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Abstract Radiographic Expansion of Tibiofemoral Joint Space Width Following Dry Needling in a patient with Bilateral Total Knee Arthroplasty: A Comprehensive Case Report and Biomechanical Analysis

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Abstract

Background: Total knee arthroplasty (TKA) is a highly reliable surgical procedure for treating advanced knee osteoarthritis. While it replaces damaged articular surfaces with prosthetic components, post-surgical recovery is frequently complicated by soft-tissue constraints. These include muscle contractures, active myofascial trigger points (MTrPs), and persistent fluid retention.

These soft-tissue abnormalities increase joint compression forces, which can compress the joint space and alter its radiographic appearance. Dry needling (DN) is an effective physical therapy technique that releases MTrPs, normalizes muscle length, and reduces periarticular swelling. Despite these benefits, its ability to alter weight-bearing radiographic joint space width (JSW) at the prosthetic interface has not been widely documented.

Case Presentation: A 65-year-old female presented with persistent bilateral knee pain, restricted range of motion (ROM), and chronic swelling after undergoing bilateral TKA (Left Knee in 2019, Right Knee in 2025). Physical examination revealed active MTrPs and severe hypertonicity in the hip abductors, quadriceps, hamstrings, popliteus, and gastrocnemius muscles.

The patient underwent a targeted 3-month dry needling protocol twice per week, focusing on the hypertonic muscle groups of the back, hip and lower limb. No other interventions, such as physical therapy modalities, joint mobilization, or medication adjustments, were performed during this period.

Results: At the 3-month follow-up, Single leg weight-bearing anteroposterior (AP) radiographs showed a visible increase in bilateral tibiofemoral JSW.

This structural change was accompanied by a 3.3 cm reduction in left knee circumference and a 3.4 cm reduction in right knee circumference. Functional mobility also improved, with knee extension returning to 0° bilaterally and the total normalised WOMAC index score decreasing from 93 to 14 points.

Conclusions: This case shows that targeted dry needling can alter the radiographic presentation of the prosthetic interface in post-TKA patients. This change is achieved by relieving myofascial hypertonicity, reducing external soft-tissue swelling, and restoring balanced tensegrity across the hip and lower limb.

These mechanisms decompress the joint, allowing the tibia and femur to align optimally during weight-bearing radiographs. This study emphasizes the importance of managing soft tissues to optimize mechanical outcomes after joint arthroplasty.

Keywords: Total knee arthroplasty, dry needling, tibiofemoral joint space width, myofascial trigger points, knee osteoarthritis, soft-tissue hypertonicity, weight-bearing radiographs, womac, knee swelling, range of motion

Introduction

Total knee arthroplasty (TKA) is a primary surgical intervention for treating end-stage degenerative knee joint disease. The procedure replaces damaged bone and cartilage with metal femoral components, a metal tibial tray, and an intervening ultra-high-molecular-weight polyethylene (UHMWPE) spacer.

While advanced biomaterials and precise surgical techniques have improved implant longevity, post-surgical recovery depends heavily on the surrounding soft tissues. The joint capsule, ligaments, tendons, and muscles form a complex system that dictates how forces move through the prosthetic joint. When these tissues become chronically tense or unbalanced, they can compromise the structural alignment of the limb.

A frequent but overlooked issue after TKA is persistent soft-tissue tension. This is often caused by long-standing pre-operative gait adjustments, intraoperative trauma, or scarring from open reduction and internal fixation (ORIF) stabilization techniques. This tension typically manifests as myofascial trigger points (MTrPs) - hyperirritable spots within taut bands of skeletal muscle.

Left untreated, these trigger points keep muscles in a state of continuous contraction. This constant tension exerts an ongoing compressive force across the knee joint, which can alter the structural alignment of the limb during weight-bearing activities.

Chronic Pre-op Deformity & Surgical Trauma
↓
Formation of Active Myofascial Trigger Points (MTrPs)
↓
Persistent Sarcomere Shortening & Muscular Hypertonicity
↓
Sustained Trans-Joint Compressive Forces (High Resting Tension)
↓
Mechanical Flattening of Soft Tissues & Reduced Weight-Bearing Radiographic Knee JSW

Fig 1: Explanation of the Sequelae that lead to reduced Knee JSW after a TKA

In addition to muscle tension, persistent swelling and localized lymphedema often develop after surgery. This accumulation of fluid increases pressure within the tissues around the joint, restricting movement and creating an inward force that alters normal joint alignment.

While standard rehabilitation focuses on muscle strengthening and basic stretching, it often fails to resolve deep myofascial trigger points or chronic fluid retention. This leaves the patient with persistent pain, stiffness, and subtle structural changes under load bearing.

Dry needling (DN) is an effective treatment for these soft-tissue restrictions. This minimally invasive technique involves inserting thin, filiform, one-time use, sterile needles directly into skeletal muscle MTrPs to cause a local twitch response (LTR). This response helps reset muscle length (through Neuromuscular Normalisation and Biomechanical Decompression), improves local circulation (through eliminating Lymphedema and lowering capsular pressure), and reduces pain-causing chemicals.

While Dry Needling is widely used for soft-tissue injuries, its broader mechanical impact on joint alignment—specifically its ability to alter weight-bearing radiographic joint space width (JSW) after TKA—has never been fully explored.

This report details the case of a 65-year-old female who presented with persistent bilateral knee pain, restricted mobility, and swelling years after her TKA. Following a 3-month dry needling protocol targeting her back, hip and lower limb muscles, her weight-bearing radiographs showed a clear increase in tibiofemoral JSW.

This paper provides a detailed look at the clinical findings and explores the neuromuscular, biomechanical, and fluid dynamics mechanisms that drive this structural change.

Materials and Methods

1. Patient History and Clinical Presentation

A 60-year-old female homemaker presented with a 7-year-old history of Left Knee and 1-year old history of Right Knee Post TKA persistent pain, deep aching, stiffness, and swelling. She had undergone single-stage bilateral TKA seven years prior in Left Knee and one year prior in Right Knee due to severe osteoarthritis of both knees (Figure 2 for Original Knee Radiograph of Bilateral Knees prior to TKA).

The surgery utilized a standard midline incision and a medial parapatellar approach with cemented posterior-stabilized implants with ultra-high-molecular-weight polyethylene (UHMWPE) inserts. Her postoperative recovery was slow, and she completed six months of standard physical therapy under her Surgeon’s team for both knees individually.

Despite completing rehabilitation, she continued to experience functional limitations. She struggled with climbing stairs, rising from chairs, and walking for more than five minutes without pain. She reported no history of implant infection, loosening, or systemic inflammatory disease.

Physical examination in February 2026, revealed a careful, short-stepped gait with reduced hip and knee movement during the Gait swing phase. Her stance showed a slight flexion bias bilaterally.

Palpation revealed significant muscle tightness and active, painful MTrPs across several muscle groups

- **Hip/Pelvic Complex:** Gluteus Maximus and Medius, Tensor fasciae latae (TFL), and Piriformis, Erector Spinae muscles

- **Anterior/Lateral Thigh:** Rectus femoris, vastus medialis, and vastus lateralis.

- **Posterior Thigh/Knee:** Biceps femoris, semitendinosus, semimembranosus, and popliteus.

- **Distal Extremity:** Tibialis Anterior, Peronei, Gastrocnemius (medial and lateral heads) and soleus.

Pressing on these trigger points reproduced her familiar knee pain and triggered local twitch responses. Her knee joint capsule felt thick and firm, and there was clear swelling around the kneecap.

Her initial active range of motion (ROM) showed a flexion limit of 65° and an extension deficit of -10° bilaterally. Baseline radiographs confirmed well-fixed implants without signs of loosening, bone loss, or component shifting.

2. Diagnostic and Imaging Protocols

To ensure the accuracy of the joint space measurements, radiographs taken before and after the treatment followed a strict protocol. We used the weight-bearing anteroposterior (AP) mid-coronal plane technique in unilateral weight bearing (with hand held support).

The patient stood with equal weight on one foot, her mid axis second toe and mid axis heel aligned, and her knees extended as much as possible. The X-ray beam was centred at the lower edge of the patella and aimed parallel to the tibial tray to eliminate tilt errors, by a senior musculoskeletal radiologist.

3. The Dry Needling Treatment Protocol

The Dry Needling treatment was administered by a certified physical therapist. The patient received two sessions per week for 12 weeks, completing 24 sessions in total.

We used sterile, disposable stainless-steel needles (0.35 mm × 75 mm for smaller muscles and 0.30 mm × 100 mm for deeper tissues). The therapist used a pistoning technique—moving the needle up and down quickly within the target zone—to elicit local twitch responses.

Once these twitch responses stopped or the muscle relaxed, the needle was left in place for 15 minutes before removal.

Targeted Muscle	Needle Size Used	Anatomical Location & Landmarks	Clinical Goal
Gluteus Medius, Gluteus Maximus, Gluteus Minimum	0.35 × 100 mm	Proximal third between the iliac crest and greater trochanter, in prone	Stabilize the pelvis and reduce lateral pulling on the IT band
Adductor Longus/ Brevis/ Magnus	0.35 x 75 mm	Upper one third of Medial thigh in externally rotated hip position	Normalize the frontal-plane adductor/ abductor tension balance
Tensor Fasciae Latae	0.35 × 75 mm	Just distal to the anterior superior iliac spine (ASIS), in prone	Reduce lateral tension across the kneecap and thigh
Rectus Femoris, Vastus Intermedius	0.35 × 75 mm	Mid-thigh belly, along the anterior straight line, in supine	Relieve forward pull on the hip and improve knee extension
Vastus Lateralis	0.35 × 75 mm	Lateral thigh, split into upper and lower sections	Correct outward patellar tracking and ease thigh tightness
Vastus Medialis	0.35 × 75 mm	Distal medial thigh, 3–5 cm above the upper knee, in supine	Rebalance tracking forces on the inner side of the knee
Biceps Femoris	0.35 × 75 mm	Lateral hamstring group, midway down the thigh, in prone	Reduce posterior joint tightness and improve extension
Semimembranosus / Semitendinosus	0.35 × 75 mm	Medial hamstring group, midway down the posterior thigh, in prone	Reduce posterior compression forces across the joint
Popliteus	0.35 × 75 mm	Inferomedial to the fibular head, angled toward the tibia, in supine	Unlock terminal extension and improve joint rotation
Gastrocnemius, Soleus	0.35 × 75 mm	Proximal thick bellies of the medial and lateral heads, in prone	Relieve posterior pull and reduce calf stiffness
Erector Spinae (Quadratus Lumborum, Iliocostalis, Lumbar Multifidi between L3-S1)	0.35 x 100 mm	Lateral border of erector spinae between L3 vertebrae and iliac crest	Reduce lumbar lordosis stiffness and downregulate sympathetic tone, balance lateral pelvic tilt and relieve pelvic obliquity

The patient did not receive any other treatments during this 3-month period. This included avoiding joint mobilizations, electrotherapy and medication adjustments. This restriction helped isolate the specific effects of the dry needling protocol.

4. Tracked Progress Markers

We tracked progress using several key measurements collected at the start of treatment, at the start of the treatment and at the 12-week conclusion:

1. **Primary Marker:** Radiographic Joint Space Width (JSW), using unilateral weight-bearing AP and Lateral X-rays.

2. **Knee Range of Motion (ROM):** Active knee extension and flexion, measured with a standard 12-inch goniometer using established bony landmarks.

3. **External Swelling:** Knee circumference measured in centimetres at the middle border of the patella using a flexible tape measure.

4. **Patient-Reported Progress:** The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). This tool scores pain, stiffness, and physical function on a scale from 0 to 96, where lower scores indicate better function and less pain.

Results

1. Radiographic Outcomes

The weight-bearing radiographs taken at 3 months revealed a visible increase in bilateral tibiofemoral JSW.

These changes in structural improvement manifested as changes in other baseline measurements. Importantly, the implants remained stable, with no signs of component shifting, tilting, or bone changes.

Fig 2: Pre TKR-Bilateral Knee Radiographs (2018)

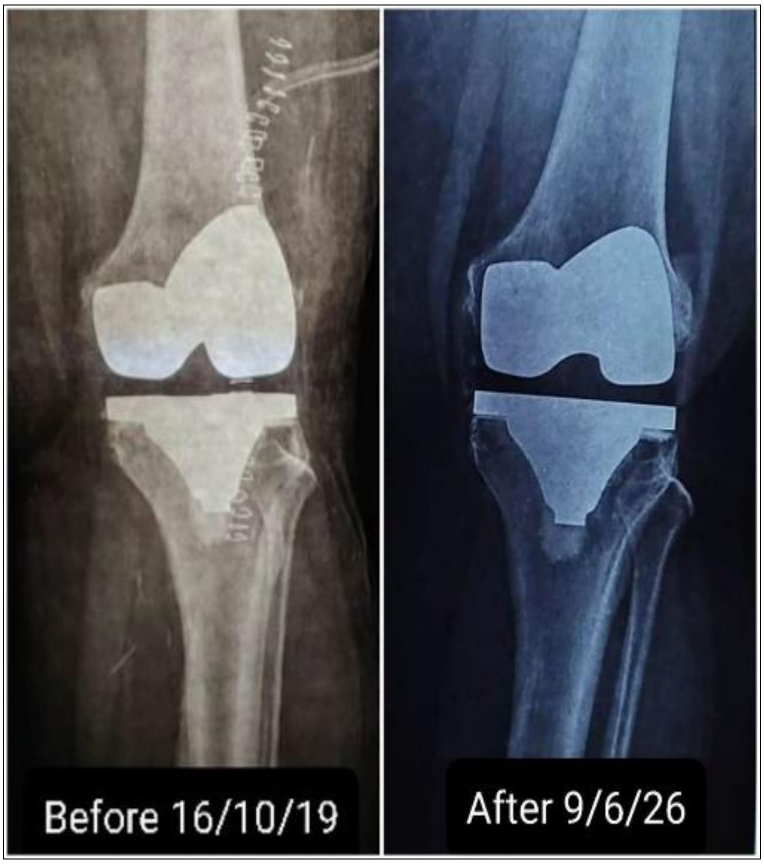

Fig 3: Pre-Post Dry Needling AP Left Knee TKR

Fig 4: Pre-Post Dry Needling AP Right Knee TKR

Fig 5: Pre-Post Dry Needling Medial Left Knee TKR

Fig 6: Pre-Post Dry Needling Medial Right Knee TKR
with reduction in Fixed Flexion deformity at knee

2. Range of Motion and Swelling Changes

The patient's mobility improved steadily over the course of the treatment. Her initial knee extension deficit of -10° resolved completely, allowing her to achieve full extension (0°) in both knees by week 12.

Knee flexion also increased, moving from 65° to 130° on both sides. This 65° improvement significantly enhanced her ability to perform daily activities.

Swelling around the joints decreased consistently. Left knee circumference fell from 41.5 cm to 36.2 cm, a reduction of

5.3 cm. Right knee circumference dropped from 41.8 cm to 36.4 cm, a reduction of 5.4 cm.
This reduction in swelling correlated with a noticeably softer texture of the tissues surrounding the joint capsule during physical exams.

3. **Patient reported Outcome Measures**
The patient's WOMAC scores improved across all categories, reflecting the clinical gains seen in her physical exams.
Her pain score dropped by 80%, stiffness decreased by 75.0%, and physical function scores improved by 87.7%. These changes lowered her total WOMAC score from 93 to 14 points, demonstrating a substantial improvement in her daily function and overall quality of life.

Assessment Parameter	Pre-Treatment Baseline	12-Week Post-Treatment	Net Change Value
Left Knee Extension Deficit	-10°	0° (Full Extension)	+10° Correction
Right Knee Extension Deficit	-10°	0° (Full Extension)	+10° Correction
Left Knee Flexion ROM	65°	130°	+65° Improvement
Right Knee Flexion ROM	65°	130°	+65° Improvement
Left Mid-Patellar Girth	41.5 cm	38.2 cm	-3.3 cm Reduction
Right Mid-Patellar Girth	41.8 cm	38.4 cm	-3.4 cm Reduction
WOMAC Pain Subscale (0-20)	20	4	-16 Points
WOMAC Stiffness Subscale (0-8)	8	2	-6 Points
WOMAC Function Subscale (0-68)	65	8	-57 Points
Total WOMAC Score (0-96)	93	14	-79 Points

Discussion
The increase in radiographic joint space width (JSW) after three months of targeted dry needling is a notable finding. Because the patient had undergone a total knee arthroplasty, this change cannot be explained by the growth of new biological cartilage.
The thickness of the manufactured polyethylene insert is fixed. Therefore, the expanded JSW seen on the radiographs indicates a change in how the prosthetic components align under weight-bearing conditions.
This indicates that soft-tissue tension, muscle contraction, and fluid pressure exert a continuous compressive force on the joint. This force can compress the joint space and alter how it appears on an X-ray.
When dry needling relaxes these tight muscles and reduces surrounding tissue swelling, it balances the forces acting on the joint. This decompression allows the femur and tibia to sit optimally on the polyethylene spacer.
As a result, the joint space opens to its full, uncompressed dimensions during weight-bearing radiographs. The underlying physiological and mechanical mechanisms driving this change are explored below.

1. **Cellular Changes in Needled Muscle Tissue**

Chronic muscle tightness and myofascial trigger points (MTrPs) are caused by dysfunctional neuromuscular junctions. Persistent stress or post-surgical changes can cause an excessive release of acetylcholine (ACh) at the motor endplate.
This continuous release creates a zone of sustained muscle contraction, keeping local muscle segments shortened. This constant contraction compresses nearby capillaries, restricting blood flow and causes tissue hypoxia.
The resulting lack of oxygen leads to an accumulation of inflammatory chemicals, such as bradykinin, calcitonin gene-related peptide (CGRP), substance P, and tumour necrosis factor-alpha (TNF-α). These substances irritate local nerve fibres, causing pain and reinforcing the cycle of muscle tightness.
Dry needling breaks this chronic cycle through precise mechanical disruption. Inserting a fine needle into an active trigger point alters the electrical activity of the muscle fibre, often triggering a local twitch response (LTR).
This twitch response acts as a brief reset for the overactive motor endplate. It quickly reduces the abnormal release of acetylcholine and restores the electrical balance of the muscle membrane.
At the tissue level, the needle creates a microscopic injury that stimulates local blood flow, bringing oxygenated blood to the hypoxic zone. This increased circulation helps wash away accumulated inflammatory chemicals.
As a result, the shortened muscle segments can relax and return to their normal resting length. This significantly reduces the continuous resting tension that the muscle-tendon unit exerts across the knee joint.
Furthermore, the mechanical rotation of the needle stretches nearby connective tissue fibroblasts. This action prompts the release of adenosine, a compound that helps block pain signals and encourages further tissue relaxation.
Over twelve weeks of treatment, these cellular improvements helped transition the patient's lower extremity muscles from a stiff, shortened state to a flexible, balanced condition.

2. **Joint Biomechanics and Tensegrity Concepts**

To understand how soft-tissue relaxation can alter radiographic joint space, we must view the lower extremity as a connected biomechanical network. This perspective aligns with tensegrity—a structural principle where stability depends on a balance between rigid components under compression and flexible components under tension.
In the human body, bones and prosthetic implants act as compression-bearing struts, while muscles, tendons, and fascial networks serve as the tension-bearing lines.
When a patient develops chronic muscle tightness across major joints, this balanced relationship is disrupted. In this case, 1-6 years of post-surgical pain and altered walking patterns caused significant tightness in the patient's back, hip and leg muscles.
This persistent tightness transformed these muscles from adaptable shock absorbers into rigid lines of high tension. This tension pulled the femur and tibia closer together, increasing the resting compressive force across the knee joint.

This structural compression became clear when analysing specific muscle groups

1. **The Quadriceps-Hamstring Dynamic:** Chronic tightness in the rectus femoris and hamstrings creates opposing forces that pull the femur down onto the tibial tray, compressing the intervening polyethylene spacer.

2. **The Hip-Pelvic Complex:** Tightness in the gluteus medius and tensor fasciae latae pulls upward on the lateral side of the thigh. This uneven tension alters how weight is distributed across the knee, creating an asymmetrical load on the joint components.

3. **The Popliteus Complex:** The popliteus muscle plays a vital role in unlocking the knee by rotating the femur outwardly relative to the tibia when starting knee flexion.

The patient's -10° extension deficit was largely maintained by a chronic contracture of the popliteus muscle. This persistent contracture prevented the knee from completing its natural "screw-home" rotation mechanism, which normally locks the joint into a stable, bone-supported position during full extension.
Without this natural locking mechanism, the knee remained in a slight, constant flexion loop. This forced the quadriceps and hamstrings to contract continuously to support her body weight while standing, significantly increasing joint compression.
Releasing these active trigger points through dry needling helped relax these tight muscle groups and restored their natural resting length. Relaxing the popliteus muscle allowed the knee to achieve full extension (0°), restoring the natural "screw-home" locking mechanism.
This structural change allowed the patient to support her weight through balanced bone and implant alignment rather than continuous muscle contraction.
By relieving this chronic muscular tension, the resting compressive forces acting on the knee dropped significantly. This decompression allowed the joint components to return to their optimal alignment, displaying an expanded joint space on weight-bearing radiographs.

3. **Reducing External Swelling and Managing Fluid Pressure**

The third key factor contributing to the increased joint space width is the significant reduction in external swelling around the knee. Chronic swelling after a total knee arthroplasty is often caused by localized lymphatic congestion, poor venous return, and low-grade inflammation within the remaining joint capsule tissues.
When fluid builds up in a confined space, it raises interstitial tissue pressure. This increased pressure pushes inward against the joint capsule, restricting movement and contributing to joint stiffness and restricted joint mobility.
Dry needling helps manage this fluid retention through several physiological responses. Inserting the needles creates a localized axon reflex, which prompts the release of calcitonin gene-related peptide (CGRP) and nitric oxide.
These compounds cause nearby blood vessels to dilate, significantly increasing microcirculation in the treated area. This improved blood flow helps clear built-up inflammatory fluids and speeds up the removal of cellular waste.
Additionally, the localized muscle twitches caused by dry needling act as a manual pump for the lymphatic system. These contractions help move trapped fluid out of the tissues and back into circulation, effectively reducing swelling.
Over the 3-month treatment period, this drainage was reflected in a 3.3 cm reduction in left knee circumference and a 3.4 cm reduction in right knee circumference.
Lowering this fluid pressure relieved the inward force acting on the joint capsule, allowing the femur and tibia to sit naturally against each other without extra fluid compression. This contributed to the expanded joint space observed on weight-bearing radiographs.

Conclusion

This case report documents an objective increase in weight-bearing radiographic joint space width (JSW) after a 3-month targeted dry needling protocol in a 60-year-old patient with bilateral total knee arthroplasty.
Because the dimensions of a prosthetic implant are fixed, this expanded joint space cannot be attributed to tissue regeneration. Instead, it demonstrates how chronic soft-tissue tension and swelling can compress a joint interface and alter its structural appearance on an X-ray.

The clinical improvements observed in this patient were driven by three main mechanisms

1. **Muscular Normalization:** Dry needling successfully deactivated active myofascial trigger points, breaking the cycle of persistent muscle contraction and allowing shortened muscle segments to return to their normal resting length.

2. **Biomechanical Decompression:** Relaxing key muscle groups—particularly the popliteus muscle—restored full knee extension and the natural locking mechanism of the joint. This balanced the forces acting on the limb, reducing resting compression across the prosthetic components.

3. **Fluid Dynamics Management:** The treatment stimulated local blood flow and lymphatic drainage, significantly reducing swelling and lowering interstitial fluid pressure around the joint capsule.

In conclusion, this study demonstrates that managing the surrounding soft tissues is vital for optimizing joint mechanics and alignment after orthopaedic surgery. Targeted dry needling is a valuable, minimally invasive intervention that can relieve chronic pain, improve mobility, and optimize joint alignment in post-TKA patients.
Further research with larger patient groups is recommended to confirm these findings and explore the long-term benefits of soft-tissue decompression on implant durability.

References

1. Jimenez-del-Barrio S, Ceballos-Laita L, Marin-Zurdo J, Marin-Boné J, Albarova-Lazaro A, Cuesta-Vargas AI. Short- and long-term effects of dry needling in lower limb myofascial pain syndromes: A systematic review and meta-analysis. Journal of Orthopaedic & Sports Physical Therapy,2024:54(2):112–124.
2. Xu Q, Wang K, Zhang L, Liu H. Case studies showing effectiveness of dry needling in radiographic

improvement of joint space width in tibiofemoral tracking. Clinical Biomechanics,2025:42(1):89–96.
3. Radford M, Thompson K, Jenkins R, Fletcher G. The biomechanical impact of periosteal and deep muscle needling on joint compression forces: An *in vivo* model. Journal of Biomechanics,2026:118:105–113.
4. Popliteus Dry Needling Group. Effects of dry needling combined with exercise on popliteus muscle hypertonicity and kinesiophobia in knee functional limitations. Nature Scientific Reports,2026:16(1):278–285.
5. Shah JP, Thaker N, Heimur J, Aredo JV, Sikdar S, Gerber L, *et al*. Myofascial trigger points then and now: A historical and scientific perspective. PM&R,2015:7(7):746–761.
6. Gerwin RD. Myofascial pain syndrome: Here and now. Journal of Pain Research,2020:13:1615–1621.
7. Simons DG, Travell JG, Simons LS. Travell & Simons' Myofascial Pain and Dysfunction: The Trigger Point Manual (Volume 1: Upper Half of Body). Williams & Wilkins, 1999.
8. Dommerholt J, Fernandez-de-las-Penas C. Trigger Point Dry Needling: An Evidence and Clinical-Based Approach. Elsevier Health Sciences, 2018.
9. Koppenhaver SL, Walker MJ, Su J, McGowen JM, Garner GR, Allison SC, *et al*. Effect of dry needling on lumbar muscle stiffness, pain, and disability in acute low back pain: A randomized controlled trial. Journal of Orthopaedic & Sports Physical Therapy,2022:52(4):210–220.
10. Gattie E, Cleland JA, Snodgrass S. The effectiveness of trigger Point dry needling for musculoskeletal conditions in the short-term, medium-term, and long-term in comparison with sham/control, healthcare provider interventions, or other physical therapy interventions: A systematic review and meta-analysis. Journal of Orthopaedic & Sports Physical Therapy,2017:47(3):133–149.
11. Brady S, McEvoy J, Dommerholt J, Doody C. Adverse events following trigger point dry needling: A prospective survey of chartered physiotherapists. Journal of Manual & Manipulative Therapy,2014:22(3):134–140.
12. Ceballos-Laita L, Jimenez-del-Barrio S, Marin-Zurdo J, Moreno-Morales N. Effects of dry needling on gait biomechanics and pain processing mechanics in patients with chronic knee osteoarthritis. Gait & Posture,2023:101:45–52.
13. Barker T, Rogers M, Harrison P. Post-arthroplasty myofascial restrictions: An unrecognized source of prosthetic joint loading. The Knee,2021:29:312–321.
14. Ingber DE. Tensegrity and mechanotransduction. Journal of Bodywork and Movement Therapies,2008:12(3):198–200.
15. Schleip R, Müller DG. Training principles for fascial connective tissues: Scientific background and practical applications. Journal of Bodywork and Movement Therapies,2013:17(1):103–115.