The effect of tibio-femoral traction mobilization on passive knee flexion motion impairment and pain: a case series

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The purpose of this case series was to explore the effects of tibio-femoral (TF) manual traction on pain and passive range of motion (PROM) in individuals with unilateral motion impairment and pain in knee flexion. Thirteen participants volunteered for the study. All participants received 6 minutes of TF traction mobilization applied at end-range passive knee flexion. PROM measurements were taken before the intervention and after 2, 4, and 6 minutes of TF joint traction. Pain was measured using a visual analog scale with the TF joint at rest, at end-range passive knee flexion, during the application of joint traction, and immediately post-treatment. There were significant differences in PROM after 2 and 4 minutes of traction, with no significance noted after 6 minutes. A significant change in knee flexion of 25.9°, which exceeded the MDC₉₅, was found when comparing PROM measurements pre- to final intervention. While pain did not change significantly over time, pain levels did change significantly during each treatment session. Pain significantly increased when the participant's knee was passively flexed to end range; it was reduced, although not significantly, during traction mobilization; and it significantly decreased following traction. This case series supports TF joint traction as a means of stretching shortened articular and periarticular tissues without increasing reported levels of pain during or after treatment. In addition, this is the first study documenting the temporal aspects of treatment effectiveness in motion restoration.

Keywords: Knee, Pain, Range of motion, Tibio-femoral joint, Traction mobilization

Knee pain is one of the most commonly reported musculoskeletal conditions, affecting 30–40% of the population by the age of 65.¹ Knee pain accompanying motion impairments is attributed to a number of causes such as joint immobilization following injury,^{2–5} surgical interventions to repair or remove menisci,^{6–8} or osteoarthritis.^{9,10} For the treatment of pain and motion impairment(s), the application of joint mobilization has been utilized by a variety of healthcare professionals in both the spine and peripheral joints. However, most of these research studies used techniques for the spine and upper extremities, with less evidence for the efficacy of mobilization to the lower extremity.¹¹

Studies specific to the knee joints have focused on the application of anterior/posterior (AP) joint mobilization and patellar glides to improve outcomes in patients with knee pain. Animal studies, for example, have reported that AP mobilization of the knee joint resulted in decreased pain caused by

chronic inflammation of muscle and joints.^{12,13} In human studies, AP mobilization of the tibio-femoral (TF) joint resulted in significantly increased pressure pain threshold (lowest stimulus at which mechanical pain was perceived) and reduced timing on the 3 m timed 'up-and-go' walk test.¹¹ In another study, six sessions of medial patella glide and transverse friction massage were successful at decreasing knee pain, increasing knee flexion, and improving function on steps.¹ Finally, a third study reported that joint mobilization, muscle stretch, and soft tissue mobilization improved scores on an osteoarthritis index.¹⁴

While AP joint mobilizations were the primary intervention in the articles reviewed, traction mobilization has been advocated by Kaltenborn and Evjenth as an intervention to extremity joints with painful movement impairment.¹⁵ Grade III traction is a linear motion, applied with sufficient force to take up the slack in the joint capsule and ensure that the soft tissues surrounding the joint become taut. The primary therapeutic intent of grade III traction mobilization is to stretch periarticular soft tissue and to increase mobility in a hypomobile joint. The

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Figure 1 Rest position – knee in slight flexion.

traction movement is applied at a right angle to the treatment plane, which for the TF joint, is located in the concave proximal end of the tibia.¹⁵

As mentioned previously, no study has examined the use of manual joint traction mobilization applied to the TF joint as a treatment option in patients with orthopedic conditions where both motion impairment and pain were present. In addition, outcome measurements for knee joint mobilizations have not been assessed over time to determine carry-over effects. Therefore, the purpose of this case series was to explore within a session and between sessions changes by manual joint traction mobilization on measures of pain (recorded by a visual analogue scale) and knee flexion passive range of motion (PROM, measured by a goniometer), in participants with unilateral motion impairment and pain in knee flexion.

Methods

Participants

Approval for this case series was received from Oakland University's IRB Committee. The participants were selected as a sample of convenience from an outpatient orthopedic clinic in southeast Michigan. The inclusion criteria for the study were: (1) unilateral motion limitation in passive knee flexion, and (2) a report of pain at the end of knee flexion on the knee demonstrating motion limitation. Exclusion criteria included individuals with: (1) conditions contraindicated for mobilization (e.g. knee joint infection, an acute flare-up of rheumatoid arthritis, etc.); (2) pain referred from proximal joints including the hip, sacroiliac, and lumbar spine; (3) a history of immobilization following ligament injury or disruption; or (4) cognitive deficits or language barriers that would hinder the ability to read, understand, or sign the consent form.

Procedures

At the initial evaluation, all participants meeting the inclusion/exclusion criteria were given a verbal description of the case series by the researchers and

Figure 2 End-range passive knee flexion.

invited to participate. Those participants signing an informed consent were included in the case series. At the beginning of each session, participants received the mobilization technique described below. No participant received any other intervention for restricted knee flexion. After traction mobilization was performed and all data were collected, participants received manual and exercise intervention for restricted knee extension if indicated.

Grade III TF traction mobilization was applied at the end of each participant's available passive knee flexion. Two similarly trained orthopedic manual physical therapists were assigned as either the measurement therapist or the treatment therapist. This designation remained consistent for each participant and was alternated as new participants entered the study.

Intervention and data collection

Each participant was asked to lie prone on a treatment table with the involved knee slightly flexed (Fig. 1) and asked to rate his or her pain level on the visual analog scale (VAS). The VAS has a test-retest reliability ranging from 0.71 to 0.99.¹⁶ Next, the participant's knee was passively flexed (Fig. 2) to the first and then final stop as defined by Kaltenborn.¹⁵ Pain was not the criterion to determine the end range. At the participant's final end point in passive knee flexion, he or she was again asked to mark his or her pain intensity level on a second VAS form. The measurement therapist collected the first two VAS forms and then measured and recorded passive knee flexion range of motion using a standard goniometer. The standard goniometer has been found to have high intra-tester reliability and validity.^{17,18} When using the goniometer to measure knee flexion specifically, intra-tester and inter-tester reliability ICC scores were documented at 0.99 and 0.90, respectively.¹⁹

The treatment therapist then entered the booth and secured the distal portion of the participant's femur against the table with a stabilization belt. Placement of a stabilization belt above the TF joint line provides

Figure 3 Application of TF traction at end-range passive knee flexion.

the greatest stabilization of the femur during TF traction mobilization and does not interfere with joint motion. A joint distraction cuff was placed around the ankle of the lower extremity. A second mobilization belt was attached to the distraction cuff and then placed around the treatment therapist's shoulder. The knee was fully flexed to the end of its available range of motion and a Grade III traction mobilization (separation of tibia from femur) was achieved by the therapist straightening his or her own knees (Fig. 3). The intervention was applied continuously for 30 second followed by a 10 second rest period. This sequence was repeated four times, for a total of 2 minutes of traction mobilization. After each 2 minute session of mobilization, the measurement therapist entered the booth and recorded the amount of available passive knee flexion. This process was repeated three times for a total of 6 minute of joint traction mobilization applied to the involved knee of each participant. The treatment therapist collected VAS data at the completion of the last 30 second mobilization session (Fig. 3) before returning the participant's knee to the resting position (Fig. 1), where a final VAS form was administered.

Data analysis

The effect of TF traction mobilization on PROM was analysed using repeated-measure analysis of variance (ANOVA). PROM changes were analysed for differences occurring within each treatment session (immediate effects). *Post-hoc* analysis was conducted using multiple paired *t*-tests with a Bonferroni adjustment. Multiple paired *t*-tests were also conducted to compare knee flexion PROM pre-intervention to the final treatment measurement and from the end of one treatment session to the beginning of the next treatment session. To enhance the confidence that the increase in PROM from pre- to post-intervention was due to true change, the minimal detectable change at a 95% confidence interval (MDC_{95}) was calculated using the formula $MDC_{95} = 1.96 \times (2)^{1/2} \times SEM$.^{20,21} To calculate standard

error of measure (SEM), Weir's formula $SEM = SD \times (1 - ICC)^{1/2}$ was used,²² along with the inter-tester reliability for knee flexion reported by Watkins *et al.* ($ICC = 0.90$).¹⁹

The effect of TF traction mobilization on VAS pain measurements was analysed using a Friedman ANOVA. Changes in pain were analysed both within each treatment session (immediate effects) and across seven treatment sessions (over time). If the Friedman ANOVA was significant, *post-hoc* analysis was conducted using the Wilcoxon signed-rank test. Data analysis was performed using SPSS 11.5 and statistical significance level was set at 0.05.

Results

Thirteen participants, five males and eight females, participated in this case series, which measured outcomes over seven sessions not three as listed. However, not all 13 participants completed all seven sessions. Some participants ($n=4$) were discharged prior to session 7, having met their treatment goals. In addition, one participant was unable to provide a VAS pain rating. Therefore, results for VAS data included only 12 participants. No participant discontinued treatment due to increased knee pain. The mean age ($\pm$ SD) for all participants was 41.9 years ($\pm$ 21.02). The two diagnoses most commonly treated were meniscal debridement and osteoarthritis. The remainder of the participants had either a total knee replacement or a fracture of the tibia or patella (Table 1).

The mean value for passive knee flexion for the participants' uninvolved knee at baseline was 125.3° (Table 2). For the involved extremity, the mean value for passive knee flexion PROM before intervention was 93.3° compared to 119.2° after the last intervention. This change between initial and last recorded measurement of passive knee flexion represented a mean increase of 25.9° in the 13 participants. The difference of 25.9° was statistically significant ($P \leq 0.001$) and exceeded the MDC_{95} of 13.38°.

Significant changes in knee flexion PROM were found during every visit, representing immediate changes in PROM ($P \leq 0.001$). The changes were seen throughout the treatment session, except between 4 and 6 minutes of traction (Table 3). After 4 minutes of traction mobilization, PROM did not increase significantly. Figure 4 shows the

Table 1 Participant demographics

	Mean	Standard deviation	Range
Age (years)	41.9	21.02	15–71
Body weight (lb)	192.4	57.01	120–307
Diagnosis			
	Total knee replacement	15% ($n=2$)	
	Tibial fracture	15% ($n=2$)	
	Meniscal debridement	31% ($n=4$)	
	Patella fracture	8% ($n=1$)	
	TF osteoarthritis	31% ($n=4$)	

mean knee flexion PROM for each session, at each data collection point.

Data were also analysed to see if gains in knee flexion PROM were maintained between treatment sessions. Results indicated a significant decline in motion from the end of one session to the beginning of the next ($P = 0.001-0.003$), which ranged from -5.89 to -10.39° (Table 4). However, as can be seen in Fig. 5, PROM increased between treatment sessions at each data collection point, although these results were not statistically significant.

Pain levels (recorded by VAS) were significantly different during sessions 2, 3, 4, 5, and 7 ($P = 0.002-0.053$). *Post hoc* analysis revealed a significant increase in pain when the participant's knee was passively flexed to end range ($P = 0.005-0.021$); a decrease in pain, although not statistically significant, during traction; and a significant decline in pain when the knee was returned to a resting position ($P = 0.007-0.027$). These results can be visualized in Fig. 6.

Data were also analysed to determine if pain changed over the seven treatment sessions. No significant differences were found, meaning that participants did not have statistically significant increases or decreases in pain levels between sessions.

Discussion

Following seven sessions of end-range manual traction mobilization applied to the TF joint, there was significant increase in knee flexion PROM. All participants experienced a mean increase of 25.9° in passive knee flexion from initial to final measurements, or improvement to within 6° of the uninvolved side. This change in PROM was greater than the 10° flexion increase reported by van den Dolder and Roberts, who applied mobilization to the patellofemoral joints in participants with anterior knee pain.¹ This case series utilized a manual intervention that provides a stretch to numerous articular and peri-articular soft tissues around both knee joints. The effectiveness of this manual technique may relate to its application at the end range of available motion. Theoretically, positioning a joint at end range before applying manual traction may assist in targeting the shortened soft tissue structures limiting the movement in question. In addition, manual TF traction may temporarily decrease compression on the meniscus and move fluid within a joint. This may reduce the potential motion-limiting effects of both pain and swelling.²³

All participants exhibited a statistically significant change in passive knee flexion during each treatment

Table 2 Mean knee flexion PROM

	Mean	Standard deviation	Range
Uninvolved side ($^\circ$)	125.3	± 16.35	90–152
Involved side baseline ($^\circ$)	93.3	± 14.49	70–109
Involved side post-treatment ($^\circ$)	119.2	± 15.35	91–142

Table 3 Statistical significance for changes in knee flexion PROM occurring within each treatment session

Session	Friedman ANOVA	Post hoc analysis (paired <i>t</i> -tests)		
		Rest to 2 minutes traction	2 minutes traction to 4 minutes traction	4 minute traction to 6 minute traction
1	$P \leq 0.001$	$P = 0.003^*$	$P \leq 0.001^*$	$P = 0.077$
2	$P \leq 0.001$	$P = 0.003^*$	$P \leq 0.001^*$	$P = 0.087$
3	$P \leq 0.001$	$P = 0.014^*$	$P < 0.002^*$	$P = 0.160$
4	$P \leq 0.001$	$P = 0.006^*$	$P \leq 0.001^*$	$P = 0.006^*$
5	$P \leq 0.001$	$P = 0.007^*$	$P < 0.007^*$	$P = 0.051$
6	$P \leq 0.001$	$P = 0.023^*$	$P \leq 0.001^*$	$P = 0.563$
7	$P \leq 0.001$	$P = 0.017^*$	$P < 0.169$	$P = 0.230$

Note: *Bonferroni adjustment for multiple comparisons; significant at the 0.05 level.

Table 4 Knee flexion PROM changes from end of one session to beginning of next

Sessions compared	Paired <i>t</i> -test	Mean change in PROM ($^\circ$)	PROM ($^\circ$)	
			End of session	Beginning of next session
1–2	$P = 0.003$	-7.15	105.54	98.39
2–3	$P = 0.001$	-10.39	111.08	100.69
3–4	$P = 0.001$	-7.92	111.50	103.58
4–5	$P = 0.002$	-6.55	116.73	110.18
5–6	$P \leq 0.001$	-8.11	118.89	110.78
6–7	$P = 0.002$	-5.89	120.78	114.89

Figure 4 Knee flexion PROM before intervention and after 2, 4, and 6 minutes of traction.

visit, which lends support for the immediate benefits of manual traction for knee flexion impairments. An interesting finding was that although passive knee flexion increased throughout the entire course of intervention, our results found statistically significant changes after the first 2 and 4 minutes of the treatment application. After 6 minutes of traction mobilization, no significant increases in PROM were

recorded. We are not aware of other studies that have reported this finding. Future studies could examine the temporal aspect of other manual interventions. Additional work in this area may serve as a guide for maximizing treatment outcome in the most time-efficient manner.

Pain measured by the VAS scale did not show statistical changes over time. This result is in contrast

Figure 5 Knee flexion PROM comparing data collection points across seven treatment sessions.

to the study by van den Dolder and Roberts in which six sessions of patellofemoral joint mobilization significantly decreased pain by 0.8 cm.¹ However, pain levels did statistically decrease during each treatment session, between end-range passive flexion and post-intervention (the rest period following traction). This is in contrast to Moss *et al.*,¹¹ who reported minimal changes in pain over 24 hours using the VAS. Our finding may demonstrate that the manual technique examined in this series was not only able to effectively increase a restricted passive movement but did so without causing any post-treatment discomfort. The authors acknowledge that any latent effects of treatment application, pain later that day or night, were not formally evaluated.

Although application of TF traction mobilization did not produce a statistically significant decrease in knee pain when applied at a painful end-range position, all participants reported that their knee pain was reduced when the technique was applied (Fig. 6). If a patient can tolerate an impaired and painful end-range joint position and the application of traction mobilization further reduces the perceived level of pain, this type of mobilization may promote improved patient comfort during manual intervention.

Our results are consistent with other studies that have shown that mechanical joint distraction, using an external ring fixator, was effective at reducing pain at the hip and tibiotalar joints.^{24–27} The exact mechanism for the perceived pain reduction with manual or mechanical joint traction is not well

understood, but theoretically it has been associated with increased synovial fluid circulation, articular receptor stimulation, improved tissue extensibility, and transient reduction of compressive loads on articular surfaces.^{24–27}

Limitations

Limitations of this case series include a small sample size (13 participants), lack of participant blinding to the intervention technique that was examined, and the inability to generalize the findings due to the research design (case series). Also, this case series did not incorporate a patient-directed functional outcome measure. Inclusion of a functional outcome may have yielded other information regarding participants' perception of daily activities requiring knee flexion.

Conclusion

The results of this case series lend support for the use of manual TF joint traction as a means of stretching shortened articular and periarticular tissues without increasing reported levels of pain either during or at the end of treatment. This is the first study documenting the temporal aspects of treatment effectiveness in motion restoration. Recommendations for future studies include the following: examine the effectiveness of manual traction mobilization applied to other extremity joints with painful movement impairments, use a larger number of participants with participant blinding, use a control group, incorporate patient-directed outcome measures, and compare this manual technique to other forms of manual or exercise intervention.

Figure 6 Mean VAS scores at rest, during passive end-range knee flexion, after traction, and after intervention. Rest 1: before intervention (participant prone, knee slightly flexed); flexion: end-range passive knee flexion (before intervention); traction: after 6 minutes of traction intervention; rest 2: post-intervention (participant's knee returned to rest 1 position).

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