rule for identifying radiographic osteoarthritis in people with first metatarsophalangeal joint pain. *Osteoarthritis Cartilage* 2011;19(8):939–45.
 43. Moseley J, O'Malley K, Petersen N, et al. A controlled trial of arthroscopic surgery for osteoarthritis of the knee. *N Engl J Med* 2002;347(2):81–8.
 44. Hochberg MC, Altman RD, April KT, et al. American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. *Arthritis Care Res* 2012;64(4):465–74.
 45. Roukis TS. Clinical outcomes after isolated periarticular osteotomies of the first metatarsal for hallux rigidus: a systematic review. *J Foot Ankle Surg* 2010;49(6):553–60.