Section: Orthopaedics

Original Research Article

PRESENTATION AND PATTERNS OF MENISCAL DAMAGE ASSOCIATED WITH ANTERIOR CRUCIATE LIGAMENT TEAR

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Abstract

Background: The incidence of meniscal injuries is notably high in patients with ACL tears, the incidence, location, and pattern of meniscal injuries vary depending on the timing of the injury. The optimal timing for meniscal repair and the types of tear patterns that require repair are subjects of ongoing debate. This differentiation in tear configurations is crucial for guiding clinical decisions and interventions, ensuring an appropriate and effective approach tailored to the specific characteristics of the meniscal tear. This study aims to meticulously document the prevalence and distribution of meniscal lesions accompanying ACL tears, focusing on the time from injury to reconstruction. Furthermore, the study seeks to identify patterns of meniscal injury in the acute, subacute, and chronic phases of ACL reconstruction. **Materials and Methods:** Retrospective study, this research encompassed 32 patients diagnosed with ACL tears, with concomitant meniscal injuries. A total of 32 patients, satisfying the stipulated inclusion criteria, were selected for the study, and the ACL diagnosis was revalidated during the reconstruction process. The precise location and grade of meniscal injuries were meticulously documented. The patients were categorically classified into three groups based on the chronicity of their ACL tear, and the corresponding patterns of associated meniscal injuries were recorded. Group I consisted of patients who had undergone ACL reconstruction within 2 months of their injury, Group II encompassed those treated within 2-6 months, and Group III comprised individuals who received treatment within 6-12 months of their initial injury. Furthermore, the meniscal injuries were categorized based on the classification system developed by Tangodan et al. **Results:** The study population comprised three distinct groups, encompassing a total of 32 patients, consisting of 24 males and 8 females. Patients were stratified into these groups based on both the nature of their injury and the time elapsed before treatment initiation. In GROUP I, there were 9 patients in the acute phase, who underwent reconstruction within 2 months of sustaining their injury. GROUP II comprised 11 patients in the subacute phase, with surgeries performed within the 2–6-month timeframe. Finally, GROUP III consisted of 12 chronic cases, where reconstruction took place late, between 6-12 months post-injury. The male demographic represented 75% of the entire patient cohort with injuries, leaving the remaining 25% attributed to females. The analysis revealed no statistically significant difference in the average age of patients across Group I, II, and III. Overall, medial meniscal injuries constituted 75% of cases, while lateral meniscal injuries accounted for 19%, and the occurrence of both medial and lateral meniscal injuries represented 6%. Overall, in medial meniscal injuries, longitudinal tears (25%) exhibited a significantly higher prevalence, followed by degenerative tears (19%), bucket handle, and radial tears (13%). Complex tears (6%) and flap and oblique tears (3%) were observed to a lesser extent. Overall, in lateral meniscal injuries, longitudinal tears were predominant, accounting for 50%, followed by radial tears at 25%, and a combination of bucket handle and complex tears at 13%. **Conclusion:** This study demonstrated that the incidence of meniscal injury increased over time in ACL deficient knees. Lateral meniscal injuries were more common in

acute ACL tears, and as patients progressed through the acute and sub-acute phases, the proportion of medial meniscal injuries increased due to knee instability. Longitudinal, radial, bucket handle, and complex tears involved both the medial and lateral menisci in ACL injuries, while oblique tears, degenerative tears, and flap tears predominantly affected the medial meniscus. Specifically, in acute ACL injuries, longitudinal, radial, bucket handle, and oblique tear patterns were observed involving both menisci. In subacute ACL injuries, longitudinal, radial, and complex tear patterns predominated. In chronic ACL tears, complex and degenerative tears predominated, mainly involving the medial meniscus.

INTRODUCTION

Meniscal tears often result from a combination of compression and twisting movements. Delay in treating anterior cruciate ligament (ACL) tears has been associated with a greater likelihood of meniscal injuries. The incidence of meniscal injuries is notably high in patients with ACL tears, with reported rates ranging from 55% to 65%. Both the medial and lateral menisci can be affected. In cases of acute ACL injury, there is a higher occurrence of lateral meniscus tears compared to medial. The incidence, location, and pattern of meniscal injuries vary depending on the timing of the injury. The lateral meniscus is relatively less firmly attached to the tibial plateau than the medial meniscus, making it more susceptible to injury in cases of acute ACL tears. In situations of chronic ACL tears, the medial meniscus can become wedged between the condyles, resulting in significant injury. The optimal timing for meniscal repair and the types of tear patterns that require repair are subjects of ongoing debate. A study by Brambilla et al. suggested a higher occurrence of medial meniscal tears in injuries treated after 12 months.

In a study conducted by Roshan ET AL, the posterior horn of the medial meniscus constituted 50% of injuries, possibly due to primary and secondary injury to the knee joint, while lateral meniscal tears were more associated with partial ACL tears. However, Smith and Barrete found no association between the type of medial and lateral meniscal tears and ACL injuries. The pattern of meniscal injury influences the onset of joint degeneration. Stable longitudinal tears, whether complete or incomplete, might not require immediate treatment. However, root tears, bucket-handle tears, and radial tears should be promptly repaired Numerous studies have shown that longitudinal tears constituted 52.71% of medial meniscus injuries, of which 27% were bucket handle tears and complex tears. Posterior horn tears and horizontal posterior tears were more frequent in the lateral meniscus.

In a study by Thompson and Fu, posterior horn tears accounted for over half of meniscal tears in both acute and chronic ACL tears, with a higher prevalence in the medial meniscus. Complete ACL tears were associated with medial meniscal tears involving the posterior horns, while partial ACL tears involved the posterior and middle horns. Tears were almost equally distributed in cases of lateral meniscus injury. While statistically significant differences exist between medial and lateral tears, tears involving the medial meniscus are significantly associated with the posterior horn and the peripheral meniscocapsular junction.

Meniscal tears can be classified into various configurations, each carrying distinct clinical implications. Longitudinal and oblique configurations typically fall under the category of reparable tears, offering a more favourable prognosis. In contrast, tears characterized by horizontal, radial, and complex configurations generally present challenges for repair and often necessitate partial meniscectomy as the preferred course of treatment. This differentiation in tear configurations is crucial for guiding clinical decisions and interventions, ensuring an appropriate and effective approach tailored to the specific characteristics of the meniscal tear.

Studies have indicated that early ACL reconstruction reduces the incidence of meniscal injury and subsequent osteoarthritis compared to delayed reconstruction. Keays and colleagues emphasized that a delay between ACL tear and reconstruction might indicate subsequent meniscal tears and osteoarthritis. Treatment options for meniscal tears include conservative management, meniscectomy, or repair. Conservative treatment can be suitable for individuals with lower activity demands and acute ACL injuries, enabling engagement in low-risk pivoting sports. Injuries in the vascular meniscal zone tend to heal better with repair. Therefore, identifying tears early and considering timely repair is advisable Chronic-stage meniscal tears are less amenable to repair, and lateral meniscectomy increases the risk of osteoarthritis. The primary goal of ACL reconstruction is to prevent secondary meniscal and chondral injuries. Hence, avoiding unnecessary delays in ACL surgery is recommended.

This study aims to meticulously document the prevalence and distribution of meniscal lesions accompanying ACL tears, focusing on the time from injury to reconstruction. Furthermore, the study seeks to identify patterns of meniscal injury in the acute, subacute, and chronic phases of ACL reconstruction.

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MATERIALS AND METHODS

Conducted as a retrospective study, this research encompassed 32 patients diagnosed with ACL tears, with concomitant meniscal injuries. Comprehensive data, inclusive of preoperative physical examinations, operative techniques, and subjective accounts of pain, dysfunction, or gait issues, was meticulously extracted from patient records. Diagnosis was uniformly confirmed through MRI assessments in all patients, and these MRI findings were subsequently validated via arthroscopic procedures. Inclusion criteria for the study were restricted to males and females between 16 and 60 years of age who had undergone primary ACL reconstruction, with associated meniscal injuries, while patients with collateral ligament injuries, posterior cruciate injuries, or those seeking revision ACL surgeries were excluded.

A total of 32 patients, satisfying the stipulated inclusion criteria, were selected for the study, and the ACL diagnosis was revalidated during the reconstruction process. The precise location and grade of meniscal injuries were meticulously documented. All patients received Arthroscopic ACL Reconstruction, and for Grade II and III meniscal tears, treatment entailed either meniscectomy or repair.

The patients were categorically classified into three groups based on the chronicity of their ACL tear, and the corresponding patterns of associated meniscal injuries were recorded. Group I consisted of patients who had undergone ACL reconstruction within 2 months of their injury, Group II encompassed those treated within 2-6 months, and Group III comprised individuals who received treatment within 6-12 months of their initial injury.

Furthermore, the meniscal injuries were categorized based on the classification system developed by Tangodan et al, which differentiates injuries into Longitudinal, Degenerative, Radical, Complex, and FLAP types, based on both MRI and arthroscopy findings.

In terms of statistical analysis, the distribution of patients across the three groups was assessed using the chi-square test. The Kolmogorov-Smirnov test was employed to confirm the distribution of patients within specific age groups. The average age of patients was verified through the F-test, while the ratio of patients sustaining Medial meniscus injuries, Lateral meniscus injuries, or exhibiting no meniscal injuries was assessed using the chi-square test.

RESULTS

The study population comprised three distinct groups, encompassing a total of 32 patients, consisting of 24 males and 8 females. Patients were stratified into these groups based on both the nature of their injury and the time elapsed before treatment initiation. In GROUP I, there were 9 patients in the acute phase, who underwent reconstruction within 2 months of sustaining their injury. GROUP II comprised 11 patients in the subacute phase, with surgeries performed within the 2–6-month timeframe. Finally, GROUP III consisted of 12 chronic cases, where reconstruction took place late, between 6-12 months post-injury. The patient distribution across these groups followed a ratio of 1:2:2, a balance verified through a chi-square test ($\chi 2 = 1.2772$, p value = 0.5280 > 0.05).

The male demographic represented 75% of the entire patient cohort with injuries, leaving the remaining 25% attributed to females. Breaking down the gender distribution within each group, Group I comprised 56% males and 44% females. Moving to Group II, a higher proportion of 82% were males, while 18% were females. In Group III, the majority were males at 83%, with females constituting 17%. These gender-specific breakdowns are summarized in Table 1. [Table 1]

The examination of mean and standard deviation of age across the three groups, as outlined in Table 3, aimed to assess the influence of meniscal tears with increasing age in the study cohorts. The analysis revealed no statistically significant difference in the average age of patients across Group I, II, and III. This conclusion was further corroborated by employing an F test, resulting in F=1.5401 with a P value of 0.2191, which exceeds the threshold of significance (0.05). Consequently, the impact of ACL injury on meniscal tears remained consistent, unaffected by the advancing age of patients within the examined age bracket. [Table 2]

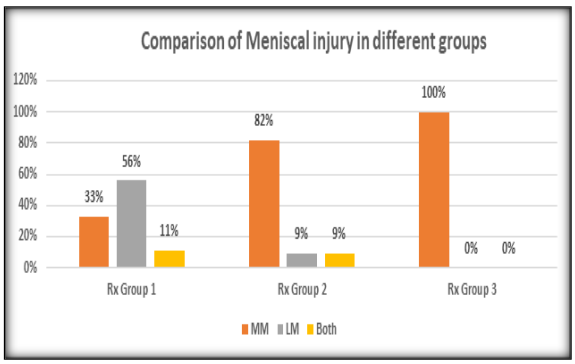

Figure 1

In Group I, 33% of patients presented with a medial meniscal injury, 56% had a lateral meniscal injury, and 11.5% exhibited both medial and lateral meniscal injuries. In Group II, the distribution was 82% with a medial meniscal injury, 9% with a lateral meniscal injury, and 9% with both types of meniscal injuries. Moving to Group III, 100% of patients were diagnosed with a medial meniscal injury. Overall, medial meniscal injuries constituted 75% of cases, while lateral meniscal injuries accounted for 19%, and the occurrence of both medial and lateral meniscal injuries represented 6%. These findings are summarized to provide a

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comprehensive overview of meniscal injury patterns in the three groups.

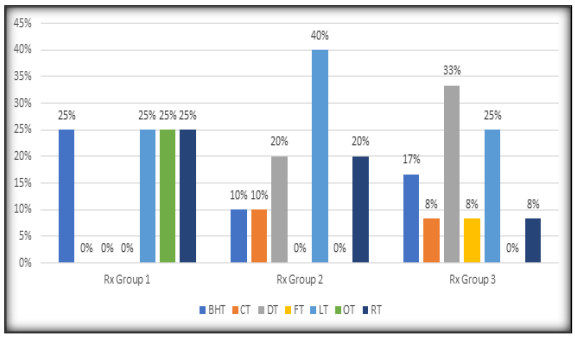

Figure 2

The examination of medial meniscal injuries across the acute (Group I), subacute (Group II), and chronic (Group III) categories revealed distinct patterns. In Group I, 25% of tears were characterized as bucket handle, longitudinal, oblique, and radial. In Group II, the breakdown included 10% bucket handle and complex tears, while 20% were degenerative and radial, with longitudinal tears constituting 40%. Group III displayed 33% degenerative tears, 17% bucket handle, and 8% complex tears, flap, and radial tears. Overall, in medial meniscal injuries, longitudinal tears (25%) exhibited a significantly higher prevalence, followed by degenerative tears (19%), bucket handle, and radial tears (13%). Complex tears (6%) and flap and oblique tears (3%) were observed to a lesser extent. These findings provide a comprehensive overview of the varied nature of medial meniscal injuries across the three groups.

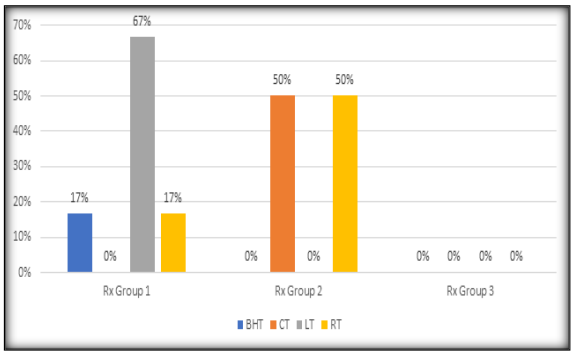

Figure 3

The analysis of lateral meniscal injuries across the acute (Group I), subacute (Group II), and chronic (Group III) categories revealed diverse patterns. In Group I, longitudinal tears constituted 67% of meniscal injuries, while bucket handle and radial tears made up 17%. In Group II, 50% of injuries were characterized as complex and radial tears. Interestingly, Group III patients did not exhibit any lateral meniscal injuries.

Overall, in lateral meniscal injuries, longitudinal tears were predominant, accounting for 50%, followed by radial tears at 25%, and a combination of bucket handle and complex tears at 13%. These findings provide insight into the varied nature of lateral meniscal injuries across the three groups, with a notable prevalence of longitudinal tears.

Table 1: Gender Based Distribution of Cases

Gender	Rx Group			Total
	1	2	3	
Male	5 (56%)	9 (82%)	10 (83%)	24 (75%)
Female	4 (44%)	2 (18%)	2 (17%)	8 (25%)
Total	9 (100%)	11 (100%)	12 (100%)	32 (100%)

Table 2: Mean and SD of Age of patients

Age	Mean	SD	Mean-SD	Mean+SD
Group 1	34.5	9.7	24.8	44.2
Group 2	36.3	12.1	24.2	48.4
Group 3	28.3	10	18.3	38.3

Table 3: Comparison of Meniscal injury in different groups

Meniscal injury	Rx Group			Total
	1	2	3	
Medial	3 (33%)	9 (82%)	12 (100%)	24 (75%)
Lateral	5 (56%)	1 (9%)	0 (0%)	6 (19%)
Both	1 (11%)	1 (9%)	0 (0%)	2 (6%)
Total	9 (100%)	11 (100%)	12 (100%)	32 (100%)

Table 4: Pattern of Medial meniscal injury associated with ACL Deficient Knee

Meniscus Medial	Rx Group			Total
	Rx Group 1	Rx Group 2	Rx Group 3	
Repairable				
LT (Longitudinal Tear)	1 (25%)	4 (40%)	3 (25%)	8 (25%)
OT (Oblique Tear)	1 (25%)	0 (0%)	0 (0%)	1 (3%)
Irreparable				
RT (Radial Tear)	1 (25%)	2 (20%)	1 (8%)	4 (13%)
BHT (Bucket Handle Tear)	1 (25%)	1 (10%)	2 (17%)	4 (13%)

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CT (Complex tear)	0 (0%)	1 (10%)	1 (8%)	2 (6%)
DT (Degenerative Tear)	0 (0%)	2 (20%)	4 (33%)	6 (19%)
FT (FLAP Tear)	0 (0%)	0 (0%)	1 (8%)	1 (3%)
Total	4 (100%)	10 (100%)	12 (100%)	32 (100%)

Table 5: Pattern of Lateral meniscal Injury associated with ACL deficient knee

Meniscus lateral	Rx Group			Total
	Rx Group 1	Rx Group 2	Rx Group 3	
Repairable				
LT (Longitudinal Tear)	4 (67%)	0 (0%)	0 (0%)	4 (50%)
Irreparable				
RT (Radial Tear)	1 (17%)	1 (50%)	0 (0%)	2 (25%)
BHT (Bucket Handle Tear)	1 (17%)	0 (0%)	0 (0%)	1 (13%)
CT (Complex tear)	0 (0%)	1 (50%)	0 (0%)	1 (13%)
Total	6 (100%)	2 (100%)	0 (0%)	8 (100%)

DISCUSSION

In our study, we demonstrated that following an anterior cruciate injury, the risk of meniscal tears increased with a delay in reconstruction. Although age-related changes may induce meniscal tissue vulnerability leading to meniscal dysfunction and tears, as shown by Tsujji and Nakumura Et al, we were not able to demonstrate an association between age and meniscal tears, probably due to the short assessment period of one year in chronic cases. Meniscal tears were identified in patients in group I, II, and group III. The incidence of meniscal tears increased over time in ACL-deficient knees, as shown by Papastergiou et al, with medial meniscal injury found to be significantly higher than lateral meniscus injury.

In the 10 patients operated on in the acute stage (Group I), the lateral meniscus was found torn in 75%, predominantly as Grade 1 tears left without intervention. Medial meniscal injury accounted for only 12.5%, often requiring Meniscectomy or repair. The 12 knees operated on in the sub-acute stage (Group II) showed a similar pattern, with only 25% of lateral menisci torn, left untreated, while 31.25% of medial meniscal injury required partial Meniscectomy or repair.

In the chronic stage (Group III), a different pattern of associated lesions emerged, with the lateral meniscus intact in all patients. The medial meniscus was involved in 37.5%, with the majority requiring subtotal Meniscectomy for complex tears. It could be sutured in only 5.7% with a less favorable prognosis Patterns we encountered in this study and their association with ACL Injury.

Longitudinal Tears

Longitudinal tears, characterized by a vertical orientation extending throughout the meniscal circumference in a parallel manner, are frequently linked with ACL tears. In one study, 17% of patients with an acute ACL tear displayed a medial meniscal peripheral longitudinal tear, while 10% exhibited a lateral peripheral longitudinal tear, often leading to a bucket-handle displacement. These tears predominantly affect both menisci, especially the posterior horn. Occasionally, the peripheral longitudinal tear migrates centrally into the joint, forming a lifted bucket handle, identifiable through various signs such as the double PCL sign and flipped meniscus sign. In our study, these tears constituted 25% of medial meniscus and 50% of lateral meniscal tears, with 40% of these tears in the sub-acute group for the medial meniscus and 67% in the acute group for the lateral meniscus.

Oblique Tears (OT)

Oblique tears commonly manifest symptoms and lead to functional limitations, often causing painful locking of the knee, particularly during knee bending. These tears produce unstable flaps, resulting in clicking and locking within the knee. Resection is necessary to prevent progression and knee locking. In our study population, oblique tears involved 3% of the medial meniscus, 25% of which were observed in acute ACL injuries.

Radial Tears (RT)

In cases of acute ACL disruption, radial tears with an oblique configuration affecting the posterior horn predominate. These LMORTs differ from other meniscal tears in factors such as location, oblique configuration, and association with acute ACL injury. Research suggests that stable lateral meniscal tears in the periphery often heal without intervention,[6] while large radial tears with symptoms often necessitate repair. Our study observed this pattern in 13% of medial meniscus tears, with 25% in the acute group, and 25% in lateral meniscus tears, with 50% in the subacute group.

Bucket Handle Tears (BHT)

A subset of meniscal injuries, bucket handle meniscal tears (BHMT), are characterized by a longitudinal tear with an attached fragment displaced away from the periphery of the meniscus, typically seen in the less mobile medial meniscus. This tear pattern is often associated with a complete rupture of the ACL and a double posterior cruciate ligament sign, indicative of a bucket handle tear of the medial meniscus. Thirteen percent of our study population manifested a BHMT in both medial and lateral menisci, with a preponderance in acute ACL injuries.

Complex Tears (CT)

Complex tears result from two or more basic tear patterns, commonly experienced by younger

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individuals due to sport-related traumatic events. The most prevalent complex tear involves a combination of radial and horizontal tears. In chronic ACL tear cases, the complexity of meniscal tears increases significantly, making repair unfeasible. Medial meniscus tears associated with chronic ACL injury are more common compared to lateral meniscus tears. These tears constituted 6% and 13% in medial and lateral meniscal tears, respectively, with a significantly higher proportion in the sub-acute and chronic groups, mostly in the medial meniscus.

Degenerative Tears (DT)

Approximately 50% of individuals diagnosed with an ACL or meniscus tear develop osteoarthritis 10 to 20 years post-diagnosis, leading to associated pain and functional impairment. Despite this, evidence supporting a protective role of repair or reconstructive surgery against osteoarthritis development is lacking. Cartilage degeneration and other degenerative changes in the knee continue to progress despite functionally stable ACL reconstruction. Multiple repeated microtraumas can result in intrasubstance degeneration of the meniscus. Poor knee stability resulting from an ACL partial tear significantly increases the likelihood of joint injury. Thirty percent of meniscus tears occur between the ages of 41-50 in males and 61-70 in females due to age-related desiccation or deterioration of the meniscus. In our study, degenerative tears involved 19% of the study population of medial meniscal tears, with 33% in the chronic group.

Flap Tears (FT)

A flap tear occurs when the meniscus tears within its substance, often in a horizontal pattern, causing the torn component to displace from its original site, commonly seen at the medial meniscal body.[8]

Flap tears can lead to persistent knee pain, effusion, and symptoms like locking and clicking. Displaced flap tears typically cause worse pain, possibly due to pressure and traction at the meniscocapsular junction, richly innervated. Horizontal tears can result in superior or inferior flap tears. Oblique tears may also produce mechanically unstable flaps with associated symptoms. In our study population, 3% of the medial meniscus presented with a flap tear, 8% of which involved the chronic group alone.

The incidence of tears occurring in both menisci increased as the instability became chronic, and it has been shown that a meniscal injury increases the rate of osteoarthritis in separate studies done by Aglietti et al, Beynnon et al, Cohen et al 2007, Jomha et al. Our study was in accordance with the findings of Bellabarba et al, Thompson et al, Melissa wherein they found that lateral meniscal tears are more frequently encountered than medial meniscal tears in acute and subacute stages, while medial meniscal tears are more common in chronic injuries.

The present study being retrospective depends on the data that was collected from chart reviews and also the time of injury to surgery as presented by the patient may have flaws. Nonetheless the data points to the fact that early reconstruction of ACL tears should be a better option than to expose the patient to meniscal tears and secondary osteoarthritis. Patient preferences should be taken into consideration and also the functional level of the individual assessed and the possibility of meniscal tear and subsequent osteoarthritis explained.

CONCLUSION

This study demonstrated that the incidence of meniscal injury increased over time in ACL deficient knees. Lateral meniscal injuries were more common in acute ACL tears, and as patients progressed through the acute and sub-acute phases, the proportion of medial meniscal injuries increased due to knee instability. Longitudinal, radial, bucket handle, and complex tears involved both the medial and lateral menisci in ACL injuries, while oblique tears, degenerative tears, and flap tears predominantly affected the medial meniscus. Specifically, in acute ACL injuries, longitudinal, radial, bucket handle, and oblique tear patterns were observed involving both menisci. In subacute ACL injuries, longitudinal, radial, and complex tear patterns predominated. In chronic ACL tears, complex and degenerative tears predominated, mainly involving the medial meniscus. Therefore, early ACL reconstruction within two months of injury followed by structured rehabilitation emerged as a favorable option for patients as it helped prevent further meniscal damage.

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