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A Prospective Study of Isolated Meniscus Injuries in Stable Knees Undergoing Arthroscopy

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ABSTRACT
The objective of this prospective observational study was to determine the prevalence of isolated meniscus tears based on age, gender, type and location. Additionally, the study aimed to identify risk factors associated with meniscal injuries, including high body mass index (BMI), work-related activities (such as kneeling, squatting, climbing stairs, lifting heavy weights, prolonged standing and walking), smoking and alcohol consumption. The study spanned 72 weeks and included patients between the ages of 18-60 years with symptomatic knees and isolated meniscus injuries undergoing arthroscopy. Patient profiles, detailed histories and clinical examinations were conducted and documented. Clinical and arthroscopic findings were recorded in a standardized proforma and work-related activities were assessed using a questionnaire. Of the 72 cases included in the study, meniscal tears were found in 56% of males and 44% of females. Medial meniscus tears accounted for 64% of the cases, with red-white zone tears comprising 68% and posterior 1/3rd zone tears comprising 60%. Bucket-handle tears were reported by 28% of the patients, followed by horizontal tears at 25%. Among the identified risk factors, a high BMI was found in 62% of the population, including those who were overweight (25-29.9) and obese (30-34.9). Lateral meniscus tears were more common in females (78%) below 40 years of age and in males (73%) above 40 years of age. Isolated medial meniscus tears were less prevalent in younger females compared to males. The study observed that meniscal injuries were more common among individuals in their 4th and 5th decades of life. It was concluded that the medial meniscus was more prone to injury compared to the lateral meniscus and increasing age was associated with isolated medial meniscus injuries in both sexes. High BMI and work-related activities such as kneeling, squatting, prolonged standing and walking were found to have an impact on the occurrence of meniscal injuries.

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Key Words
Body mass index, work-related activities, arthroscopy

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INTRODUCTION

Meniscal tears are one of the most common injuries seen in orthopedic clinics. Initially it was thought to be a vestigial remnant of a leg muscle with less function. However, the meniscus is now recognized as an integral component of the complex function of the knee[1,2]. The Meniscus of the knee plays a crucial role in shock absorption, stability and act as a joint filler, compensating for gross incongruity between the femoral and tibial articulating surfaces. They also play a vital role in load-bearing and shock absorption within the joint[3].

The menisci are important structures within the knee, with complex biomechanical functions. They are thought to bear 40-70% of the load across the knee[1,2]. The menisci increase the contact area between articulating surfaces and act as secondary restraint for knee stability[4,5]. Meniscal tears commonly occur in combination with ACL tears or other intra-articular or extra-articular lesions. Numerous studies have evaluated the occurrence of these injuries[6-11]. However, there is dearth of literature on isolated meniscal tears.

The main objective of this study was to document the characteristics of isolated meniscal tears, including their type and location, in knees with intact cruciate ligaments. Additionally, the study aimed to determine the prevalence of these tears, any variations between sexes and therisk factors associated with their occurrence.

Having knowledge about the anatomical characteristics, type, location, frequency, risk factors of the most common tears that occur in stable knees is of significant importance. It aids in making informed decisions regarding the appropriate treatment approach, whether it be repair or excision. Furthermore, this knowledge can contribute to the prevention of meniscal tears in groups with modifiable risk factors, thereby avoiding complications. Identifying the risk factors is crucial for accurate diagnoses of knee disorders and plays a pivotal role in developing prevention strategies for knee osteoarthritis.

Aim: To provide data on the prevalence of isolated meniscus tears in stable kneesundergoing arthroscopy.

Objectives:

- To observe the prevalence of isolated meniscus tears with respect to age, gender, type and location
- To determine the presence of risk factors leading to meniscal injuries, such as:
- High body mass index (BMI):
- Work-related activities involving kneeling and squatting
- Climbing stairs and carrying heavy weights
- Prolonged standing and walking
- Smoking and alcohol consumption

MATERIALS AND METHODS

Source of data: Data will be collected from patients who visit the Outpatient Department (OPD) and the Department of Orthopedics at Sanjay Gandhi institute of trauma and Orthopedics in Bangalore. These patients will have knee joint injuries and will be scheduled for Arthroscopic surgery. Prior to data collection, informed consent will be obtained from each patient.

Sample size: A total of 72 patients were included in the study.

Study period: The study was conducted for a duration of two years, from January 2021 to December 2022.

Type of study: Prospective observational study.

Inclusion criteria: The study included patients who had undergone knee arthroscopy.

Patients in the age group between 18 and 60 years were included in the study.

Included patients were those with documented evidence of a meniscal tear, either in the lateral or medial compartment. Only stable knees without any concomitant injuries or previous procedures were included.

Exclusion criteria: Age groups below 18 years and above 60 years were excluded from the study. Additionally, patients with unstable knees and concomitant ligament injuries were also excluded.

Degenerative tears, discoid meniscus and cysts were excluded from the study population.

Patients with inflammatory or infective arthritis, as well as those with a history of major knee injuries such as open fractures around the knee, were also excluded.

Data collection and methodology: The study was designed as a prospective observational study. It spanned a period of 2 years and included patients between the ages of 18 and 60 years who had symptomatic knees with isolated meniscus injuries and were scheduled to undergo arthroscopy.

Patient profiles, detailed histories and clinical examinations were conducted and documented. Clinical and arthroscopic findings were recorded in a proforma and work-related activities were assessed through a questionnaire, which included the following headings:

High body mass index (BMI):

- Work-related activities involving kneeling and squatting
- Climbing stairs and carrying heavy weights
- Prolonged standing and walking
- Smoking and alcohol consumption

Demographic data, including occupation, of the patients was collected. A detailed history was obtained, including information about the mode of onset of knee pain, whether it was related to a specific injury (contact or non-contact) or occurred gradually over time (insidious onset). The impact of the knee pain on daily activities and functioning, leading to limitations, was assessed.

Additionally, any co-morbidities and personal habits of the patients were documented as part of the study.

A detailed examination of the involved knee joint was conducted. The presence of swelling, locking and deformity of the knee joint was assessed. Bony tenderness along the medial or lateral joint lines was examined and the presence of crepitus was checked. Range of motion of the knee joint was evaluated and special tests for meniscal injuries, such as the McMurray test, were performed and documented.

Arthroscopic findings were recorded using a standard Arthroscopic proforma.

All patients included in the study underwent arthroscopic confirmation of meniscal lesions using a standard probe. The lesions were documented according to the Cooper classification system. The tears were identified as occurring in either the medial or lateral meniscus.

Patients with a clinical, radiological, or post-arthroscopic diagnosis of meniscal tears were screened according to the inclusion and exclusion criteria by the principal investigator. Each patient was provided with an explanation of their participation in the study and written informed consent was obtained before their enrollment.

Work-related activities (in an average working day):

- **Kneeling and squatting:** <30 min day^{-1}, >1 hr day^{-1}, Insignificant
- **Climbing stairs:** >30 flights of stairs day^{-1}, Insignificant
- **Prolonged standing:** <2 hrs day^{-1}, >2 hrs day^{-1}, Insignificant
- **Walking distance:** <1 km day^{-1}, >1 km day^{-1}, 1-2 km day^{-1}
- **Lifting weights:** Insignificant, >10 kg by hand >10 times week^{-1}, >25 kg by hand >10 times week^{-1}

Alcohol intake (units consumed per week):

- Non-alcohol
- 1-14 units per week
- 15 units per week

Smoking (pack years):

- Yes (pack years)
- No

Note: 1 unit contains 10 mL or 8 g of alcohol. Pack years = (number of cigarettes per day/20)×number of years smoked

Sample size: The sample size was estimated using repeated measures ANOVA, based on the primary objective, using the equation:

$$n = \frac{(Z1-\alpha/2+Z1-\beta)^2\ o^2\ 2\ [1+(m-1)\ \rho]}{md^2}$$

where, n is sample size, Z1-α/2 = 1.96 at α = 0.05 Z1-β is 0.84 at 80% power σ is standard deviation m is number of assessments is 4 ρ is interclass correlation (0.3) d is clinically significant difference is 7.

Upon calculation, for 80% power of the study with a confidence interval of 95%, accounting for a dropout rate of 15%, the minimum sample size was estimated to be 90. However, we were able to recruit 72 patients for this study.

Statistical analysis: Statistical analysis was performed using SPSS for Windows (version 11.5; SPSS, Chicago, IL, USA). Microsoft Excel was used to calculate statistical values and create diagrams. Continuous variables were presented as Mean±standard deviation, while categorical variables were reported as counts and percentages.

The Kruskal-Wallis ANOVA test and post-hoc tests were utilized to assess the effects of age, sex, BMI and other risk factors on the prevalence, sites and types of meniscal tears. Correlations and risk analyses were conducted separately and a p-value less than 0.05 was considered statistically significant, indicating rejection of the null hypothesis.

RESULTS

Among the 72 participants, 56% were males and 44% were females. It was observed that right-side meniscal tears accounted for 56% of the cases, while left-side tears accounted for 44%.

Within the age group of 18-60 years, the majority of participants (38%) fell within the age range of 51-60 years. The mean age of all participants was calculated to be 42.18±12.64 years.

TheBMI of the observed patients with meniscal injuries was found to be higher in the overweight and obese population combined, accounting for 62% of the cases, which was statistically significant. In the age group of >40 years, both males and females had higher BMI values, comprising 38% of the observed cases. The mean age of the participants was 42.18±12.64 years, with a mean BMI of 28.03±3.88 kg m^{-2}. Among the occupation categories, the highest percentage of meniscal tears was observed in housewives (24%) and manual laborers (23%). Out of the total cases observed, 32% of patients reported atraumatic or insidious onset of injury, while 31% reported a twist injury (non-contact). This may be attributed to the fact that these occupations involve regular kneeling and squatting activities.

In this study, it was found that work-related activities such as kneeling, squatting and prolonged standing and walking had a significant impact on the occurrence of meniscal tears, as indicated by a statistically significant p-value. On the other hand, lifting heavy weights and climbing stairs were observed to have a minimal impact on the occurrence of meniscal tears in the study, with no significant association found.

In this study, a higher number of meniscal tears were observed in the non- smoker group, accounting for 75% of the total patients. Similarly, the non-alcoholic group had a greater prevalence of meniscal tears, representing 64% of the total patients. In comparison, the smoker group accounted for only 25% of the observed cases, while the alcoholic group represented 36% of the cases.

In this study, the majority of meniscal tears involved the medial meniscus, accounting for 64% of the cases, while the lateral meniscus tears represented 28% of the cases. Combined, both medial and lateral meniscus tears accounted for 8% of the total cases. Unstable tears were found to be more common, representing 76% of the observed cases, while stable tears accounted for 24% of the cases.

In this study, meniscal tears were observed to occur more frequently in the red-white zone, accounting for 68% of the cases. Tears in the posterior 1/3 of the meniscus were observed in 60% of the cases. The red-red zone accounted for 26% of the tears, while tears in the body of the meniscus were observed in 33% of the cases (Fig. 1).

In this study, of the 72 cases observed, bucket handle type tears were reported in 28% of the patients. Horizontal tears were the second most common type, accounting for 25% of the cases, followed by complex tears in 21% of the cases. Flap tears and radial tears were observed less frequently in this study. These findings indicate that bucket handle, horizontal and complex tears are the predominant types of meniscal tears in the studied population.

In this study, the most common tear pattern observed in the medial meniscus was the bucket handle tear, accounting for 33% of the cases. In the lateral meniscus, the most common tear pattern observed was complex tears, representing 35% of the cases. These findings suggest that bucket handle tears are more prevalent in the medial meniscus, while complex tears are more common in the lateral meniscus.

In this study, no significant gender difference was observed in the occurrence of medial and lateral meniscus tears. Both males and females were equally affected by these types of tears. However, when analyzing specific tear patterns, it was found that among males, bucket handle tears were more commonly observed, accounting for 35% of the cases, followed by complex tears at 22%. On the other hand, among females, horizontal tears were more prevalent, representing 34% of the cases, followed by bucket handle tears at 22%. These findings suggest that there may be some variation in the distribution of tear patterns between males and females. In this study, it was observed that medial meniscus tears were more common in patients above 40 years of age, regardless of sex. Among females, 73% of the cases involved medial meniscus tears, while among males, the prevalence was 62%. Interestingly, a lower prevalence of isolated medial meniscus tears was found in younger females compared to males.

On the other hand, lateral meniscus tears were found to be more common in females below 40 years of age, with a prevalence of 78%. Among males above 40 years of age, the prevalence of lateral meniscus tears was 73%. These findings suggest that the distribution of meniscus tears differs based on age and sex, with medial tears being more prevalent in older individuals and lateral tears being more prevalent in younger females and older males (Fig. 2).

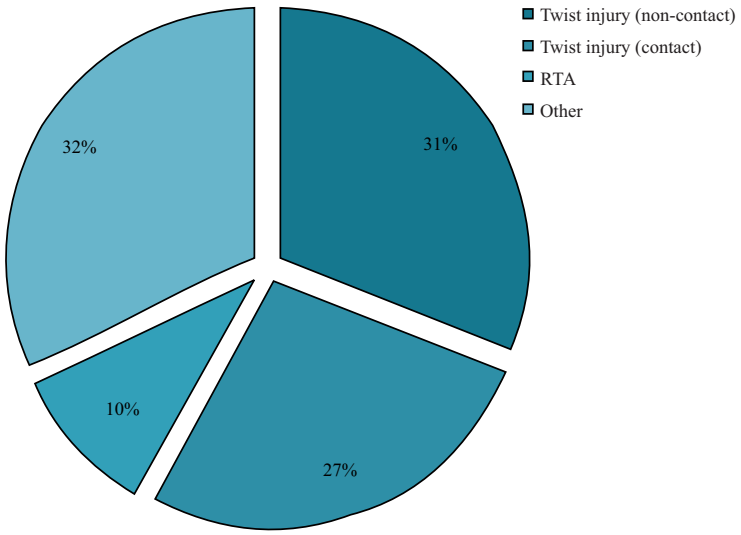

Fig. 1: Mode of meniscal injury

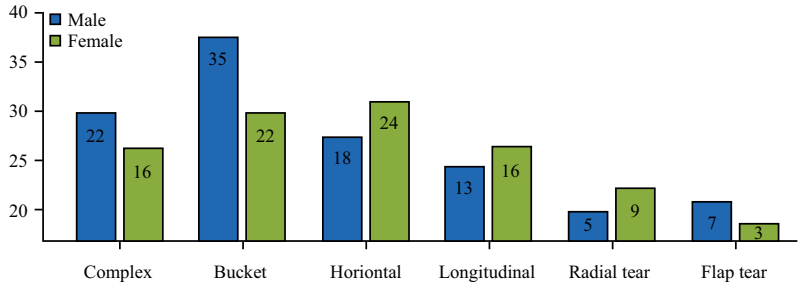

Fig. 2: Gender distribution of meniscal tear shape

DISCUSSIONS

It is well known that a patient's prognosis depends on the type and location of the meniscal tear, as well as the presence or absence of an articular cartilage lesion. The choice of surgical procedure is determined by the type and location of the meniscal tear, specifically whether it is located in the avascular or vascular zone[12,13].

Out of the 72 patients included in the study, 40 were males and 32 were females. Among them, 46 patients had an isolated medial meniscus tear (group 1), 20 patients had an isolated lateral meniscus tear (group 2) and 6 patients had tears in both menisci (group 3). These findings are consistent with the rates reported in the existing literature.

In this study, it was observed that right-sided meniscal tears were more prevalent, accounting for 56% of cases, compared to left-sided tears which accounted for 44% of cases. The percentage of male and female patients with these tears were as follows: 52 and 48% for medial meniscus tears, 55 and 45% for lateral meniscus tears and 75 and 25% for tears in both menisci, respectively.

Our data indicates a difference in the ratio of medial (64%) to lateral (36%) meniscal tears. A study by Smith and Barrett[8] found that 53% of tears occurred in the medial meniscus and 47% in the lateral meniscus, while another study from the same team reported proportions of 73% and 19%, respectively, in stable knees[14]. This difference in tear occurrence between the medial and lateral menisci is often attributed to anatomical and functional differences that exist between the two, particularly in ACL-deficient knees.

The higher percentage of medial meniscal tears observed in this study can be explained by the anatomical and biomechanical characteristics of the medial meniscus. The medial meniscus is firmly attached to the tibia, particularly at the posterior horn[10]. This strong attachment makes the medial meniscus more susceptible to injury.

Biomechanically, the medial meniscus serves as a secondary stabilizer of the knee, particularly in cases of ACL injury. It helps to resist anterior displacement of the tibia and is subjected to anteroposterior shear forces[15]. These shear stresses and forces on the

medial meniscus increase the likelihood of tears occurring in this region.

In contrast, the lateral meniscus is more mobile and has a less rigid attachment to the tibia. This mobility and reduced attachment make the lateral meniscus less prone to the same shear forces and stresses as the medial meniscus, resulting in a lower percentage of tears in this region.

Therefore, the higher prevalence of medial meniscal tears can be attributed to both the anatomical attachment and the biomechanical role of the medial meniscus in knee stability.

Indeed, further studies are needed to validate and support the theory behind the higher incidence of medial meniscal tears. The tight attachment of the medial meniscus and its exposure to different forces and injury mechanisms compared to the lateral meniscus suggest that these factors may contribute to the higher prevalence of medial meniscal tears.

The lateral meniscus, on the other hand, is relatively loosely attached to the tibial plateau, allowing for greater mobility. It has a minimal stabilizing function in the knee, further distinguishing it from the medial meniscus.

When describing the tears, similar terminology was used as in previous studies by various authors. For instance, Dandy reported that 75% of medial meniscal tears were vertical and 23% were horizontal, with vertical tears more commonly occurring in the fourth decade of life and horizontal tears in the fifth decade[16]. Poehling *et al*.[17] described 6,039 meniscal tears from multiple centers and found that 56% were vertical and 42% were horizontal. Metcalf and Barrett conducted a prospective evaluation of 1,485 meniscal tears in patients with stable knees and found that 40% of tears were vertical and 60% were horizontal[18].

These findings provide insights into the types and prevalence of meniscal tears, highlighting the importance of understanding the specific tear patterns for appropriate diagnosis and treatment.

In this study, it was found that 33% of the tears in the medial meniscus were bucket handle tears and 26% were horizontal tears. In the lateral meniscus, the percentage was 35% for complex tears and 23% for horizontal tears. The incidence of bucket handle tears was higher in the medial meniscus compared to the lateral meniscus. These findings are consistent with other studies that have also reported a higher prevalence of bucket handle tears in the medial meniscus regardless of the chronicity of the injury[8,14].

When considering the gender distribution of meniscal tears in this study, it was observed that bucket handle tears were more common in males (35%), followed by complex tears (22%). In females, horizontal tears were more commonly observed (34%), followed by bucket handle tears (22%).These findings highlight the different tear patterns and their distribution among genders, providing valuable insights into the characteristics of meniscal tears in this study population.

Cerabona *et al*. have proposed a theory that recurrent trauma experienced by the medial meniscus while acting as a cushion in an ACL-deficient knee may lead to posterior horn tears[19]. This could be attributed to the relative immobility of the medial meniscus, which reduces its ability to absorb shear stresses during subluxation of the tibial plateau during the pivot shift phenomenon[20]. In this study, it was observed that medial meniscus tears were more common in patients above 40 years of age, with a prevalence of 73% in females and 62% in males. This finding aligns with the existing literature, which suggests a significant impact of aging on the menisci. The effects of aging on the menisci may involve vascular changes, biochemical changes and degenerative changes[21-23]. These age-related factors contribute to the higher incidence of medial meniscus tears in older individuals.

In this study, a lower prevalence of isolated medial meniscus tears was found in younger females compared to males. On the other hand, lateral meniscus tears were more common in females below 40 years (78%) and in males above 40 years (73%). Metcalf and Barrett[18] reported that in stable knees, 39% of meniscal tears involved the peripheral zones (zones O and/or 1), with no significant difference in the circumferential zones affected in medial and lateral tears. A similar study conducted by the senior author on unstable knees found that 60.7% of tears were located in the peripheral zones.

The location of the meniscal tear, whether in the vascular or avascular zone, has implications for the type of treatment required. Surgeons can use knowledge of the type and location of the meniscal lesion in specific sports to predict the most appropriate therapeutic approach, such as partial meniscectomy or repair.

Regarding the radial zones, this study found that 60% of the tears involved the posterior horn of the meniscus. This percentage is lower compared to the findings of Metcalf and Barrett[18], who reported 87% involvement of the posterior horn in stable knees and Smith and Barrett[8], who reported 93.9% involvement in unstable knees.

In this study, it was also observed that tears occurred more frequently in the red-white zone (68%) and the posterior 1/3rd zone (60%) of the meniscus. Additionally, there was a correlation between increased BMI and a higher incidence of medial meniscus tears. Obesity generally has a negative impact on the knee joint and previous studies have shown a significant correlation between meniscal tears and increasing BMI, as reported by Ford *et al*.[24].

BMI was found to have a significant effect on the incidence of meniscal tears in this study, with patients having higher BMI having a higher likelihood of isolated meniscal tears ($p<0.03$). The mean age of the participants was 42.18±12.64 years, with a mean BMI of 28.03±3.88 kg m^{-2}. The relationship between BMI and meniscal tears may be explained biomechanically, as increased BMI can lead to higher torque in the knee joint during rotation, potentially causing more meniscal injuries[25].

Several factors have been reported to increase the risk of meniscal tears in ACL-deficient patients. These factors include older age, male gender, increased body weight and repetitive activities[26-29]. Squatting, in particular, has been associated with an increased incidence of meniscus tears. A recent biomechanical study demonstrated increased frontal plane motion during squatting, which is known to elevate the risk of meniscal tears and subsequent knee osteoarthritis.

In this study, the highest percentage of meniscal tears was observed in individuals with occupations such as housewives, manual laborers and farmers. This observation may be attributed to the fact that these occupations often involve activities that require frequent kneeling and squatting, which can put additional stress on the knee joint and increase the risk of meniscal tears. Furthermore, prolonged standing and walking were found to be associated with an increased risk of meniscal tears in this study ($p < 0.02$). This suggests that occupations or activities that involve prolonged periods of standing and walking may contribute to the development of meniscal tears.

In this study, the effects of alcohol consumption and smoking on the occurrence of meniscal tears were investigated while adjusting for BMI and joint laxity, as these factors were considered potential confounders. The findings of the study indicated minimal or no evidence to support an association between smoking, alcohol consumption and the occurrence of meniscal tears. This suggests that, in the context of this study, smoking and alcohol consumption may not be significant risk factors for the development of meniscal tears. However, it is important to note that further research may be needed to fully understand the relationship between these factors and meniscal tears, as different studies may yield varying results.

CONCLUSION

Meniscal injuries were found to be more common among individuals in their fourth and fifth decade of life. Increasing age was associated with a higher incidence of medial meniscus tears, regardless of tear location. Medial meniscus tears accounted for 64% of the observed tears, while lateral meniscus tears accounted for 36%. High BMI was found to be a contributing factor in the occurrence of meniscal injuries. Among various work-related activities, kneeling, squatting, prolonged standing and walking were identified as factors influencing the occurrence of meniscal tears. In males, the incidence of medial meniscal tears increased with age. In female patients younger than 40 years, lateral meniscal tears were more prevalent than medial meniscal tears. Bucket handle tears were the most commonly observed type of tear, followed by horizontal tears, in cases of isolated meniscus injuries.

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