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TIBIAL TORSION AFTER MENISCUS INJURY IN YOUNG INDIVIDUALS

Dr. Kumari Nidhi, Dr. Reena Kumari, Dr. Mohit Bhatt, Dr.Saurabh Anand

Student – Masters of Physiotherapy (Apex College of Physiotherapy), HoD Physiotherapy Department (Sardar Bhagwan Singh University), Professor (Sardar Bhagwan Singh University), Professor (Apex College of Physiotherapy)
Department of physiotherapy,
Apex College of physiotherapy, Varanasi, India

ABSTRACT

This study has been undertaken to investigate the meniscal injury, commonly affecting young individuals and the elderly, that can lead to tibial torsion and in-toeing injury can be traumatic or degenerative, with tears often resulting from twisting or axial loading. Meniscal tears frequently involve the medial meniscus and are prevalent in sports like football and basketball.

The purpose of this study was to evaluate the relationship between torsional variation of the lower extremity after meniscus injury.

Total number of articles included in this study-30, Clinical studies-4, Systematic review-7, Comparative case control trial study-4, Experimental study- 3, Descriptive epidemiology study-1

Total study included 30 articles out of which 11 articles excluded during the exclusion criteria articles, 19 included in this study out of which from the above study it is concluded that greater risk of tibial torsion in young individuals due to meniscus injury.

Meniscal injuries often caused by twisting forces on a semi flexed knee can be partial, or complete tears affecting the medial or lateral meniscus with medial tears being more common men are more prone to these injuries due to involvement in contact sports and are more likely to experienced bucket handle tears. These injuries may also involve other ligament and are influenced by limb malalignment which can healing. while which can affect healing while unloader braces are recommended for protecting the meniscus there is no strong evidence supporting their effectiveness.

Meniscal injury can affect the normal tibial alignment the most common mechanism of injury is a twisting injury in a semi flexed lime through meniscus injuries are often seen in athletes because of sports injury

1. INTRODUCTION

Tibial torsion, particularly internal rotation, is frequently observed after meniscus injury—especially in young, active individuals. Meniscal tears are often symptomatic in this group and may lead to in-toeing, alongside other conditions like metatarsus adducts, femoral anteversion, and internal tibial torsion.

Meniscus injuries commonly result from trauma or degeneration, often seen in patients with **genu varum** or **valgum**. A twisting injury, typically in sports like football or basketball, is the most common mechanism—especially involving the medial meniscus due to its reduced mobility and stronger capsular attachment.

Injury to the **ACL, PCL, and meniscus** alters knee biomechanics, including flexion and tibial rotation. Patients with **patellofemoral instability** show increased external tibial torsion, while those with **osteoarthrosis** may exhibit internal torsion. Pathological torsion patterns contribute to gait adaptations and joint degeneration.

Medial meniscus posterior root tears (MMPRT) are associated with **pathological external tibial rotation** during flexion. Pullout repair techniques reduce this abnormal rotation. Unusual tibial alignment also increases the risk of **lateral meniscus tears** in patients with **ACL ruptures**.

1.1 Postoperative Tibial Rotation Measurements:

1. **Pre-op:** Internal rotation ≈ +1.07° (10° flexion), +1.27° (90° flexion)
2. **Post-op:** Internal rotation ≈ +1.60° (10° flexion), +4.33° (90° flexion)

1.2 Clinical Features and Diagnosis:

Symptoms of meniscal injury vary based on severity:

- **Minor tears:** Minimal trauma, delayed swelling
- **Major tears (e.g., bucket handle):** Pain, locking, restricted motion, often with ACL injuries

The **menisci** are fibrocartilaginous, crescent-shaped pads that aid in load distribution, joint stability, and cartilage protection.

1.3 Zones:

1. **Red zone:** Vascular outer third
2. **White zone:** Avascular inner two-thirds
3. **Red-white zone:** Transitional middle

1.4 Embryology:

Develop between 8–10 weeks gestation from mesenchymal tissue. Vascularity decreases and collagen content increases with age. In adults, only 10–30% remains vascularized.

1.5 Mobility and Attachments:

1. **Lateral meniscus:** More mobile
2. **Medial meniscus:** Less mobile, more prone to injury
3. **Movement:** Flexion and rotation cause anteroposterior displacement; flexion displaces posterior horn tears
4. **Ligamentous attachments:** Cruciate ligaments, joint capsule, meniscofemoral ligament, coronary ligaments

1.6 Incidence

Meniscal injury requiring meniscectomy occurs in **61 per 100,000** annually (M: F = 3:1). **Medial tears** are more common (81%) except in wrestling, where lateral tears are equally prevalent.

1.7 Need for Study

Tibial torsion is a critical parameter in clinical orthopaedics. Post-meniscal injury, changes in rotational alignment can affect outcomes and require thorough evaluation for treatment planning.

1.8 Aim and Objective

Aim: To evaluate clinical, biomechanical, and radiographic outcomes in patients with tibial torsion following meniscal injury.

Objective: To analyse the relationship between lower limb torsional variation and meniscal injury, aiding in early detection and improved treatment strategies.

2. PATHOMECHANICS

2.1 Modes of meniscus injury

Meniscal tears typically result from either:

1. Excessive force applied to a normal meniscus, or
2. A normal force acting on a degenerative meniscus.

The most common mechanism of injury is a twisting motion on a semi-flexed knee. These injuries are frequently observed in athletes because of sports-related trauma.

Meniscal tears can be partial or complete and may involve either the medial or lateral meniscus. Medial meniscus tears are more commonly reported than lateral tears.

2.2 Predisposing Factors and Associations

Gender Differences:

Men are more commonly affected, likely due to greater participation in aggressive sports. They are also more likely to sustain bucket-handle lesions, which are typically trauma-related.

Weight-Bearing Role:

Meniscal tears occur in the weight-bearing knee, and are often associated with injuries to other ligaments, especially:

1. ACL (Anterior Cruciate Ligament)
2. MCL (Medial Collateral Ligament)

2.3 Limb Malalignment:

1. Varus alignment: Increases load on the medial compartment, stressing the medial meniscus.
2. Valgus alignment: Increases load on the lateral compartment, stressing the lateral meniscus.

These altered biomechanics can impair meniscal healing post-injury or surgery. Limb malalignment is also associated with degenerative meniscal tears, which have reduced healing capacity.
While unloader braces are suggested to reduce stress during healing, scientific evidence supporting their efficacy is lacking.

2.4 Types of Meniscal Tear Patterns

a) Longitudinal/Vertical Tear:

- Occurs along the length of the meniscus.
- If extended, it can become a bucket-handle tear, which runs almost the entire length of the meniscus.
- A displaced flap may become trapped in the intercondylar notch, causing locking.

b) Horizontal Tear (Horizontal Slit):

- Begins at the inner edge of the meniscus and extends towards the capsule.
- May be part of complex tear patterns.

c) Discoid Meniscus Tear (Usually lateral side):

- Incomplete Discoid: Larger than normal meniscus, but still attached.
- Complete Discoid: Covers the entire tibial plateau, also typically attached.
- Discoid menisci are more prone to tearing due to their abnormal shape and structure.

d) Radial Tear:

- Starts at the inner margin and extends outward toward the capsule.
- Commonly occurs in the mid-portion of the meniscus.
- Lateral radial tears are often associated with ACL injuries.
- Radial tears compromise the circumferential fibres, significantly reducing meniscal function.

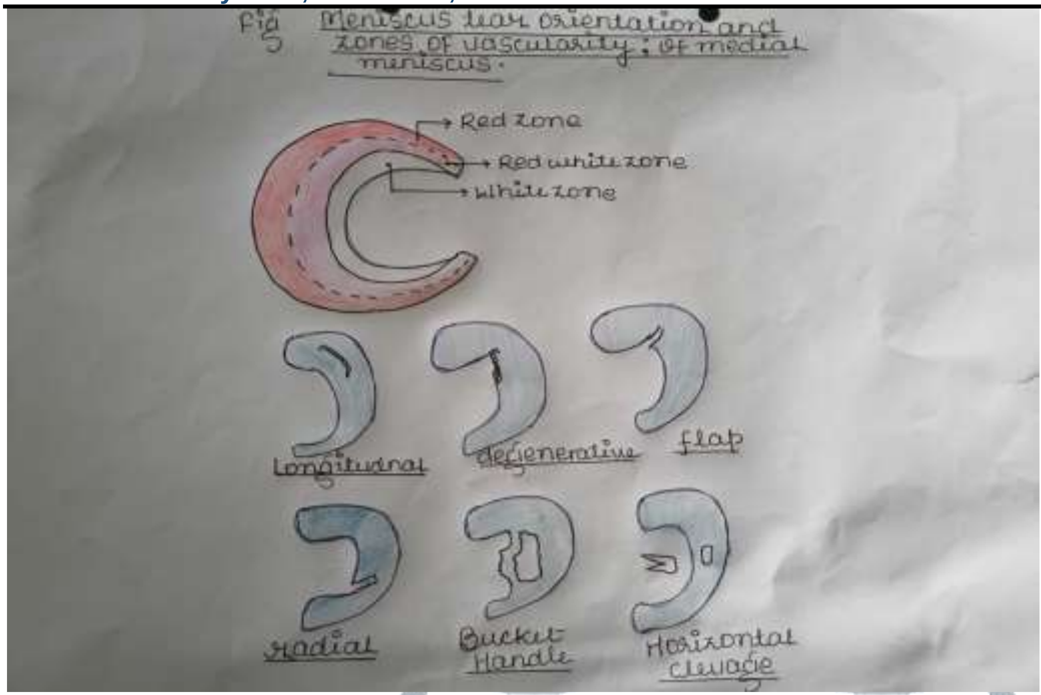

Fig1.meniscus tear orientation

Tibial torsional deformities may either be congenital, developmental, or post traumatic. The congenital and developmental deformities usually show spontaneous correction. whereas the post traumatic variety requires osteotomy if the deformity is severe.

2.5 The effect of tibial torsion after meniscus injury on the pathology of the knee:

These effects are either difficult to measure or unsubstantiated. The effects of femoral anteversion in adult life, tibial torsion, and the usefulness of de-rotation procedures are unknown. Although the deleterious effect of valgus and varus deformities in the frontal plane of the knee are well recognised, axial deviations are relatively neglected.

In children with various neuromuscular disorders the role of torsional deformity is better understood

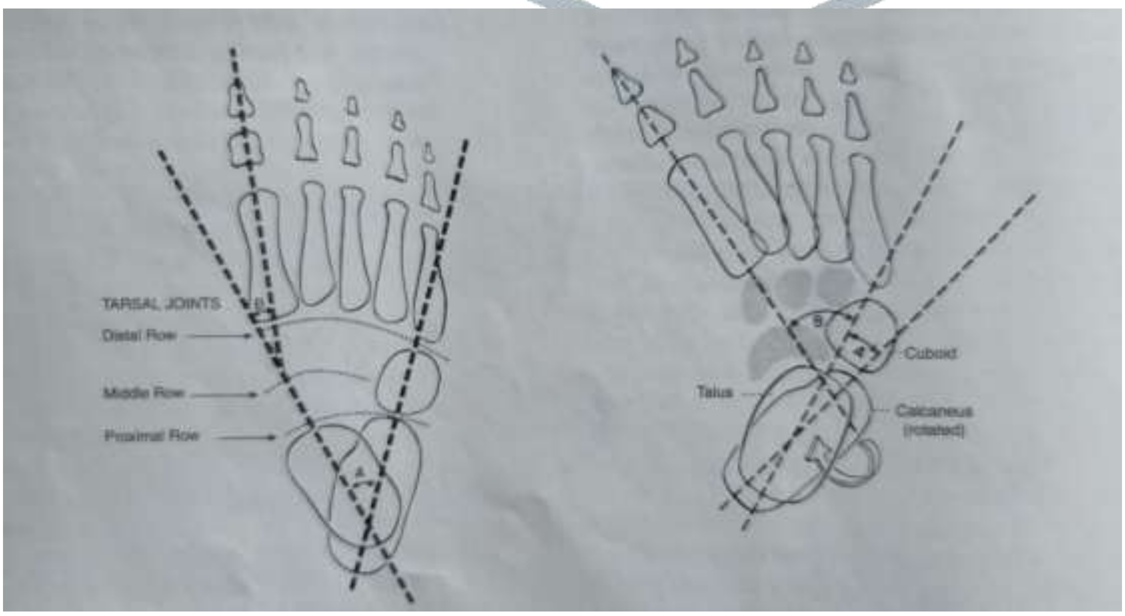

Fig2. radiographic evaluation of clubfeet.note the "parallelism" of the talus and calcaneus with a talo calcaneal angel a of <20° and negative talus first metatarsals angle b on the clubfoot side.

2.6 Tibial torsion and knee joint pathology

Association Between Tibial Torsion and Knee Pathology: To examine the association between tibial torsion and knee joint pathology, measurements were conducted using a simple tropometer, suitable for outpatient settings. Data from patients in 11 diagnostic groups were compared to a control group.

Significant findings:

I. Patients with patellofemoral instability exhibited greater than normal external tibial torsion.
II. Patients with pan-articular osteoarthritis (OA) of the knee showed reduced external tibial torsion or even true internal torsion.

Abnormal torsion affects gait, leading to altered external loading on the knee, potentially contributing to the development or progression of osteoarthritis.

- There is also a correlation between reduced lateral torsion and the severity of knee OA, as well as with general osteoporotic changes.

2.7 Tibial Torsion Angle (TTA) After ACL Reconstruction

Malalignment in the lower extremity—particularly increased femoral anteversion and abnormal tibial torsion angle (TTA)—are key intrinsic risk factors for both ACL injuries and re-injuries.

Dynamic valgus and torsional alignment abnormalities are modifiable risk factors and can be influenced by:

a) Muscle fatigue
b) Limb strength deficits

The typical mechanism of ACL injury includes:

1. Internal rotation of the tibia relative to the femur
2. Combined rotational torque and compression, especially during hard landings
3. External tibial rotation combined with valgus knee movement is also implicated, though this might occur after the ACL has ruptured

Additionally, congenital absence of the ACL—more common than previously thought—is associated with abnormal tibial torsion and other developmental anomalies in bone and soft tissue.

2.8 Tibial Torsion and Knee Instability in Meniscal Injuries

In young populations and athletes, meniscal injuries often coincide with:

1. Patellar dislocation
2. Anterior knee pain
3. Abnormal gait patterns (e.g., crouch gait, reduced flexion during swing phase)
4. Ligamentous instability (including ruptured cruciate ligaments)
5. Varus or valgus malalignment

The most common lower leg alignment issue in these cases is tibial torsion either internal or external:

- Internal tibial torsion may cause knee varus
- External tibial torsion may cause knee valgus

In meniscal injury, torsional instability can be difficult to detect and manage. Rotational osteotomies are often required in cases with significant torsional deformity. In younger patients, simpler fixation methods (e.g., pins and plaster) can be effective. However, increased external tibial torsion has been observed over time as the child grows.

2.9 ACL Injury from Internal Tibial Torsion and Tibiofemoral Compression

The most frequent kinetic mechanism leading to ACL rupture is:

- Internal tibial rotation relative to the femur, or
- Combined torque and compression during landing from a jump.

Post-injury biomechanics often show:

- Posterior displacement of the femu**r** relative to the tibia
- Significant increase in **valgus rotation of the femur**

More than **50% of ACL ruptures** are associated with **meniscal injuries**.

2.10 Common Running Injuries: Knee Pain from Meniscus Damage

Running-related meniscal injuries are more likely in:

- Older individuals
- Athletes who run on uneven surfaces
- Those performing sudden directional changes or hard stops (e.g., soccer)

A torn meniscus can cause:

- Knee pain
- Swelling and stiffness
- Locking or giving way, especially if a torn flap interferes with joint motion
- Tibial torsion can worsen the mechanical strain on the knee during running, compounding the injury.

2.11 Biomechanics of the knee

The knee joint must withstand substantial mechanical loads during both weight-bearing and motion. Its proper function relies heavily on the alignment of the lower limb.

Malalignment alters force transmission across the joint, increasing the risk for:

- Intra-articular damage (e.g., cartilage or meniscal injury)
- Increased contact pressures

Medial compartment overload due to varus malalignment is particularly concerning.

This can be surgically addressed using:

1. Medial Opening Wedge (MOW) Osteotomy
2. Lateral Closing Wedge (LCW) Osteotomy

Biomechanical studies show:

- Varus malalignment correlates with increased medial meniscal extrusion
- This results in higher tibiofemoral contact pressures on the medial compartment
- To unload the medial compartment, valgus-producing high tibial osteotomies (HTOs) are commonly used.
- Only 28% of varus malalignment cases stem from isolated tibial deformity, highlighting the need for a comprehensive approach to limb realignment.

Tibiofemoral alignment and weight bearing forces:
1. The anatomical longitudinal axis of the femur is oblique, directed inferiorly and medially from its proximal to distal end. The anatomical axis of the tibia is directed almost vertically. The femoral and tibial longitudinal axes normally form an angle medially at the knee joint of 180 to 185 degree; that is the femur is angled up to the 5degree off vertical, creating a slight physiological [normal] valgus angle at the knee.
2. If the medial tibiofemoral angle is greater than 185 degree an abnormal condition called genu valgum [knock knee] exists. If the medial tibiofemoral angle is 175degree or less, the resulting abnormality is called genu varum [bow leg].

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2.12 Loading the anterior cruciate ligament through combined motions:

The anterior cruciate ligament is attached distally to the tibia on the lateral and anterior aspect of the medial intercondylar tibial spine. It extends superiorly, laterally, and posteriorly to attach to the posteromedial aspect of the lateral femoral condyle.

The translation and rotational movement that stress the anterior cruciate ligament can in combination generate even greater stress on the ligament. It is combination of either varus or valgus forces with anterior translation of the tibia increases the strain on the ACL, as did the combination of a valgus forces and medial rotation.

A combination of medial rotation and anterior translation increased the force on the ACL beyond that of isolated anterior translation during a knee ROM from 5degree of hyperextension to 10degree of flexion. The inclusion of tibial lateral rotation with anterior tibial translation reduced the force on the ACL at all knee flexion angles greater than 10degree.

2.13 Tibiofemoral joint function:

The primary angular motion of the tibiofemoral joint is flexion extension, although both medial /lateral rotation and varus v/valgus motion occur to a lesser extent Role of the cruciate ligaments and menisci in flexion/extension:

During weight bearing knee extension, the femoral condyles roll anteriorly on the tibial plateau until the rigid posterior cruciate ligament checks further anterior progression of the femur, creating a posterior translation force on the femora condyles. The anterior glide of the femur during weight bearing flexion may be further facilitated by the shape of the menisci. Because the menisci create a circular wedge around the tibial plateau, as the femoral condyles roll posteriorly on tibial plateau, they must roll "uphill" with weight bearing knee flexion.

2.13 Hip and patellofemoral joint loading during gait are increased in children with torsional deformity:

Torsional deformity of the femur and tibia are associated with gait impairment and joint pain. femoral neck anteversion and external tibial torsion for the patient ere[mean+-SD]38degree + 9degree and 40degree+10degree.respectively. patient had increased internal hip rotation and external knee rotation as well as increased pelvic tilt during gait patella-tuberosities tibia and malleolus as reference points and made anthropometric measurements with the "BROCA" device and obtained an average value of 23.7° The method of measurement "tibiofibular torsion evaluation using a trigonometric method. Lower extremity alignment problems such as increased femoral anteversion and TTA are one of the most important intrinsic risk factors for ACL injuries and re- injuries. Dynamic valgus and torsional alignment differences are modifiable risk factors for ACL tears.

2.14 The Effect of Excessive Tibial Torsion on Muscle Capacity During Single-Limb Stance

Excessive tibial torsion—a rotational deformity along the long axis of the tibia—is frequently observed in patients with meniscal injuries and contributes to abnormal lower limb biomechanics.

To assess the biomechanical impact of tibial torsion, a dynamic model was used to evaluate how this deformity affects muscle function during the single-limb stance phase of normal gait, a phase that places significant demand on the hip and knee extensors to maintain posture and forward motion.

3. ASSESSMENT AND TREATMENT

3.1 Biomechanics of Tibial Rotation and Meniscal Movement (Kinematic MRI Study)

Study Design:

- 30 volunteers with healthy knees were imaged using **kinematic MRI**.
- Imaging occurred through **knee flexion (0°–40°)** and **extension (40°–0°)** in the **transverse plane**.

Key Findings:

- **Tibial Rotation**:
  - **Internal rotation during flexion**: 11.55° ± 3.20°
  - **External rotation during extension**: 11.40° ± 3.0°
- **No significant differences were found between:**
  - Internal and external tibial rotation angles ($P > 0.05$)
  - Male vs. female participants ($P > 0.05$)
  - Left vs. right knee joints ($P > 0.05$)
- **Significant difference in tibial rotation angle:**
  - Between flexion angles of **0°–24° vs. 24°–40°** ($P < 0.01$)

Meniscal Movement:

- **Posterior translation** of both medial and lateral menisci during knee flexion
- Increased meniscal **height**
- Greater movement range in:
  - **Anterior horn > posterior horn**

  - ○ **Lateral meniscus > medial meniscus** ($P < 0.01$)

- **Decreased distance** between anterior and posterior horns during flexion
  - ○ **More pronounced in the lateral meniscus** ($P < 0.01$)

- **Minimal medial-lateral (side-to-side)** meniscal movement

3.2 Imaging and Arthroscopic Correlation of Meniscal Injuries

Study Overview:

- 78 menisci examined in 39 patients (MRI + MDCT; 28 had arthroscopy)
- **Meniscal Abnormalities** (33/78 menisci; 42%):
- **Longitudinal tears**: 11 (33%)
- **Meniscal contusions**: 17 (52%)
- **Flap tears**: 4 (12%)
- **Horizontal tears**: 6 (18%)
- **Radial tears**: 6 (18%)

Stability:

14 out of 16 patients with meniscal tears had **unstable lesions**

Imaging Agreement:

- Good correlation between **CT and clinical measurements**
- CT measurements were significantly **greater** than radiographic ones ($p = 0.001$)
- **Intra-class correlation coefficient**: 0.63 (moderate reliability)

3.3 Physical Therapy Assessment and Special Tests

Clinical Tests for Meniscal Injury:

1. McMurray's Test:

- IR + varus stress → **lateral meniscus**
- ER + valgus stress → **medial meniscus**

2. Apley's Test:

- Compression + rotation = more pain → **meniscus lesion**
- Distraction + rotation = more pain → **ligament involvement**

3.4 Functional Performance Testing (ALESA Protocol)

Pre-test Dynamic Warm-Up *(10–15 min)*:

- Light jogging, side shuffles, high knees, butt kicks, dynamic stretches, hops

Tests (Scoring: Pass = 1, Fail = 0):

1. **Bilateral squat**
2. **Single-leg squat** (≥80% both limbs)
3. **Broad jump for distance** (PASS = jump ≥ height)
4. **Single-leg hop for distance** (LSI ≥ 85%)
5. **Single-leg hop for time (6 m)** (LSI ≥ 85%)
6. **Single-leg triple hop** (LSI ≥ 85%)

3.4 Treatment Options for Meniscal Injuries

1. Conservative Management ***(Preferred for minor, degenerative, or stable tears)***

Key criteria for return to sport:

- No swelling (effusion)
- Full ROM
- Strong quadriceps and hamstrings
- Good hip rotator function
- Proprioception restored
- Tolerates sport-specific drills

Best outcomes: In **red or red-white zones** (vascularized regions of the meniscus)

2. Surgical Management

Procedures:

- **Arthroscopic meniscectomy**
- **Partial meniscectomy** (shaving)
- **Meniscal repair** (favoured if tear is peripheral, recent, in young/stable patients)

Poor candidates for repair:

- Degenerative, complex, flap, and horizontal cleavage tears

3.5 Rehabilitation Protocol (Before and After Arthroscopic Partial Meniscectomy)

Prehabilitation Goals:

- Reduce pain/swelling
- Maintain strength (quads, hamstrings, hips)
- Protect joint (crutches if needed)
- Educate patient

Post-Op Rehab Phases:

Phase 1 (Days 1–7): Acute Phase

- **Goals**: Decrease swelling, restore ROM, activate quads
- Interventions:
  - Cryotherapy, compression
  - Electrical stimulation
  - Quad sets, SLR, mini-squats (30°)
  - AAROM, weight bearing as tolerated

Phase 2 (Days 7–14): Subacute

- Full extension to 90° flexion
- Begin **leg press, hamstring curls, cycling** (if ROM > 100°)
- Proprioceptive drills, balance training

Phase 3 (Weeks 4–6): Strength & Motion

- Remove brace
- Full ROM
- Strengthen hip/knee musculature

Phase 4 (Weeks 6–10+): Return to Sport

- Full ROM and strength
- Dynamic proprioceptive training
- **Sport-specific drills**

4. METHODOLOGY

Total articles included: 30

- **Clinical studies:** 4
- **Systematic reviews:** 7
- **Comparative case-control trials:** 4
- **Experimental studies:** 3
- **Descriptive epidemiology studies:** 1

5. REVIEW OF LITERATURE

Literature Review and Conclusions

S.no	Author &year	Study designs	No. of patients	Assessment applied	Treatment	Outcomes measures	Conclusions
1.	Okazaki et al 2021	Clinical study	Ninety-one patients (68 women and 23 men	CT study	Transtibial pullout repair of MMPRT	The ERA and the meniscal healing score were significantly associated, confirming that increased ERAs were correlated with worse meniscal healing status (R-0.28; P<0.001).	It concludes that Postoperative tibial rotation could be one of the factors affecting postoperative outcomes of pullout repair of MMPRT. Controlling the tibial rotation may possibly improve meniscal healing
2.	Brian J Vial et al. 2021	Retrospective cohort study	167 cases	Demographic and surgical characteristics were recorded.	Complete lateral meniscal posterior root tears (LMPRTs) repair	MRI, CT scan	Complete LMPRTS warranting repair are encountered with a significantly greater frequency at RACLR as compared with PACLR. The overall incidence of LMPRT repair at RACLR is high.

3	Hiranaka et al 2021	Systematic review	91 Patients	Computed tomography	arthroscopy	MRI	Post operative tibial could be one of the factors affecting postoperative outcomes of pullout repair of MMPRT Controlling the tibial rotation may possibly improve meniscal healing.
4	ÜRKLÜ et al 2020	Experimental	21patients	CT scan	ACL reconstruction with HT autograft and then completed the ACL rehabilitation.	Muscle strength dynamometer and goniometer used as outcomes measure.	It was concluded that the effect of ACL reconstruction in tibial torsion angle.
5	Okoroha et al. 2019	Clinical study	200 patients	Assessed by MRI images	Arthroscopic surgery	MRI and CT scan	Patients with greater tibia varus angles, increased tibial angles have an increased risk of ACL injury and lateral meniscus posterior root tear.
6	RODEO ET AL.2019	Systemic review	10-20 patients	MRI	Meniscectomy	MRI	It concluded that after injury to meniscus due to poor intrinsic vascularity, hypocellularity, inflammatory mediator and various protease in the synovial fluid environment, and the complex mechanical loads on the healing tissue are the factor that can cause later OA and torsional deformity.

7	Guler et al.2016	Retrospective comparative study	71 patients	MRI	Arthroscopic surgery	Mean FFA and TMA Values	It concluded that there is relationship between internal tibial torsion and medial collateral ligament injury in patients undergoing knee arthroscopy due to tear in the posterior one third of the medial meniscus.

6. RESULTS

Study design: This study is review of literature entitle tibial torsion after meniscus injury in young individuals.

Study material: This article was identified through PubMed, Google scholar, Medscape, science direct.

Objective of the study: To detail about ethology, Patho mechanics and rehabilitation program after surgery.

Setting of the study: Sardar Bhagwan Singh Post Graduate Institute of Biomedical Science and Research, Balawala Dehradun, Uttrakhand

Key words: Tibial torsion, meniscectomy, Meniscal injury, TFA, varus/valgus malalignment
Results: Total study included 30 articles out of which 11 articles excluded during the exclusion criteria articles, 19 included in this study out of which

7. DISCUSSION

The most significant finding of the present study is that satisfactory outcomes have been observed in patients with tibial torsion following meniscal injury, particularly when timely and appropriate interventions are applied. However, an isolated meniscal tear treated with limited meniscectomy is associated with a high risk of radiographic deterioration and symptomatic progression.

The purpose of this study was to evaluate the relationship between torsional variation of the lower extremity and meniscal injury outcomes. Meniscal tears occur either due to an excessive force applied to a healthy meniscus or a normal force acting on a degenerative meniscus. The most common mechanism of injury is a twisting motion on a semi-flexed limb, which is frequently seen in athletes, particularly during sports that involve pivoting and rapid direction changes.

A meniscus can suffer a partial or complete tear, affecting either the medial or lateral meniscus. Medial meniscus tears are reported more commonly than lateral tears. Men are more frequently affected than women, likely due to higher participation in physically demanding sports. Bucket-handle lesions

The primary goal of meniscal surgery is to preserve as much of the native meniscus as possible, as the meniscus plays a critical role in load transmission, joint stability, and cartilage protection. Arthroscopic meniscal repair using sutures is preferred in cases.

8. CONCLUSION

From the above study it is concluded that greater risk of Tibial torsion in young individuals due to meniscus injury. Meniscal injury can affect the normal Tibial alignment. The most common mechanism of injury is a twisting injury in a semi flexed limb through meniscus injuries are often seen in athletes because of sports injury. Meniscal tear require meniscectomy. The aim of surgery is to preserve as much of the meniscus as possible. Rehabilitation should always commence prior to surgery and in some cases, surgery can be avoided because pre rehabilitation leads full recovery.

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