The effect of a manual therapy knee protocol on osteoarthritic knee pain: a randomised controlled trial

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Background: *Knee osteoarthritis is a highly prevalent condition with a significant socioeconomic burden to society. It is known to effect sufferers through pain, loss of function and changes in health related quality of life. Management typically involves pharmacologic and/or exercise based therapy approaches to reduce pain. Previous studies have shown multimodal treatment approaches incorporating manual therapy to be efficacious. The aim of this study is to determine if a manual therapy technique knee protocol can alter the self reported pain experienced by a group of chronic knee osteoarthritis sufferers in a randomised controlled trial.*

Methods: *43 participants with a chronic, non-progressive history of osteoarthritic knee pain, aged between 47 and 70 years were randomly allocated following a screening procedure to an intervention group (n=26; 18 men and 8 women, mean age 56.5 years) or a control group (n=17; 11 men and 6 women, mean age 54.6 years). Participants were matched for present knee pain intensity measured on a visual analogue scale. The intervention consisted of the Macquarie Injury Management Group Knee Protocol whilst the control involved a non-forceful manual contact to the knee followed by interferential therapy set at zero. Participants received three treatments per week for two consecutive weeks with a follow up immediately after the final treatment. Post-treatment Participants completed 11 questions including present knee pain intensity and feedback regarding their response to treatment utilizing*

Antécédents : *Arthrose du genou ou gonarthrose est une condition très présente, ce qui constitue un poids socio-économique important pour la société. On sait qu'elle affecte les personnes qui en souffrent, en leur infligeant des douleurs, des pertes de motricité et des atteintes à leur santé, en plus de s'attaquer à leur qualité de vie. La gestion du cas fait d'habitude appel à la pharmacologie et/ou à l'exercice, fondée sur des approches thérapeutiques pour atténuer la douleur. Des études antérieures ont démontré qu'une méthode de traitement combinée, y compris une thérapie manuelle, s'avérait efficace. L'objectif de la présente étude consiste à vérifier, dans un essai clinique comparatif randomisé, si une technique de thérapie manuelle, appliquée au protocole de traitement du genou, peut atténuer la douleur dont fait état un groupe de patients souffrant de gonarthrose chronique.*

Méthode : *43 participants, âgés de 47 à 70 ans et ayant un historique chronique mais non progressif de gonarthrose, ont été choisis au hasard à la suite d'une procédure de sélection ; ils ont été répartis entre un groupe d'intervention (n=26 ; 18 hommes et 8 femmes, dont la moyenne d'âge est de 56,5 ans) et un groupe témoin (n=17 ; 11 hommes et 6 femmes, dont la moyenne d'âge était 54,6 ans). Les participants ont été regroupés en fonction de l'intensité de la douleur mesurée par l'Échelle visuelle analogue. L'intervention a consisté à appliquer le « Macquarie Injury Management Group Knee Protocol » alors que le groupe de contrôle*

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a visual analogue scale. Results were analysed using descriptive statistics.

Results: *Prior to the intervention, there was no significant differences in age or present knee pain intensity. Following treatment, the intervention group reported a significant decrease in the present pain severity (mean 1.9) when compared to the control group (mean 3.1). Response to treatment questions indicated that compared to the control group, the intervention group felt the intervention had helped them (intervention mean 7.0; control mean 3.4), felt it decreased their knee symptoms such as crepitus (intervention mean 6.0; control mean 3.4) and improved their knee mobility (intervention mean 6.4; control mean 3.4) and their ability to perform general activities (intervention mean 6.5; control mean 3.8). Importantly the MIMG Knee Protocol intervention group reported no adverse reactions during treatment.*

Conclusions: *A short-term manual therapy knee protocol significantly reduced pain suffered by participants with osteoarthritic knee pain and resulted in improvements in self-reported knee function immediately after the end of the 2 week treatment period.*
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consistait en un contact manuel non énergique au genou, suivi par une thérapie interférentielle établie à zéro. Les participants ont reçu trois traitements par semaine pendant deux semaines consécutives, puis un suivi tout de suite après la fin du traitement. Après le traitement, les participants ont rempli un formulaire comptant 11 questions, dont une sur l'intensité de la douleur qu'ils ressentaient au moment de fournir leurs réponses et leurs commentaires sur leur réaction au traitement faisant appel à l'Échelle visuelle analogue. Les résultats ont été analysés en utilisant la grille de statistiques descriptives.

Résultats : *Avant l'intervention, il n'y avait pas de différence entre les âges et l'intensité de la douleur aux genoux. Après le traitement, le groupe d'intervention a rapporté une réduction importante de l'intensité de la douleur (moyenne de 1,9) par comparaison au groupe témoin (moyenne de 3,1). Les réponses aux questions sur le traitement indiquent que, par comparaison au groupe de contrôle, le groupe d'intervention a senti que le traitement avait fait du bien (moyenne du groupe d'intervention 7,0 ; groupe de contrôle, 3.4),a perçu une réduction des symptômes aux genoux, la crépitation articulaire, (moyenne du groupe d'intervention 6,0; moyenne du groupe de contrôle 3,4) et a amélioré la motricité de leurs genoux (moyenne d'intervention 6,4; groupe de contrôle 3,4) et leur capacité d'effectuer des activités générales (moyenne du groupe d'intervention 6,5; groupe de contrôle 3,8). Il est important de souligner que le Groupe d'intervention du protocole du genou MIMG a rapporté qu'aucune réaction indésirable ne s'était manifestée après le traitement.*

Conclusions : *Un protocole de thérapie manuelle du genou a permis de réduire de manière importante la douleur pour les participants souffrant de gonarthrose et s'est traduit par l'amélioration de la motricité des genoux chez les participants, immédiatement à la fin des deux semaines de traitement.*
(JACC 2008; 52(4):229–242)

Background

Osteoarthritis (OA) is one of the most prevalent articular disorders affecting humankind and a major cause of disability and socioeconomic burden.[1,2] The increasing impact of such disorders on patients and healthcare systems has seen the designation of the Decade of Bone and Joint from 2000 to 2010.[3] OA is a chronic degenerative disorder of multifactorial aetiology, including acute and/or chronic insults from normal wear and tear, age, obesity, and joint injury.[4,5] The true pathogenesis remains poorly understood.[1] OA is characterized by degradation of the articular cartilage, resulting in an alteration of its biomechanical properties.[6] This contributes to a focal loss of articular cartilage, loss of joint space, osteophyte formation, focal areas of synovitis, periarticular bone remodelling and subchondral cysts.[7] Evidence of knee osteoarthritic change on radiographs increases with age[8] and has been found in 72.1% of symptomatic participants and 41.6% of asymptomatic participants aged 40 or older.[9] However, there is a low level of agreement between examiners in determining the degree of knee osteoarthritic change on radiographs[10] and considerable variability in determining the progression of OA radiographically.[11] Furthermore, evidence of radiological OA is not an accurate predictor of pain or disability.[12,13] Radiological evaluation of knee osteoarthritis is of limited ability as a guide for management in most cases and it falls to more subjective measures of pain and disability to guide clinical practice.

At the knee joint, soft tissue changes can include decreases in the strength of the quadriceps and sagittal range of motion, as well as increased soft tissue contracture.[14] Collectively these changes produce the typical clinical picture of joint pain; worsening symptoms with activity and weight bearing, and stiffness developing at rest. These facilitate the decline in physical function and progression of disability.[7] If advanced, OA may ultimately require total knee arthroplasty, a management option that is under scrutiny to evaluate its cost-effectiveness, particularly considering the revision rate[15] and the substantial costs involved.[16]

The knee joint, along with other major weight bearing joints including joints of the spine and hip, are commonly subject to degenerative changes[17]. There is a higher prevalence of OA with advanced age[18] and in females.[18,19] In fact, most knee pain in the elderly is due to OA.[20] Knee osteoarthritis produces significant changes in health-related quality of life, particularly physical, mental and social components of health.[21,22] Determining accurate prevalence and incidence rates of knee osteoarthritis is difficult due to the lack of homogeneity in published studies.[18] Figures regarding prevalence of symptomatic knee osteoarthritis in the general population vary, with estimates of 7.2% in those aged 40 or older,[9] 12.5% in those aged over 45[23] and 14.8% in those aged 50 or older.[24] OA in young adults is most commonly a result of a specific injury to the knee, particularly intra-articular injury involving the anterior cruciate ligament (ACL).[25] Ten years after ACL injury approximately half of all patients display clinical signs of knee osteoarthritis and extrapolating these results indicates that nearly all patients will have OA after 15–20 years.[26] These figures appear regardless of whether reconstructive surgery is performed.[27] Former Finnish world class athletes were found to have an increased prevalence of musculoskeletal disorders than the normal population.[28] Swedish soccer and ice hockey players reported a significant relationship with the presence of osteoarthritis, but only with previous knee injurues.[29] However in Australia, a significantly greater prevalence and severity of knee osteoarthritis, producing a twofold increased risk of knee replacement, was found in Australian Rules Football players.[30] Occupational stresses including prolonged kneeling and/or squatting and lifting may also increase the risk of knee osteoarthritis[31].

The treatment of knee osteoarthritis is currently limited to the management of symptoms rather than reducing disease progression.[1] An evidence based approach to management should include patient education about OA and its management, including pain management, options to improve function, decrease disability, and prevent or retard progression of the disease.[32] Common current treatment strategies involve pharmacological treatments, non-pharmacological treatments and surgical interventions. Analgesic and anti-inflammatory drugs are widely used in management,[33] despite known serious adverse effects associated with long term NSAID use[34] and doubts about their efficacy.[35] Paracetamol is the primary oral analgesic and, if successful, the preferred long term analgesic.[32] NSAIDs are considered in patients unresponsive to paracetamol.[32] Current best evidence suggests NSAIDs may be beneficial in the reduction of pain in the short term, but there is no support for their long term use.[36] Intra-articular corticosteroids are an option for inflam-

mation and pain relief, however the short term pain reduction provides relatively short lived benefits, and no difference in knee function is evident long-term.[37] Intra-articular corticosteroids are indicated for flare up of knee pain, especially if accompanied with effusion.[32] Recent times has seen the advancement of alternative so-called 'natural' pharmaceutical options such as glucosamine and chondroitin.[38] Supplementation use is supported by a growing, but heterogeneous research base of mixed methodological quality than other pharmaceutical interventions.[32] It has been demonstrated that these products have a slower onset of action but their symptomatic effects tend to be more long lasting after the end of treatment.[39] Invasive interventions may include arthroscopy and joint replacement surgery that are considered when other treatment modalities have failed and for patients who generally have more severe pain and disability with radiographic evidence of OA.[32] In a randomised placebo-controlled trial the outcomes after arthroscopic lavage or arthroscopic debridement were no better than those after a placebo procedure and at no point did either of the intervention groups report less pain or better function than the placebo group.[40] Alternatively, replacement surgery is considered an effective procedure in improving knee function, decreased pain, and may provide the opportunity to resume a more active lifestyle.[41]

Whilst these forms of therapy help to deal with symptoms, osteoarthritis is often viewed as a problem of biomechanical function. In order to treat the large and growing number of sufferers, various treatment approaches outside the use of drugs are utilised. Thus, many sufferers visit practitioners who provide therapy intended to improve their function. To address the concerns of lost function, including the ability to ambulate, several forms of physical therapy have been advocated, with various strength-based and exercise programs the cornerstone of treatment. Prescription of an aerobic walking and quadriceps strengthening exercise program had been used successfully, producing a reduction in both pain and disability.[42] The implementation of laterally wedged shoe orthotics has also been shown to provide symptomatic relief.[43] Such interventions are typically used in combination with pharmaceutical interventions.

A requirement also exists for simple and inexpensive treatment protocols to fill the void between medication, exercise and surgery. Multimodal approaches utilizing a combination of exercises and individualized manual therapy (received twice weekly for 4 weeks) has resulted in significant improvements in knee pain and function when compared to a placebo therapy of sub-therapeutic ultrasound in both the short term and long term follow up.[44] Another trial compared clinic based treatment incorporating supervised exercise, individualized manual therapy and a home exercise program over a four week period to a home exercise program.[45] The results indicated that in both group's knee pain decreased and function improved in the short and long term. Another randomised controlled trial investigated high velocity thrust techniques (received 8 times over 3 weeks) to the knee compared with NSAIDs. They found no objective or subjective differences between the groups; both were equally effective.[46] Therefore, use of manual therapy should be offered as an alternative to pharmaceutical administrations.

Recently, there has been interest in research of the clinical efficacy of chiropractic manual therapy techniques for spinal structures.[47] Whilst this interest is both appropriate and desirable, much less attention has been focused upon chiropractic interventions directed towards peripheral joints. The application of chiropractic knee techniques has been previously documented in the literature.[46,48] Furthermore, little research has been directed into chiropractic interventions for the aging population. The aim of this investigation was to determine if a/the Macquarie Injury Management Group (MIMG) knee protocol can alter the self reported pain experienced by a group of chronic knee osteoarthritis sufferers compared to a control group in a randomised trial.

Methods

This study sought and received approval from the Macquarie University and the University of Wollongong Human Ethics Committees. Participants gave written informed consent prior to participation in the study. A CONSORT diagram is provided for your reference (Figure 1).

Participants

Fifty-seven people responded to a print media advertising campaign. After identification of the appearance of OA in one or both knees on radiographs and meeting the inclusion criteria for the study (Table 1), 43 participants were included in the study. Nine participants were excluded as they could not meet the required dosage, 3 participants

Figure 1   *Modified Consolidated Standard for Reporting Clinical Trials (CONSORT) diagram*
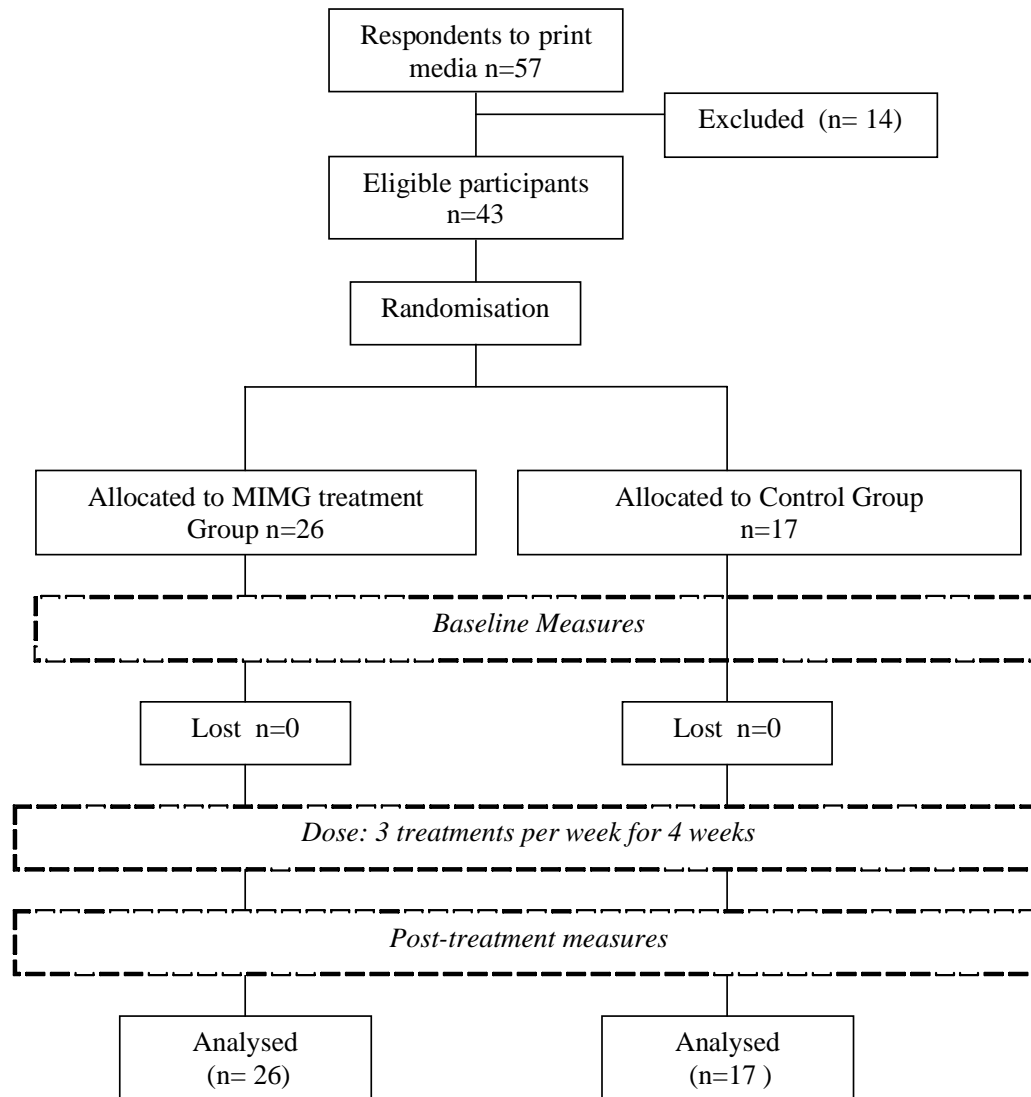
were excluded as they experienced significant concurrent pain in the lower limb, 1 participant was excluded as they demonstrated significant varus deformity and one participants was excluded as they suffered a concurrent golden staff infection in the lower limb. It was not investigated whether participants were currently undertaking concurrent treatment or supplementation. Participants then completed a knee pain questionnaire representing the present pain intensity on a graduated 10 centimetre rule, or visual analogue scale (VAS). The participants then drew a card

from a sealed container. The container held 2 identical cards, with either 'Card 1' or 'Card 2' typed on the inside of them. The participants gave the card to a research assistant who wrote down the allocation to intervention group (card 1) or control group (card 2). The card was then replaced into the container, and shuffled before the next participant drew from the container. Participants were randomly allocated to an intervention group (n=26) or a control group (n=17). The non-homogenous division between groups was due to the random nature of group allocation.

Figure 2   *Macquarie Injury Management Group Knee Protocol Part One: Myofascial Mobilisation Technique*

Technique Table 1: Myofascial Mobilisation Technique	
Description of technique	**Illustration of the technique**
The patient lies supine near the homolateral edge of the couch. The practitioner sits on the homolateral side of the couch with the cephalad thigh under the leg of the patient's involved limb and superior to the patients knee. The patients lower hamstring area rests on the practitioners thigh with their knee able to rest in 90° of flexion.	
The practitioner has a choice of two contacts: 1. A pincer contact with the thumb and index either side of the medial and lateral superior poles of the patella 2. A reinforced web contact supporting the medial and lateral superior poles of the patella. The second position is recommended for those practitioners with a hypermobile thumb.	
The patient is then instructed to begin actively extending their knee through the pain free range of motion while the practitioner maintains contact at the patella. The force through the patella is in a plane applied at a tangent to the angle of the knee to avoid a compressive load.	
The patient extends the knee as far as possible in a pain free manner from the initial starting position. The practitioner maintains the contact at the patella during this movement. This is repeated up to ten times. Patients are able to cease particpation at any point during the application of the procedure. In addition, an impulse thrust may be applied at any point through the range of motion	
Alternatively, the initial contact can be taken with a bias towards medial or lateral rotation of the patella. This picture demonstrates a contact applied with medial rotation. Generally, the practitioner adopts a start position where the patella is held medially to enhance medial rotation or laterally to enhance lateral rotation. This position is held through the subsequent flexion and extension ranges of motion, rather than trying to actively apply such traction or rotation throughout the range of motions.	

Figure 3 *Macquarie Injury Management Group Knee Protocol Part Two: Myofascial Manipulation*
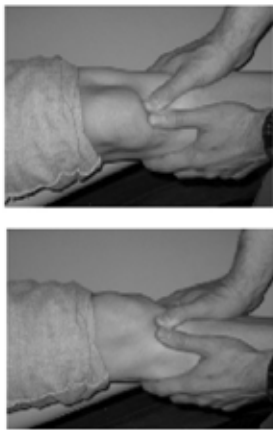

Technique Table 2: Myofascial Manipulation	
Description of technique	**Illustration of the technique**
The patient lies supine near the homolateral edge of the couch, with the involved knee overhanging the edge of the couch. The practitioner stands on the homolateral side of the couch with the patients leg (at the level of the lower calf) gripped between the thighs to apply a distractive force to produce traction over the tibio-femoral joint.	
The practitioner contacts the knee with hands either side. Both thumbs contact on the tibial tuberosity and the fingers wrap around the knee to the distal end of the popliteal space. Care should be exercised not to place too much digital pressure in the popliteal space. An impulse type thrust is then delivered, directed in the caudal direction to mobilise the joint in a near full extension position.	
Alternatively, the initial contact can be taken with a bias towards medial or lateral rotation of the tibio-femoral joint. Generally, the practitioner adopts a start position where the tibia is held with medial rotation or lateral rotation. This position is held through the subsequent traction and impulse thrust	

Table 1   *Inclusion criteria*

Inclusion Criteria
Participants must be aged between 45 and 70 years and must suffer the following:
– A prior medical diagnosis of osteoarthritis in the knee(s) as per Forman et al (1983)
– Self reported mild to moderate knee pain of at least one year duration
– Self reported knee crepitus
– Self reported restricted range of motion and/or joint deformity of the knee
– No history of joint replacement therapy
– No recent history of meniscal or other knee surgery (less than 6 months)

Table 2   *Change in 11 post study questions utilizing the visual analog scale*

	Visual Analogue Scale	**Control mean**	**Treatment mean**	**Difference (CI)**	**p value**
1	How would you rate your pain?	3.1	1.9	1.1 (0.1, 2.2)	0.042*
2	Do you feel the treatment has helped you?	4.1	7	–2.9 (–4.8, –1.1)	0.002*
3	Has the pain / discomfort inside your knee improved?	3.5	6.7	–3.1 (–4.9, –1.4)	0.001*
4	Has the mobility in your knee improved?	3.9	6.4	–2.5 (–4.2, –0.7)	0.007*
5	The treatment was painful to receive	0.5	0.6	–0.1 (–1.2, 1.0)	0.874
6	Compared with other treatment (analgesic / anti-inflammatory medication), I feel this treatment to be effective	4.2	7.4	–3.2 (–5.1, –1.2)	0.002*
7	I can perform general activities better than before the treatment	3.8	6.5	–2.7 (–4.8, –0.6)	0.013*
8	The clicking and grinding sensations in my knee have improved	3.4	6	–2.6 (–4.7, –0.5)	0.017*
9	The changes occurring in my knee have changed the mobility in my hip	2.5	2.8	–0.2 (–2.3, 1.8)	0.815
10	I feel that this type of treatment should be used in the management of my knee pain	4.1	1.8	2.3 (0.8, 3.8)	0.004*
11	How would you rate this treatment program in terms of the effectiveness on decreased pain and increased function	4.7	7.8	–3.1 (–5.0, –1.3)	0.002*

Intervention Group

The intervention group received a MIMG chiropractic knee protocol, explained in Figures 2 and 3. It consists of a non-invasive myofascial mobilisation procedure and an impulse thrust procedure performed on the symptomatic knee of participants. It cases were OA was bilateral; mobilisation was perform on both knees. The mobilisation procedure directed a small, sustained load and specific force to the patellofemoral articulation in a pre-determined direction of movement. This load was achieved through the active extension and flexion of the knee in the range starting from 90° of knee flexion to available full extension. During this movement, the patella is actively mobilised in a supero-inferior direction in a plane directed tangentially to the patella. In this position, minimal compressive load is placed upon the patellofemoral articulation, as this movement is usually perceived as painful in osteoarthritic patients. This allows the subject to actively articulate through knee flexion and not excessively tighten the quadriceps to cause a vector that compresses the patella onto the femur. A positive orthopaedic test finding is pain reproduction upon compressing patellofemoral structures. The mobilization procedure stretches the joint capsule in the sagittal plane, gently mobilises any restriction to normal movement within the limits of patient tolerance and likely loosens adhesions of the patellofemoral articulation. In addition, it may be used on anterior thigh musculature to effectively mobilise tight myofascial thigh structures.

Control Group

The control intervention consisted of a palmar contact to the knee without the application of force followed by interferential set at zero. The control group were told that

Table 3   *Changes in group pain scores between the control and treatment groups*

VAS	n	Pre-Test Mean (CI)	Post-Test Mean (CI)	p value
Control Group	17	3.5 (2.2, 4.7)	3.1 (2.1, 4.1)	0.602
Treatment Group	26	3.3 (2.6, 4.0)	1.9 (1.3, 2.6)	0.004*

Table 4   *Changes between control group and treatment in pain scores*

VAS	Difference (CI)	p value
Pre-Test	0.2 (–1.1, 1.5)	0.771
Post-Test	1.1 (0.1, 2.2)	0.042*

the procedure was a micro current application that they should not be able to feel. The experimental protocol was performed so that participants were not aware to which group they were assigned. The participants were informed that one treatment might be more effective than another. The treatment regime consisted of 3 treatments per week for 2 consecutive weeks with a follow-up assessment after the final treatment.

Immediately following their involvement in the 2 week trial, participants completed 11 post treatment questions including present knee pain intensity and questions regarding feedback on their response to treatment utilising a VAS. This scale was utilised as per previous researchers.[49] The 11 short questions required a response of between 0 and 10 on a 10 centimetre rule, and can be seen in Table 2. The minimum or zero point response on the VAS represented the response: none (Question 1), no effect (Questions 2, 10), no improvement (Questions 3, 4, 8), not painful (Question 5), not effective (Question 6, 11), and no change (Questions 7, 9). The 10 or maximum response on the VAS represented the following responses: unbearable (Questions 1,5), very effective (Questions 2, 6, 11), excellent improvement (Questions 3, 4, 8), much better (Questions 7, 9), and strongly disagree (Question 10). Gallagher reports a 13 mm difference on the VAS represents the smallest measurable change in pain severity that is clinically important.[50]

A post-intervention session was held after all the results had been collected and the results tabulated. Participants in the control group were offered the treatment program, of which all participants accepted but one.

Statistical Analysis
Statistical data was entered into power Macintosh computer, and utilised via a database soft ware package. Statistical analysis utilised Minitab v8.2. Repeated ANOVA calculations were made to describe differences between the groups. The p value used for all analyses was p>0.05. Results were found to be statistically significant at the 5% level.

Results
Participants were randomly assigned to the intervention group (mean age 56.5 years) or a control group (mean age 54.6 years). Prior to the intervention no significant difference in present intensity knee pain between the intervention and control groups was evident (Table 3). It was a requirement that the participants had mild to moderate knee pain (as determined by a the McGill Pain Questionnaire). Following treatment the intervention group rated their pain less (1.9) while no change was noted in the control group (3.1) (Table 4). This change in pain in the intervention group was statistically significant when compared with the control (Table 3).

The results to the remaining 10 questions can be found in Table 2. When the participants were asked if the treatment helped them, the intervention group indicated a positive response (7.0), which was significant when compared with the control group (4.1). Furthermore, when participants were asked if pain within the knee had improved, the intervention group (3.5) had significantly improved when compared with the control group (6.7). The participants were asked if a general improvement in

knee mobility was noted since the treatment had begun (Question 4). The responses indicate a significant improvement in the intervention group (6.4) greater than the control group (3.9). When asked if the clicking and grinding sensations (crepitus) in the knee had changed (Question 8), the intervention group (6.0) indicated a significant improvement when compared with the control group (3.4). The intervention group (6.5) also indicated a significantly improved ability to perform general activities (Question 7) when compared to the control group (3.8). When asked to comment on whether their hip movement had been improved by the knee treatment (Question 4), the results indicated significantly improved mobility in the intervention group (6.4) when compared to the control group (3.9).

Following these questions several other questions were asked regarding the type of treatment that the participant received. When asked if the treatment was painful to receive (Question 5) the participants' responses indicated that little discomfort was experienced with the treatment; the results were similar for both the intervention group (0.6) and the control group (0.5). When asked to compare the short-term effect of their treatment to previous pharmacologic based prescriptions they had received (including analgesics and anti-inflammatory medication) (Question 6), the results demonstrated a significant subjective feeling of effectiveness for the intervention group (7.4) when compared to the control group (4.2). When asked if the treatment that they received should be included into the management protocol of their knee pain (Question 10), the results demonstrated a significant difference between groups. Those in the intervention group (1.8) felt strongly that the management that they had received should be included in the management of "arthritis," but the control group (4.1) were somewhat unequivocal. Finally, the participants were asked to rate the treatment they received in terms of the effectiveness on decreased pain and increased function (Question 11). Again, the intervention group (7.8) rated the treatment as being more effective when compared to the equivocal result of the control group (4.6).

Discussion

The results indicated that a MIMG knee protocol was successful in reducing self reported present intensity osteoarthritic knee pain in the short-term and that this change was statistically significant when compared with a control group. It is unlikely that the results for the intervention group can be explained in terms of a spontaneous remission or through natural resolution, as it was a requirement of the study for the knee pain to have been a chronic stable condition.

Research into arthritis and particularly OA has largely investigated medical interventions and physical therapy modalities including exercise. Much less emphasis has been placed on other manual therapy approaches. Several studies have investigated manual therapy for OA of the knee.[44,45] employing protocols that included other forms of therapy in a multi-modal approach. Our particular study employed one manual therapy discipline for effective pain reduction in osteoarthritic knee patients.

An important consideration revealed in the post treatment questionnaire was the issue of pain and discomfort created by the treatment. Whilst concern may surround the use of manual therapy in the elderly,[51] or in degenerative cases, it is understood there are a range of chiropractic methods suitable for certain patients and specific scenarios.[52–55] Our results indicate that the treatment caused little or no discomfort to the patients. Such findings are valuable as participant's ages ranged from 47 to 70 years old. Whilst practitioner precaution is advised in dealing with patient conditions related to bone weakness, ligamentous laxity, deformity and tumour, much can be offered to the individual that has good bony and ligamentous integrity that also happens to suffer from osteoarthritis of the knee.

The MIMG protocol used for the intervention consisted of a non-invasive myofascial mobilisation procedure and an impulse thrust procedure specific to the patellofemoral articulation. The patient is able to actively articulate through knee flexion and not excessively tighten the quadriceps to cause a vector that compresses the patella onto the femur. The mobilization procedure stretches the joint capsule in the sagittal plane, gently mobilises any restriction to normal movement within the limits of patient tolerance and likely loosens adhesions of the patellofemoral articulation. In addition, it may be used on anterior thigh musculature to effectively mobilise tight myofascial thigh structures. Together these effects allow the knee greater mobility with less effort, restriction and pain. An important aspect of the procedure is that participants are able to cease participation at any point during the application of

the procedure or at any time during the experimentation, meaning it is performed voluntary within their tolerance levels. This is an important first step in determining the limit to which force is used in the application of the manual therapy. It provides direct feedback to the practitioner about the degree of stiffness, limitation and pain present in the afflicted knee. The MIMG technique is a potentially useful addition to prehabilitation programs (rehabilitation aimed at improving range of motion, strength and reducing swelling prior to surgery). Of the conditions to which this procedure has been applied, only the leg with a marked degree of lateral instability (genu valgus or genu varus), or acute meniscal lesions seemed not to tolerate it. It has become a useful addition to many techniques often used to treat knee dysfunction.

The second part of the procedure utilises a manual therapy procedure that is not under the voluntary control of the patient. It involves the application of a longitudinal traction of the tibio-femoral joint in a manner designed to distract the knee and mobilise the joint in a near full extension position. An impulse type thrust directed in the caudal direction is delivered to the knee of the patient. The leg of the patient is held in a position of light traction with the hands of the practitioner placed either side of the knee with the thumbs contacting on the tibial tuberosity and the fingers wrapping around the knee to the popliteal space. In addition to the above placement, the practitioner may optionally enhance the leverage available by placing the involved leg of the patient between the practitioner's legs (at the level of the lower calf) in order to add further traction leverage. The object of this procedure is not to produce joint cavitation, more so to mobilise the joint. In cases of tibial rotational restriction, the pre-manipulative set up could include a rotated tibia as a start point. The thrust component remains the same and is directed purely caudal in direction. Done correctly, this procedure is painless and has been used anecdotally to treat chronic meniscal injury. However, this procedure requires intact ligamentous and capsular structures to operate successfully. It also requires practice by the practitioner to acquire the motor skills necessary to perform the procedure.

Of interest to clinicians and patients alike, a significant treatment effect was found after only a short course of treatment. The study consisted of 3 treatments per week for 2 consecutive weeks, a total of 6 treatments that pro-duced significant self-reported pain and dysfunction. Previous studies have attempted to estimate the relationship between dosage and outcome parameters for low back pain[56], headache[57] and fibromyalgia.[58] They found between 9–12 chiropractic treatments were feasible for pain relief and between 15 and 30 for quality of sleep and fatigue level. Further research should implement dosage characteristics of treatment modalities for improvements in valid and reliable measurement outcomes. This would hasten the transfer of information from researcher to the clinician.

The importance of the patellofemoral compartment in knee dysfunction and knee osteoarthritis is well established.[59,60] Disease of the patellofemoral articulation can cause pain, and be responsible for a great deal of difficulty in the everyday activities of squatting, using steps and stairs, kneeling, and rising up from chairs.[61] Misalignment of the patella laterally has been proposed as a cause of the much of the pain associated with many patellofemoral conditions.[62] These misalignment syndromes are often referred to as "tracking" problems[63] and are classically managed by physiotherapists through taping based protocols of the patella to correct the tracking problem.[64] However, such protocols for knee osteoarthritis have shown it be no more effective than placebo in a randomised, double blind, placebo controlled trial.[65]

Preliminary findings of this study promote future research for chiropractic protocols in the management of OA and other similar degenerative disorders. Large Randomised clinical trials could investigate unimodal or multimodal chiropractic protocols. Further research should also attempt to address the dosage and duration of treatment required to resolve or manage a condition. Future investigations should study objective measurements of function and pain, with a medium to long term follow up to assess the duration of treatment effect or surgical intervention.

Limitations
A limitation of this study was that a superior objective outcome measure for treatment was not provided. The use of validated and reliable questionnaires such as the Knee Injury and Osteoarthritis Outcome Score (KOOS), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the short form 36 Health Survey Questionnaire and objective functional tests such as dis-

tance walked in 6 minutes would benefit future study. Once known, these data may be compared with the data gained from other approaches to the treatment of OA in the knee, and the pain and suffering that it causes in the older population.

Another limitation was the absence of strict exclusion criteria based around the use of concurrent therapies or additional supplementation. Investigation of these variables in future study can provide stronger evidence on the effectiveness of a manual therapy intervention for OA of the knee.

Finally, the outcomes of this study were assessed immediately following a 2 week intervention period. It outlines the short-term effects of this protocol on osteoarthritis, however further research is necessary to investigate long-term results of such an intervention for osteoarthritis. The clinical relevance of a short-term treatment program for osteoarthritis, which is chronic in nature, is uncertain.

Conclusions

The MIMG manual therapy knee protocol outlined in this research demonstrated significant short-term relief of self-reported pain and dysfunction in participants with knee osteoarthritis. In addition, no participants in either group reported adverse effects/discomfort with intervention. In light of these findings, it is recommended that further research be conducted to determine the utility of this protocol in patients not achieving satisfactory pain management with traditional approaches of exercises and medication for knee osteoarthritis. Further research should also focus on the duration of the clinical effects as measured by the reduction of symptoms in medium and long-term objective measures of pain and disability.

Competing interests

No funding was received in the preparation of this manuscript. The authors have no conflict of interest directly related to the content of the manuscript. The investigators do not stand to benefit from the commercial use of the protocol or the teaching of this protocol.

Authors' contributions

HP conceived of the study, participated in its design, constructed the literature review, provided treatment to the Participants, and helped to draft and edit the manuscript.

GW participated in the design and helped edit and draft the manuscript.

WH assisted with the literature review and helped edit and draft the manuscript.

KH assisted with the literature review and helped edit and draft the manuscript.

All authors read and approved the manuscript.

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